Washington Comprehensive Assessment of Science

Test Design & Item Specifications

Grade 8

Washington Office of Superintendent of
PUBLIC INSTRUCTION

Developed by OSPI in collaboration with WestEd

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Purpose Statement

The purpose of the Washington Comprehensive Assessment of Science (WCAS) is to measure the level of science proficiency that Washington students have achieved based on the *Washington State 2013 K–12 Science Learning Standards*. The standards are the *Next Generation Science Standards* (NGSS) and are organized into four domains: Physical Sciences; Life Sciences; Earth and Space Sciences; and Engineering, Technology, and the Applications of Science. Each domain has three-dimensional performance expectations that integrate science and engineering practices, disciplinary core ideas, and crosscutting concepts. The assessments were first administered in grades 5, 8, and 11 for federal and state accountability purposes in spring 2018.

This item specifications document describes how the item clusters (stimuli and items) and standalone items for the WCAS assessments are developed to assess the NGSS (referred to as “the standards” in the remainder of this document) and includes the second publicly released drafts of the item specifications for the WCAS.

The item specifications are based on the Performance Expectations (PEs) in the standards. The item specification for an individual PE describes how students can demonstrate understanding of the PE on the WCAS. The item specifications are updated annually based on input from Washington educators. Each draft will be accompanied by a modifications log that is updated at each subsequent publication.

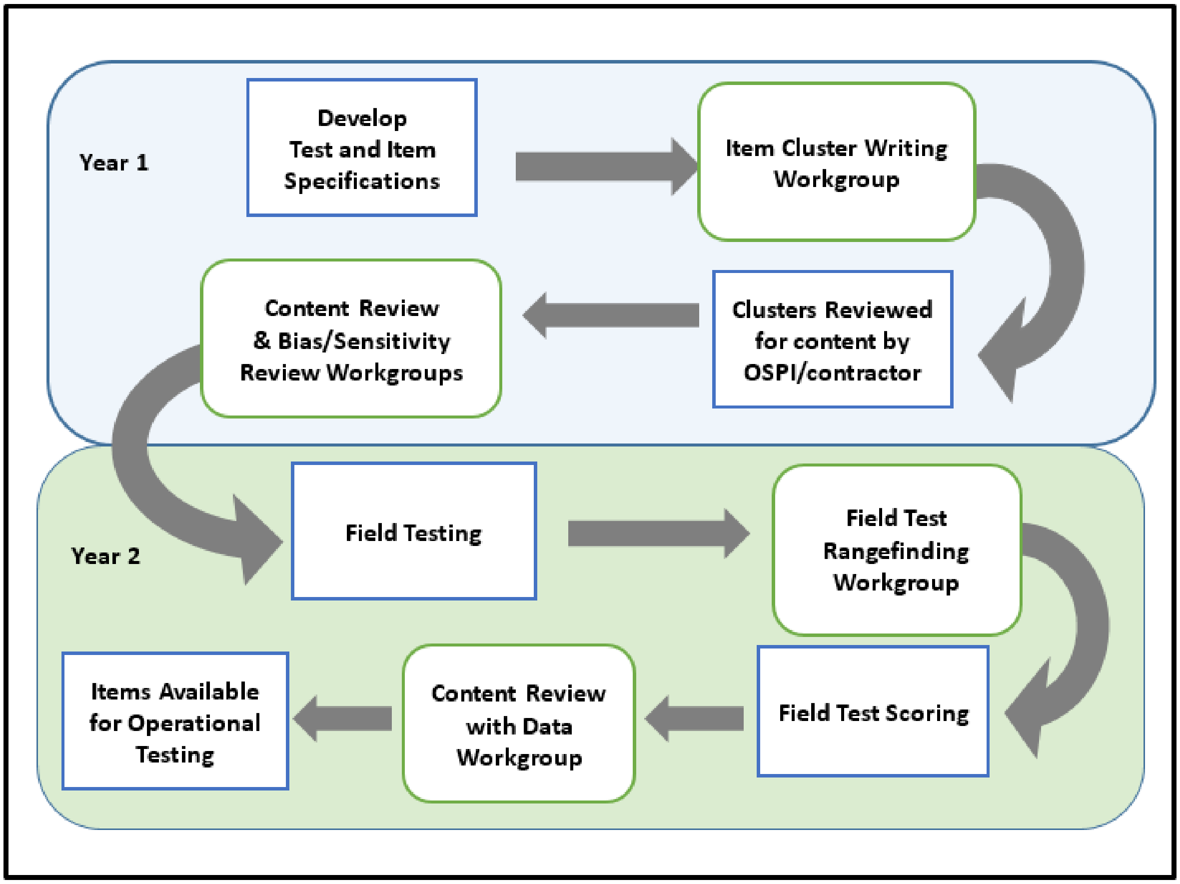
Assessment Development Cycle

The WCAS is written by trained science educators from Washington. Each item cluster and standalone item is planned by the Office of Superintendent of Public Instruction (OSPI) Science Assessment Development Team in conjunction with an educational assessment contractor and then written, reviewed, and revised by educators during an item cluster writing workshop. From there, the development process involves formal reviews with science educators for all clusters and standalone items and for the scoring criteria in the rubrics of technology-enhanced and short-answer items. The development process assures the assessment contains items that meet the following criteria:

- Include authentic stimuli describing scientific phenomena that are grade-level appropriate
- Achieve tight alignment to a specified two- or three-dimensional item specification
- Provide a valid measure of a specified science learning standard
- Include item scoring rubrics that can be validly applied
- Include technology-enhanced and short answer items that can be reliably scored

The Science Assessment Development Cycle flowchart summarizes the two-year process of review and field testing that precedes clusters and standalone items being used on an operational test.

Science Assessment Development Cycle



OSPI solicits critical input from Washington educators by means of four key workgroups each year:

In the **Item Cluster Writing Workgroup**, teams of two to three educators write stimuli, items, and rubrics designed to validly measure student understanding of the standards.

In the **Content Review Workgroup**, educators review the products of the item cluster writing workgroup to ensure that every stimulus, item, and rubric is scientifically accurate and gathers appropriate evidence about student understanding and application of the standards. At the same time, a separate committee of community members reviews the items and stimuli for any bias or sensitivity issues.

In the **Field Test Rangefinding Workgroup**, educators look at a range of student responses to short answer items and decide how to score each response. This educator workgroup refines scoring rubrics and produces the materials that are used to score the field test items.

In the **Content Review with Data Workgroup**, educators use item performance data, as well as participants' science content knowledge, to decide whether the item should become available for operational testing.

Universal Design

Each phase of the test development process reflects the integration of Universal Design principles with sound measurement theory, current research, and best practices in assessment. These practices result in assessments that are valid, reliable, fair, free from bias, and accessible to all students, including English language learners and students with disabilities.

Universal Design provides a framework for maximizing student participation in an assessment and for providing all students with an opportunity to truly demonstrate what they know and are able to do. The National Center on Educational Outcomes has identified seven elements of universally designed assessments: inclusive assessment population; precisely defined constructs; accessible, non-biased items; amenability to accommodations; simple, clear, and intuitive instructions and procedures; maximum readability and comprehensibility; and maximum legibility (Thompson, Johnstone, Anderson, & Miller, 2005).

Structure of the Test

The WCAS is composed of item clusters and standalone items aligned to the PEs. Advisory groups composed of national education experts, science assessment experts, and science educators recommend the item cluster structure for large-scale assessment of the standards because item clusters involve significant interaction of students with stimulus materials leading to a demonstration of the students' application of knowledge and skills. Standalone items increase the PE coverage that can be achieved in a single test administration.

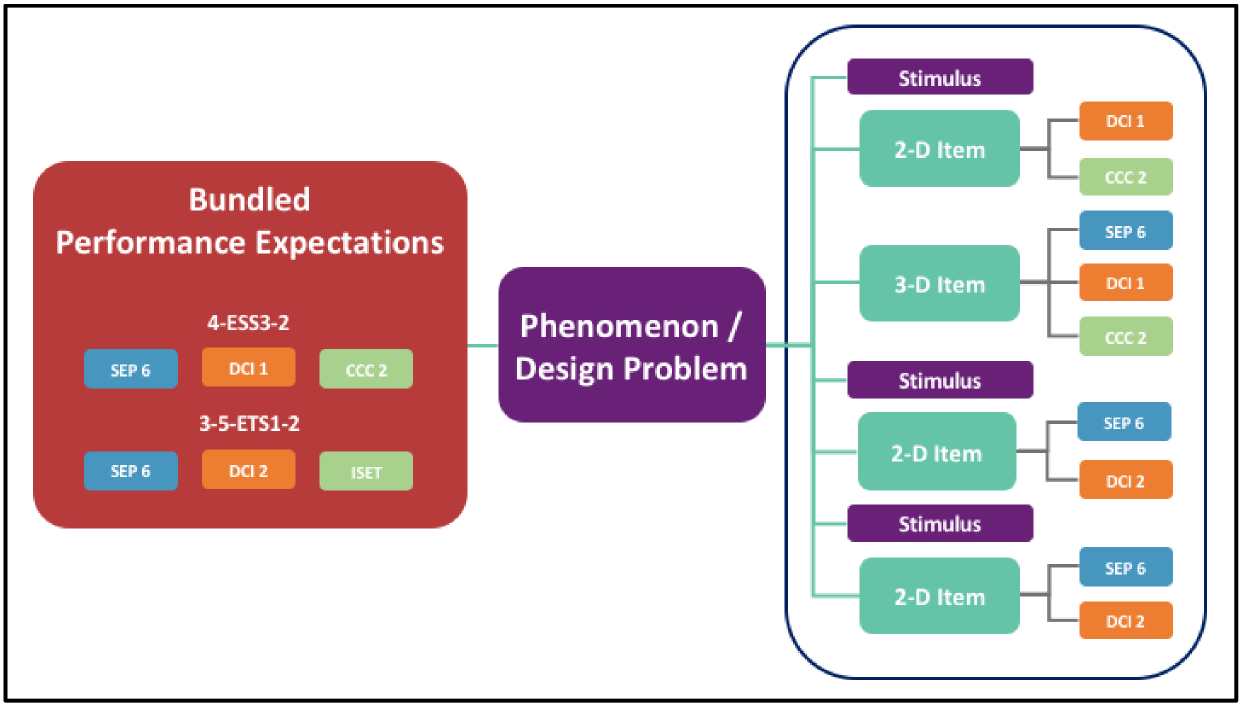
Item Clusters

Item clusters that assess a PE bundle make up the core of the WCAS. A PE bundle is generally two or three related PEs that are used to explain or make sense of a scientific phenomenon or a design problem. A phenomenon gives an item cluster conceptual coherence. The items within an item cluster are interconnected and focused on the given phenomenon. Items are also structured to support a student's progression through the cluster.

Students must make sense of the phenomenon for an item cluster by using the science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) represented in the PE bundle. PE bundles are often within a single domain but may include PEs from different domains. PE bundles sometimes share a similar practice or crosscutting concept or may include multiple practices or crosscutting concepts. Each item within the cluster aligns to two or three dimensions (2-D, 3-D) from one or more of the PEs in the bundle, and there is at least one item in the cluster that aligns to all three dimensions of each PE in the bundle. Achieving as full coverage as possible requires developing items that target a variety of the dimensions represented in the PE bundle. In all cases, item clusters achieve full coverage of the dimensions of each PE within a PE bundle.

The Sample Item Cluster Map shows how the items in a sample cluster work together to achieve full coverage of the dimensions in a two-PE bundle.

Sample Item Cluster Map



Standalone Items

A standalone item is a focused measurement tool that uses a single item to address two or three dimensions of one PE.

Online Test Delivery

The WCAS is delivered online using the same platform as the Smarter Balanced ELA and Mathematics assessments. Students should be familiar with most of the online features of the WCAS; however, there are a few unique features that support efficient and reliable delivery of the clusters and standalone items.

Collapsible Stimuli

The WCAS has some item clusters that include more than one stimulus. Each stimulus is delivered along with the items most closely associated to that stimulus. Once a stimulus is presented, it is available to the student throughout the cluster. To minimize vertical scrolling and the need to move back to previous screens within a cluster, a stimulus is collapsed once the next stimulus is provided. A +/- icon in the heading of a collapsed stimulus section allows the stimulus to be hidden from view or expanded to suit a student’s current need.

Locking Items

WCAS clusters include some locking items in which the student cannot change their answer once they have moved to a different item. A padlock icon next to the item number alerts students that they are answering a locking item. When they start to move on from the item, an “attention” box warns the student that they will not be able to change their answer once they move on. The student can either return to the item or move on and lock in their answer.

Locking items allow the student to be updated with correct information in subsequent items or stimuli. In addition, locking items help to limit item interaction effects or clueing between items in a cluster.

Students can return and view an item that has been locked. The student will see their answer, but they cannot change their answer.

Animation

In addition to diagrams and graphics, the online platform supports the use of animations in stimuli. The animations provide additional scaffolding for the student.

Screen Display

Item clusters are displayed with a stimulus pane and an item pane on the same screen. The stimulus occupies 40% of the screen, while the item occupies 60% of the screen. However, by clicking expansion arrows, a student can expand either pane to a width of 90% of the screen. Standalone items are displayed on the entire width of the screen.

Color

WCAS graphics are developed and delivered in color. An educational assessment contractor's graphics team evaluates the text and colors in each graphic using standard tools (e.g., Colour Contrast Analyser (CCA), Sim Daltonism) to ensure the graphic's content is discernible for the widest range of viewers, including those with common types of colorblindness. In the graphics team's use of the tool to determine acceptable color contrast, they consider indicators defined in the Web Content Accessibility Guidelines (WCAG 2.1), which were adopted by the federal government for compliance to Section 508 of the Rehabilitation Act (29 U.S.C. § 794d). Information about supports and/or accommodations for students with visual impairments can be found in the Guidelines on Tools, Supports, & Accommodations, which can be downloaded from the Washington Comprehensive Assessment Program (WCAP) Portal.

Item Types

The WCAS include several item types. Collectively, these item types enable measurement of understanding and core competencies in ways that support student engagement. The majority of the item types are represented on the WCAS Training Tests, which are accessed on the WCAP Portal.

Edit Task Inline Choice (ETC)

- Students select words, numbers, or phrases from drop-down lists to complete a statement.
- The number of drop-down lists in an item is typically between two and four.
- The length of options in a drop-down list is typically one to four words.
- A drop-down list can be part of a table.

Grid Interaction (GI)

- Drag and drop
  - Students place arrows, symbols, labels, or other graphical elements on a background graphic.
  - The elements are designated as refreshable (able to be used multiple times) or non-refreshable (able to be used only one time).
- Hot Spot
  - Students construct simple graphs or select a region on a graphic.

Hot Text (HT)

- Students move statements into an ordered sequence.
- The statements are designated as refreshable (able to be used multiple times) or non-refreshable (able to be used only one time).

Multiple Choice (MC)

- Includes a question, or a statement followed by a question.
- The question presents a clear indication of what is required so students know what to do before looking at the answer choices.
- Students typically select from four options (one correct answer and three distractors).
- The options are syntactically and semantically parallel.
- The options are arranged in numerical or chronological order or according to length.
- Distractors can reflect common errors, misunderstandings, or other misconceptions.
- Distractors are not partially correct.
- The options “All of the above” and “None of the above” are not used.

Multiple Select (MS)

- Includes a clear direction or includes a statement followed by a clear direction.
- The clear direction indicates how many options a student should select to complete the item (e.g., "Select **two** pieces of evidence that support the student's claim").
- The direction presents a clear indication of what is required so students know what to do before looking at the answer choices.
- Students select from a maximum of eight options that have at least two correct responses.
- There should be at least three more distractors than correct answers.
- The options are syntactically and semantically parallel.
- The options are arranged in numerical or chronological order or according to length.
- Distractors can reflect common errors, misunderstandings, or other misconceptions.
- Distractors are not partially correct.
- The options "All of the above" and "None of the above" are not used.

Short Answer (SA)

- Students write a response based on a specific task statement.
- Directions give clear indications of the response required of students.
- When appropriate, bullets after phrases like "In your description, be sure to:" provide extra details to assist students in writing a complete response.
- A response that requires multiple parts may be scaffolded with response boxes to draw attention to the parts.
- Any SA item that requires the students to use information from a stimulus specifically prompts for the information, such as "Use data from the table to …" or "Support your answer with information from the chart."
- Students type text and/or numbers into a response box using the keyboard. SA items are scored by human readers using a scoring rubric.

Simulation (SIM)

- Students use a simulation to control an investigation and/or generate data.
- Simulations can vary in their interaction, design, and scoring.
- The data can be scored directly or used to answer related questions, or both.

Table Input (TI)

- Students complete a table by typing numeric responses into the cells of the table using the keyboard.
- Positive values, negative values, and decimal points are accepted.

Table Match (MI)

- Students check boxes within the cells of a table to make identifications, classifications, or predictions.
- Students are informed when a row or column may be checked once, more than once, or not at all.

Scoring Rubric Development Guidelines

- An item-specific scoring rubric is developed for each ETC, GI, HT, SIM, TI, MI, and SA during the writing of the item.
- Scoring rubrics do not consider conventions of writing (complete sentences, usage/grammar, spelling, capitalization, punctuation, and paragraphing).
- Scoring rubrics are edited during field test rangefinding and rubric validation based on student responses.
- Scoring rubrics may be edited during operational rangefinding based on student responses.

Multipart Items

Some items are divided into multiple parts. Typically, this includes two parts (part A and part B). Item parts are mutually reinforcing and strengthen alignment to a PE.

Multipart items can use different types of interactions in each part (e.g., an MC followed by an ETC). One example of this approach is an item that asks a student to evaluate a claim in part A, and then in part B asks the student to identify how a particular trend in data or piece of evidence supports their evaluation of that claim.

Multipart items are scored collectively, with each part contributing toward a single point, or separately, with each part earning a single point.

When assessed in an item that does not have multiple parts, the following score points are typically assigned for each item type:

- ETC, GI, HT, MC, MS, SIM, TI, and MI items are worth 1 point.
- SA items are worth 1 or 2 points.

Test Design

Operational Test Form

Each operational test form contains the same items in a given year. This is known as a "fixed-form test," which is unlike the "adaptive" Smarter Balanced test. Approximately 33% of the points of the fixed-form test are anchoring (linking) items with established item calibrations from previous years.

The operational component of the WCAS counts toward a student's score and is composed of five clusters and six to twelve standalone items.

In addition:

- One PE from each domain (ESS, PS, LS, and ETS) is included in at least one item cluster.
- A minimum of three different SEPs are included across the clusters.
- A minimum of three different CCCs are included across the clusters.
- Standalone items increase DCI, SEP, and CCC coverage.

Field Test Items

Operational test forms contain embedded field test items, which are either a set of items associated with a cluster, a group of standalone items, or a combination of one cluster and one or more standalone items. Several clusters and standalone items are field tested in a given administration. The field test items do not contribute to the student's score.

Testing Times

The WCAS is intended to be administered online in one to three sessions. The approximate 135-minute administration time includes 30 minutes for giving directions and distributing materials, 90 minutes for the operational form, and 15 minutes for the embedded field test. Contact your district testing coordinator for further information on the specific test schedule for your district or building.

Online Calculator

A calculator is embedded in the online platform for all items in the WCAS. Students should be familiar with the functionality of the calculator prior to using it on the assessment. The calculator is available online and as an app for practice. In grade 5, students use a basic four-function calculator. In grades 8 and high school, students use a scientific calculator.

Periodic Table

A periodic table is embedded in the online platform for all items in the WCAS for grade 8 and high school. A printable version of the periodic table can be downloaded from the WCAP Portal for classroom use.

