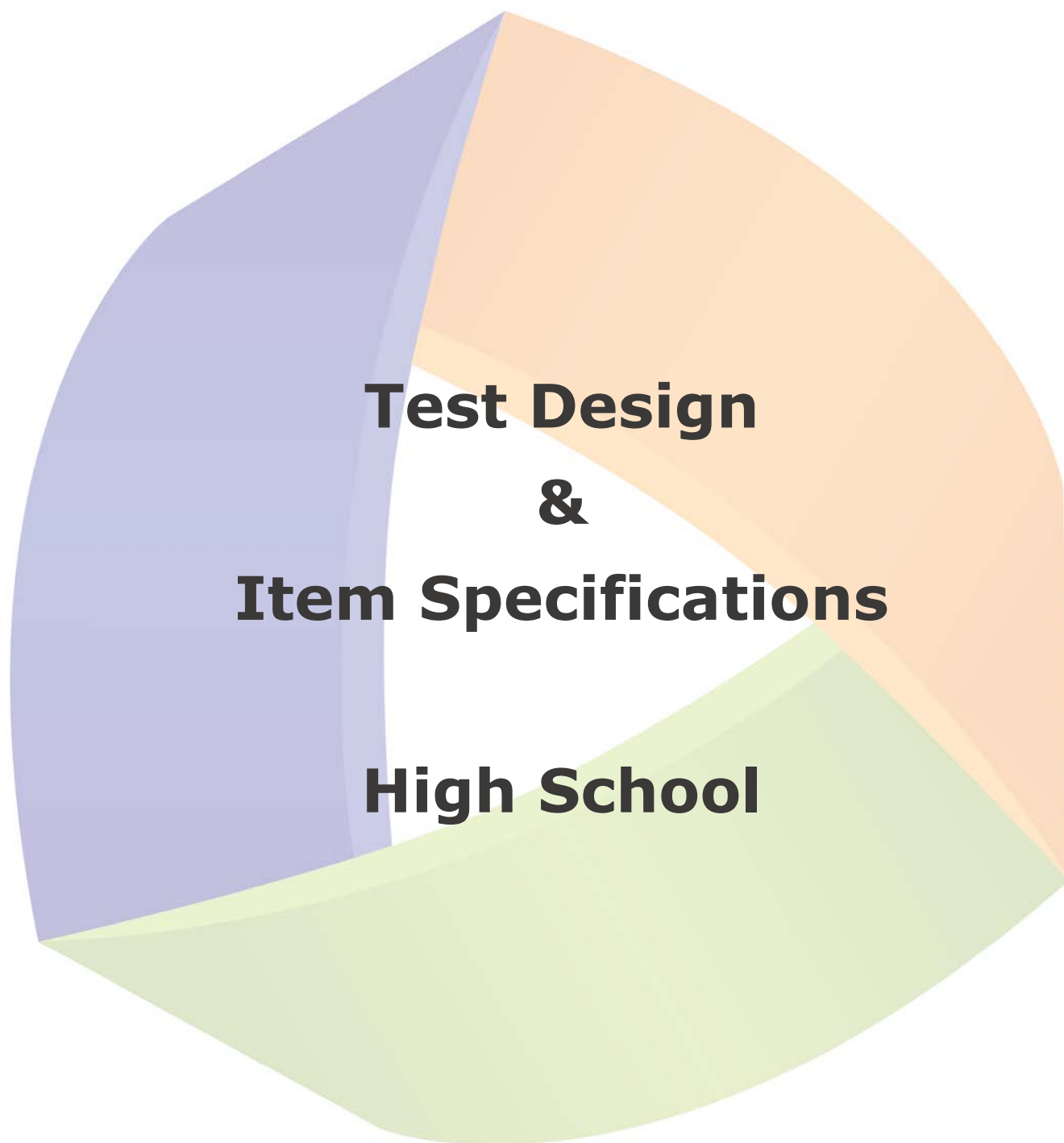


Washington Comprehensive Assessment of Science



Office of Superintendent of Public Instruction

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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, which 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 current draft represents a small sample of PEs; full PE coverage should be achieved by the end of the 2018-19 school year. The item specifications will be updated annually based on input from Washington educators. Future drafts will include a modification log that will be updated at each subsequent publication.

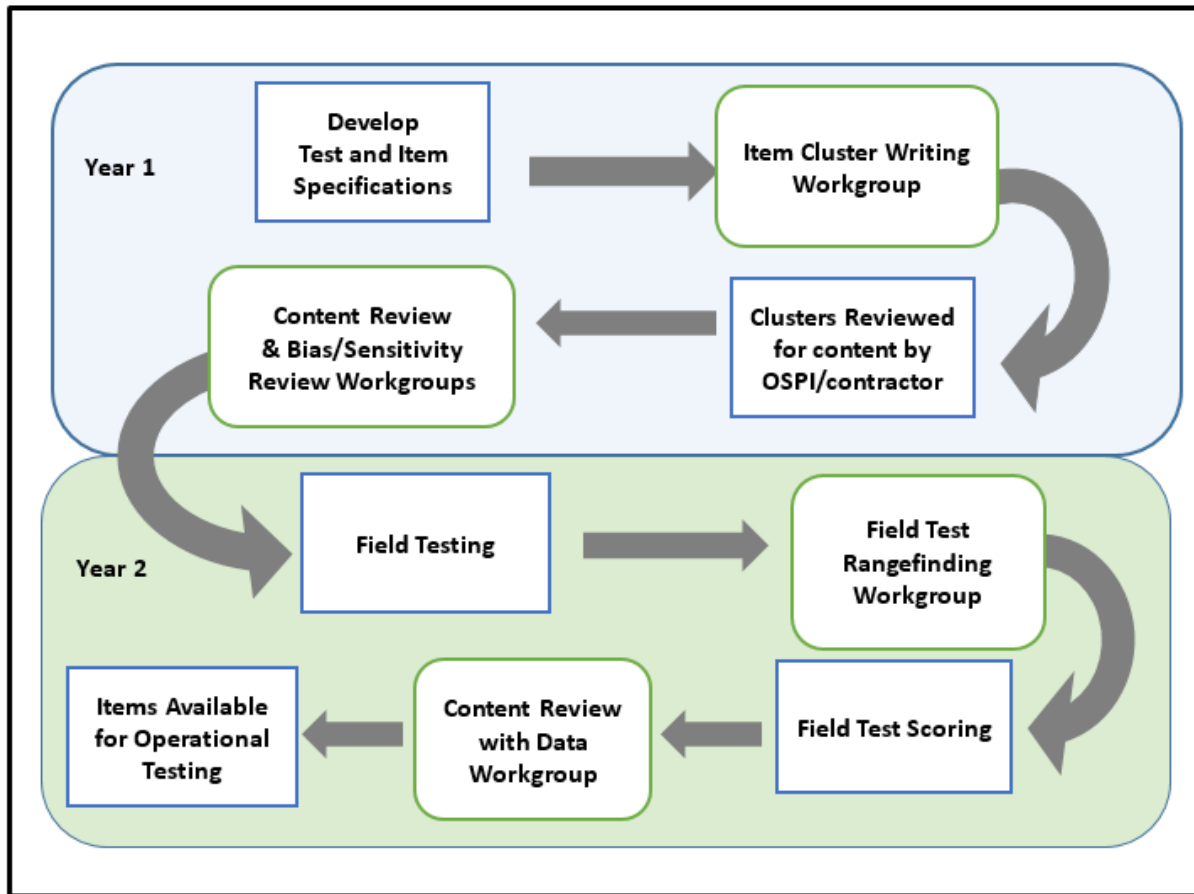
Assessment Development Cycle

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 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 students might encounter
- 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 applied in a valid manner
- Include technology-enhanced and short-answer items that can be scored in a reliable manner

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 2–3 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 Ranging 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 will be 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.