Tools, Supports, and Accommodations

The WCAS may be taken with or without tools, supports, or accommodations. Tools are available to all students and can be used at the student's discretion. Supports are available to English language learners and any student with a need identified by an educator. Accommodations are available for students who receive special education services with a documented need noted in an IEP or 504 plan. More information is available in the Guidelines on Tools, Supports, & Accommodations, which can be downloaded from the WCAP Portal.

Test Blueprint

The total number of points for the WCAS at grade 8 is 40 points. The point percentages of the WCAS reflect the percentages of the PEs per domain within the standards.

The Engineering, Technology, and Applications of Science (ETS) domain is not represented by a separate item cluster, but is bundled in at least one item cluster with one or more PEs from the Physical Sciences (PS), Life Sciences (LS), or Earth and Space Sciences (ESS) domain. ETS points are not specified, and ETS PEs were not included when calculating the percentages in Table 1.

Table 1 specifies the percentage and point ranges of the WCAS in reference to the reporting claims.

Table 1

Reporting Area	Percentage of PEs per Science Domain in the Standards	Percentage Range for the WCAS per Science Domain	Score Point Range for the WCAS per Science Domain
Practices and Crosscutting Concepts in Physical Sciences	35%	30–40%	12–16
Practices and Crosscutting Concepts in Life Sciences	38%	33–43%	13–17
Practices and Crosscutting Concepts in Earth and Space Sciences	27%	22–32%	9–13

Washington Standards Overview

The WCAS is designed to align to the standards in a way that honors the original intent of the document *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (2012) and supports Washington educators in their interpretation of assessment results, instructional design, and classroom practice. This section discusses the structure and usage of PEs as a guiding framework for the development of the WCAS item specifications.

Performance Expectations

The standards are organized into Performance Expectations (PEs). Each PE provides a statement of what students should be able to do by the end of instruction. There are 45 PEs for grades 3–5, 59 PEs for middle school, and 71 PEs for high school. The PEs are further categorized by grade or grade band (K, 1, 2, 3, 4, 5, MS, HS) and by domain: Physical Sciences (PS); Life Sciences (LS); Earth and Space Sciences (ESS); and Engineering, Technology, and Applications of Science (ETS).

Identifying a PE

Each PE is identified by a three-part PE code. The first set of letters or numbers indicates the grade level (or grade band) of the PE (e.g., HS for high school). The middle set of letters and numbers in a PE code refers to an overarching organizing concept that is developed across grades. For example, in MS-ESS1-2, “ESS1” refers to “Earth’s Place in the Universe.”

Finding Related PEs

Searching the NGSS website for an organizing concept results in a complete list of associated PEs at the given grade level. For example, searching the website for MS-ESS1 results in a list of associated PEs at the middle school level (MS-ESS1-1 through MS-ESS1-4). Substituting another grade level for “MS” results in a complete list of standards related to “Earth’s Place in the Universe” for any other grade level. This strategy is helpful for understanding where a particular PE fits in a learning progression, and it can provide insight into the assessable boundaries of a PE.

PE Structure

Each PE starts with the PE statement, which is a brief synopsis of the performance the PE is meant to address. Each PE statement incorporates the three dimensions of the NGSS framework: one or more Science and Engineering Practices (SEPs), one or more Disciplinary Core Ideas (DCIs), and one or more Crosscutting Concepts (CCCs). The PE statement can provide some insight as to how students are expected to utilize the SEPs, DCIs, and CCCs together to achieve the PE.

Clarification Statements and Assessment Boundaries

The PE statement may be followed by a clarification statement and/or an assessment boundary. When present, the clarification statement supplies examples or additional clarification to the PE. The assessment boundaries are meant to specify limits for large-scale assessment of a PE. They are **not** meant to limit what can or should be taught or how it is taught. The main function of an assessment boundary statement is to provide guidance to assessment developers.

Dimensions—SEPs, DCIs, and CCCs

Science and Engineering Practices

The standards include a total of eight SEPs that develop across grade levels and grade bands:

1. Asking Questions and Defining Problems
2. Developing and Using Models
3. Planning and Carrying Out Investigations
4. Analyzing and Interpreting Data
5. Using Mathematical and Computational Thinking
6. Constructing Explanations and Designing Solutions
7. Engaging in Argument from Evidence
8. Obtaining, Evaluating, and Communicating Information

For the standards and the WCAS Item Specifications, the SEP statement is presented in the leftmost column inside a blue box. Each SEP statement contains a particular skill or practice from a particular grade level, as determined by the PE. Bulleted text under the grade-level description of the SEP presents a subskill associated with the specific PE. Additional details on the subskills and their progressions across grade bands are located in NGSS Appendix F.

Disciplinary Core Ideas

Science knowledge is represented as a collection of disciplinary core ideas, which have been explicitly developed in grade-level progressions. For the standards and the WCAS Item Specifications, the DCI statement is presented in the middle column inside an orange box. The number of DCIs is intentionally limited, so as to allow deeper exploration and eventual proficiency of key concepts as students broaden and deepen their understanding of science. The sum total of all DCIs is not meant to be an exhaustive list of all topics that should be taught in a science classroom. Rather, DCIs provide for links among classroom lesson or activity topics at a high level. DCIs are broken up into several groups within four domains: Physical Sciences (PS), Life Sciences (LS), Earth and Space Sciences (ESS), and Engineering, Technology, and Applications of Science (ETS).

Each DCI statement contains key ideas appropriate to a particular grade level, as determined by the PE. Bulleted text under the grade-level description of the DCI presents ideas and understandings associated with the specific DCI. Additional details on these ideas and understandings and their progressions across grade bands are located in NGSS Appendix E.

Crosscutting Concepts

The standards contain seven CCCs that progress throughout each grade level and grade band. The seven CCCs are:

1. Patterns
2. Cause and Effect
3. Scale, Proportion, and Quantity
4. Systems and System Models
5. Energy and Matter
6. Structure and Function
7. Stability and Change

For the standards and the WCAS Item Specifications, the CCC statement is presented in the rightmost column, inside a green box. Bulleted text under the grade-level description of the CCC presents sub-concepts associated with the specific PE. Additional details on these sub-concepts and their progressions across grade bands are located in NGSS Appendix G.

NGSS Progressions Appendices

When working to establish learning progressions or continuity and growth of skills across grade levels, educators will find value in the NGSS progressions appendices (see the "Resources" section). Organized by dimension (SEP, DCI, and CCC), the appendices present detailed learning progressions and comparisons of various skills and competencies across grade levels.

The WCAS Item Specifications use the NGSS progressions appendices in unpacking PE dimension statements to reveal and incorporate elements from a given learning progression. For example, consider a grade 4 PE that lists Planning and Carrying Out Investigations as its SEP dimension and has bulleted text that focuses on making observations. According to the NGSS learning progressions, making observations may be expanded within grade 4 to also include elements of planning, prediction, or evaluations of a fair test. Therefore, from an assessment perspective, items written using these linked subskills align to the SEP.

Evidence Statements

The NGSS evidence statements were designed to support a granular analysis of proficiency with specific PEs, via an explicit articulation of how students can use SEPs to demonstrate their understanding of DCIs through the lens of the CCCs. They do this by clarifying several important details related to the three dimensions:

- How the three dimensions can be assessed together, rather than in independent units
- The underlying knowledge required to develop each DCI
- The detailed approaches to application of the SEP
- How CCCs might be used to deepen content understanding and practice-driven learning

The NGSS evidence statements informed the development of the WCAS Item Specifications.

Resources

Resource	Description
K–12 Framework	Provides information about the foundational principles that were used to develop the NGSS.
SAIC Assessment Framework	Provides options and rationales for development of high-quality, NGSS-aligned summative assessment items.
SAIC Prototype Item Cluster	Demonstrates a three-dimensional NGSS-aligned item cluster using a variety of stimuli and innovative item types.
Developing Assessments for the Next Generation Science Standards	Provides guidance on an approach to science assessment that supports the vision of the NGSS.
NGSS Appendix E	Includes tables showing the **DCI** progressions by grade level.
NGSS Appendix F	Includes tables showing the **SEP** progressions by grade level.
NGSS Appendix G	Includes tables showing the **CCC** progressions by grade level.
NGSS Evidence Statements	Provides additional detail on what students should know and be able to do based on performance expectations.

References

Council of Chief State School Officers (CCSSO). (2015). *Science Assessment Item Collaborative (SAIC) Assessment Framework*. Council of Chief State School Officers.

National Research Council (NRC). (2012). *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. National Academies Press.

National Research Council. (2014). *Developing Assessments for the Next Generation Science Standards*. The National Academies.

Next Generation Science Standards (NGSS) Lead States. (2013). *Next Generation Science Standards: For States, By States*. The National Academies Press.

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WCAS Item Specifications

Introduction

The science assessment team at OSPI worked with assessment research and development partners to create assessment item specifications that support multidimensional item development and assist teachers in their interpretation of WCAS assessment data. The following two pages present a sample of one such item specification.

The WCAS Item Specifications are a guiding framework that is built to evolve and change; OSPI revises them as needed, in collaboration with teachers and other stakeholders. While the item specifications are not intended to dictate curricula in any way, examples of science topics or contexts within the scope of the PE may occasionally be provided in the details and clarifications section. Such examples are noted in parenthetical remarks after a particular clarification, and denoted with the convention “e.g.”

The first page of a WCAS item specification consolidates key information under the same PE code used by the corresponding standard in the NGSS. It also directs users to pertinent pages in the *K–12 Framework* and the NGSS progressions appendices for each dimension (SEP, DCI, or CCC). The first page also presents any clarification statements or assessment boundaries associated with the PE. Items in the grade 8 WCAS use language targeted to the previous grade or lower reading level with the exception of the expected science terms. A list of expected DCI, SEP, and CCC vocabulary is included at the end of this document.

The second page of each item specification presents four alignment codes for the PE. These codes identify the various combinations of PE dimensions that can be measured using a multidimensional item. Additionally, each item specification includes a list of details and clarifications that help unpack the elements used to determine item alignment.

For example, when using the WCAS Item Specifications, an item with an alignment code of 4-LS1-1.2 indicates that the item aligns to both the SEP and DCI dimensions of the PE 4-LS1-1. The item specification suggests that this type of item involves making observations of specific types of evidence related to the DCI. The Details and Clarifications section lists examples of observations that are permissible under this PE, as well as the forms of evidence that are within the bounds of the PE.

As stated earlier in this document, item specifications are updated annually based on input from Washington educators. Each publication of the updated item specifications includes a modifications log.

Physical Sciences

Disciplinary Core Ideas:

- PS1 Matter and Its Interactions
- PS2 Motion and Stability: Forces and Interactions
- PS3 Energy
- PS4 Waves and Their Applications in Technologies for Information Transfer

Performance Expectation	**MS-PS1-1** Develop models to describe the atomic composition of simple molecules and extended structures.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Developing and Using Models Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to predict and/or describe phenomena.	**PS1.A: Structure and Properties of Matter** • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).	**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.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 56–59	pp. 106–109	pp. 89–91
NGSS Appendices	Appendix F p. 6	Appendix E p. 7	Appendix G pp. 6–7
Clarification Statement	Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.		
Assessment Boundary	Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.		

Items may ask students to:

Code	Alignment	Item Specification
MS-PS1-1.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to describe the **atomic composition** of **simple molecules** and/or **extended structures** that are on a **scale too small** to be seen.
MS-PS1-1.2	SEP-DCI	**Develop** and/or **use** a **model** to describe the **atomic composition** of **simple molecules** and/or **extended structures**.
MS-PS1-1.3	DCI-CCC	Connect the **atomic composition** of **simple molecules** and/or **extended structures** to systems that are on a **scale too small** to be seen.
MS-PS1-1.4	SEP-CCC	**Develop** and/or **use** a **model** to describe systems at different scales.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions and/or to describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- **Models** may include, but are NOT limited to:
  - diagrams
  - simulations
  - tables

- The **atomic composition** of **simple molecules** and/or **extended structures** that are on a **scale too small** to be seen may include, but is NOT limited to:
  - molecules composed of few atoms (e.g., ammonia)
  - molecules composed of many atoms (e.g., diamonds)
  - molecules composed of one type of atom (e.g., hydrogen)
  - molecules composed of different types of atoms (e.g., glucose)
  - molecules that connect to each other (e.g., water)
  - extended structures with repeating subunits (e.g., sodium chloride)

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS1-2 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
• Analyze and interpret data to determine similarities and differences in findings.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
• Science knowledge is based upon logical and conceptual connections between evidence and explanations.</td><td>PS1.A: Structure and Properties of Matter
• Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

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.</td><td>Patterns
• Macroscopic patterns are related to the nature of microscopic and atomic level structure.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 61–63</td><td>pp. 106–109
pp. 109–111</td><td>pp. 85–87</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 9
Appendix H
p. 5</td><td>Appendix E
p. 7</td><td>Appendix G
pp. 3–5</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-PS1-2.1	SEP-DCI-CCC	**Analyze** and/or **interpret patterns** in **data** on the **properties** of **substances** before and after the substances interact to determine if a **chemical reaction** has occurred.
MS-PS1-2.2	SEP-DCI	**Analyze** and/or **interpret data** on the **properties** of **substances** before and after the substances interact to determine if a **chemical reaction** has occurred.
MS-PS1-2.3	DCI-CCC	Use the **properties** of **substances** before and after the substances interact to determine if a **chemical reaction** has occurred.
MS-PS1-2.4	SEP-CCC	**Analyze** and/or **interpret data** to determine patterns in a system.

Details and Clarifications

- **Analyze** and/or **interpret data** is expanded to include:
    - organizing and/or interpreting data
    - identifying similarities and/or differences in findings
    - using patterns in data to distinguish between causal and/or correlational relationships and/or to draw conclusions based on data

- **Data** may include, but are NOT limited to:
    - observations
    - measurements
    - tables
    - graphs
    - diagrams
    - models
    - statistical information (e.g., mean, median, mode, variability)

- **Properties** of **substances** before and after **chemical reactions** are limited to
    - density
    - melting point
    - boiling point
    - solubility
    - flammability
    - odor
    - arrangement of atoms

- Examples of **patterns** in data may include, but are not limited to:
    - Similarities and/or differences in properties among different substances
    - Trends in properties among substances
    - Differences in the properties of a substance before and after an interaction

Performance Expectation	**MS-PS1-3** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.		
	Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Dimensions	**Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods. • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or now supported by evidence.	**PS1.A: Structure and Properties of Matter** • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. **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.	**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. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. **Influence of Science, Engineering and Technology on Society and the Natural World** • The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 74–77	pp. 106–109 pp. 109–111	pp. 96–98 pp. 210–214
NGSS Appendices	Appendix F p. 15	Appendix E p. 7	Appendix G pp. 9–10 Appendix J p. 3 pp. 3–4
Clarification Statement	Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.		
Assessment Boundary	Assessment is limited to qualitative information.		

Items may ask students to:

Code	Alignment	Item Specification
MS-PS1-3.1	SEP-DCI-CCC	**Gather** and/or **synthesize information** to describe that **synthetic materials** come from **chemical reactions** with **natural resources**, how their **structure** relates to their **function**, and/or how they **impact society**.
MS-PS1-3.2	SEP-DCI	**Gather** and/or **synthesize information** to describe that **synthetic materials** come from **natural resources**.
MS-PS1-3.3	DCI-CCC	Connect **synthetic materials** that come from **chemical reactions** with **natural resources** to their **structure** and **function** and/or their **impact** on **society**.
MS-PS1-3.4	SEP-CCC	**Gather** and/or **synthesize information** about the structure and function of materials.

Details and Clarifications

- **Gather** and/or **synthesize information** is expanded to include:
  - using patterns in and/or evidence from information to support a claim and/or describe a scientific phenomenon
  - evaluating the credibility and/or accuracy and/or bias of claims from different sources

- **Information** formats may include, but are NOT limited to:
  - text
  - diagrams
  - graphs
  - tables
  - models
  - animations

- Examples of **synthetic materials** that come from **chemical reactions** with **natural resources** may include, but are NOT limited to:
  - burning limestone to produce concrete
  - processing willow bark to make aspirin
  - polymerizing petroleum to produce plastics

- Examples of how the **structure** of **synthetic materials** relates to their **function** may include, but are NOT limited to:
  - a synthetic material with low friction not sticking to food
  - a synthetic material being strong so that it can be used to pick up heavy objects
  - a synthetic cloth retaining its shape so it does not wrinkle easily

- Examples of how **synthetic materials impact society** may include, but are NOT limited to:
  - how the synthetic material satisfies a societal need and/or desire
  - the effects of making and/or using synthetic materials on natural resources

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS1-4 Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Developing and Using Models
Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.
• Develop a model to predict and/or describe phenomena.</td><td>PS1.A: Structure and Properties of Matter
• Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
• In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
• The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

PS3.A: Definitions of Energy
• The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (secondary)
• The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (secondary)</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K-12 Framework</td><td>pp. 56–59</td><td>pp. 120–124</td><td>pp. 87–89</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 6</td><td>Appendix E
p. 7</td><td>Appendix G
pp. 5–6</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">An assessment boundary is not provided for this PE.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-PS1-4.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to predict and/or describe **cause and effect** relationships between changes in the **state, particle motion,** and/or **temperature** of pure substances and **thermal energy transfers**.
MS-PS1-4.2	SEP-DCI	**Develop** and/or **use** a **model** to describe changes in the **state, particle motion**, and/or **temperature** of pure substances and/or **thermal energy transfers**.
MS-PS1-4.3	DCI-CCC	Use **cause and effect** relationships to predict and/or describe changes in the **state, particle motion,** and/or **temperature** of pure substances and **thermal energy** transfers.
MS-PS1-4.4	SEP-CCC	**Develop** and/or **use** a **model** to describe cause and effect relationships.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions and/or describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- **Models** may include, but are NOT limited to:
  - a diagram, simulation, and/or description of interactions among components in a system
  - a diagram, simulation, and/or description of a state of matter and/or particle motion within a substance

- **Cause and effect** relationships between changes in the **state**, **particle motion**, and/or **temperature** of substances and **thermal energy transfers** may include, but are NOT limited to:
  - adding thermal energy to a pure substance causes the average kinetic energy of the substance, the motion of the particles, the distance between particles, and/or the average temperature of the substance to increase
  - removing thermal energy from a pure substance causes the average kinetic energy of the substance, the motion of the particles, the distance between particles, and/or the average temperature of the substance to decrease
  - adding thermal energy to a substance causes the substance to change from a solid to a liquid and/or from a liquid to a gas
  - removing thermal energy from a substance causes the substance to change from a gas to a liquid and/or from a liquid to a solid

<table>
<tr><td>Performance Expectation</td><td colspan="3">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.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Developing and Using Models
Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.
• Develop a model to describe unobservable mechanisms.

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
• Laws are regularities or mathematical descriptions of natural phenomena.</td><td>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.</td><td>Energy and Matter
• Matter is conserved because atoms are conserved in physical and chemical processes.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 56–59</td><td>pp. 109–111</td><td>pp. 94–96</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 6
Appendix H
p. 5</td><td>Appendix E
p. 7</td><td>Appendix G
pp. 8–9</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-PS1-5.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to describe how **matter** is **conserved** in a **chemical reaction**.
MS-PS1-5.2	SEP-DCI	**Develop** and/or **use** a **model** to identify the numbers, types, and/or masses of atoms before and/or after a **chemical reaction.**
MS-PS1-5.3	DCI-CCC	Connect the **conservation** of **matter** to the total number of each type of atom in a **chemical reaction**.
MS-PS1-5.4	SEP-CCC	**Develop** and/or **use** a **model** to describe how matter is conserved in a process.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions and/or to describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent a current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- **Models** may include, but are NOT limited to, a diagram, image, table, and/or equation that includes:
  - chemical and/or structural formulas
  - atoms and/or molecules
  - chemical symbols

- Examples of how **matter** is **conserved** in a **chemical reaction** may include, but are NOT limited to:
  - the numbers and/or types of atoms in the reactants and/or the products for a given reaction remaining constant
  - the mass of a given atom being the same regardless of the molecule the atom is found in
  - atoms in reactant molecules rearranging to form product molecules

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS1-6 Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.
• Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.</td><td>PS1.B: Chemical Reactions
• Some chemical reactions release energy, others store energy.

ETS1.B: Developing Possible Solutions
• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (secondary)

ETS1.C: Optimizing the Design Solution
• Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (secondary)☐
• The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (secondary)☐</td><td>Energy and Matter
• The transfer of energy can be tracked as energy flows through a designed or natural system.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 67–71</td><td>pp. 109–111
pp. 206–208
pp. 208–210</td><td>pp. 94–96</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
pp. 11–12</td><td>Appendix E
p. 7
Appendix I
pp. 1–7</td><td>Appendix G
pp. 8–9</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">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.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-PS1-6.1	SEP-DCI-CCC	**Construct**, **test**, and/or **modify** a **device** that either **releases** or **absorbs thermal energy** by **chemical processes**.
MS-PS1-6.2	SEP-DCI	**Construct**, **test**, and/or **modify** a **device** that uses a **chemical process**.
MS-PS1-6.3	DCI-CCC	Track the flow of **thermal energy** as the energy is either **released** or **absorbed** by **chemical processes**.
MS-PS1-6.4	SEP-CCC	**Construct**, **test**, and/or **modify** a **device** that transfers energy.

Details and Clarifications

- **Construct**, **test**, and/or **modify** a **device** is expanded to include:
  - using valid data, models, and/or scientific knowledge to construct, revise, and/or support an explanation and/or design a solution
  - using qualitative and/or quantitative relationships between variables to predict and/or describe phenomena
  - using models and/or evidence to support explanations
  - applying scientific principles to design a tool, process, and/or system that meets specific criteria and/or constraints

- A **device** may include, but is NOT limited to:
  - components to or from which energy is transferred
  - a chemical reaction that releases or absorbs thermal energy
  - a method for tracking energy transfers

- **Chemical processes** that either **release** or **absorb thermal energy** may include, but are NOT limited to:
  - combustion reactions
  - neutralization reactions
  - combining some substances with water (e.g., calcium chloride)

Performance Expectation	**MS-PS2-1** Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • 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. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 67–71	pp. 114–116	pp. 91–94 pp. 212–214
NGSS Appendices	Appendix F pp. 11–12	Appendix E p. 7	Appendix G pp. 7–8 Appendix J pp. 3–4
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.		
Assessment Boundary	Assessment is limited to vertical or horizontal interactions in one dimension.		

Items may ask students to:

Code	Alignment	Item Specification
MS-PS2-1.1	SEP-DCI-CCC	**Apply** Newton's Third Law to **design** a **solution** to a problem involving the motion of two colliding objects in a **system**.
MS-PS2-1.2	SEP-DCI	**Apply** Newton's Third Law to **design** a **solution** to a problem involving the motion of two colliding objects.
MS-PS2-1.3	DCI-CCC	Use a **model** to connect Newton's Third Law to the motion of two colliding objects in a **system.**
MS-PS2-1.4	SEP-CCC	**Design** a **solution** to a problem involving interactions within a system.

Details and Clarifications

- **Design** a **solution** is expanded to include:
    - using valid data, models, and/or scientific knowledge to construct, revise, and/or support an explanation and/or design a solution
    - using qualitative and/or quantitative relationships between variables to predict and/or describe phenomena
    - using models and/or evidence to support explanations
    - applying scientific principles to design a tool, process, and/or system that meets specific criteria and/or constraints

- **Apply** Newton's Third Law may include, but is NOT limited to:
    - identifying the components involved in a collision
    - identifying criteria for a successful design (e.g., reducing damage to colliding objects)
    - identifying constraints that limit the success of a given design (e.g., relatively high cost)
    - identifying the value of the design
    - describing technologies used in the design
    - calculating the forces exerted by each object involved in the collision

- Examples of **systems** may include, but are NOT limited to**:**
    - lab carts colliding on the classroom floor
    - a puck and a paddle colliding on an air hockey table
    - a bat and a ball colliding

<table>
<tr><td>Performance Expectation</td><td colspan="3">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.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.
• 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.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
• Science knowledge is based upon logical and conceptual connections between evidence and explanations.</td><td>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.
• All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.</td><td>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.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 59–61</td><td>pp. 114–116</td><td>pp. 98–101</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
pp. 7–8
Appendix H
p. 5</td><td>Appendix E
p. 7</td><td>Appendix G
pp. 10–11</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">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.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">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.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-PS2-2.1	SEP-DCI-CCC	**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/or the **mass** of the object.
MS-PS2-2.2	SEP-DCI	**Plan** an **investigation** to provide **evidence** of the **sum** of the **forces** on a moving object and/or the **mass** of the moving object.
MS-PS2-2.3	DCI-CCC	Connect the **change** in an object's **motion** to the **sum** of the **forces** on the object and/or the **mass** of the object.
MS-PS2-2.4	SEP-CCC	**Plan** an **investigation** to provide evidence of stability and/or change in a system.

Details and Clarifications

- **Plan** an **investigation** is expanded to include:
  - conducting an investigation to produce evidence
  - identifying independent, dependent, and/or controlled variables
  - making predictions about what would happen if a variable changes
  - evaluating appropriate methods and/or tools for collecting and/or recording data

- Types of **evidence** that an object's **change** in **motion** depends on the **sum** of the **forces** on the object and/or the **mass** of the object may include, but are NOT limited to:
  - unbalanced forces causing a change in an object's motion
  - balanced forces not causing a change in the object's motion
  - the force needed to change an object's motion varying with the mass of an object
  - the change in an object's motion varying with the net force on the object

Performance Expectation	**MS-PS2-3** Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Asking Questions and Defining Problems Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.	**PS2.B: Types of Interactions** • Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 54–56	pp. 116–118	pp. 87–89
NGSS Appendices	Appendix F pp. 4–5	Appendix E p. 7	Appendix G pp. 5–6
Clarification Statement	Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.		
Assessment Boundary	Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.		

Items may ask students to:

Code	Alignment	Item Specification
MS-PS2-3.1	SEP-DCI-CCC	**Ask questions** about **data** to determine **cause and effect** relationships that affect the **strength** of **electric** and/or **magnetic forces**.
MS-PS2-3.2	SEP-DCI	**Ask questions** about **data** to determine the **strength** of **electric** and/or **magnetic forces**.
MS-PS2-3.3	DCI-CCC	Connect **cause and effect** relationships to the **strength** of **electric** and/or **magnetic forces**.
MS-PS2-3.4	SEP-CCC	**Ask questions** about **cause and effect** relationships.

Details and Clarifications

- **Ask questions** is expanded to include:
  - asking and/or identifying questions that arise from observation and/or investigation to seek additional information
  - asking questions to determine relationships between independent and dependent variables
  - asking questions to clarify and/or refine a model, an explanation, and/or an engineering problem
  - asking questions that frame a hypothesis based on observations and/or scientific principles
  - defining a simple design problem that can be solved through the development of an object, tool, process, and/or system
  - describing criteria for a successful solution
  - describing constraints that could limit the success of a solution

- Examples of **data** may include, but are NOT limited to:
  - magnitude of an electric current
  - magnitude and/or signs of electrically charged objects
  - strength of a magnetic force
  - distance between and/or orientation of interacting magnetic objects
  - strength of an electromagnet
  - speed of an electric motor

- **Cause and effect** relationships that affect the **strength** of **electric** and/or **magnetic forces** may include, but are NOT limited to:
  - Decreasing the magnitude of the electric charges of interacting objects decreases the electric force between the objects.
  - Increasing the distance between interacting magnets decreases the magnetic force between the objects.
  - Increasing the number of turns in a wire coil increases the strength of an electromagnet.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS2-4 Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds from K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.
• Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
• Science knowledge is based upon logical and conceptual connections between evidence and explanations.</td><td>PS2.B: Types of Interactions
• Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.</td><td>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.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 71–74</td><td>pp. 116–118</td><td>pp. 91–94</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
pp. 13–14
Appendix H
p. 5</td><td>Appendix E
p. 7</td><td>Appendix G
pp. 7–8</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment does not include Newton’s Law of Gravitation or Kepler’s Laws.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-PS2-4.1	SEP-DCI-CCC	**Construct** and/or **present arguments** using **evidence** to support the claim that **gravitational interactions** are **attractive** and/or depend on the **masses** of **interacting objects** in a system.
MS-PS2-4.2	SEP-DCI	**Construct** and/or **present arguments** using **evidence** to support the claim that **gravitational interactions** are **attractive** and/or depend on the **masses** of **interacting objects**.
MS-PS2-4.3	DCI-CCC	Use a system model to represent that **gravitational interactions** are **attractive** and/or depend on the **masses** of **interacting objects**.
MS-PS2-4.4	SEP-CCC	**Construct** and/or **present arguments** using **evidence** to explain interactions within a system.

Details and Clarifications

- **Construct** and/or **present arguments** is expanded to include:
  - describing the similarities and/or differences between two arguments
  - developing an argument and/or making a claim based on evidence, data, and/or a model
  - using evidence and/or scientific reasoning to support or refute an explanation and/or a model
  - identifying flaws in explanations, procedures, models, and/or solutions
  - evaluating competing design solutions based on how well the solutions meet the criteria and/or constraints of a problem

- **Evidence** that show that **gravitational interactions** are **attractive** and/or depend on the **masses** of **interacting objects** may include, but are NOT limited to:
  - gravitational force increasing as the masses of interacting objects increase
  - gravitational force decreasing as the distance between interacting objects increases
  - the direction of gravitational force changing as one object orbits another object

- Examples of **interacting objects** may include, but are NOT limited to:
  - an object near Earth’s surface and Earth
  - a planet and its moon
  - a planet and the sun
  - two solar system objects (e.g., asteroids)

Performance Expectation	**MS-PS2-5** Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. • Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.	**PS2.B: Types of Interactions** • Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 59–61	pp. 116–118	pp. 87–89
NGSS Appendices	Appendix F pp. 7–8	Appendix E p. 7	Appendix G pp. 5–6
Clarification Statement	Examples of this phenomenon could include the interactions of magnets, electrically charged strips of tape, and electrically charged pith balls. Examples of investigations could include first-hand experiences or simulations.		
Assessment Boundary	Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.		

Items may ask students to:

Code	Alignment	Item Specification
MS-PS2-5.1	SEP-DCI-CCC	**Conduct** and/or **evaluate** an **investigation** to provide **evidence** of the **cause and effect** relationships between **forces** that can act at a distance and the **fields** that exist between objects.
MS-PS2-5.2	SEP-DCI	**Conduct** and/or **evaluate** an **investigation** to provide **evidence** of **forces** that act at a distance and/or **fields** that exist between objects.
MS-PS2-5.3	DCI-CCC	Use **cause and effect** relationships to connect **forces** that act at a distance to **fields** between objects.
MS-PS2-5.4	SEP-CCC	**Conduct** and/or **evaluate** an **investigation** about cause and effect relationships.

Details and Clarifications

- **Conduct** and/or **evaluate** an **investigation** is expanded to include:
  - conducting an investigation to produce evidence
  - identifying independent, dependent, and/or controlled variables
  - making predictions about what would happen if a variable changes
  - evaluating appropriate methods and/or tools for collecting and/or recording data

- **Forces** and/or **fields** may include:
  - electric fields and/or magnetic fields
  - electric forces and/or magnetic forces

- **Evidence** of **cause and effect** relationships may include, but is NOT limited to:
  - observation of change in motion due to attraction or repulsion between magnets
  - observation of change in motion due to attraction or repulsion between electric charges
  - descriptions of how the force exerted by one magnetic object causes another magnetic object to move or change motion
  - descriptions of how the force exerted by one charged object causes another charged object to move or change motion

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS3-1 Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
• Construct and interpret graphical displays of data to identify linear and nonlinear relationships.</td><td>PS3.A: Definitions of Energy
• Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.</td><td>Scale, Proportion, and Quantity
• Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 61–63</td><td>pp. 120–124</td><td>pp. 89–91</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 9</td><td>Appendix E
p. 7</td><td>Appendix G
pp. 6–7</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">An assessment boundary is not provided for this PE.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-PS3-1.1	SEP-DCI-CCC	**Construct** and/or **interpret** graphical displays of **data** to describe **proportional relationships** between the **kinetic energy** of an object and the **mass** and/or **speed** of that object.
MS-PS3-1.2	SEP-DCI	**Construct** and/or **interpret** graphical displays of **data** to describe the **kinetic energy**, **mass**, and/or **speed** of an object.
MS-PS3-1.3	DCI-CCC	Use **proportional relationships** to connect the **kinetic energy** of an object to the **mass** and/or **speed** of that object.
MS-PS3-1.4	SEP-CCC	**Construct** and/or **interpret** graphical displays of **data** to identify scale, proportion, and/or quantity relationships in a system.

Details and Clarifications

- **Construct** and/or **interpret** graphical displays of **data** is expanded to include:
  - organizing and/or interpreting data
  - identifying similarities and/or differences in findings
  - using patterns in data to distinguish between causal and/or correlational relationships and/or to draw conclusions based on data

- **Data** may include, but are NOT limited to:
  - observations
  - measurements
  - tables
  - graphs
  - diagrams
  - models
  - statistical information (e.g., mean, median, mode, variability)

- Examples of **proportional relationships** between the **kinetic energy** of an object and the **mass** and/or **speed** of that object may include, but are NOT limited to:
  - Kinetic energy doubles if the mass of the object doubles.
  - Kinetic energy halves if the mass of the object halves.
  - Kinetic energy quadruples if the speed of the object doubles.
  - Kinetic energy decreases by a factor of four if the speed of the object is halved.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS3-2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Developing and Using Models
Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.
• Develop a model to describe unobservable mechanisms.</td><td>PS3.A: Definitions of Energy
• A system of objects may also contain stored (potential) energy, depending on their relative positions.

PS3.C: Relationship Between Energy and Forces
• When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.</td><td>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.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 56–59</td><td>pp. 120–124
pp. 126–127</td><td>pp. 91–94</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 6</td><td>Appendix E
p. 7
Appendix E
p. 8</td><td>Appendix G
pp. 7–8</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate’s hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment is limited to two objects and electric, magnetic, and gravitational interactions.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-PS3-2.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to describe that when the arrangement of **objects interacting** at a distance changes, different amounts of **potential energy** are stored in the **system**.
MS-PS3-2.2	SEP-DCI	**Develop** and/or **use** a **model** to describe that when the arrangement of **objects interacting** at a distance changes, the **potential energy** of each object changes.
MS-PS3-2.3	DCI-CCC	Connect changes in the arrangement of **objects interacting** at a distance to changes in the amounts of **potential energy** stored in the **system**.
MS-PS3-2.4	SEP-CCC	**Develop** and/or **use** a **model** to represent interactions within a system.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions and/or describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- Components of a **model** may include, but are NOT limited to:
  - two interacting objects
  - forces (e.g., electric, magnetic, gravitational) involved in an interaction between two objects
  - distance between the two objects
  - potential energy

- Examples of changes in the arrangement of **interacting objects** resulting in changes in the **potential energy** stored in the **system** may include, but are NOT limited to:
  - gravitational potential energy increasing as an object moves farther from the surface of Earth
  - magnetic potential energy decreasing as the north pole of one magnet gets closer to the south pole of a second magnet
  - electric potential energy increasing as the distance between two like-charged particles decreases
  - a force applied to move two attracting objects farther apart transferring energy to the system
  - a force applied to move two repelling objects closer together transferring energy to the system

Performance Expectation	**MS-PS3-3** Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.	**PS3.A: Definitions of Energy** • Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. **PS3.B: Conservation of Energy and Energy Transfer** • Energy is spontaneously transferred out of hotter regions or objects and into colder ones. **ETS1.A: Defining and Delimiting an Engineering Problem** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. *(secondary)* **ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. *(secondary)*	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 67–71	pp. 120–123 pp. 124–126 pp. 204–205 pp. 206–208	pp. 94–96
NGSS Appendices	Appendix F pp. 11–12	Appendix E p. 7 Appendix I pp. 1–7	Appendix G pp. 8–9
Clarification Statement	Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.		
Assessment Boundary	Assessment does not include calculating the total amount of thermal energy transferred.		

Items may ask students to:

Code	Alignment	Item Specification
MS-PS3-3.1	SEP-DCI-CCC	**Apply scientific** and **design principles** to design, construct, and/or test a **device** that either minimizes or maximizes **thermal energy transfer**.
MS-PS3-3.2	SEP-DCI	Due to strong overlap between the DCI and the CCC, items are not coded MS-PS3-3.2.
MS-PS3-3.3	DCI-CCC	Track **energy transfers** in a system that either minimizes or maximizes **thermal energy transfers**.
MS-PS3-3.4	SEP-CCC	**Apply scientific** and **design principles** to design, construct, and/or test a design that tracks energy flow in a system.

Details and Clarifications

- **Apply scientific** and **design principles** to design, test, and modify a **device** may be expanded to include:
  - using valid data, models, and/or scientific knowledge to construct, revise, and/or support an explanation and/or design a solution
  - using qualitative and/or quantitative relationships between variables to predict and/or describe phenomena
  - using models and/or evidence to support explanations
  - applying scientific principles to design a tool, process, and/or system that meets specific criteria and/or constraints

- **Apply design principles** may be expanded to include:
  - describing criteria for a successful solution (e.g., the minimum or maximum difference in temperature the device is designed to maintain; the relative amount of time the device is required to maintain the minimum or maximum temperature; the relative durability, cost, and/or availability of the materials for the device; the relative rate at which the device transfers thermal energy)
  - describing constraints that may limit the success of a solution (e.g., the cost and/or availability of the materials required for the design, the safety of the device, the time to manufacture the device)
  - describing a test to use for evaluating how well a given solution meets criteria and/or constraints for a successful solution

- **Thermal energy transfers** may include, but is NOT limited to:
  - energy transferred from hotter areas to colder areas within and/or between systems
  - energy transferred when two systems or objects are different temperatures

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS3-4 Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.
• 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.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
• Science knowledge is based upon logical and conceptual connections between evidence and explanations</td><td>PS3.A: Definitions of Energy
• Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

PS3.B: Conservation of Energy and Energy Transfer
• The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.</td><td>Scale, Proportion, and Quantity
• Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 59–61</td><td>pp. 120–124
pp. 124–126</td><td>pp. 89–91</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
pp. 7–8
Appendix H
p. 5</td><td>Appendix E
p. 7</td><td>Appendix G
pp. 6–7</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment does not include calculating the total amount of thermal energy transferred.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-PS3-4.1	SEP-DCI-CCC	**Plan** and/or **conduct** an **investigation** to determine the **proportional relationships** among the **energy transferred**, the **type** of **matter**, the **mass**, and/or the **change** in the **average kinetic energy** of the **particles** as measured by the temperature of the sample.
MS-PS3-4.2	SEP-DCI	**Plan** and/or **conduct** an **investigation** to determine the **energy transferred,** the **type** of **matter**, the **mass**, and/or the **change** in the **average kinetic energy** of the **particles** as measured by the **temperature** of the sample.
MS-PS3-4.3	DCI-CCC	Describe **proportional relationships** among **energy transfer, type** of **matter**, **mass**, and/or the **change** in the **average kinetic energy** of the **particles** as measured by the **temperature** of the sample.
MS-PS3-4.4	SEP-CCC	**Plan** and/or **conduct** an **investigation** to identify scale, proportion, and/or quantity relationships in a system.