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.

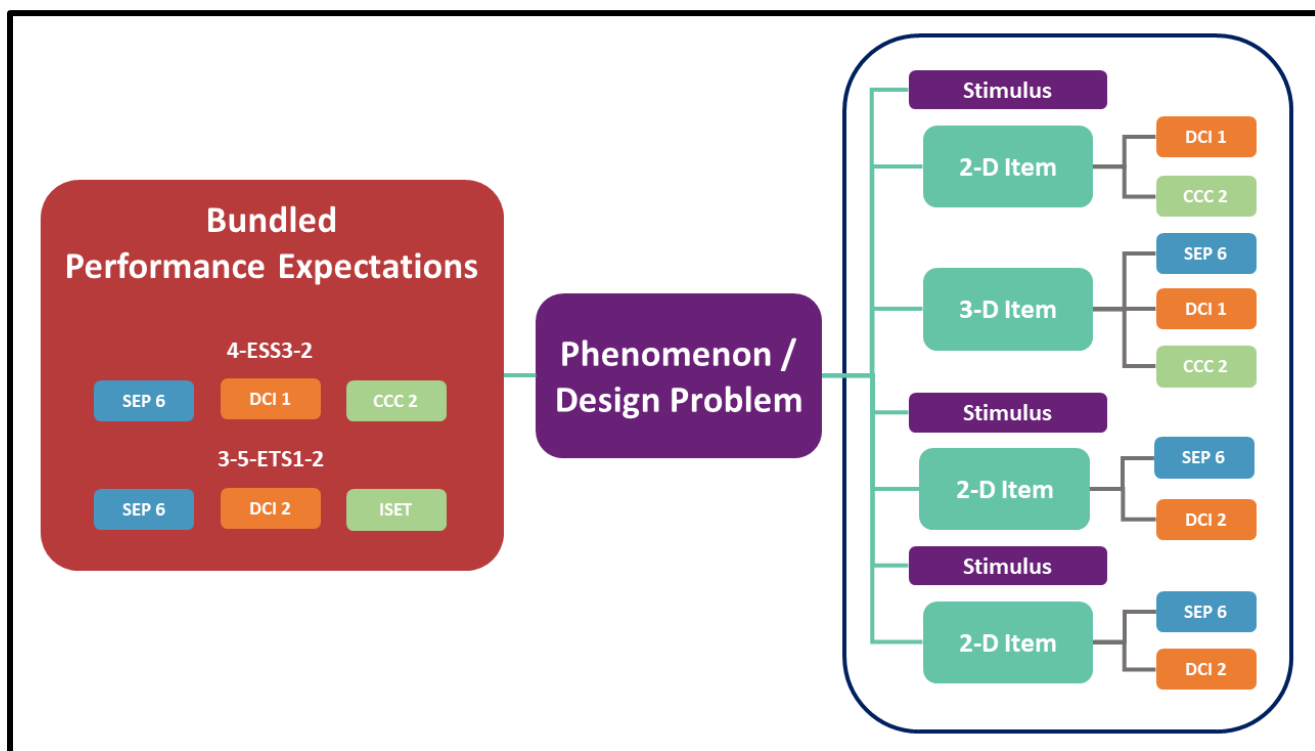
Item Clusters

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 a science and engineering practice (SEP), disciplinary core idea (DCI), and crosscutting concept (CCC) 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 will align to two or three dimensions (2-D, 3-D) from one or more of the PEs 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 will 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 on to the next 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 forward 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 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.

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 [Washington Comprehensive Assessment Program \(WCAP\) 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 will typically be between two and four.
- The length of options in a drop-down list will typically be 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 into predesignated boxes 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 interact with and construct simple graphs.

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 will present a clear indication of what is required so students will 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 will not be partially correct.
- The options “All of the above” and “None of the above” will not be 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 will present a clear indication of what is required so students will 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 will not be partially correct.
- The options "All of the above" and "None of the above" will not be used.

Short Answer (SA)

- Students write a response based on a specific task statement.
- Directions will give clear indications of the response required of students.
- When appropriate, bullets after phrases like “In your procedure, be sure to include:” or “In your description, be sure to:” will 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 will specifically prompt 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 will be developed for each ETC, HT, SIM, TI, MI, and SA during the writing of the item.
- Scoring rubrics will not consider conventions of writing (complete sentences, usage/grammar, spelling, capitalization, punctuation, and paragraphing).
- Scoring rubrics will be 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 interaction in each part (e.g., an MC followed by an ETC). One example of this approach would be 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 can be 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, HT, MC, MS, SIM, TI, and MI items are worth 1 point.
- GI and SA items are worth 1 or 2 points.

Test Design

Operational Test Form

Each operational test form will contain 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 test are anchored or 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 six clusters and six to twelve standalone items.

In addition:

- One PE from 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 will increase DCI, SEP, and CCC coverage to achieve overall expectations.

Field Test Items

Operational test forms will contain embedded field test items, which will either be a set of items associated with a cluster or a group of standalone items. Several clusters and/or standalone items will be field tested in a given administration. The field test items will not contribute to the student’s score.

Testing Times

The WCAS is intended to be administered online in one to three sessions. The approximate 150-minute administration time includes 30 minutes for giving directions and distributing materials, 105 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.

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 for classroom use on the [WCAP Portal](#).

Test Blueprint

The total number of points for the WCAS in high school will be 45 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 will not be represented by a separate item cluster, but will be bundled in at least one item cluster. ETS points are not specified, and ETS PEs were not included when calculating the percentages.

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	36%	31–41%	14–18
Practices and Crosscutting Concepts in Life Sciences	36%	31–41%	14–18
Practices and Crosscutting Concepts in Earth and Space Sciences	28%	23–33%	11–15

Two high school test forms were administered in Spring 2018. The points for a few reporting areas fell slightly outside of the score point range due to the limited size of the item bank. Forms for the 2019 WCAS and beyond will meet all reporting area ranges.

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 will pull up a complete list of associated PEs at the given grade level. For example, searching the website for MS-ESS1 will pull up a list of associated PEs at the middle school level (MS-ESS1-1 through MS-ESS1-4). Substituting another grade level for “MS” will pull up 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 can be found 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.