Details and Clarifications

- **Plan** and/or **conduct** an **investigation** is expanded to include:
  - conducting an investigation to produce evidence
  - identifying independent, dependent, and/or controlled variables
  - making predictions about what would happen if a variable changes
  - evaluating appropriate methods and/or tools for collecting and/or recording data

- **Proportional relationships** among the **energy transferred**, the **type** of **matter**, the **mass,** and the **change** in the **average kinetic energy** of **particles** may include, but are NOT limited to:
  - The greater the average kinetic energy of particles in a sample, the higher the temperature of the sample.
  - If the mass of a sample increases, the amount of energy required to change the temperature of the sample by a set number of degrees increases proportionally.
  - The energy required to change the temperature of a given amount of one type of matter by a specified number of degrees is different than the energy needed to change the temperature of the same amount of a different type of matter by the same number of degrees.

Performance Expectation	**MS-PS3-5** Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds. • Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations	**PS3.B: Conservation of Energy and Energy Transfer** • When the motion energy of an object changes, there is inevitably some other change in energy at the same time.	**Energy and Matter** • Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 71–74	pp. 124–126	pp. 94–96
NGSS Appendices	Appendix F pp. 13–14 Appendix H p. 5	Appendix E p. 7	Appendix G pp. 8–9
Clarification Statement	Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.		
Assessment Boundary	Assessment does not include calculations of energy.		

Items may ask students to:

Code	Alignment	Item Specification
MS-PS3-5.1	SEP-DCI-CCC	**Construct**, **use**, and/or **present** an **argument** to support the claim that when the **kinetic energy** of an object changes, **energy** is **transferred** to or from the object in various **forms**.
MS-PS3-5.2	SEP-DCI	Due to a strong overlap between the DCI and the CCC, items are not coded MS-PS3-5.2.
MS-PS3-5.3	DCI-CCC	Connect **changes** in the **kinetic energy** of an object to the energy **transferred** to or from the object.
MS-PS3-5.4	SEP-CCC	**Construct, use,** and/or **present** an **argument** about energy changes in a system.

Details and Clarifications

- **Construct, use,** and/or **present** an **argument** is expanded to include:
  - describing the similarities and/or differences between two arguments
  - developing an argument and/or making a claim based on observations, data, and/or a model
  - using evidence and/or scientific reasoning to support or refute an explanation and/or a model
  - identifying flaws in explanations, procedures, models, and/or solutions
  - evaluating competing design solutions based on how well the solutions meet the criteria and/or the constraints of a problem

- Examples of **forms** of **energy** may include, but are NOT limited to:
  - energy in fields
  - kinetic energy
  - thermal energy
  - sound
  - light

- Evidence of **energy** being **transferred** to or from an object may include, but is NOT limited to:
  - changes in the features of an object (e.g., motion, temperature, sound)
  - changes in the features of interacting objects and/or an object’s surroundings

<table>
<tr><th>Performance Expectation</th><th colspan="3">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.</th></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Using Mathematics and Computational Thinking
Mathematical and computational thinking at the 6–8 level builds on K–5 and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.
• Use mathematical representations to describe and/or support scientific conclusions and design solutions.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
• Science knowledge is based upon logical and conceptual connections between evidence and explanations.</td><td>PS4.A: Wave Properties
• A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.</td><td>Patterns
• Graphs and charts can be used to identify patterns in data.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 64–67</td><td>pp. 131–133</td><td>pp. 85–87</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 10
Appendix H
p. 5</td><td>Appendix E
p. 8</td><td>Appendix G
pp. 3–5</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Emphasis is on describing waves with both qualitative and quantitative thinking.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment does not include electromagnetic waves and is limited to standard repeating waves.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-PS4-1.1	SEP-DCI-CCC	Use **mathematical representations** to describe a **simple model** for **patterns** in **waves**.
MS-PS4-1.2	SEP-DCI	Use **mathematical representations** to describe a **simple model** for **waves**.
MS-PS4-1.3	DCI-CCC	Describe a **simple model** for **patterns** in **waves**.
MS-PS4-1.4	SEP-CCC	Use **mathematical representations** to identify patterns in a system.

Details and Clarifications

- Use **mathematical representations** is expanded to include:
  - analyzing data sets for patterns and/or trends
  - using mathematical representations to describe and/or support scientific conclusions and/or design solutions
  - ordering steps to solve a problem
  - applying mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and/or engineering questions and/or problems
  - using digital tools, mathematical concepts, and/or mathematical arguments to compare proposed solutions to an engineering design problem

- **Mathematical representations** may include, but are NOT limited to:
  - mathematical models
  - probability statements
  - proportional reasoning
  - trends
  - averages
  - graphs

- Examples of **patterns** in a **simple model** may include, but are NOT limited to:
  - waves representing repeating quantities
  - wave frequency (beats per second, crests per second)
  - wave amplitude (height of crest and/or trough)
  - wavelength (distance between crests or troughs)

- Examples of **mathematical representations** to describe **patterns** in **waves** may include, but are NOT limited to:
  - The amount of energy transferred by waves in a given time is proportional to frequency (e.g., if twice as many water waves hit a shore each minute, then twice as much energy will be transferred to the shore).
  - The energy of the wave is proportional to the square of the amplitude (e.g., if the height of a wave is doubled, each wave will have four times the energy).
  - The wavelength of a wave is inversely proportional to the frequency of the wave (e.g., waves with longer wavelengths have lower frequencies compared to waves with shorter wavelengths).

Performance Expectation	**MS-PS4-2** Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Developing and Using Models Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • 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.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 56–59	pp. 131–136	pp. 96–98
NGSS Appendices	Appendix F p. 6	Appendix E p. 8	Appendix G pp. 9–10
Clarification Statement	Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.		
Assessment Boundary	Assessment is limited to qualitative applications pertaining to light and mechanical waves.		

Items may ask students to:

Code	Alignment	Item Specification
MS-PS4-2.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to describe that **wave interactions** with materials are related to the **structure and function** of the materials.
MS-PS4-2.2	SEP-DCI	**Develop** and/or **use** a **model** to describe **wave interactions** with different materials.
MS-PS4-2.3	DCI-CCC	Connect **wave interactions** with materials to the **structure and function** of the materials.
MS-PS4-2.4	SEP-CCC	**Develop** and/or **use** a **model** to describe the structure and function of materials.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
    - using a given complete or partial model to make predictions and/or describe phenomena
    - using a model to show relationships among variables
    - revising a given complete or partial model
    - describing the limitations of a complete or partial model
    - using a model to represent current understanding of a system
    - using a model to aid in the development of questions and/or descriptions

- **Models** of the properties of **wave interactions** with materials may include, but are NOT limited to, a diagram, simulation, or written description of:
    - the amplitude, frequency, wavelength, and/or path of a mechanical wave propagating through a medium or interacting with a material
    - the amplitude, frequency, wavelength, and/or path of a light wave interacting with a material
    - properties of a medium (e.g., state of matter, temperature) through which a sound wave propagates
    - properties of a material (e.g., texture, color, transparency, hardness) that is interacting with a wave
    - changes in amplitude, frequency, wavelength, and/or direction of light or mechanical waves that result from interactions with materials
    - the reflection of waves by smooth surfaces
    - the absorption of waves by materials
    - the transmission of waves through materials
    - the bending of wave paths that pass from one material or medium to another

- **Structure and function** relationships between waves and materials may include, but are NOT limited to:
    - the functions of reflective, translucent, or opaque materials
    - the speed of waves through different materials
    - the use of lenses to bend light

Performance Expectation	**MS-PS4-3** Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods. • Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.	**PS4.C: Information Technologies and Instrumentation** • Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.	**Structure and Function** • Structures can be designed to serve particular functions. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. **Connections to Nature of Science** **Science is a Human Endeavor** • Advances in technology influence the progress of science and science has influenced advances in technology.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 74–77	pp. 136–137	pp. 96–98 pp. 210–214
NGSS Appendices	Appendix F p. 15	Appendix E p. 8	Appendix G pp. 9–10 Appendix J pp. 3–4 Appendix H p. 6
Clarification Statement	Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.		
Assessment Boundary	Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.		

Items may ask students to:

Code	Alignment	Item Specification
MS-PS4-3.1	SEP-DCI-CCC	**Integrate** qualitative scientific and/or technical **information** to support the claim that **features** of **digitized signals** provide a more reliable way to **encode** and/or **transmit information** than **analog signals**.
MS-PS4-3.2	SEP-DCI	**Integrate** qualitative scientific and/or technical **information** to support the claim that **digitized signals** provide a more reliable way to **encode** and/or **transmit information** than **analog signals**.
MS-PS4-3.3	DCI-CCC	Connect the **features** of **digitized signals** to the ways they **encode** and/or **transmit information** more reliably than **analog signals**.
MS-PS4-3.4	SEP-CCC	**Integrate** qualitative scientific and/or technical **information** to describe relationships between structure and function.

Details and Clarifications

- **Integrate** qualitative scientific and technical **information** is expanded to include:
  - using patterns in and/or evidence from information to support a claim and/or describe a scientific phenomenon
  - evaluating the credibility and/or accuracy and/or bias of claims from different sources

- **Information** formats may include, but are NOT limited to:
  - text
  - diagrams
  - graphs
  - tables
  - models
  - animations

- **Digitized signals** may include, but are NOT limited to:
  - light pulses in fiber-optic cables
  - radio wave pulses in Wi-Fi devices
  - sound wave pulses in computers and/or cell phones

- Examples of how the **features** of **digitized signals** provide a **more reliable** way to **encode** and/or **transmit information** than **analog signals** may include, but are NOT limited to:
  - information being reliably recorded
  - information being stored for future recovery
  - information being transmitted over long distances without degradation
  - information being transmitted faster

Life Sciences

Disciplinary Core Ideas:

- LS1 From Molecules to Organisms: Structures and Processes
- LS2 Ecosystems: Interactions, Energy, and Dynamics
- LS3 Heredity: Inheritance and Variation of Traits
- LS4 Biological Evolution: Unity and Diversity

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS1-1 Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Planning and Carrying Out Investigations
Planning and carrying out investigations in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.
• Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.</td><td>LS1.A: Structure and Function
• All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).</td><td>Scale, Proportion, and Quantity
• Phenomena that can be observed at one scale may not be observable at another scale.

Connections to Engineering, Technology and Applications of Science

Interdependence of Science, Engineering, and Technology
• Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 59–61</td><td>pp. 143–145</td><td>pp. 89–91
pp. 210–214</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 7–8</td><td>Appendix E
p. 4</td><td>Appendix G
pp. 6–7
Appendix J
p. 3</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">An assessment boundary is not provided for this PE.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-LS1-1.1	SEP-DCI-CCC	**Plan** and/or **conduct** an **investigation** to provide **evidence** that living things are made of either **one cell** or **many cells** and/or are observable at different **scales**.
MS-LS1-1.2	SEP-DCI	**Plan** and/or **conduct** an **investigation** to provide **evidence** that living things are made of **one cell** or **many cells**.
MS-LS1-1.3	DCI-CCC	Use observations at different **scales** to describe that living things are made of **one cell** or **many cells**.
MS-LS1-1.4	SEP-CCC	**Plan** and/or **conduct** an **investigation** to produce evidence at different scales.

Details and Clarifications

- **Plan** and/or **conduct** an **investigation** is expanded to include:
  - conducting an investigation to produce evidence
  - identifying independent, dependent, and/or controlled variables
  - making predictions about what would happen if a variable changes
  - evaluating appropriate methods and/or tools for collecting and/or recording data

- **Evidence** that living things are made of **one cell** or **many cells** may include, but is NOT limited to:
  - observations of single-celled organisms
  - observations of cells that make up parts of multicellular organisms (e.g., onion skin, plant leaf)
  - observations of different types of cells in a multicellular organism (e.g., muscle cells, nerve cells)
  - observation of the absence of cells in non-living things

- Examples of **different scales** may include, but are NOT limited to:
  - cells and/or organisms observable with the unaided eye
  - cells and/or organisms observable only with a magnification device (e.g., magnifying glass, microscope)
  - cells and/or organisms observed at different powers of magnification

Performance Expectation	**MS-LS1-2** Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.	**LS1.A: Structure and Function** • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.	**Structure and Function** • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 56–59	pp. 143–145	pp. 96–98
NGSS Appendices	Appendix F p. 6	Appendix E p. 4	Appendix G pp. 9–10
Clarification Statement	Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.		
Assessment Boundary	Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS1-2.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to describe the **function** of a **cell** as a **whole** and/or ways **parts** of a **cell** contribute to the **function**.
MS-LS1-2.2	SEP-DCI	**Develop** and/or **use** a **model** to describe the **function** of a **cell** and/or the **parts** of a **cell**.
MS-LS1-2.3	DCI-CCC	Describe the **function** of a **cell** as a **whole** and/or ways **parts** of a **cell** contribute to the **function**.
MS-LS1-2.4	SEP-CCC	**Develop** and/or **use** a **model** to describe how the function of a system depends on the relationships among its parts.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions and/or to describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- **Parts** of a **cell** include:
  - nucleus
  - chloroplast
  - mitochondria
  - cell membrane
  - cell wall

- Examples of ways **parts** of a **cell** contribute to the **function** of a **cell** may include, but are NOT limited to:
  - mitochondria providing energy to maintain a cell's internal processes
  - the cell wall and cell membrane providing structure to a cell and controlling what enters and leaves the cell
  - chloroplasts producing food during photosynthesis

<table>
<tr><th>Performance Expectation</th><th colspan="3">MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.</th></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).
• Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.</td><td>LS1.A: Structure and Function
• In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.</td><td>Systems and System Models
• Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

Connections to Nature of Science

Science is a Human Endeavor
• Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 71–74</td><td>pp. 143–145</td><td>pp. 91–94</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
pp. 13–14</td><td>Appendix E
p. 4</td><td>Appendix G
pp. 7–8
Appendix H
p. 6</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-LS1-3.1	SEP-DCI-CCC	Use an **argument** supported by **evidence** for how the **body** is a **system** of **interacting subsystems** composed of **groups** of **cells**.
MS-LS1-3.2	SEP-DCI	Use an **argument** supported by **evidence** for how the **body** is composed of **subsystems** and/or **groups** of **cells**.
MS-LS1-3.3	DCI-CCC	Use the **body** as a **system** to connect **interacting subsystems** to **groups** of **cells.**
MS-LS1-3.4	SEP-CCC	**Use** an **argument** supported by **evidence** that systems may have subsystems, may interact with other systems, and/or may be a part of a complex system.

Details and Clarifications

- **Use** an **argument** is expanded to include:
  - describing the similarities and/or differences between two arguments
  - developing an argument and/or making a claim based on observations, data, and/or a model
  - using evidence and/or scientific reasoning to support or refute an explanation and/or a model
  - identifying flaws in explanations, procedures, models, and/or solutions
  - evaluating competing design solutions based on how well the solutions meet the criteria and/or the constraints of a problem

- **Subsystems** are limited to:
  - circulatory
  - excretory
  - digestive
  - respiratory
  - muscular
  - nervous

- **Evidence** for how the **body** is a **system** of **interacting subsystems** composed of **groups** of **cells** may include, but is NOT limited to:
  - groups of cells forming different tissues (e.g., nervous, muscular, epithelial)
  - interacting tissues in organs that carry out a function (e.g., muscle, connective, and epithelial tissues allow the heart to receive and/or pump blood)
  - interacting organs carrying out a function (e.g., heart and blood vessels work together to transport blood throughout the body)
  - organs and organ systems interacting to carry out functions (e.g., digestive, respiratory, and circulatory systems transport food and/or oxygen to body cells for energy, growth, and/or repair)

Performance Expectation	**MS-LS1-4** Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Use 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 a solution to a problem.	**LS1.B: Growth and Development of Organisms** • Animals engage in characteristic behaviors that increase the odds of reproduction. • Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 71–74	pp. 145–147	pp. 87–89
NGSS Appendices	Appendix F pp. 13–14	Appendix E p. 4	Appendix G pp. 5–6
Clarification Statement	Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS1-4.1	SEP-DCI-CCC	**Use** an **argument** based on empirical evidence and scientific reasoning to support an explanation for **cause and effect** relationships between characteristic **animal behaviors** and/or **specialized plant structures** and the **probability** of **successful reproduction**
MS-LS1-4.2	SEP-DCI	**Use** an **argument** based on empirical evidence and scientific reasoning to support an explanation of relationships between characteristic **animal behaviors** and/or **specialized plant structures** and the **probability** of **successful reproduction**.
MS-LS1-4.3	DCI-CCC	Use **cause and effect** relationships to connect characteristic **animal behaviors** and/or **specialized plant structures** to the **probability** of **successful reproduction.**
MS-LS1-4.4	SEP-CCC	**Use** an **argument** based on empirical evidence and scientific reasoning to support an explanation for cause and effect relationships.

Details and Clarifications

- **Use** an **argument** is expanded to include:
  - describing the similarities and/or differences between two arguments
  - developing an argument and/or making a claim based on observations, data, and/or a model
  - using evidence and/or scientific reasoning to support or refute an explanation and/or a model
  - identifying flaws in explanations, procedures, models, and/or solutions
  - evaluating competing design solutions based on how well the solutions meet the criteria and/or the constraints of a problem

- Examples of **cause and effect** relationships between **animal behaviors** and the **probability** of successful animal **reproduction** may include, but are NOT limited to:
  - building shelters (e.g., nests, burrows, webs) to hide from predators
  - migrating seasonally to increase access to food
  - protecting a territory (e.g., sounds, scents) to increase access to resources
  - displaying during mating season (e.g., movements, sounds, physical features)

- Examples of **cause and effect** relationships between **animal behaviors** and the **probability** of successful plant **reproduction** may include, but are NOT limited to:
  - collecting pollen from and/or transferring pollen among flowers
  - grazing in areas where burrs stick to fur
  - eating fruit and passing seeds as waste

- Examples of **cause and effect** relationships between **specialized plant structures** and the **probability** of successful plant **reproduction** may include, but are NOT limited to:
  - having bright, colorful flowers to attract pollinators
  - having seed coats that stick to animal fur for seed dispersal
  - producing seeds with strong coats that resist damage from animals

Performance Expectation	**MS-LS1-5** Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. • 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.	**LS1.B: Growth and Development of Organisms** • Genetic factors as well as local conditions affect the growth of the adult plant.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 67–71	pp. 145–147	pp. 87–89
NGSS Appendices	Appendix F pp. 11–12	Appendix E p. 4	Appendix G pp. 5–6
Clarification Statement	Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.		
Assessment Boundary	Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS1-5.1	SEP-DCI-CCC	**Construct** a **scientific explanation** based on evidence of **cause and effect** relationships for how **environmental** and/or **genetic factors** influence the **growth** of organisms.
MS-LS1-5.2	SEP-DCI	**Construct** a **scientific explanation** based on evidence for how **environmental** and/or **genetic factors** influence the **growth** of organisms.
MS-LS1-5.3	DCI-CCC	Use **cause and effect** relationships to connect **environmental** and/or **genetic factors** to the **growth** of organisms.
MS-LS1-5.4	SEP-CCC	**Construct** a **scientific explanation** based on evidence of cause and effect relationships.