To build the links, DCIs are broken up into several groups within three primary domains: Life Sciences (LS), Physical Sciences (PS), and Earth and Space Sciences (ESS). The Engineering, Technology, and Applications of Science (ETS; also sometimes called Engineering Design) DCIs are treated somewhat differently from the other DCIs in that they appear in separate ETS PEs.

For both the standards and the WCAS Item Specifications, the DCI statement is presented in the central column, inside an orange box. 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 can be found 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 both 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 can be found in [NGSS Appendix G](#).

Evidence Statements

OSPI uses the NGSS [evidence statements](#) to guide development of two- and three-dimensional items. The 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

Evidence statements are written primarily from the focus of the SEP dimension. Therefore, developing two-dimensional items aligned to a DCI and a CCC sometimes requires moving entirely outside the scope of the evidence statement. With that said, it is also acceptable to write items to a particular part of an evidence statement (e.g., leaving the SEP portion of the evidence statement out of the item design and writing only to the CCC and DCI elements). Aligning an item to a combination of evidence statements is also permissible, and is often done when items leverage the complexity of real-world scientific phenomena.

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 still align to the SEP.

WCAS Item Specifications

The science assessment team at OSPI has been working 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 will revise 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 will be 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 on the grade 11 exam use language targeted to an eighth grade or lower reading level with the exception of the expected science terms. A list of expected 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 will involve making observations of specific types of evidence related to the DCI. The Details and Clarifications section lists types of observations that are permissible under this PE, as well as the forms of evidence that are within the bounds of the PE.

Performance Expectation	4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Engaging in Argument from Evidence Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). <ul style="list-style-type: none"> Construct an argument with evidence, data, and/or a model. 	LS1.A: Structure and Function <ul style="list-style-type: none"> Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. 	Systems and System Models <ul style="list-style-type: none"> A system can be described in terms of its components and their interactions.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 71–74	pp. 143–145	pp. 91–94
NGSS Appendices	Appendix F pp. 13–14	Appendix E p. 4	Appendix G pp. 7–8
Clarification Statement	Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin.		
Assessment Boundary	Assessment is limited to macroscopic structures within plant and animal systems.		

Items may ask students to:

Code	Alignment	Item Specification
4-LS1-1.1	SEP-DCI-CCC	Construct an argument using system models to describe plants and/or animals in terms of their structures and how the structures interact to serve various survival, growth, behavioral, and/or reproductive functions .
4-LS1-1.2	SEP-DCI	Construct an argument to show that plant and/or animal structures serve various survival, growth, behavioral, and/or reproductive functions .
4-LS1-1.3	DCI-CCC	Use system models to show how plant and/or animal structures serve various survival, growth, behavioral, or reproductive functions .
4-LS1-1.4	SEP-CCC	Construct an argument that connects system components and interactions in a system model.
Details and Clarifications		
<ul style="list-style-type: none"> • Construct an argument is expanded to include: <ul style="list-style-type: none"> ○ using evidence to support an argument and/or a claim ○ developing an argument based on evidence, data, or a simple model ○ distinguishing between observations and inferences in an explanation or argument ○ comparing and/or refining arguments based on evidence ○ providing feedback on an explanation, an argument, and/or a claim • Structures and functions may include, but are NOT limited to structures that work together to support: <ul style="list-style-type: none"> ○ plants <ul style="list-style-type: none"> • obtaining water/sunlight/air • growing toward sunlight and/or water • defending against herbivores • attracting pollinators ○ animals <ul style="list-style-type: none"> • pumping blood/breathing/moving/digesting food • obtaining food • defending against predators • attracting mates • System models may include, but are NOT limited to: <ul style="list-style-type: none"> ○ an entire organism (plant or animal) ○ a subsystem within a plant or animal ○ the interactions of structures working together within a plant or animal system or subsystem 		

As stated earlier in this document, the item specifications that follow represent a small sample of PEs; full PE coverage should be achieved by the end of the 2018-19 school year. The item specifications will be updated annually based on input from Washington educators. Future drafts will include a modification log that will be updated at each subsequent publication.

Resources

Resource	Description
<u>K–12 Framework</u>	Provides information about the foundational principles that were used to develop the NGSS.
<u>SAIC Assessment Framework</u>	Provides options and rationales for development of high-quality, NGSS-aligned summative assessment items.
<u>SAIC Prototype Item Cluster</u>	Demonstrates a three-dimensional NGSS-aligned item cluster using a variety of stimuli and innovative item types.
<u>Developing Assessments for the Next Generation Science Standards</u>	Provides guidance on an approach to science assessment that supports the vision of the NGSS.
<u>NGSS Appendix E</u>	Includes tables showing the DCI progressions by grade level.
<u>NGSS Appendix F</u>	Includes tables showing the SEP progressions by grade level.
<u>NGSS Appendix G</u>	Includes tables showing the CCC progressions by grade level.
<u>NGSS Evidence Statements</u>	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*. Washington, DC: Council of Chief State School Officers.

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

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

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

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

The item specifications that follow represent a **sample** of PEs. The sample will continue to expand until this document contains all the PEs. The sample of PEs represents only a part of what could be assessed on the WCAS. The inclusion of a PE in this document does not indicate that PE will be assessed by an item on the WCAS, nor does the absence of a PE from this document indicate that the PE will not be assessed on the WCAS.

Future item specifications drafts will include modification logs that will be updated at each subsequent publication.

Performance Expectation	HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. <ul style="list-style-type: none"> • Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. 	PS1.B: Chemical Reactions <ul style="list-style-type: none"> • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. 	Patterns <ul style="list-style-type: none"> • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 67–71	pp. 109–111	pp. 85–87
NGSS Appendices	Appendix F p. 11	Appendix E p. 7	Appendix G pp. 3–4
Clarification Statement	Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.		
Assessment Boundary	Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.		

Items may ask students to:

Code	Alignment	Item Specification
HS-PS1-5.1	SEP-DCI-CCC	Apply scientific principles and evidence from observed patterns to provide an explanation about the effects of changing the temperature or concentration of reacting particles on the rate at which a reaction occurs.
HS-PS1-5.2	SEP-DCI	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of reacting particles on the rate at which a reaction occurs.
HS-PS1-5.3	DCI-CCC	Use patterns to connect the effects of changing the temperature or concentration of reacting particles on the rate at which a reaction occurs.
HS-PS1-5.4	SEP-CCC	Apply scientific principles and evidence from observed patterns to provide an explanation about a phenomenon.
Details and Clarifications		
<ul style="list-style-type: none"> • Provide an explanation is expanded to: <ul style="list-style-type: none"> ○ making claims about relationships between dependent and independent variables ○ using valid and/or reliable evidence to construct and/or revise an explanation ○ applying scientific ideas, principles, and/or evidence to describe a scientific phenomenon and/or solve a problem ○ using evidence to evaluate how well a solution meets the criteria for success ○ using evidence to evaluate the constraints that may limit the success of a solution ○ using knowledge, evidence, criteria, and/or tradeoffs to evaluate and/or refine a solution • Patterns may include, but are NOT limited to: <ul style="list-style-type: none"> ○ the relationship between temperature and reaction rate ○ the relationship between reactant concentration and reaction rate ○ the relationship between product concentration and reaction rate ○ collisions between molecules that break or form new bonds ○ the rearrangement of atoms into new molecules ○ changes in the bond energy and/or kinetic energy of molecules in a reaction 		

Performance Expectation	HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. <ul style="list-style-type: none"> • Use mathematical representations of phenomena to support claims. 	PS1.B: Chemical Reactions <ul style="list-style-type: none"> • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. 	Energy and Matter <ul style="list-style-type: none"> • The total amount of energy and matter in closed systems is conserved. Connections to Nature of Science Scientific Knowledge Assumes an Order and Consistency in Natural Systems <ul style="list-style-type: none"> • Science assumes the universe is a vast single system in which basic laws are consistent.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 64–67	pp. 109–111	pp. 94–96
NGSS Appendices	Appendix F p. 10	Appendix E p. 7	Appendix G pp. 8–9
Clarification Statement	Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.		
Assessment Boundary	Assessment does not include complex chemical reactions.		