Details and Clarifications

- **Construct** a **scientific explanation** is expanded to include:
  - using valid data, models, and/or scientific knowledge to construct, revise, and/or support an explanation and/or design a solution
  - using qualitative and/or quantitative relationships between variables to predict and/or describe phenomena
  - using models and/or evidence to support explanations
  - applying scientific principles to design a tool, process, and/or system that meets specific criteria and/or constraints

- Examples of **environmental factors** that influence the **growth** of organisms may include, but are NOT limited to:
  - availability of resources (e.g., food, light, space, water)
  - presence of pollutants

- Examples of **genetic factors** that influence the **growth** of organisms may include, but are NOT limited to:
  - genetic makeup of a species of plant and/or animal
  - genetic makeup of a modified (e.g., artificial selection, gene modification) plant and/or animal

- Examples of **cause and effect** relationships may include, but are NOT limited to:
  - differences in environmental conditions resulting in differences in growth rates among animals of the same species
  - differences in pond size resulting in fish growing larger or smaller

Performance Expectation	**MS-LS1-6** Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. • 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. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical connections between evidence and explanations.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. **PS3.D: Energy in Chemical Processes and Everyday Life** • The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. *(secondary)*	**Energy and Matter** • Within a natural system, the transfer of energy drives the motion and/or cycling of matter.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 67–71	pp. 147–148 pp. 128–130	pp. 94–96
NGSS Appendices	Appendix F pp. 11–12 Appendix H p. 5	Appendix E p. 4 p. 8	Appendix G pp. 8–9
Clarification Statement	Emphasis is on tracing movement of matter and flow of energy.		
Assessment Boundary	Assessment does not include the biochemical mechanisms of photosynthesis.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS1-6.1	SEP-DCI-CCC	**Construct** a **scientific explanation** based on evidence for the **role** of **photosynthesis** in the **cycling** of **matter** and/or the **flow** of **energy** into and out of organisms.
MS-LS1-6.2	SEP-DCI	**Construct** a **scientific explanation** based on evidence for the **role** of **photosynthesis** in organisms.
MS-LS1-6.3	DCI-CCC	Connect the **cycling** of **matter** to the **flow** of **energy** into and out of organisms during **photosynthesis**.
MS-LS1-6.4	SEP-CCC	**Construct** a **scientific explanation** based on **evidence** for the cycling of matter and/or the flow of energy in a system.

Details and Clarifications

- **Construct** a **scientific explanation** is expanded to include:
  - using valid data, models, and/or scientific knowledge to construct, revise, and/or support an explanation and/or design a solution
  - using qualitative and/or quantitative relationships between variables to predict and/or describe phenomena
  - using models and/or evidence to support explanations
  - applying scientific principles to design a tool, process, and/or system that meets specific criteria and/or constraints

- Examples of the **role** of **photosynthesis** in the **cycling** of **matter** and/or the **flow** of **energy** may include, but are NOT limited to:
  - photosynthetic organisms (e.g., plants, algae) requiring energy (i.e., sunlight), carbon dioxide, and water to survive
  - photosynthetic organisms using energy from the sun to convert carbon dioxide and water into sugar and oxygen
  - animals taking in food (sugar) and oxygen to provide energy and materials for growth and/or survival
  - animals eating plants and/or other animals that have eaten plants
  - plants and/or animals using energy released from food for life functions (e.g., growth, repair, seed production)
  - animals breathing in oxygen produced during photosynthesis in plants

<table>
<tr><td>Performance Expectation</td><td colspan="3">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</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Developing and Using Models
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
• Develop a model to describe unobservable mechanisms.</td><td>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 involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary)</td><td>Energy and Matter
• Matter is conserved because atoms are conserved in physical and chemical processes.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K-12 Framework</td><td>pp. 56–59</td><td>pp. 147–148
pp. 128–130</td><td>pp. 94–96</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 6</td><td>Appendix E
p. 4
Appendix E
p. 8</td><td>Appendix G
pp. 8–9</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment does not include details of the chemical reactions for photosynthesis or respiration.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-LS1-7.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to describe how **matter** is **conserved** in **chemical reactions** that rearrange food molecules to form new molecules and/or release energy in organisms.
MS-LS1-7.2	SEP-DCI	**Develop** and/or **use** a **model** to describe **chemical reactions** that rearrange food molecules to form new molecules and/or release energy in organisms.
MS-LS1-7.3	DCI-CCC	Connect the **conservation** of **matter** to **chemical reactions** that rearrange food molecules to form new molecules and/or release energy in organisms.
MS-LS1-7.4	SEP-CCC	**Develop** and/or **use** a **model** to describe how matter is conserved during a chemical reaction.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions and/or describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- **Models** may include, but are NOT limited to:
  - diagrams
  - simulations
  - descriptions

- **Models** that describe how **matter** is **conserved** in **chemical reactions** may include, but are NOT limited to:
  - a diagram, simulation, and/or description that shows how food molecules are rearranged into new molecules during cellular respiration
  - a diagram, simulation, and/or description that shows the release of energy when food molecules are broken down
  - a chemical equation showing that the number and/or type of atoms before a chemical reaction is equal to the number and/or type of atoms after a chemical reaction

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS1-8 Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods.
• Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.</td><td>LS1.D: Information Processing
• Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural systems.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 74–77</td><td>pp. 149–150</td><td>pp. 87–89</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 15</td><td>Appendix E
p. 4</td><td>Appendix G
pp. 5–6</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">A clarification statement is not provided for this PE.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment does not include mechanisms for the transmission of this information.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-LS1-8.1	SEP-DCI-CCC	**Gather** and/or **synthesize information** about **cause and effect** relationships between **sensory receptors** and their response to **stimuli** by sending messages to the brain for immediate **behavior** and/or storage as **memories**.
MS-LS1-8.2	SEP-DCI	**Gather** and/or **synthesize information** about **sensory receptors**, **stimuli**, **behavior**, and/or **memory** storage.
MS-LS1-8.3	DCI-CCC	Use **cause and effect** relationships to connect **sensory receptors** to their response to **stimuli** by sending messages to the brain for immediate **behavior** and/or storage as **memories**.
MS-LS1-8.4	SEP-CCC	**Gather** and/or **synthesize information** about cause and effect relationships in a system.

Details and Clarifications

- **Gather** and/or **synthesize information** is expanded to include:
  - using patterns in and/or evidence from information to support a claim and/or describe a scientific phenomenon
  - evaluating the credibility and/or accuracy and/or bias of claims from different sources

- **Information** formats may include, but are NOT limited to:
  - text
  - diagrams
  - graphs
  - tables
  - models
  - animations

- Examples of **sensory receptors** and their **stimuli** may include, but are NOT limited to:
  - chemoreceptors that respond to smell and/or taste
  - thermoreceptors that respond to changes in temperature
  - mechanoreceptors that respond to touch and/or movement
  - photoreceptors that respond to changes in light energy

- Examples of **cause and effect** relationships between **sensory receptors** and **behavior** and/or **memories** may include, but are NOT limited to:
  - a loud noise stimulus being processed and causing an animal to startle
  - a strong smell stimulus being processed and stored as a memory
  - a sharp decrease in temperature resulting in an animal seeking shelter based on previous experiences

Performance Expectation	**MS-LS2-1** Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.		
	Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Dimensions	**Analyzing and Interpreting Data** Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to provide evidence for phenomena.	**LS2.A: Interdependent Relationships in Ecosystems** • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. • Growth of organisms and population increases are limited by access to resources.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 61–63	pp. 150–152	pp. 87–89
NGSS Appendices	Appendix F p. 9	Appendix E p. 5	Appendix D pp. 5–6
Clarification Statement	Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS2-1.1	SEP-DCI-CCC	**Analyze** and/or **interpret data** to provide **evidence** of **cause and effect** relationships between the availability of **resources** and the growth and/or reproduction of **organisms** and/or **populations of organisms** in an ecosystem.
MS-LS2-1.2	SEP-DCI	**Analyze** and/or **interpret data** to provide **evidence** of the availability of **resources** and/or the growth and/or reproduction of **organisms** and/or **populations of organisms** in an ecosystem.
MS-LS2-1.3	DCI-CCC	Use **cause and effect** relationships to connect the availability of **resources** to the growth and/or reproduction of **organisms** and/or **populations of organisms** in an ecosystem.
MS-LS2-1.4	SEP-CCC	**Analyze** and/or **interpret data** to provide evidence for cause and effect relationships.

Details and Clarifications

- **Analyze** and/or **interpret data** is expanded to include:
  - organizing and/or interpreting data
  - identifying similarities and/or differences in findings
  - using patterns in data to distinguish between causal and/or correlational relationships and/or to draw conclusions based on data

- **Data** may include, but are NOT limited to:
  - observations
  - measurements
  - tables
  - graphs
  - diagrams
  - models
  - statistical information (e.g., mean, median, mode, variability)

- Types of **evidence** may include, but are NOT limited to:
  - population size and/or growth rate
  - reproduction rate
  - individual size and/or growth rate
  - type, amount, distribution, and/or concentration of an available resource
  - distributions of species that compete for resources

- **Cause and effect** relationships between the availability of **resources** and the growth and/or reproduction of **organisms** and/or **populations of organisms** may include, but are NOT limited to:
  - the growth of an individual organism changes as a function of resource availability (e.g., food, water, space)
  - the reproduction rate of a population changes as a function of resource availability (e.g., food, water, space)
  - resource availability affects interactions between organisms (e.g., competition)
  - competition and/or mutually beneficial relationships affect population sizes or growth rates
  - newly introduced species reduce available resources in an ecosystem

Performance Expectation	**MS-LS2-2** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.	**LS2.A: Interdependent Relationships in Ecosystems** • Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.	**Patterns** • Patterns can be used to identify cause and effect relationships.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 67–71	pp. 150–152	pp. 85–87
NGSS Appendices	Appendix F pp. 11–12	Appendix E p. 5	Appendix G pp. 3–5
Clarification Statement	Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS2-2.1	SEP-DCI-CCC	**Construct** an **explanation** that predicts **patterns** of **interactions** among and/or between **organisms** across multiple **ecosystems**.
MS-LS2-2.2	SEP-DCI	**Construct** an **explanation** for **interactions** among and/or between **organisms** across multiple **ecosystems**.
MS-LS2-2.3	DCI-CCC	Use **patterns** to predict **interactions** among and/or between **organisms** across multiple **ecosystems**.
MS-LS2-2.4	SEP-CCC	**Construct** an **explanation** using patterns in a system.

Details and Clarifications

- **Construct** a **explanation** is expanded to include:
  - using valid data, models, and/or scientific knowledge to construct, revise, and/or support an explanation and/or design a solution
  - using qualitative and/or quantitative relationships between variables to predict and/or describe phenomena
  - using models and/or evidence to support explanations
  - applying scientific principles to design a tool, process, and/or system that meets specific criteria and/or constraints

- Examples of **interactions** among **organisms** may include, but are not limited to:
  - competitive (e.g., shrubs and trees competing for water and/or space)
  - predatory (e.g., coyotes eating rabbits)
  - mutually beneficial (e.g., pollinators receiving nectar from plants while transferring pollen from plant to plant)

- Examples of **patterns** of **interactions** among **organisms** across multiple **ecosystems** may include, but are not limited to:
  - relationships between predators and prey are similar in grassland and marine environments.
  - grasses and shrubs compete for water in prairie and forest ecosystems.

Performance Expectation	**MS-LS2-3** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.		
	Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Dimensions	**Developing and Using Models** Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe phenomena.	**LS2.B: Cycle of Matter and Energy Transfer in Ecosystems** • Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a natural system. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 56–59	pp. 152–154	pp. 94–96
NGSS Appendices	Appendix F p. 6	Appendix E p. 5	Appendix G pp. 8–9 Appendix H p. 6
Clarification Statement	Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.		
Assessment Boundary	Assessment does not include the use of chemical reactions to describe the processes.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS2-3.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to describe the **cycling** of **matter** and/or **flow** of **energy** among the **living** and/or **nonliving parts** of an ecosystem.
MS-LS2-3.2	SEP-DCI	**Develop** and/or **use** a **model** to describe the **living** and/or **nonliving parts** of an ecosystem.
MS-LS2-3.3	DCI-CCC	Track the **cycling** of **matter** and/or **flow** of **energy** among the **living** and/or **nonliving parts** of an ecosystem.
MS-LS2-3.4	SEP-CCC	**Develop** and/or **use** a **model** to describe the cycling of matter and/or flow of energy through a system.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions and/or describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- **Models** may include, but are NOT limited to, a diagram, simulation, or description of:
  - interacting parts of an ecosystem
  - energy flow through the living and/or nonliving parts of an ecosystem
  - the boundaries of an ecosystem
  - a food web

- **Living parts** of an ecosystem may include, but are NOT limited to:
  - producers (e.g., grass, trees)
  - consumers (e.g., rabbits, deer)
  - decomposers (e.g., mushrooms, bacteria)

- **Nonliving parts** of an ecosystem may include, but are NOT limited to:
  - water
  - nutrients
  - air
  - sunlight
  - soil

- The **flow** of **energy** and/or **cycling** of **matter** may include, but is NOT limited to:
  - decomposers using matter and/or energy obtained from the breakdown of producers and/or consumers
  - producers using matter and/or energy to make food
  - atoms cycling among the living and/or nonliving parts of an ecosystem
  - matter being conserved as it cycles in and/or out of the physical environment

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).
• 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 a solution to a problem.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
• Science disciplines share common rules of obtaining and evaluating empirical evidence.</td><td>LS2.C: Ecosystem Dynamics, Functioning, and Resilience
• Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.</td><td>Stability and Change
• Small changes in one part of a system might cause large changes in another part.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 71–74</td><td>pp. 154–156</td><td>pp. 98–101</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
pp. 13–14
Appendix H
p. 5</td><td>Appendix E
p. 5</td><td>Appendix G
pp. 10–11</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">An assessment boundary is not provided for this PE.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-LS2-4.1	SEP-DCI-CCC	**Construct** an **argument** supported by empirical evidence that **changes** to **physical** and/or **biological components** of an ecosystem affect **populations**.
MS-LS2-4.2	SEP-DCI	**Construct** an **argument** supported by empirical evidence about the **physical** and/or **biological components** and/or the **populations** of an ecosystem.
MS-LS2-4.3	DCI-CCC	Connect **physical** and/or **biological changes** in an ecosystem to **changes** in **populations**.
MS-LS2-4.4	SEP-CCC	**Construct** an **argument** supported by evidence about changes in a system.

Details and Clarifications

- **Construct** an **argument** is expanded to include:
  - describing the similarities and/or differences between two arguments
  - developing an argument and/or making a claim based on observations, data, and/or a model
  - using evidence and/or scientific reasoning to support or refute an explanation and/or a model
  - identifying flaws in explanations, procedures, models, and/or solutions
  - evaluating competing design solutions based on how well the solutions meet the criteria and/or the constraints of a problem

- Examples of **physical changes** may include, but are NOT limited to:
  - lack of rainfall
  - forest fires
  - increase in pollution

- Examples of **biological changes** may include, but are NOT limited to:
  - predator removal
  - species introduction

- **Changes** in **populations** may include, but are NOT limited to:
  - the migration of species into or out of an area
  - the extinction of species
  - the formation of a new species
  - differences in the types and/or total numbers of organisms in one or more populations

Performance Expectation	**MS-LS2-5** Evaluate competing design solutions for maintaining biodiversity and ecosystem services.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. **LS4.D: Biodiversity and Humans** • Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.*(secondary)* **ETS1.B: Developing Possible Solutions** • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. *(secondary)*	**Stability and Change** • Small changes in one part of a system might cause large changes in another part. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. **Science Addresses Questions About the Natural and Material World** • Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 71–74	pp. 154–156 pp. 166–167 pp. 206–208	pp. 98–101 pp. 210-214
NGSS Appendices	Appendix F pp. 13–14	Appendix E pp. 5–6 Appendix I pp. 1–7	Appendix G pp. 10–11 Appendix J pp. 3-4
Clarification Statement	Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS2-5.1	SEP-DCI-CCC	**Evaluate** given competing design **solutions** for maintaining **biodiversity** and/or **ecosystem services** when **changes** in one part of an ecosystem **cause changes** in another part of the ecosystem.
MS-LS2-5.2	SEP-DCI	**Evaluate** given competing design **solutions** for maintaining **biodiversity** and/or **ecosystem services**.
MS-LS2-5.3	DCI-CCC	Connect **changes** in an ecosystem to the maintenance of **biodiversity** and/or **ecosystem services** for a given ecosystem.
MS-LS2-5.4	SEP-CCC	**Evaluate** given competing design **solutions** that address stability and change in a system.

Details and Clarifications

- **Evaluate** competing design **solutions** is expanded to include**:**
  - describing the similarities and/or differences between two arguments
  - developing an argument and/or making a claim based on observations, data, and/or a model
  - using evidence and/or scientific reasoning to support or refute an explanation and/or a model
  - identifying flaws in explanations, procedures, models, and/or solutions
  - evaluating competing design solutions based on how well the solutions meet the criteria and/or the constraints of a problem

- **Solutions** for maintaining **biodiversity** and **ecosystem services** may include, but are NOT limited to:
  - providing habitat for a variety of organisms (e.g., installing nesting boxes for migratory birds)
  - regulating human activities (e.g., hunting, recreation, development)

- **Ecosystem services** may include, but are NOT limited to:
  - water purification
  - nutrient recycling
  - erosion prevention
  - climate stabilization
  - pollination

- **Changes** in one part of an ecosystem that **cause changes** in another part of an ecosystem may include, but are NOT limited to:
  - the removal of trees causing a shift in types and/or numbers of organisms
  - the introduction of new species resulting in the migration of organisms
  - increases in human population causing increases in air and/or water pollution
  - the overuse of resources causing a change in the distribution of a population

Performance Expectation	**MS-LS3-1** Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.	**LS3.A: Inheritance of Traits** • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. **LS3.B: Variation of Traits** • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.	**Structure and Function** • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 56–59	pp. 158–159 pp. 160–161	pp. 96–98
NGSS Appendices	Appendix F p. 6	Appendix E p. 6	Appendix G pp. 9–10
Clarification Statement	Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.		
Assessment Boundary	Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS3-1.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to describe how the **structure** of genes affects the **structure** and/or **function** of proteins and/or how **structural changes** to genes may result in harmful, beneficial, or neutral effects to the **structure** and/or **function** of the organism.
MS-LS3-1.2	SEP-DCI	**Develop** and/or **use** a **model** to show that genes are located on chromosomes and/or to show how information flows from genes to proteins to traits and/or to show that **structural changes** can be harmful, beneficial, or neutral.
MS-LS3-1.3	DCI-CCC	Connect the **structure** of genes and/or **structural changes** to genes to the **structure** and/or **function** of proteins and/or to the harmful, beneficial, or neutral effects to the **structure** and/or **function** of the organism.
MS-LS3-1.4	SEP-CCC	**Develop** and/or **use** a **model** to describe how complex structures can be analyzed to determine how they function.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions and/or describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- **Models** that show how the **structure of** genes affects the **structure** and/or **function** of other components may include, but are NOT limited to, a diagram, simulation, or description of:
  - structural and/or functional relationships between chromosomes, genes, proteins, traits, and/or organisms

- **Models** that show how **structural changes** to genes affect the **structure** and/or **function** of other components may include, but are NOT limited to, a diagram, simulation, or description of:
  - how a mutation changes the structure and/or function of genes and/or proteins

- **Structure** and **function** relationships between genes, proteins, traits, and/or organisms may include, but are NOT limited to:
  - the structure of a gene determines the structure of a protein
  - protein structure influences protein function
  - protein structure influences the expression of a trait
  - a mutation changes the structure and/or function of a gene
  - a mutation may affect the structure and/or function of a protein
  - a mutation may affect the structure and/or function of an organism in a beneficial, neutral, or harmful way

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Developing and Using Models
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
• Develop and use a model to describe phenomena.</td><td>LS1.B: Growth and Development of Organisms
• Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary)

LS3.A: Inheritance of Traits
• Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.

LS3.B: Variation of Traits
• In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural systems.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K-12 Framework</td><td>pp. 56–59</td><td>pp. 145–147
pp. 158–160
pp. 160–161</td><td>pp. 87–89</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 6</td><td>Appendix E
p. 4
Appendix E
p. 6</td><td>Appendix G
pp. 5–6</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">An assessment boundary is not provided for this PE.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-LS3-2.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to describe **cause and effect** relationships between **sexual** and/or **asexual reproduction** and **genetic variation** in offspring.
MS-LS3-2.2	SEP-DCI	**Develop** and/or **use** a **model** to describe **sexual** and/or **asexual reproduction** and/or **genetic variation** in offspring.
MS-LS3-2.3	DCI-CCC	Use **cause and effect** relationships to connect **sexual** and/or **asexual reproduction** to **genetic variation** in offspring.
MS-LS3-2.4	SEP-CCC	**Develop** and/or **use** a **model** to describe cause and effect relationships.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions and/or describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- **Models** that describes **cause and effect** relationships between **sexual** and/or **asexual reproduction** and **genetic variation** may include, but are NOT limited to:
  - a diagram or simulation showing combinations of alleles inherited by offspring
  - a diagram, simulation, or description of a combination of alleles from parents

- **Cause and effect** relationships involving **variation** of **inherited traits** in **sexual reproduction** may include, but are NOT limited to:
  - two sets of chromosomes, one from each parent, combine, resulting in unique chromosome pairs in offspring
  - one allele for each of many genes is inherited from each parent, resulting in genetic variation in offspring

- **Cause and effect** relationships involving **variation** of **inherited traits** in **asexual reproduction** may include, but are NOT limited to:
  - offspring receive a set of chromosomes from one parent, with the same number and type of chromosomes as the parent, resulting in minimal genetic variation

<table>
<tr><td>Performance Expectation</td><td colspan="3">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.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
• Analyze and interpret data to determine similarities and differences in findings.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
• Science knowledge is based upon logical and conceptual connections between evidence and explanations.</td><td>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 or through radioactive dating) 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.</td><td>Patterns
• Graphs, charts, and images can be used to identify patterns in data.

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
• Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 61–63</td><td>pp. 162–163</td><td>pp. 85–87</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 9
Appendix H
p. 5</td><td>Appendix E
p. 6</td><td>Appendix G
pp. 3–5
Appendix H
p. 6</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">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.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment does not include the names of individual species or geological eras in the fossil record.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-LS4-1.1	SEP-DCI-CCC	**Analyze** and/or **interpret data** for **patterns** in the **fossil record** that document the **existence, diversity, extinction**, and/or **change** of life forms throughout history on Earth.
MS-LS4-1.2	SEP-DCI	**Analyze** and/or **interpret data** for evidence that documents the **existence, diversity, extinction**, and/or **change** of life forms throughout history on Earth.
MS-LS4-1.3	DCI-CCC	Describe **patterns** in the **fossil record** that document the **existence, diversity, extinction**, and/or **change** of life forms throughout history on Earth.
MS-LS4-1.4	SEP-CCC	**Analyze** and/or **interpret data** to identify patterns.

Details and Clarifications

- **Analyze** and/or **interpret data** is expanded to include:
  - organizing and/or interpreting data
  - identifying similarities and/or differences in findings
  - using patterns in data to distinguish between causal and/or correlational relationships and/or to draw conclusions based on data

- **Data** may include, but are NOT limited to:
  - observations
  - measurements
  - tables
  - graphs
  - diagrams
  - models
  - statistical information (e.g., mean, median, mode, variability)

- Examples of **patterns** in the **fossil record** that document the **existence, diversity, extinction,** and/or **change** of life forms throughout history on Earth may include, but are NOT limited to:
  - sets of sedimentary rock layers and the ages of the layers
  - chronological order of fossil locations in rock layers
  - periods of time showing the presence or absence of organisms and/or specific types of organisms
  - changes in the complexity of anatomical structures over time

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 evolutionary relationships.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • 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 between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.	**Patterns** • Patterns can be used to identify cause and effect relationships. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 67–71	pp. 162–163	pp. 85–87
NGSS Appendices	Appendix F pp. 11–12	Appendix E p. 6	Appendix G pp. 3–5 Appendix H p. 6
Clarification Statement	Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS4-2.1	SEP-DCI-CCC	**Apply scientific ideas** to **construct** an **explanation** for **patterns** in the **anatomical similarities** and/or **differences** among modern organisms and/or between modern and fossil organisms to infer **evolutionary relationships**.
MS-LS4-2.2	SEP-DCI	**Apply scientific ideas** to **construct** an **explanation** about the **anatomical similarities** and/or **differences** among modern organisms and/or fossil organisms to infer **evolutionary relationships**.
MS-LS4-2.3	DCI-CCC	Use **patterns** to connect **anatomical similarities** and/or **differences** among modern organisms and/or between modern and fossil organisms to **evolutionary relationships**.
MS-LS4-2.4	SEP-CCC	**Construct** an **explanation** for patterns within and/or among systems.

Details and Clarifications

- **Apply scientific ideas** to **construct** an **explanation** is expanded to include:
  - using valid data, models, and/or scientific knowledge to construct, revise, and/or support an explanation and/or design a solution
  - using qualitative and/or quantitative relationships between variables to predict and/or describe phenomena
  - using models and/or evidence to support explanations
  - applying scientific principles to design a tool, process, and/or system that meets specific criteria and/or constraints

- Examples of **patterns** in **anatomical similarities** and/or **differences** being used to infer **evolutionary relationships** may include, but are NOT limited to:
  - anatomical differences between the wings of birds and insects being used to infer that the organisms are not closely related
  - anatomical and functional similarities between the wings of birds and bats being used to infer that birds and bats are more closely related than birds and insects
  - close anatomical and functional similarities between the leg bones of zebras and horses being used to infer that the organisms are closely related
  - changes over time in the anatomical features of horses observable in the fossil record being used to infer lines of descent

Performance Expectation	**MS-LS4-3** Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze displays of data to identify linear and nonlinear relationships.	**LS4.A: Evidence of Common Ancestry and Diversity** • Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully formed anatomy.	**Patterns** • Graphs, charts, and images can be used to identify patterns in data.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 61–63	pp. 162–163	pp. 85–87
NGSS Appendices	Appendix F p. 9	Appendix E p. 6	Appendix G pp. 3–5
Clarification Statement	Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.		
Assessment Boundary	Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS4-3.1	SEP-DCI-CCC	**Analyze** pictorial **data** to compare **patterns** in the **embryological development** across multiple species to identify **evolutionary relationships** not evident in the fully formed anatomies.
MS-LS4-3.2	SEP-DCI	**Analyze** pictorial **data** to compare **embryological development** across multiple species to identify **evolutionary relationships** not evident in the fully formed anatomies.
MS-LS4-3.3	DCI-CCC	Connect **patterns** in the **embryological development** across multiple species to **evolutionary relationships** not evident in the fully formed anatomies.
MS-LS4-3.4	SEP-CCC	**Analyze data** to identify patterns within and/or among systems.

Details and Clarifications

- **Analyze data** is expanded to include:
  - organizing and/or interpreting data
  - identifying similarities and/or differences in findings
  - using patterns in data to distinguish between causal and/or correlational relationships and/or to draw conclusions based on data

- **Data** may include, but are NOT limited to:
  - observations
  - measurements
  - tables
  - graphs
  - diagrams
  - models
  - statistical information (e.g., mean, median, mode, variability)

- **Patterns** in the **embryological development** of different species that reveal **evolutionary relationships** not evident in the fully formed anatomies may include, but are NOT limited to:
  - similarities in embryo anatomy (e.g., gill slits and/or tails in early mammal and fish embryos; hind limbs in whale, land animal, and snake embryos)
  - differences in embryo development (e.g., mammal embryos lose gill slits, but the gill slits develop into gills in fish)

Performance Expectation	**MS-LS4-4** Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.	**LS4.B: Natural Selection** • Natural selection leads to the predominance of certain traits in a population, and the suppression of others.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 67–71	pp. 163–164	pp. 87–89
NGSS Appendices	Appendix F pp. 11–12	Appendix E p. 6	Appendix G pp. 5–6
Clarification Statement	Emphasis is on using simple probability statements and proportional reasoning to construct explanations.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS4-4.1	SEP-DCI-CCC	**Construct** an **explanation** that includes **cause and effect** relationships between the genetic variation of **traits** in a population and the probability of survival and/or reproduction in a specific environment.
MS-LS4-4.2	SEP-DCI	**Construct** an **explanation** that includes the genetic variation of **traits** in a population and/or probability of survival and/or reproduction in a specific environment.
MS-LS4-4.3	DCI-CCC	Use **cause and effect** relationships to connect the genetic variation of **traits** in a population to the probability of survival and/or reproduction in a specific environment.
MS-LS4-4.4	SEP-CCC	**Construct** an **explanation** of cause and effect relationships using probability.

Details and Clarifications

- **Construct** an **explanation** is expanded to include:
  - using valid data, models, and/or scientific knowledge to construct, revise, and/or support an explanation and/or design a solution
  - using qualitative and/or quantitative relationships between variables to predict and/or describe phenomena
  - using models and/or evidence to support explanations
  - applying scientific principles to design a tool, process, and/or system that meets specific criteria and/or constraints

- Examples of **traits** may include, but are NOT limited to:
  - morphological traits (e.g., body shape, wing pattern, bone structure)
  - physiological traits (e.g., disease resistance, heart rate, photosynthesis)
  - behavioral traits (e.g., feeding, mating, defense)

- Evidence of **cause and effect** relationships may include, but is NOT limited to:
  - specific traits that increase or decrease over time in a species after a change in the environment
  - specific traits that confer advantages to organisms in a particular environment and increase the probability of survival and/or reproduction
  - the increase in the proportion of organisms with advantageous traits from generation to generation
  - the decrease in the proportion of organisms with disadvantageous traits from generation to generation

Performance Expectation	**MS-LS4-5** Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods. • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.	**LS4.B: Natural Selection** • In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. **Connections to Nature of Science** **Science Addresses Questions About the Natural and Material World** • Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 74–77	pp. 163–164	pp. 87–89 pp. 210–212
NGSS Appendices	Appendix F p. 15	Appendix E p. 6	Appendix G pp. 5–6 Appendix J p. 3 Appendix H p. 6
Clarification Statement	Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS4-5.1	SEP-DCI-CCC	**Gather** and/or **synthesize information** to describe **cause and effect** relationships associated with the human use of technologies that influence the **inheritance** of **desired traits** in organisms.
MS-LS4-5.2	SEP-DCI	**Gather** and/or **synthesize information** to describe the human use of technologies that influence the **inheritance** of **desired traits** in organisms.
MS-LS4-5.3	DCI-CCC	Use **cause and effect** relationships to connect the human use of technologies and the **inheritance** of **desired traits** in organisms.
MS-LS4-5.4	SEP-CCC	**Gather** and/or **synthesize information** to describe cause and effect relationships.

Details and Clarifications

- **Gather** and/or **synthesize information** is expanded to include:
  - using patterns in and/or evidence from information to support a claim and/or describe a scientific phenomenon
  - evaluating the credibility, accuracy, and/or bias of claims from different sources

- **Information** formats may include, but are NOT limited to**:**
  - text
  - diagrams
  - graphs
  - tables
  - models
  - animations

- **Cause and effect** relationships associated with technologies that influence the **inheritance** of **desired traits** may include, but are NOT limited to:
  - allowing only plants with desirable characteristics to reproduce causes desirable characteristics to show up in the offspring
  - transplanting normal genes into cells in place of missing or defective ones can correct genetic disorders
  - using genetic engineering can produce desirable traits in crops

Performance Expectation	**MS-LS4-6** Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Using Mathematics and Computational Thinking Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. • Use mathematical representations to support scientific conclusions and design solutions.	**LS4.C: Adaptation** • Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 64–67	pp. 164–166	pp. 87–89
NGSS Appendices	Appendix F p. 10	Appendix E p. 6	Appendix G pp. 5–6
Clarification Statement	Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.		
Assessment Boundary	Assessment does not include Hardy Weinberg calculations.		

Items may ask students to:

Code	Alignment	Item Specification
MS-LS4-6.1	SEP-DCI-CCC	Use **mathematical representations** and **cause and effect** relationships to support explanations of how **adaptation** by **natural selection** may lead to **changes** in the **occurrence** of **specific traits** in populations over time.
MS-LS4-6.2	SEP-DCI	Use **mathematical representations** to support explanations of how **adaptation** by **natural selection** may lead to **changes** in the **occurrence** of **specific traits** in populations over time.
MS-LS4-6.3	DCI-CCC	Use **cause and effect** relationships to connect **adaptation** by **natural selection** to **changes** in the **occurrence** of **specific traits** in populations over time.
MS-LS4-6.4	SEP-CCC	**Use mathematical representations** to support explanations about cause and effect relationships in a system.

Details and Clarifications

- **Use mathematical representations** is expanded to include:
  - analyzing data sets for patterns and/or trends
  - using mathematical representations to describe and/or support scientific conclusions and/or design solutions
  - ordering steps to solve a problem
  - applying mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and/or engineering questions and/or problems
  - using digital tools, mathematical concepts, and/or mathematical arguments to compare proposed solutions to an engineering design problem

- **Mathematical representations** may include, but are NOT limited to:
  - mathematical models
  - probability statements
  - proportional reasoning
  - trends
  - averages
  - graphs

- **Cause and effect** relationships between **adaptation** by **natural selection** and **changes** in the **occurrence** of **specific traits** may include, but are NOT limited to:
  - changes in climate resulting in traits that better support survival and/or reproduction becoming more common
  - changes in resource availability resulting in traits that do not support survival and/or reproduction in the new environment becoming less common
  - extreme and/or sudden environmental change leading to species extinction

Earth and Space Sciences

Disciplinary Core Ideas:

- ESS1 Earth’s Place in the Universe
- ESS2 Earth’s Systems
- ESS3 Earth and Human Activity

Performance Expectation	**MS-ESS1-1** Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.	**ESS1.A: The Universe and Its Stars** • Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. **ESS1.B: Earth and the Solar System** • This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	**Patterns** • Patterns can be used to identify cause-and-effect relationships. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 56–59	pp. 173–174 pp. 175–176	pp. 85–87
NGSS Appendices	Appendix F p. 6	Appendix E p. 2	Appendix G pp. 3–5 Appendix H p. 6
Clarification Statement	Examples of models can be physical, graphical, or conceptual.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS1-1.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to describe **cyclic patterns** that can be used to identify relationships within the **Earth**-**sun-moon system** that **cause lunar phases, eclipses,** and/or **seasons**.
MS-ESS1-1.2	SEP-DCI	**Develop** and/or **use** a **model** of the **Earth**-**sun-moon system** to describe **lunar phases, eclipses,** and/or **seasons**.
MS-ESS1-1.3	DCI-CCC	Use the **cyclic patterns** in **lunar phases**, **eclipses**, and/or **seasons** to describe the relationships within the **Earth**-**sun-moon system** that **cause lunar phases, eclipses,** and/or **seasons**.
MS-ESS1-1.4	SEP-CCC	**Develop** and/or **use** a **model** to describe patterns.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include**:**
  - using a given complete or partial model to make predictions and/or describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- **Models** may include, but are NOT limited to a table, diagram, simulation, and/or description of:
  - components in a system (e.g., Earth, sun, moon)
  - interactions among components in a system (e.g., motions, orbits, rotations, revolutions, relative distances, relative sizes, tilts)

- **Cyclic patterns** that can be used to identify **relationships** within the **Earth-sun**-**moon system** that cause **lunar phases** may include, but are NOT limited to:
  - Half of the moon is always lit by solar energy from the sun.
  - The portion of the lit half of the moon seen from Earth changes in a pattern as the moon orbits Earth.
  - The moon rotates at the same rate at which the moon orbits Earth, so the side of the moon that faces Earth is always the same side.

- **Patterns** that can be used to identify relationships within the **Earth-sun**-**moon system** that cause **eclipses** may include, but are NOT limited to:
  - During solar eclipses, the moon moves between the sun and Earth, and the moon casts a shadow on Earth.
  - During lunar eclipses, the moon moves to the opposite side of Earth from the sun, and Earth casts a shadow on the moon.

- **Cyclic patterns** that can be used to identify **relationships** within the **Earth-sun**-**moon system** that cause **seasons** may include, but are NOT limited to:
  - seasons change as Earth orbits the sun, and the part of Earth tilted toward the sun changes
  - seasons are determined by the orientation and position of Earth's tilt in its orbit around the sun and by the resulting intensity of sunlight on different latitudes

Performance Expectation	MS-ESS1-2 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.		
	Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Dimensions	**Developing and Using Models** Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.	**ESS1.A: The Universe and Its Stars** • Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. • The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.	**Systems and System Models** • Models can be used to represent systems and their interactions. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 56–59	pp. 173–174 pp. 175–176	pp. 91–94
NGSS Appendices	Appendix F p. 6	Appendix E p. 2	Appendix G pp. 7–8 Appendix H p. 6
Clarification Statement	Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state).		
Assessment Boundary	Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.		

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS1-2.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to describe the **role of gravity** in the **motions** within **galaxies** and/or the **solar system**.
MS-ESS1-2.2	SEP-DCI	**Develop** and/or **use** a **model** to describe **gravity** and/or **motions** within **galaxies** and/or objects in the **solar system**.
MS-ESS1-2.3	DCI-CCC	Connect **gravity** to **motions** within **galaxies** and/or the **solar system**
MS-ESS1-2.4	SEP-CCC	**Develop** and/or **use** a **model** to represent systems and their interactions.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions and/or to describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- Components of a **model** may include, but are NOT limited to:
  - gravity
  - the sun
  - planets
  - moons
  - asteroids
  - galaxies
  - stars
  - universe
  - orbital motions
  - relative spatial scales

- Examples of the **role of gravity** in the **motions** within **galaxies** and/or the **solar system** may include, but are NOT limited to:
  - gravity acting as an attractive force between objects
  - gravity increasing as the masses of two interacting objects increases
  - gravity decreasing as the distance between two interacting objects increases
  - gravity causing smaller objects to orbit larger objects (e.g., moon orbits Earth, Earth orbits the sun)
  - gravity causing the orbital motion of stars and/or solar systems around the Milky Way center

Performance Expectation	**MS-ESS1-3** Analyze and interpret data to determine scale properties of objects in the solar system.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings.	**ESS1.B: Earth and the Solar System** • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.	**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. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 61–63	pp. 175–176	pp. 89–91
NGSS Appendices	Appendix F p. 9	Appendix E p. 2	Appendix G pp. 6–7 Appendix J p. 3
Clarification Statement	Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object’s layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.		
Assessment Boundary	Assessment does not include recalling facts about properties of the planets and other solar system bodies.		

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS1-3.1	SEP-DCI-CCC	**Analyze** and/or **interpret data** that describe the **features** of **objects** in the solar system at various **scales**.
MS-ESS1-3.2	SEP-DCI	**Analyze** and/or **interpret data** that describe the **features** of **objects** in the solar system.
MS-ESS1-3.3	DCI-CCC	Use the concept of **scale** to determine the **features** of **objects** in the solar system.
MS-ESS1-3.4	SEP-CCC	**Analyze** and/or **interpret data** observed at various scales.

Details and Clarifications

- **Analyze** and/or **interpret data** is expanded to include:
  - organizing and/or interpreting data
  - identifying similarities and/or differences in findings
  - using patterns in data to distinguish between causal and/or correlational relationships and/or to draw conclusions based on data
- **Data** may include, but are NOT limited to:
  - observations
  - measurements
  - tables
  - graphs
  - diagrams
  - models
  - statistical information (e.g., mean, median, mode, variability)
- **Features** of objects in the solar system may include, but are NOT limited to:
  - location relative to other objects
  - orbital shape and/or size
  - the relative or absolute measurements of overall size
  - the presence, absence, arrangement, abundance, and/or sizes of surface features
  - physical composition and/or makeup
  - the gravitational attraction between the sun and an object
- **Objects** in the solar system may include, but are NOT limited to:
  - the sun
  - planets
  - moons
  - asteroids, meteors, comets
- **Scale** may include, but is NOT limited to:
  - mathematical relationships among features of objects
  - absolute measurements of features of objects
  - model scales that represent features of objects
  - the proportional relationship between the size of a feature and the distance from which the feature was observed

<table>
<tr><td>Performance Expectation</td><td colspan="3">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 4.6-billion-year-old history.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
• 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.</td><td>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.</td><td>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.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 67–71</td><td>pp. 177–179</td><td>pp. 89–91</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
pp. 11–12</td><td>Appendix E
p. 2</td><td>Appendix G
pp. 6–7</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth’s history. Examples of Earth’s major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment does not include recalling the names of specific periods or epochs and events within them.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS1-4.1	SEP-DCI-CCC	**Construct** a scientific **explanation** based on **evidence** from rock strata for how the **geologic time scale** is used to organize **Earth's** 4.6-billion-year-old **history**.
MS-ESS1-4.2	SEP-DCI	**Construct** a scientific **explanation** about **Earth's history** based on **evidence** from rock strata.
MS-ESS1-4.3	DCI-CCC	Connect **evidence** from rock strata to the **geologic time scale** used to organize **Earth's** 4.6-billion-year-old **history**.
MS-ESS1-4.4	SEP-CCC	**Construct** a scientific **explanation** of a phenomenon observed at various time scales.