Items may ask students to:

Code	Alignment	Item Specification
HS-PS1-7.1	SEP-DCI-CCC	Use mathematical representations to support the claim that atoms , and therefore mass , are conserved during a chemical reaction.
HS-PS1-7.2	SEP-DCI	Due to a strong overlap between the DCI and the CCC, items are not coded HS-PS1-7.2.
HS-PS1-7.3	DCI-CCC	Connect the conservation of matter to atoms , and therefore mass during a chemical reaction.
HS-PS1-7.4	SEP-CCC	Use mathematical representations to support claims that the total amount of matter in closed systems is conserved.

Details and Clarifications

- **Use mathematical representations** is expanded to include:
 - describing and/or revising a computational model or simulation of a phenomenon, designed device, process, or system.
 - using mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
 - applying techniques of algebra and/or functions to represent and/or solve scientific and engineering problems.
- Components of **mathematical representations** may include, but are NOT limited to:
 - quantities of reactants and products (e.g., number of atoms, number of moles, mass)
 - molar masses
 - balanced chemical equations
- **Use mathematical representations** to support the claim that **atoms**, and therefore **mass**, are **conserved** during a chemical reaction may include, but is NOT limited to:
 - describing and/or calculating quantities of reactants and products
 - using Avogadro's number to convert between the atomic and macroscopic scales (e.g., moles to mass, moles to molecules)
 - using balanced equations to determine mole ratios between two substances
 - predicting the relative number of atoms of reactants and/or products, given some information
 - predicting the mass of one substance in a chemical reaction, given the masses of all of the other substances in the reaction
 - using given calculations to support a claim about the conservation of matter and/or conversions between the atomic and macroscopic scales

Performance Expectation	HS-PS2-2 Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. <ul style="list-style-type: none"> • Use mathematical representations of phenomena to describe explanations. 	PS2.A: Forces and Motion <ul style="list-style-type: none"> • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. 	Systems and System Models <ul style="list-style-type: none"> • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 64–67	pp. 114–116	pp. 91–94
NGSS Appendices	Appendix F p. 10	Appendix E p. 7	Appendix G pp. 7–8
Clarification Statement	Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.		
Assessment Boundary	Assessment is limited to systems of two macroscopic bodies moving in one dimension.		

Items may ask students to:

Code	Alignment	Item Specification
HS-PS2-2.1	SEP-DCI-CCC	Use mathematical representations to describe that momentum is conserved when there is no net force on a system of two interacting objects.
HS-PS2-2.2	SEP-DCI	Use mathematical representations to describe that momentum is conserved for interacting objects when no net force acts on an object.
HS-PS2-2.3	DCI-CCC	Apply systems concepts to analyze changes in momentum among interacting objects.
HS-PS2-2.4	SEP-CCC	Use mathematical representations to describe a system.

Details and Clarifications

- **Use mathematical representations** is expanded to include:
 - describing and/or revising a computational model or simulation of a phenomenon, designed device, process, or system
 - using mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations
 - applying techniques of algebra and/or functions to represent and/or solve scientific and engineering problems
- **Mathematical representations** may include, but are NOT limited to:
 - the masses, speeds, and/or directions of motion of two interacting objects in a system
 - the momentum of each object in a system, calculated by multiplying the mass and the velocity of the object ($p=mv$)
 - a change in the momentum of each object as a result of an interaction
 - the total momentum of the system
- Evidence that **momentum** is **conserved** within the system may include, but is NOT limited to:
 - calculating, modeling, and/or describing that the total momentum of two interacting objects in a system is constant if there is no net force applied to the system
 - calculating, modeling, and/or describing that a change in the momentum of one interacting object is balanced by a change in the momentum of the other interacting object within a system
 - calculating, modeling, and/or describing that a change in the momentum of a system is balanced by a change in momentum of objects outside the system
- Describing a **system** may include, but is NOT limited to:
 - describing components, boundaries, and/or initial conditions (e.g., initial momentum of each system object)
 - describing forces external to a system

Performance Expectation	HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. <ul style="list-style-type: none"> • Use mathematical representations of phenomena to describe explanations. Connections to Nature of Science Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena <ul style="list-style-type: none"> • Theories and laws provide explanations in science. • Laws are statements or descriptions of the relationships among observable phenomena. 	PS2.B: Types of Interactions <ul style="list-style-type: none"> • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. 	Patterns <ul style="list-style-type: none"> • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 64–67	pp. 116–118	pp. 85–87
NGSS Appendices	Appendix F p. 10 Appendix H p. 5	Appendix E p. 7	Appendix G pp. 3–5
Clarification Statement	Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.		
Assessment Boundary	Assessment is limited to systems with two objects.		

Items may ask students to:

Code	Alignment	Item Specification
HS-PS2-4.1	SEP-DCI-CCC	Use mathematical representations of Newton’s Law of Universal Gravitation and Coulomb’s Law to describe and/or predict patterns in the effects of gravitational and electrostatic forces between objects.
HS-PS2-4.2	SEP-DCI	Use mathematical representations of Newton’s Law of Universal Gravitation and Coulomb’s Law to describe and predict gravitational and electrostatic forces between objects.
HS-PS2-4.3	DCI-CCC	Due to a strong overlap between the SEP and DCI, items are not coded HS-PS2-4.3.
HS-PS2-4.4	SEP-CCC	Use mathematical representations to describe and/or predict patterns.

Details and Clarifications

- **Use mathematical representations** is expanded to include:
 - describing and/or revising a computational model or simulation of a phenomenon, designed device, process, or system
 - using mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations
 - applying techniques of algebra and/or functions to represent and/or solve scientific and engineering problems
- Given **mathematical representations** include:
 - Newton’s Law of Universal Gravitation: gravitational attraction between two objects is the product of their masses divided by the square of the distance between the objects

$$(F_g = -G \frac{m_1 m_2}{d^2})$$
 - Coulomb’s Law: electrostatic force between two objects is the product of their individual charges divided by the square of the distance between the objects $(F_e = k \frac{q_1 q_2}{d^2})$
- The effects of **gravitational forces** between objects may include, but are NOT limited to:
 - objects with mass are sources of and/or affected by gravitational fields
 - gravitational forces are always attractive
- The effects of **electrostatic forces** between objects may include, but are NOT limited to:
 - objects with electric charges are sources of and/or affected by electric fields
 - electrostatic forces can be attractive or repulsive
- **Patterns** may include, but are NOT limited to:
 - the change in energy of objects interacting through electrical and/or gravitational forces depends on the distance between objects
 - the gravitational force is only attractive because mass is always positive
 - the electrostatic force can be attractive or repulsive because electric charges can be positive or negative

Performance Expectation	HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. <ul style="list-style-type: none"> Communicate scientific and technical information (e.g., about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). 	PS2.B: Types of Interactions <ul style="list-style-type: none"> Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. 	Structure and Function <ul style="list-style-type: none"> Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 74–77	pp. 116–118	pp. 96–98
NGSS Appendices	Appendix F p. 15	Appendix E p. 7	Appendix G pp. 9–10
Clarification Statement	Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.		
Assessment Boundary	Assessment is limited to provided molecular structures of specific designed materials.		

Items may ask students to:

Code	Alignment	Item Specification
HS-PS2-6.1	SEP-DCI-CCC	Communicate information about the role of attraction and repulsion of electric charges at the atomic scale in determining the structure , properties, and/or transformations of matter and/or the resulting function of designed materials.
HS-PS2-6.2	SEP-DCI	Communicate information about how atomic-level attraction and repulsion explains the structure, properties, and/or transformations of matter.
HS-PS2-6.3	DCI-CCC	Use the attraction and repulsion of electric charges at the atomic scale to determine the structure , properties, and/or transformations of matter and/or the resulting function of designed materials.
HS-PS2-6.4	SEP-CCC	Communicate information about the structure and function of the system.
Details and Clarifications		
<ul style="list-style-type: none"> • Communicate information is expanded to include: <ul style="list-style-type: none"> ○ identifying scientific and/or technical evidence, concepts, processes, or information ○ evaluating the validity and/or reliability of claims from different sources ○ integrating multiple sources of information to construct and/or support an explanation ○ summarizing complex information • Information formats may include, but are NOT limited to: <ul style="list-style-type: none"> ○ text ○ tables ○ diagrams ○ graphs ○ models ○ animations • Examples of attraction and repulsion may include, but are NOT limited to: <ul style="list-style-type: none"> ○ attractive and/or repulsive electrical (i.e. electrostatic) forces between molecules ○ attraction and/or repulsion among electric charges among atoms within a molecule • Examples of structure and function relationships may include, but are NOT limited to: <ul style="list-style-type: none"> ○ how the structure and/or properties of matter and/or the types of interactions of matter at the atomic scale determine macroscopic properties of a designed material ○ how a designed material's properties make it suitable for use in its designed function 		

Performance Expectation	HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.		
Dimensions	Science & Engineering Practice	Disciplinary Core Ideas	Crosscutting Concept
	Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. <ul style="list-style-type: none"> Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. 	PS3.A: Definitions of Energy <ul style="list-style-type: none"> At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. PS3.D: Energy in Chemical Processes <ul style="list-style-type: none"> Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. ETS1.A: Defining and Delimiting an Engineering Problem <ul style="list-style-type: none"> Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (<i>secondary</i>) 	Energy and Matter <ul style="list-style-type: none"> Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. Connections to Engineering, Technology, and Applications of Science Influence of Science, Engineering and Technology on Society and the Natural World <ul style="list-style-type: none"> Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 67–71	pp. 120–124 pp. 128–130 pp. 204–206	pp. 94–96 pp. 212–214
NGSS Appendices	Appendix F pp. 11–12	Appendix E p. 7 Appendix E p. 8 Appendix I pp. 1–7	Appendix G pp. 8–9 Appendix J pp. 2–3
Clarification Statement	Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.		
Assessment Boundary	Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.		

Items may ask students to:

Code	Alignment	Item Specification
HS-PS3-3.1	SEP-DCI-CCC	Design, evaluate, and/or refine a device that converts energy from one form into another form in a system while meeting given criteria and/or constraints .
HS-PS3-3.2	SEP-DCI	Due to a strong overlap between the DCI and CCC, items are not coded HS-PS3-3.2.
HS-PS3-3.3	DCI-CCC	Analyze a system to track the conversion of energy from one form into another form.
HS-PS3-3.4	SEP-CCC	Due to a strong overlap between the DCI and CCC, items are not coded HS-PS3-3.4.

Details and Clarifications

- **Design, evaluate, and/or refine** is expanded to include:
 - making claims about relationships between dependent and independent variables
 - using valid and/or reliable evidence to construct and/or revise an explanation
 - applying scientific ideas, principles, and/or evidence to describe a scientific phenomenon and/or solve a problem
 - using evidence to evaluate how well a solution meets the criteria for success
 - using evidence to evaluate the constraints that may limit the success of a solution
 - using knowledge, evidence, criteria, and/or tradeoffs to evaluate and/or refine a solution
- **Devices** that **convert energy** may include, but are NOT limited to:
 - a battery that converts chemical energy into electricity
 - a heater that converts electrical energy into thermal energy
 - a bulb that converts electrical energy into light and/or thermal energy
- **Evaluate a system** may include, but is NOT limited to:
 - describing energy inputs to, outputs of, and/or flows within a defined system
- **Criteria** for determining the success of the device may include, but are NOT limited to:
 - minimizes transfer of energy out of a given system
 - uses materials with desired and/or required properties
 - provides a specific benefit to civilization
 - low impact on the environment
 - low risk of injury
 - ready availability of technology
 - effective in solving specific aspects of the given problem
- **Constraints** that can limit the success of the device may include, but are NOT limited to:
 - high cost
 - low availability of materials and resources
 - low efficiency of energy conversion
 - physical, social, ethical, aesthetic, and/or time issues

Performance Expectation	HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. <ul style="list-style-type: none"> • Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. 	PS4.A: Wave Properties <ul style="list-style-type: none"> • The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. 	Cause and Effect <ul style="list-style-type: none"> • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 64–67	pp. 131–133	pp. 87–89
NGSS Appendices	Appendix F p. 10	Appendix E p. 8	Appendix G pp. 5–6
Clarification Statement	Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.		
Assessment Boundary	Assessment is limited to algebraic relationships and describing those relationships qualitatively.		