Details and Clarifications

- **Construct** a scientific **explanation** is expanded to include:
  - using valid data, models, and/or scientific knowledge to construct, revise, and/or support an explanation and/or design a solution
  - using qualitative and/or quantitative relationships between variables to predict and/or describe phenomena
  - using models and/or evidence to support explanations
  - applying scientific principles to design a tool, process, and/or system that meets specific criteria and/or constraints

- **Evidence** from rock strata may include, but is NOT limited to:
  - types, orders, and/or relative ages of rock strata and/or geologic events
  - types, orders, and/or relative ages of fossils

- Using the **geological time scale** used to organize **Earth's history** may include, but is NOT limited to:
  - ordering geologic events in Earth's history (e.g., formation of mountain chains, ocean basins, volcanic eruptions, glaciations, asteroid impacts, lava flows)
  - ordering ecological or biological events in Earth's history based on fossil evidence (e.g., extinctions of groups of organisms, evolution of groups of organisms, changes in types of ecosystems)
  - ordering rocks based on relative ages (e.g., undisturbed newer rock layers sit on top of older rock layers, features that cut across existing rock strata are younger than the rock strata that they cut across)

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Developing and Using Models
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
• Develop and use a model to describe phenomena.</td><td>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.</td><td>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.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 56–59</td><td>pp. 179–182</td><td>pp. 98–101</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 6</td><td>Appendix E
p. 2</td><td>Appendix G
pp. 10–11</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">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.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment does not include the identification and naming of minerals.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS2-1.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to describe **changes** that accompany the **cycling** of **Earth materials** and/or the **flow** of **energy** that drives the **process**.
MS-ESS2-1.2	SEP-DCI	**Develop** and/or **use** a **model** to describe the **cycling** of **Earth materials** and/or the **flow** of **energy** that drives the **process**.
MS-ESS2-1.3	DCI-CCC	Connect **changes** to the **process** that **cycles Earth materials** and/or the **flow** of **energy** that drives the **process**.
MS-ESS2-1.4	SEP-CCC	**Develop** and/or **use** a **model** to describe stability and change in a system.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions and/or to describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent a current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- **Processes** that **cycle Earth materials**, driven by a **flow** of **energy**, may include, but are NOT limited to:
  - melting, crystallization, and/or deformation driven by energy from Earth’s interior
  - weathering, erosion, and/or sedimentation driven by energy from the sun

- **Earth materials** may include, but are NOT limited to**:**
  - lava
  - magma
  - rock
  - sediment
  - minerals

- **Changes** may include, but are NOT limited to:
  - changes in rock type (e.g., sedimentary, igneous, metamorphic)
  - changes in rock shape
  - changes in phase (e.g., liquid, solid)
  - changes in density

<table>
<tr><th>Performance Expectation</th><th colspan="3">MS-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.</th></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
• 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 nature operate today as they did in the past and will continue to do so in the future.</td><td>ESS2.A: Earth’s Materials and Systems
• The planet’s systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. 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.</td><td>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.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K-12 Framework</td><td>pp. 67–71</td><td>pp. 179–182
pp. 184–186</td><td>pp. 89–91</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
pp. 11–12</td><td>Appendix E
pp. 2–3</td><td>Appendix G
pp. 6–7</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">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 large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. 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.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">An assessment boundary is not provided for this PE.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS2-2.1	SEP-DCI-CCC	**Construct** an **explanation** based on **evidence** for how **geoscience processes** have changed **Earth's surface features** at varying **time** and/or **spatial scales**.
MS-ESS2-2.2	SEP-DCI	**Construct** an **explanation** based on **evidence** for how **geoscience processes** have changed **Earth's surface features**.
MS-ESS2-2.3	DCI-CCC	**Connect geoscience processes** to changes in **Earth's surface features** at varying **time** and/or **spatial scales**.
MS-ESS2-2.4	SEP-CCC	**Construct** an **explanation** based on evidence of a phenomenon that can be observed at various scales.

Details and Clarifications

- **Construct** an **explanation** is expanded to include:
  - using valid data, models, and/or scientific knowledge to construct, revise, and/or support an explanation and/or design a solution
  - using qualitative and/or quantitative relationships between variables to predict and/or describe phenomena
  - using models and/or evidence to support explanations
  - applying scientific principles to design a tool, process, and/or system that meets specific criteria and/or constraints

- **Evidence** of **geoscience processes** that change **Earth's surface features** may include, but is NOT limited to:
  - stream tables to model erosion and/or deposition
  - maps and/or models that track the motion of tectonic plates/damage from moving water
  - maps to show the locations of earthquakes and/or volcanoes

- **Geoscience processes** that change **Earth's surface features** at various **time** and/or **spatial scales** may include, but are NOT limited to:
  - fast, large-scale volcanic eruption that forms a lahar
  - slow, large-scale motion of tectonic plates that form mountains
  - water carrying large and/or small materials (e.g., boulders, grains of sand) to form a canyon
  - weathering that slowly wears down a mountaintop

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.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to provide evidence for phenomena. **Connections to Nature of Science** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Science findings are frequently revised and/or reinterpreted based on new evidence.	**ESS1.C: The History of Planet Earth** • Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. *(HS.ESS1.C GBE),(secondary)* **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.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 61–63	pp. 177–179 pp. 182–183	pp. 85–87
NGSS Appendices	Appendix F p. 9 Appendix H p. 5	Appendix E p. 2	Appendix G pp. 3–5
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).		
Assessment Boundary	Paleomagnetic anomalies in oceanic and continental crust are not assessed.		

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS2-3.1	SEP-DCI-CCC	**Analyze** and/or **interpret data** on **patterns** in the distribution of **fossils** and/or Earth's **surface features** to provide **evidence** of past **plate motions**.
MS-ESS2-3.2	SEP-DCI	**Analyze** and/or **interpret data** on the distribution of **fossils** and/or **Earth's surface features** to provide **evidence** of past **plate motions**.
MS-ESS2-3.3	DCI-CCC	Connect **patterns** in the distribution of **fossils** and/or Earth's **surface features** to past **plate motions**.
MS-ESS2-3.4	SEP-CCC	**Analyze** and/or **interpret data** to provide evidence for patterns in phenomena in a system.

Details and Clarifications

- **Analyze** and/or **interpret data** is expanded to include:
  - organizing and/or interpreting data
  - identifying similarities and/or differences in findings
  - using patterns in data to distinguish between causal and/or correlational relationships and/or to draw conclusions based on data

- **Data** may include, but are NOT limited to:
  - observations
  - measurements
  - tables
  - graphs
  - diagrams
  - models
  - statistical information (e.g., mean, median, mode, variability)

- **Evidence** of past **plate motions** may include, but is NOT limited to:
  - mountains and/or deep ocean trenches formed when plates come together
  - ocean floor formed at a mid-ocean ridge when plates move apart
  - surface faults formed where plates interact
  - volcanic chains formed above a subduction zone

- **Patterns** in **fossils** and/or Earth's **surface features** may include, but are NOT limited to:
  - distributions and ages of fossils, rocks, and/or minerals found on different continents
  - continent shapes that appear to fit together
  - oceanic crust that increases in age from the center to the edges of an ocean
  - distribution, formation, and/or destruction of seafloor structures
  - locations of earthquakes and/or volcanoes between continents and oceans
  - locations of mountain chains in the interiors of continents

Performance Expectation	**MS-ESS2-4** Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe unobservable mechanisms.	**ESS2.C: The Roles of Water in Earth's Surface Processes** • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. • Global movements of water and its changes in form are propelled by sunlight and gravity.	**Energy and Matter** • Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 56–59	pp. 184–186	pp. 94–96
NGSS Appendices	Appendix F p. 6	Appendix E p. 3	Appendix G pp. 8–9
Clarification Statement	Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.		
Assessment Boundary	A quantitative understanding of the latent heats of vaporization and fusion is not assessed.		

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS2-4.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** to describe how **transfers of energy** drive the **processes** that result in the cycling of water through **Earth systems**.
MS-ESS2-4.2	SEP-DCI	**Develop** and/or **use** a **model** to describe characteristics of **Earth systems**.
MS-ESS2-4.3	DCI-CCC	Use the concept of **energy transfer** to connect the cycling of water through **Earth systems** to processes that drive the cycling.
MS-ESS2-4.4	SEP-CCC	**Develop** and/or **use** a **model** to describe the transfers of energy that drive the cycling of matter within a system.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions or describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- **Models** may include, but are NOT limited to:
  - descriptions of processes that drive global motions of water and/or phase changes in water
  - descriptions of energy transfers that drive the hydrologic cycle

- **Processes** that result in the cycling of water may include, but are NOT limited to:
  - the transformation of water from liquid to vapor by living things
  - surface waters releasing water vapor into the air
  - water vapor forming clouds, fog, or frost
  - liquid surface water forming ice sheets
  - falling rain, snow, or ice
  - the flow of liquid water and/or glacial ice toward lower elevations

- Components of **Earth systems** may include, but are NOT limited to:
  - living things
  - groundwater
  - rivers, streams, lakes, ponds, and/or oceans
  - clouds, fog, and/or water vapor
  - glacial ice, ice sheets, and/or snow

- **Transfers of energy** may include, but are NOT limited to:
  - the gravity-driven downward motion of liquid water and/or ice over a sloped surface
  - the gravity-driven downward fall of various forms of water from the atmosphere
  - thermal energy transfer to or from water that drives a phase change (e.g., melting, freezing)

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS2-5 Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Planning and Carrying Out Investigations
Planning and carrying out investigations in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.
• Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.</td><td>ESS2.C: The Roles of Water in Earth's Surface Processes
• The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

ESS2.D: Weather and Climate
• Because these patterns are so complex, weather can only be predicted probabilistically.</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 59–61</td><td>pp. 184–186
pp. 186–189</td><td>pp. 87–89</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
pp. 7–8</td><td>Appendix E
p. 3</td><td>Appendix G
pp. 5–6</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS2-5.1	SEP-DCI-CCC	**Collect data** to provide evidence of how the **motions** and/or **complex interactions** of **air masses** can **cause** and/or be used to **predict** changes in **weather conditions.**
MS-ESS2-5.2	SEP-DCI	**Collect data** to provide evidence of how the **motions** and/or **complex interactions** of **air masses** can change **weather conditions**.
MS-ESS2-5.3	DCI-CCC	Use the **motions** and/or **complex interactions** of **air masses** to **predict** changes in **weather conditions.**
MS-ESS2-5.4	SEP-CCC	**Collect data** to provide evidence about cause and effect relationships that can be used to predict phenomena.

Details and Clarifications

- **Collect data** is expanded to include:
    - conducting an investigation to produce evidence
    - identifying independent, dependent, and/or controlled variables
    - making predictions about what would happen if a variable changes
    - evaluating appropriate methods and/or tools for collecting and/or recording data

- **Data** may include, but are NOT limited to:
    - tables
    - graphs
    - diagrams
    - models
    - maps
    - statistical information (e.g., mean, median, mode, variability)

- Observations of **weather conditions** may include, but are NOT limited to:
    - temperature
    - pressure
    - humidity
    - precipitation
    - wind

- **Motions** and/or **complex interactions** of **air masses** that can **cause** and/or be used to **predict** changes in weather conditions may include, but are NOT limited to:
    - air masses moving from high pressure to low pressure
    - a front forming between air masses when the air masses collide
    - ocean currents, mountain ranges, and/or deserts affecting the formation and/or movement of air masses

Performance Expectation	**MS-ESS2-6** Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.	**ESS2.C: The Roles of Water in Earth's Surface Processes** • Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. **ESS2.D: Weather and Climate** • Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. • The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.	**Systems and System Models** • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 56–59	pp. 184–186 pp. 186–189	pp. 91–94
NGSS Appendices	Appendix F p. 6	Appendix E p. 3	Appendix G pp. 7–8
Clarification Statement	Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.		
Assessment Boundary	Assessment does not include the dynamics of the Coriolis effect.		

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS2-6.1	SEP-DCI-CCC	**Develop** and/or **use** a **model** of **Earth** as a **system** to describe the **interactions** that cause **patterns** of **atmospheric** and/or **oceanic circulation** that determine **regional climates**.
MS-ESS2-6.2	SEP-DCI	**Develop** and/or **use** a **model** to describe **patterns** of **atmospheric** and/or **oceanic circulation** that determine **regional climates**.
MS-ESS2-6.3	DCI-CCC	Describe the **interactions** that cause **patterns** of **atmospheric** and/or **oceanic circulation** that determine **regional climates** in the **Earth system**.
MS-ESS2-6.4	SEP-CCC	**Develop** and/or **use** a **model** to describe interactions within a system.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions and/or to describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- A **model** of the **Earth** as a **system** may include, but is NOT limited to, a complete and/or partial diagram, map, and/or simulation of:
  - representations of the components of the Earth system (e.g., a globe with landforms, a map of Earth's oceans, a simulation showing Earth's energy inputs and/or outputs)
  - relationships between components of the Earth system (e.g., energy distribution by latitude and/or elevation, global ocean currents, prevailing winds)

- **Interactions** that cause **patterns** of **atmospheric** and/or **oceanic circulation** may include, but are NOT limited to:
  - sunlight driving the global movement of air and water
  - air and/or water flowing from higher- to lower-density areas
  - the density of water varying with temperature and/or salinity
  - the density of air masses varying with temperature and/or altitude
  - variations in density driving global ocean currents and/or atmospheric circulation patterns
  - unequal heating of Earth's surface and/or Earth's rotation causing curved oceanic and/or atmospheric flows

- **Patterns** that determine **regional climates** may include, but are NOT limited to:
  - the flow of air from warm ocean areas to land resulting in increased precipitation along the coast
  - the absorption and/or release of energy by oceans over time resulting in coastal areas with moderate climates compared to the interiors of continents
  - mountains deflecting wind causing moist windward and dry leeward sides of mountains
  - high-elevation locations having lower temperatures than low-elevation locations

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.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • 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. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 67–71	pp. 191–192	pp. 87–89 pp. 212–214
NGSS Appendices	Appendix F pp. 11–12	Appendix E p. 3	Appendix G pp. 5–6 Appendix J pp. 3–4
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).		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS3-1.1	SEP-DCI-CCC	**Construct** a **scientific explanation** that includes **cause and effect** relationships between the **uneven distribution** of **Earth's** mineral, energy, and/or groundwater **resources** and past and/or current **geologic processes**.
MS-ESS3-1.2	SEP-DCI	**Construct** a **scientific explanation** for the **uneven distribution** of **Earth's** mineral, energy, and/or groundwater **resources** due to past and/or current **geologic processes**.
MS-ESS3-1.3	DCI-CCC	Use **cause and effect** relationships to connect the **uneven distribution** of Earth's mineral, energy, and/or groundwater **resources** to past and/or current **geologic processes**.
MS-ESS3-1.4	SEP-CCC	**Construct** a **scientific explanation** based on cause and effect relationships in a system.

Details and Clarifications

- **Construct** a **scientific explanation** is expanded to include:
  - using valid data, models, and/or scientific knowledge to construct, revise, and/or support an explanation and/or design a solution
  - using qualitative and/or quantitative relationships between variables to predict and/or describe phenomena
  - using models and/or evidence to support explanations
  - applying scientific principles to design a tool, process, and/or system that meets specific criteria and/or constraints

- Past and/or current **geologic processes** may include, but are NOT limited to:
  - volcanic eruptions
  - earthquakes
  - erosion
  - weathering

- **Cause and effect** relationships between the **uneven distribution** of **Earth's resources** and past and/or present **geologic processes** may include, but are NOT limited to:
  - copper deposits in Earth's crust are the result of volcanic activities
  - abundant petroleum resources in certain areas resulted when shifting tectonic plates "trapped" vast amounts of organic matter in a deep basin

<table>
<tr><td>Performance Expectation</td><td colspan="3">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.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
• Analyze and interpret data to determine similarities and differences in findings.</td><td>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.</td><td>Patterns
• Graphs, charts, and images can be used to identify patterns in data.

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World
• The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K-12 Framework</td><td>pp. 61–63</td><td>pp. 192–194</td><td>pp. 85–87
pp. 210–214</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 9</td><td>Appendix E
p. 3</td><td>Appendix G
pp. 3–5
Appendix J
pp. 3–4</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">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).</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">An assessment boundary is not provided for this PE.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS3-2.1	SEP-DCI-CCC	**Analyze** and/or **interpret data** about **natural hazards** to identify **patterns** that can be used to **forecast** future catastrophic events and/or inform the development of **technologies** to **mitigate** their effects.
MS-ESS3-2.2	SEP-DCI	**Analyze** and/or **interpret data** about **natural hazards** to **forecast** future catastrophic events and/or inform the development of **technologies** to **mitigate** their effects.
MS-ESS3-2.3	DCI-CCC	Identify **patterns** in **natural hazards** that can help **forecast** the locations and/or likelihoods of future events and mitigate their effects with the use of **technology**.
MS-ESS3-2.4	SEP-CCC	**Analyze** and **interpret data** to identify patterns**.**

Details and Clarifications

- **Analyze** and/or **interpret data** is expanded to include:
  - organizing and/or interpreting data
  - identifying similarities and/or differences in findings
  - using patterns in data to distinguish between causal and/or correlational relationships and/or to draw conclusions based on data

- **Data** may include, but are NOT limited to:
  - observations
  - measurements
  - tables
  - graphs
  - diagrams
  - models
  - statistical information (e.g., mean, median, mode, variability)
  - charts
  - images

- Examples of **natural hazards** may include, but are NOT limited to:
  - earthquakes
  - volcanic eruptions
  - tsunamis
  - forest fires
  - severe weather (e.g., hurricanes, tornadoes, floods)

- Examples of **patterns** that can be used to **forecast** future catastrophic events may include, but are NOT limited to:
  - location of natural hazards relative to geographic and/or geologic features
  - frequency, severity, and/or probability of natural hazards
  - types of damage caused by natural hazards
  - location and/or timing of features associated with natural hazards before and/or after an event (e.g., ash fall following volcanic eruptions, low air pressure preceding tornados)

- Examples of **technologies** that **mitigate** the effects of **natural hazards** may include, but are NOT limited to:
  - global satellite systems that monitor weather patterns
  - warning systems for people potentially affected by the natural hazard (e.g., sirens, alerts)
  - natural hazard-resistant structures (e.g., storm shelter, levee)

<table>
<tr><th>Performance Expectation</th><th colspan="3">MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.</th></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
• Apply scientific principles to design an object, tool, process or system.</td><td>ESS3.C: Human Impacts on Earth Systems
• Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
• 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.</td><td>Cause and Effect
• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World
• The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 67–71</td><td>pp. 194–196</td><td>pp. 87–89
pp. 210-214</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
pp. 11–12</td><td>Appendix E
p. 3</td><td>Appendix G
pp. 5–6
Appendix J
p. 3</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">An assessment boundary is not provided for this PE.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS3-3.1	SEP-DCI-CCC	**Apply scientific principles** to **design** a **method** for **monitoring** and/or **minimizing impacts** to the **environment caused** by and/or **correlated** to **human activities**.
MS-ESS3-3.2	SEP-DCI	**Apply scientific principles** to **design** a **method** for **monitoring** and/or **minimizing human activities** and/or **monitoring** and/or **minimizing impacts** to the **environment**.
MS-ESS3-3.3	DCI-CCC	Use **causal** and/or **correlational** relationships to connect **human activities** to **impacts** on the environment.
MS-ESS3-3.4	SEP-CCC	**Apply scientific principles** to **design** a **method** to solve a problem based on causal and/or correlational relationships.