Items may ask students to:

Code	Alignment	Item Specification
HS-PS4-1.1	SEP-DCI-CCC	Use mathematical representations to support a claim about cause and effect relationships between wave speed, frequency , and/or wavelength as a wave travels through various media .
HS-PS4-1.2	SEP-DCI	Use mathematical representations to support a claim about wave speed, frequency , and/or wavelength as a wave travels through various media .
HS-PS4-1.3	DCI-CCC	Apply cause and effect relationships to changes in wave speed, frequency , and/or wavelength as a wave travels through different media .
HS-PS4-1.4	SEP-CCC	Use mathematical representations to make or support a claim about cause and effect relationships.
Details and Clarifications		
<ul style="list-style-type: none"> • Use mathematical representations is expanded to include: <ul style="list-style-type: none"> ◦ describing and/or revising a computational model or simulation of a phenomenon, designed device, process, or system ◦ using mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations ◦ applying techniques of algebra and/or functions to represent and/or solve scientific and engineering problems • Mathematical representations may include, but are NOT limited to: <ul style="list-style-type: none"> ◦ mathematical relationships between speed, frequency, and/or wavelength for waves traveling in a specific medium, based on the given formula: $v = f\lambda$ ◦ mathematical comparison of speed, frequency, and/or wavelength for different waves traveling through different media ◦ data showing changes in wave speed as a result of changes in medium ◦ a simulation showing relationships between speed, frequency, and/or wavelength for wave traveling through various media • Relationships between the wavelength and frequency of a wave and the speed and medium may include, but are NOT limited to: <ul style="list-style-type: none"> ◦ wavelength is proportional to wave speed ◦ frequency and wavelength are inversely proportional ◦ wave speed depends on the properties of the medium (e.g., air, glass, water) • Cause and effect relationships may include, but are NOT limited to: <ul style="list-style-type: none"> ◦ when a wave meets the surface between two different materials or conditions (e.g., air and water), the wave speed can change ◦ change of speed of the wave when passing from one medium to another can cause the wavelength to change 		

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

The item specifications that follow represent a **sample** of PEs. The sample will continue to expand until this document contains all the PEs. The sample of PEs represents only a part of what could be assessed on the WCAS. The inclusion of a PE in this document does not indicate that PE will be assessed by an item on the WCAS, nor does the absence of a PE from this document indicate that the PE will not be assessed on the WCAS.

Future item specifications drafts will include modification logs that will be updated at each subsequent publication.

Performance Expectation	HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. <ul style="list-style-type: none"> • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. 	LS1.A: Structure and Function <ul style="list-style-type: none"> • Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. 	Systems and System Models <ul style="list-style-type: none"> • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 56–59	pp. 143–145	pp. 91–94
NGSS Appendices	Appendix F p. 6	Appendix E p. 4	Appendix G pp. 7–8
Clarification Statement	Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.		
Assessment Boundary	Assessment does not include interactions and functions at the molecular or chemical reaction level.		

Items may ask students to:

Code	Alignment	Item Specification
HS-LS1-2.1	SEP-DCI-CCC	Develop and/or use a model to illustrate relationships between structure and function in the hierarchical organization of interacting systems in multicellular organisms.
HS-LS1-2.2	SEP-DCI	Develop and/or use a model to illustrate relationships between structure and function in multicellular organisms.
HS-LS1-2.3	DCI-CCC	Use relationships between structure and function to connect the hierarchical organization of interacting systems in multicellular organisms.
HS-LS1-2.4	SEP-CCC	Develop and/or use a model to illustrate relationships in interacting systems.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
 - developing, revising, and/or using a model to generate data
 - developing, revising, and/or using a model to show relationships between the components of a system and/or between systems
 - using a given complete or partial model to make predictions and/or describe phenomena
 - revising a given complete or partial model
 - describing the limitations of a complete or partial model
 - comparing models of a given system
- **Models** may include, but are NOT limited to, a diagram, simulation, or written description of:
 - the functions (e.g., nutrient uptake, motion) and/or parts (e.g., organs, tissues, cells) of major body systems (e.g., circulatory, digestive, muscular, nervous, skeletal, endocrine, excretory, respiratory) in relation to the overall function of an organism
 - interactions between two or more body systems and/or subsystems within a body system
 - interactions between body systems and/or system components at different scales (e.g., cells, organs)
- **Hierarchical organization** of multicellular organisms may include, but is NOT limited to:
 - cells with interacting organelles
 - tissues composed of interacting cells
 - organs composed of interacting tissues
 - organ systems composed of interacting organs
 - organisms composed of interacting organ systems
- **Interacting systems** may include, but are NOT limited to:
 - the circulatory system delivers oxygen to/removes waste from systems in an organism
 - cardiac muscle requires nerve cell stimulus for heartbeats

Performance Expectation	HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. <ul style="list-style-type: none"> • Use mathematical and/or computational representations of phenomena or design solutions to support explanations. 	LS2.A: Interdependent Relationships in Ecosystems <ul style="list-style-type: none"> • Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. 	Scale, Proportion, and Quantity <ul style="list-style-type: none"> • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 64–67	pp. 150–152	pp. 89–91
NGSS Appendices	Appendix F p. 10	Appendix E p. 5	Appendix G pp. 6–7
Clarification Statement	Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.		
Assessment Boundary	Assessment does not include deriving mathematical equations to make comparisons.		

Items may ask students to:

Code	Alignment	Item Specification
HS-LS2-1.1	SEP-DCI-CCC	Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales .
HS-LS2-1.2	SEP-DCI	Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of an ecosystem.
HS-LS2-1.3	DCI-CCC	Apply knowledge of factors that affect carrying capacity of ecosystems at different scales .
HS-LS2-1.4	SEP-CCC	Use mathematical and/or computational representations to support explanations of a phenomenon at different scales.
Details and Clarifications		
<ul style="list-style-type: none"> • Use mathematical and/or computational representations is expanded to include: <ul style="list-style-type: none"> ◦ describing and/or revising a computational model or simulation of a phenomenon, designed device, process, or system ◦ using mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations ◦ applying techniques of algebra and/or functions to represent and/or solve scientific and engineering problems • Mathematical and/or computational representations may include, but are NOT limited to: <ul style="list-style-type: none"> ◦ graphs showing linear and/or exponential growth ◦ a simulation showing changes for populations at different scales ◦ data identifying changes in numbers and/or types of organisms over time • Factors that affect carrying capacity may include, but are NOT limited to: <ul style="list-style-type: none"> ◦ available living and/or nonliving resources (e.g., food, water) ◦ challenges of predation, competition, disease ◦ environmental conditions • Examples of ecosystems at different scales may include, but are NOT limited to: <ul style="list-style-type: none"> ◦ pond vs. ocean ◦ a small area in a forest vs. a large forest ecosystem 		

Performance Expectation	HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.		
Dimensions	Science & Engineering Practice	Disciplinary Core Ideas	Crosscutting Concept
	Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. <ul style="list-style-type: none"> Use mathematical representations of phenomena or design solutions to support and revise explanations. Connections to Nature of Science Scientific Knowledge is Open to Revision in Light of New Evidence <ul style="list-style-type: none"> Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. 	LS2.A: Interdependent Relationships in Ecosystems <ul style="list-style-type: none"> Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. LS2.C: Ecosystem Dynamics, Functioning, and Resilience <ul style="list-style-type: none"> A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. 	Scale, Proportion, and Quantity <ul style="list-style-type: none"> Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 64-67	pp. 150-152 pp. 154-156	pp. 89-91
NGSS Appendices	Appendix F p. 10 Appendix H p. 5	Appendix E p. 5	Appendix G pp. 6-7
Clarification Statement	Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.		
Assessment Boundary	Assessment is limited to provided data.		

Items may ask students to:

Code	Alignment	Item Specification
HS-LS2-2.1	SEP-DCI-CCC	Use mathematical representations to support and revise explanations about factors and interactions that affect biodiversity and/or populations in ecosystems at different scales .
HS-LS2-2.2	SEP-DCI	Use mathematical representations to support and revise explanations about factors and interactions that affect biodiversity and/or populations in an ecosystem.
HS-LS2-2.3	DCI-CCC	Connect factors and interactions to changes in biodiversity and/or populations in ecosystems at different scales .
HS-LS2-2.4	SEP-CCC	Use mathematical representations to support explanations of a phenomenon at different scales.

Details and Clarifications

- **Use mathematical representations** is expanded to include:
 - describing and/or revising a computational model or simulation of a phenomenon, designed device, process, or system
 - using mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations
 - applying techniques of algebra and/or functions to represent and/or solve scientific and engineering problems
- **Mathematical representations** may include, but are NOT limited to:
 - a graph showing changes to population sizes as a function of biotic and/or abiotic factors
 - a table showing numbers and/or types of organisms as a function of biotic and/or abiotic factors
 - a simulation showing interactions between ecosystems at different scales
- **Factors** and **interactions** that affect **biodiversity** and/or **populations** may include, but are NOT limited to:
 - availability of resources and/or habitat
 - presence of invasive species
 - changes in environmental conditions
 - changes in biotic and/or abiotic factors
 - interactions among organisms at different scales (e.g., plants and microbes)
- Examples of **ecosystems at different scales** may include, but are NOT limited to:
 - pond vs. ocean
 - a small area in a forest vs. a large forest ecosystem

Performance Expectation	HS-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. <ul style="list-style-type: none"> Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. Connections to Nature of Science Scientific Knowledge is Open to Revision in Light of New Evidence <ul style="list-style-type: none"> Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation. 	LS2.C: Ecosystem Dynamics, Functioning, and Resilience <ul style="list-style-type: none"> A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. 	Stability and Change <ul style="list-style-type: none"> Much of science deals with constructing explanations of how things change and how they remain stable.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 71–74	pp. 154–156	pp. 98–101
NGSS Appendices	Appendix F pp. 13–14 Appendix H pp. 1–10	Appendix E p. 5	Appendix G pp. 10–11
Clarification Statement	Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
HS-LS2-6.1	SEP-DCI-CCC	Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations of how the complex interactions within an ecosystem help maintain stability and/or cause change .
HS-LS2-6.2	SEP-DCI	Due to strong overlap between the DCI and the CCC, items are not coded HS-LS2-6.2.
HS-LS2-6.3	DCI-CCC	Connect complex interactions within an ecosystem to stability and/or change .
HS-LS2-6.4	SEP-CCC	Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations of how things change and/or how things remain stable.

Details and Clarifications

- **Evaluate explanations** is expanded to include:
 - identifying criteria used to critique claims
 - using evidence to compare and/or evaluate competing arguments and/or solutions
 - determining the merit of an explanation
 - using evidence to construct and/or support an argument
 - using evidence to construct and/or support a claim
- **Complex interactions** may include, but are NOT limited to:
 - relationships among different species
 - relationships between populations and their environment
 - biological disturbances and the effect on populations
 - physical disturbances and the effect on populations
 - resources affecting population size
- **Explanations of stability and change** may include, but are NOT limited to:
 - biological and/or physical disturbances can change the types and/or numbers of the ecosystem's species
 - ecosystems with modest disruptions maintain stable conditions or return to their original state after the disruption
 - extreme fluctuations in ecosystem conditions can change the resources and/or habitat availability to such a degree that the ecosystem cannot return to its original state and instead becomes a very different ecosystem
 - feedback can stabilize or destabilize an ecosystem

Performance Expectation	HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.		
Dimensions	Science & Engineering Practice	Disciplinary Core Ideas	Crosscutting Concept
	Asking Questions and Defining Problems Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. <ul style="list-style-type: none"> Ask questions that arise from examining models or a theory to clarify relationships. 	LS1.A: Structure and Function <ul style="list-style-type: none"> All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. (secondary) <i>(Note: This Disciplinary Core Idea is also addressed by HS-LS1-1.)</i> LS3.A: Inheritance of Traits <ul style="list-style-type: none"> Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. 	Cause and Effect <ul style="list-style-type: none"> Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 54–56	pp. 143–145 pp. 158–159	pp. 87–89
NGSS Appendices	Appendix F p. 4	Appendix E p. 4 Appendix E p. 6	Appendix G p. 5
Clarification Statement	A clarification statement is not provided for this PE.		
Assessment Boundary	Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.		

Items may ask students to:

Code	Alignment	Item Specification
HS-LS3-1.1	SEP-DCI-CCC	Ask questions to clarify cause and effect relationships between the structure and function of DNA and chromosomes and the inherited traits observed in an organism.
HS-LS3-1.2	SEP-DCI	Ask questions about the structure and function of DNA and chromosomes and the inherited traits observed in an organism.
HS-LS3-1.3	DCI-CCC	Use cause and effect relationships to connect the structure and function of DNA , chromosomes , and the inherited traits observed in an organism.
HS-LS3-1.4	SEP-CCC	Ask questions to clarify cause and effect relationships.

Details and Clarifications

- **Ask questions** is expanded to include:
 - asking, identifying, and/or refining questions that can be answered with evidence from an investigation
 - asking and/or identifying questions to clarify a model, argument, explanation, and/or data
 - evaluating the testability and/or relevance of a question
 - asking or evaluating questions that challenge the premise of an argument
- Relationships among **DNA**, **chromosomes**, and **inherited traits** may include, but are NOT limited to:
 - chromosomes consist of genes made from DNA
 - each chromosome pair in a cell contains two variants of each gene
 - DNA contains instructions that code for specific proteins
 - proteins produced by a cell affect an organism's inherited traits
 - mutations to genes and/or chromosomes can result in changes to proteins, resulting in changes to an organism's traits
 - not all sections of DNA on a chromosome code for inherited traits
 - the cells of an organism express different inherited traits as a result of expressing different genes
- Evidence of **cause and effect** relationships may include, but is NOT limited to:
 - the effects of cell types on the type of proteins produced by a cell
 - the effects of a genetic mutation on the type of protein produced or trait expressed
 - the effects of DNA and/or gene sequence on the type of protein produced or trait expressed