Details and Clarifications

- **Apply scientific principles** to **design** a **method** is expanded to include:
  - using valid data, models, and/or scientific knowledge to construct, revise, and/or support an explanation and/or design a solution
  - using qualitative and/or quantitative relationships between variables to predict and/or describe phenomena
  - using models and/or evidence to support explanations
  - applying scientific principles to design a tool, process, and/or system that meets specific criteria and/or constraints

- **Methods** for **monitoring impacts** may include, but are NOT limited to:
  - a process for measuring levels of pollution
  - a process for determining the biodiversity of an ecosystem

- **Methods** for **minimizing impacts** may include, but are NOT limited to:
  - a process for treating sewage
  - a process for reducing the use of natural resources
  - a process for reducing the amount of waste in landfills
  - a process for reintroducing or preserving native species in an ecosystem

- **Causal** and/or **correlational** relationships between **human activities** and **impacts** on the **environment** may include, but are NOT limited to:
  - constructing dams and/or modifying water sources and the quality, availability, and/or distribution of water
  - developing land for human settlement, mining, and/or agriculture and the removal of natural habitats
  - factory and/or agricultural runoff and the pollution of air, water, and/or land

<table>
<tr><td>Performance Expectation</td><td colspan="3">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.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).
• 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 a solution to a problem.</td><td>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.</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World
• All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World
• Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.</td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K–12 Framework</td><td>pp. 71–74</td><td>pp. 194–196</td><td>pp. 87–89
pp. 210-214</td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
pp. 13–14</td><td>Appendix E
p. 3</td><td>Appendix G
pp. 5–6
Appendix J
pp. 3–4
Appendix H
p. 6</td></tr>
<tr><td>Clarification Statement</td><td colspan="3">Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, 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.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">An assessment boundary is not provided for this PE.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS3-4.1	SEP-DCI-CCC	**Construct** an **argument** supported by **evidence** of **cause and effect** relationships between increases in human population and/or per-capita consumption of **natural resources** and the impacts to **Earth's systems**.
MS-ESS3-4.2	SEP-DCI	**Construct** an **argument** supported by **evidence** for increases in human population and/or per-capita consumption of **natural resources** and/or impacts to **Earth's systems**.
MS-ESS3-4.3	DCI-CCC	Use **cause and effect** relationships to connect increases in human population and/or per-capita consumption of **natural resources** to impacts to **Earth's systems**.
MS-ESS3-4.4	SEP-CCC	**Construct** an **argument** supported by **evidence** for cause and effect relationships in systems.

Details and Clarifications

- **Construct** an **argument** is expanded to include**:**
  - describing the similarities and/or differences between two arguments
  - developing an argument and/or making a claim based on observations, data, and/or a model
  - using evidence and/or scientific reasoning to support or refute an explanation and/or a model
  - identifying flaws in explanations, procedures, models, and/or solutions
  - evaluating competing design solutions based on how well the solutions meet the criteria and/or the constraints of a problem

- Examples of **natural resources** may include, but are NOT limited to:
  - freshwater (e.g., streams, lakes, groundwater)
  - minerals (e.g., gold, copper, diamond)
  - energy (e.g., coal, oil, natural gas)
  - land (e.g., wetlands, forests, grasslands)
  - organisms (e.g., plants, animals)

- **Earth's systems** may include, but are NOT limited to:
  - atmosphere
  - biosphere
  - cryosphere
  - geosphere
  - hydrosphere

- Examples of **evidence** of **cause and effect** relationships may include, but are NOT limited to:
  - an increase in human population causing an increase in the clearing of forests
  - an increase in human population causing an increase in fossil fuel consumption
  - an increase in the consumption of fossil fuels causing an increase in average global surface temperature
  - an increase in the use of wind-energy technologies reducing human demands for fossil fuels
  - an increase in recycling causing a decrease in the amount of trash buried in landfills

Performance Expectation	**MS-ESS3-5** Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Asking Questions and Defining Problems Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • Ask questions to identify and clarify evidence of an argument.	**ESS3.D: Global Climate Change** • Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.	**Stability and Change** • Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 54–56	pp. 196–198	pp. 98–101
NGSS Appendices	Appendix F pp. 4–5	Appendix E p. 4	Appendix G pp. 10–11
Clarification Statement	Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
MS-ESS3-5.1	SEP-DCI-CCC	**Ask questions** to clarify **evidence** of the **factors** that have caused gradual or sudden **changes** in **global temperatures** over the past century.
MS-ESS3-5.2	SEP-DCI	**Ask questions** to clarify **evidence** of the **factors** that affect **global temperatures**.
MS-ESS3-5.3	DCI-CCC	Connect gradual or sudden **changes** in **global temperatures** over the past century to the **factors** that caused the changes.
MS-ESS3-5.4	SEP-CCC	**Ask questions** to clarify **evidence** of changes in a system.

Details and Clarifications

- **Ask questions** is expanded to include:
  - asking and/or identifying questions that arise from observation and/or investigation to seek additional information
  - asking questions to determine relationships between independent and dependent variables
  - asking questions to clarify and/or refine a model, an explanation, and/or an engineering problem
  - asking questions that frame a hypothesis based on observations and/or scientific principles
  - defining a design problem that can be solved through the development of an object, tool, process, and/or system
  - describing criteria for a successful solution
  - describing constraints that could limit the success of a solution

- **Factors** may include, but are NOT limited to:
  - human activities (e.g., burning of fossil fuels, clearing of land)
  - natural processes (e.g., incoming solar radiation, volcanic activity)

- Examples of **evidence** of the **factors** that cause **changes** in **global temperatures** may include, but are NOT limited to, tables, graphs, and/or maps showing:
  - changes in global and/or regional surface temperatures
  - changes in atmospheric concentrations of greenhouse gases (e.g., carbon dioxide, methane)
  - changes in global and/or regional human populations
  - occurrences of major volcanic events
  - changes in the volume of glacial and/or sea ice
  - seasonal movements and/or behavior of plants and/or animals
  - changes in human activities (e.g., use of fossil fuels, development of land)

Engineering, Technology, and Applications of Science

Disciplinary Core Ideas:

- ETS1 Engineering Design

Performance Expectation	**MS-ETS1-1** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Asking Questions and Defining Problems Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	**ETS1.A: Defining and Delimiting Engineering Problems** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.	**Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. • The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 54–56	pp. 204–206	pp. 210–214
NGSS Appendices	Appendix F pp. 4–5	Appendix I pp. 1–7	Appendix J pp. 3–4
Clarification Statement	A clarification statement is not provided for this PE.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
MS-ETS1-1.1	SEP-DCI-CCC	**Define** the **criteria** and/or **constraints** of a **design problem** with sufficient precision to ensure a successful solution, and/or taking into account relevant scientific principles and/or potential impacts on people and/or the natural environment.
MS-ETS1-1.2	SEP-DCI	**Define** the **criteria** and/or **constraints** of a **design problem** with sufficient precision to ensure a successful solution, and/or taking into account relevant scientific principles.
MS-ETS1-1.3	DCI-CCC	Connect the **criteria** and/or **constraints** of a **design problem** and/or scientific principles to the potential impacts on people and/or the natural environment.
MS-ETS1-1.4	SEP-CCC	**Define** the **criteria** and/or **constraints** of a **design problem** taking into account potential impacts on people and/or the natural environment.

Details and Clarifications

- **Define** the **criteria** and/or **constraints** of a **design problem** is expanded to include:
  - asking and/or identifying questions that arise from observation and/or investigation to seek additional information
  - asking questions to determine relationships between independent and dependent variables
  - asking questions to clarify and/or refine a model, an explanation, and/or an engineering problem
  - asking questions that frame a hypothesis based on observations and/or scientific principles
  - defining a design problem that can be solved through the development of an object, tool, process, and/or system
  - describing criteria for a successful solution
  - describing constraints that could limit the success of a solution

- The components and/or relationships in a **design problem** may include, but are NOT limited to:
  - individuals or groups that need the problem solved
  - need(s) met by solving the problem
  - scientific issues related to the problem
  - potential societal and/or environmental impacts of the solution

- **Criteria** that can be used to determine the success of a solution may include, but are NOT limited to:
  - criteria that meet the needs of those affected by the problem
  - criteria that specify how the process, system, and/or technology should function
  - criteria that enable comparisons among different solutions

- **Constraints** that describe limitations on the success of a solution may include, but are NOT limited to:
  - time, materials, cost, and/or performance issues
  - scientific issues relevant to the problem
  - needs and/or desires of those involved
  - safety and/or risk issues
  - potential impacts of the solution on others
  - potential negative environmental effects

Performance Expectation	**MS-ETS1-2** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.		
	Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Dimensions	**Engaging in Argument from Evidence** Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	**ETS1.B: Developing Possible Solutions** • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 71–74	pp. 206–208	
NGSS Appendices	Appendix F pp. 13–14	Appendix I pp. 1–7	
Clarification Statement	A clarification statement is not provided for this PE.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
MS-ETS1-2.1	SEP-DCI-CCC	Due to the lack of a CCC, items are not coded MS-ETS1-2.1.
MS-ETS1-2.2	SEP-DCI	**Evaluate** competing **design solutions** using a **systematic process** to determine how well they meet the **criteria** and/or **constraints** of a problem.
MS-ETS1-2.3	DCI-CCC	Due to a lack of a CCC, items are not coded MS-ETS1-2.3.
MS-ETS1-2.4	SEP-CCC	Due to a lack of a CCC, items are not coded MS-ETS1-2.4.

Details and Clarifications

- **Evaluate** competing **design solutions** is expanded to include**:**
  - describing the similarities and/or differences between two arguments
  - developing an argument and/or making a claim based on observations, data, and/or a model
  - using evidence and/or scientific reasoning to support or refute an explanation and/or a model
  - identifying flaws in explanations, procedures, models, and/or solutions
  - evaluating competing design solutions based on how well the solutions meet the criteria and/or the constraints of a problem

- Examples of **design solutions** may include, but are NOT limited to:
  - model
  - device
  - process

- Examples of **systematic processes** may include, but are NOT limited to:
  - identifying scientific knowledge related to the problem and/or the design solutions
  - describing how a competing design solution could solve the problem
  - identifying strengths and/or weaknesses of competing solutions
  - evaluating competing design solutions against criteria and/or constraints
  - comparing competing design solutions based on performance

- Examples of **criteria** for a successful solution may include, but are NOT limited to:
  - relatively high degree of safety
  - relatively high effectiveness in solving specific aspects of the given problem
  - relatively low cost
  - readily available materials
  - relatively short time needed to implement

- Examples of **constraints** that could limit the success of a solution may include, but are NOT limited to:
  - deficiencies in solving specific aspects of the given problem
  - high cost
  - materials that are difficult to acquire
  - relatively long time to implement

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.</td></tr>
<tr><td rowspan="2">Dimensions</td><td>Science & Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
• Analyze and interpret data to determine similarities and differences in findings.</td><td>ETS1.B: Developing Possible Solutions
• There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
• Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.

ETS1.C: Optimizing the Design Solution
• Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.</td><td></td></tr>
<tr><td colspan="4">These item specifications were developed using the following reference materials:</td></tr>
<tr><td>K-12 Framework</td><td>pp. 61–63</td><td>pp. 206–208
pp. 208–210</td><td></td></tr>
<tr><td>NGSS Appendices</td><td>Appendix F
p. 9</td><td>Appendix I
p. 4</td><td></td></tr>
<tr><td>Clarification Statement</td><td colspan="3">A clarification statement is not provided for this PE.</td></tr>
<tr><td>Assessment Boundary</td><td colspan="3">An assessment boundary is not provided for this PE.</td></tr>
</table>

Items may ask students to:

Code	Alignment	Item Specification
MS-ETS1-3.1	SEP-DCI-CCC	Due to the lack of a CCC, items are not coded MS-ETS1-3.1.
MS-ETS1-3.2	SEP-DCI	**Analyze** and/or **interpret data** from tests to identify similarities and/or differences among design solutions to identify the best characteristics of each that can be **combined** into a new solution to better meet the **criteria** and/or **constraints** for success.
MS-ETS1-3.3	DCI-CCC	Due to the lack of a CCC, items are not coded MS-ETS1-3.3.
MS-ETS1-3.4	SEP-CCC	Due to the lack of a CCC, items are not coded MS-ETS1-3.4.

Details and Clarifications

- **Analyze** and/or **interpret data** is expanded to include:
  - organizing and/or interpreting data
  - identifying similarities and/or differences in findings
  - using patterns in data to distinguish between causal and/or correlational relationships and/or to draw conclusions based on data

- **Data** may include, but are NOT limited to:
  - observations
  - measurements
  - tables
  - graphs
  - diagrams
  - models
  - statistical information (e.g., mean, median, mode, variability)

- Examples of ways that characteristics could be **combined** for a new solution may include, but are NOT limited to:
  - changing the components of a design (e.g., changing material, adding reinforcement, removing parts)
  - rearranging or repositioning the components of a design
  - changing the way the components of a design interact
  - reordering the steps of a process

- **Criteria** for a successful solution may include, but are NOT limited to:
  - relatively high degree of safety
  - relatively high effectiveness in solving specific aspects of the given problem
  - relatively low cost
  - relatively short time needed to implement
  - readily available materials

- **Constraints** that could limit the success of a solution may include, but are NOT limited to:
  - relative lack of safety
  - relative deficiencies in solving specific aspects of the given problem
  - relatively high cost
  - relatively long time to implement
  - materials that are difficult to acquire

Performance Expectation	**MS-ETS1-4** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.		
Dimensions	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
	Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.	**ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. • Models of all kinds are important for testing solutions. **ETS1.C: Optimizing the Design Solution** • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.	
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 56–59	pp. 206–208 pp. 208–210	
NGSS Appendices	Appendix F p. 6	Appendix I pp. 1–7	
Clarification Statement	A clarification statement is not provided for this PE.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
MS-ETS1-4.1	SEP-DCI-CCC	Due to a lack of a CCC, items are not coded MS-ETS1-4.1.
MS-ETS1-4.2	SEP-DCI	**Develop** and/or **use** a **model** to generate **data** for iterative testing and/or modification of a proposed **design solution** such that an **optimal design** can be achieved.
MS-ETS1-4.3	DCI-CCC	Due to a lack of a CCC, items are not coded MS-ETS1-4.3.
MS-ETS1-4.4	SEP-CCC	Due to a lack of a CCC, items are not coded MS-ETS1-4.4.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
  - using a given complete or partial model to make predictions and/or to describe phenomena
  - using a model to show relationships among variables
  - revising a given complete or partial model
  - describing the limitations of a complete or partial model
  - using a model to represent current understanding of a system
  - using a model to aid in the development of questions and/or descriptions

- **Models** may include, but are NOT limited to:
  - clarifications of the problem to be solved
  - criteria for a successful solution
  - constraints that limit the success of a solution
  - inputs, outputs, and/or components of a solution
  - descriptions of relationships among components of a solution

- **Design solutions** may include, but are NOT limited to:
  - model
  - device
  - process

- **Data** may include, but are NOT limited to:
  - qualitative and/or quantitative information for the proposed solution
  - qualitative and/or quantitative information for iterations of the proposed solution

- **Optimal solutions** may include, but are NOT limited to:
  - trade-offs
  - features of different tested iterations of a solution

SEP, DCI, and CCC Vocabulary Used in Assessment Items at Grade 8

Items use language targeted to the previous grade level or lower readability with the exception of the required SEP, DCI, and CCC terms in the following list. Appropriate science vocabulary allowed for the grade 5 WCAS may also be used for the grade 8 WCAS. Vocabulary words from grade 5 are included in the following list.

a

Used in grade 5:
absorb
acid
advantage
amplitude
angle
apparent brightness
attract
axis

Used in grade 8:
acceleration
adaptation
algae
allele
analog signal
artificial selection
asexual reproduction
atom

b

Used in grade 5:
balanced force
behavior
biosphere

Used in grade 8:
biodiversity
boiling point

c

Used in grade 5:
camouflage
cause
characteristic
charge
claim
classify
climate
collision
communicate
compare
conclusion
condense
conductivity
conserve
constraint
continent
criteria

Used in grade 8:
cell membrane
cell wall
cellular respiration
chemical change
chemical property
chemical reaction
chloroplasts
chromosome
components
concentration (of a solution)
consumer
continental crust
correlation
crystallization

d

Used in grade 5:
data
decomposer
decrease
deep ocean trench
defend
demonstration
describe
design
development
device
diagram
digital signal
disadvantage
disease
distance

Used in grade 8:
density
durability

e

Used in grade 5:
earthquake
ecosystem
effect
electric current
electric force
electrical energy
electricity
electromagnet
energy
engineer
environment
erosion
eruption
evaporate
evidence
exert
extinct

Used in grade 8:
eclipse
electric circuit
electric field
element
embryo
emit
evolution

f

Used in grade 5:
factor
fault
food web
fossil
fossil fuel
function
fungi

Used in grade 8:
field energy
flammable
fossil record
frequency

g
Used in grade 5:
gas
geosphere
glacier
global
graph
gravitational force
gravity
groundwater

Used in grade 8:
galaxy
gene
genetic variation
geologic process
global warming
greenhouse gas

h
Used in grade 5:
habitat
hazard
heat energy
hydrosphere

i
Used in grade 5:
impact
increase
information
inherit
input
interaction
investigation

Used in grade 8:
identical
illuminate

k
Used in grade 8:
kinetic energy

l
Used in grade 5:
landform
life cycle
light energy
limitation
liquid

Used in grade 8:
latitude
lava
light intensity
longitude
lunar

m
Used in grade 5:
magnet
magnetic force
marine
mass
mate
material
matter
measure
mineral
mixture
model
motion energy

Used in grade 8:
magma
magnetic field
magnitude
medium (of a wave)
melting point
microorganism
mitochondria
molecule
mutation
mutually beneficial

n
Used in grade 5:
nonrenewable

Used in grade 8:
natural hazard
natural resource
natural selection
nucleus (of a cell)
nutrient

o
Used in grade 5:
object
observation
offspring
orbit
organism
output

Used in grade 8:
ocean current
oceanic crust
orbital period
orbital radius

p
Used in grade 5:
particle
pattern
physical property
planet
polar ice cap
pole (of a magnet)
pollen
pollution
population
precipitation
predator
prediction
prey
process
property

Used in grade 8:
percentage
photosynthesis
physical change
pixel
potential energy
probability
producer
product
proportion
protein

q
Used in grade 5:
quantity

r
Used in grade 5:
recycle
reduce
refine
reflect
relationship

renewable
repel
reproduction
research
resource
response
result
rock formation
rock layer
rotate
runoff

Used in grade 8:
reactant
refract
reservoir

s
Used in grade 5:
scientist
sediment
sense receptor
shelter
similarity
simulation
solar energy
solid
solution (to a problem)
sound energy
source
species
speed
sprout
stability
state (of matter)
stationary
structure
substance
subsystem
support
surface
survive
system

Used in grade 8:
scale
sexual reproduction
solar system
solubility
solution (chemical)
stimulus
subduction
surroundings
synthetic

t
Used in grade 5:
technology
temperature
toxin
trait
transfer
tsunami

Used in grade 8:
tectonic plate
thermal energy
tissue
transform
transmit
transpiration
trend

u
Used in grade 5:
unbalanced force

Used in grade 8:
uplift

v
Used in grade 5:
validity
variable
volcano
volume

Used in grade 8:
variation

w
Used in grade 5:
wave
wavelength
weathering
wetland
wind energy