Performance Expectation	HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.		
Dimensions	Science & Engineering Practice Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. <ul style="list-style-type: none"> Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). Connections to Nature of Science Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena <ul style="list-style-type: none"> A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. 	Disciplinary Core Idea LS4.A: Evidence of Common Ancestry and Diversity <ul style="list-style-type: none"> Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. 	Crosscutting Concept Patterns <ul style="list-style-type: none"> Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Connections to Nature of Science Scientific Knowledge Assumes an Order and Consistency in Natural Systems <ul style="list-style-type: none"> Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.
	These item specifications were developed using the following reference materials:		
K-12 Framework	pp. 74–77	pp. 162–163	pp. 85–87
NGSS Appendices	Appendix F p. 15 Appendix H p. 5	Appendix E p. 6	Appendix G pp. 3–5 Appendix H p. 6
Clarification Statement	Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
HS-LS4-1.1	SEP-DCI-CCC	Communicate scientific information that common ancestry and biological evolution are supported by patterns observed in DNA, amino acid sequences, anatomical evidence, and/or embryological evidence .
HS-LS4-1.2	SEP-DCI	Communicate scientific information that common ancestry and biological evolution are supported by DNA, amino acid sequences, anatomical evidence, and/or embryological evidence .
HS-LS4-1.3	DCI-CCC	Use patterns from DNA, amino acid sequences, anatomical, and/or embryological evidence to provide evidence of evolution .
HS-LS4-1.4	SEP-CCC	Communicate scientific information about phenomena that are supported by patterns in evidence.
Details and Clarifications		
<ul style="list-style-type: none"> • Communicate scientific information is expanded to include: <ul style="list-style-type: none"> ○ identifying scientific and/or technical evidence, concepts, processes, or information ○ evaluating the validity and/or reliability of claims from different sources ○ integrating multiple sources of information to construct and/or support an explanation ○ summarizing complex information • Information formats may include, but are NOT limited to: <ul style="list-style-type: none"> ○ text ○ tables ○ diagrams ○ graphs ○ models ○ animations ○ cladograms • Patterns in DNA that can be used to provide evidence of evolution may include, but are NOT limited to: <ul style="list-style-type: none"> ○ similarities in the DNA sequences of different species ○ similarities in DNA sequences between species with a common ancestor • Patterns in amino acid sequences that can be used to provide evidence of evolution may include, but are NOT limited to: <ul style="list-style-type: none"> ○ similarities in the pattern of amino acid sequences across different species ○ overlaps in amino acid sequences even when DNA sequences are different • Patterns in anatomical and embryological evidence that can be used to provide evidence of evolution may include, but are NOT limited to: <ul style="list-style-type: none"> ○ analogous structures between different species in the fossil record ○ progressive anatomical changes across species preserved in the fossil record ○ anatomical similarities and differences between organisms living today and organisms in the fossil record ○ embryological similarities between species at various stages of development 		

Performance Expectation	HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.		
Dimensions	Science & Engineering Practice	Disciplinary Core Ideas	Crosscutting Concept
	Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. <ul style="list-style-type: none"> • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. 	LS4.B: Natural Selection <ul style="list-style-type: none"> • Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. • The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. LS4.C: Adaptation <ul style="list-style-type: none"> • Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. • Adaptation also means that the distribution of traits in a population can change when conditions change. 	Patterns <ul style="list-style-type: none"> • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 61–63	pp. 163–164 pp. 164–166	pp. 85–87
NGSS Appendices	Appendix F p. 9	Appendix E p. 6	Appendix G pp. 3–5
Clarification Statement	Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.		
Assessment Boundary	Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.		

Items may ask students to:

Code	Alignment	Item Specification
HS-LS4-3.1	SEP-DCI-CCC	Apply concepts of statistics and/or probability to analyze patterns that support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
HS-LS4-3.2	SEP-DCI	Apply concepts of statistics and/or probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
HS-LS4-3.3	DCI-CCC	Use patterns to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
HS-LS4-3.4	SEP-CCC	Apply concepts of statistics and/or probability to observe patterns that support explanations.

Details and Clarifications

- **Apply concepts of statistics and/or probability** is expanded to include:
 - organizing and/or interpreting data, using tables, graphs, and/or statistical analysis
 - identifying relationships in data, using tables and/or graphs
 - identifying limitations (e.g., measurement error, sample selection) in data
 - comparing the consistency in measurements and/or observations in sets of data
 - using analyzed data to support a claim and/or an explanation
- **Patterns** that support explanations may include, but are NOT limited to:
 - changes in the frequency of a particular heritable trait over time
 - beneficial traits are more common in a population than harmful traits
 - changes in the distribution of adaptations (e.g., anatomical, behavioral, physiological)
 - variation in trait expression within a population
 - traits that positively affect survival becoming more common in a population
 - traits that negatively affect survival becoming less common in a population
 - changes in the distribution of alleles over time as the environment changes
 - changes in reproductive success over time across populations with or without a specific heritable trait
- **Explanations** may include, but are NOT limited to:
 - a description of how the expression of a trait affects the survival and/or reproduction of individuals
 - a description of how natural selection affects the distribution of a heritable trait over time
 - a description of how the distribution of adaptations change in a population over time

Performance Expectation	HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current or historical episodes in science. <ul style="list-style-type: none"> Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. 	LS4.C: Adaptation <ul style="list-style-type: none"> Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. 	Cause and Effect <ul style="list-style-type: none"> Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 71–74	pp. 164–166	pp. 87–89
NGSS Appendices	Appendix F pp. 13–14	Appendix E p. 6	Appendix G pp. 5–6
Clarification Statement	Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
HS-LS4-5.1	SEP-DCI-CCC	Evaluate the evidence from cause and effect relationships to make and/or support claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
HS-LS4-5.2	SEP-DCI	Evaluate evidence to make and/or support claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
HS-LS4-5.3	DCI-CCC	Use cause and effect relationships to make and/or support claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
HS-LS4-5.4	SEP-CCC	Evaluate the evidence from cause and effect relationships to make and/or support claims.

Details and Clarifications

- **Evaluate evidence** is expanded to include:
 - identifying criteria used to critique claims
 - using evidence to compare competing arguments
 - determining the merit of an explanation
 - using evidence to construct and/or support an argument
 - using evidence to construct and/or support a claim
- **Cause and effect** relationships may include, but are NOT limited to:
 - increase and/or decrease in the number of individuals of a species, due to a change (e.g., loss of habitat, introduction of a disease)
 - extinction of a species, due to a changing environment over time (e.g., pollution, habitat destruction, volcanic eruption)
 - emergence of a new species, due to geographic isolation

Earth and Space Sciences

Disciplinary Core Ideas:

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

The item specifications that follow represent a **sample** of PEs. The sample will continue to expand until this document contains all the PEs. The sample of PEs represents only a part of what could be assessed on the WCAS. The inclusion of a PE in this document does not indicate that PE will be assessed by an item on the WCAS, nor does the absence of a PE from this document indicate that the PE will not be assessed on the WCAS.

Future item specifications drafts will include modification logs that will be updated at each subsequent publication.

Performance Expectation	HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.		
Dimensions	Science & Engineering Practice	Disciplinary Core Ideas	Crosscutting Concept
	<p>Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.</p> <ul style="list-style-type: none"> • Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. <p>Connections to Nature of Science Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena</p> <ul style="list-style-type: none"> • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. • Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. 	<p>ESS1.C: The History of Planet Earth</p> <ul style="list-style-type: none"> • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. <p>PS1.C: Nuclear Processes</p> <ul style="list-style-type: none"> • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary) 	<p>Stability and Change</p> <ul style="list-style-type: none"> • Much of science deals with constructing explanations of how things change and how they remain stable.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 67–71	pp. 177–179 pp. 111–113	pp. 98–101
NGSS Appendices	Appendix F pp. 11–12 Appendix H p. 6	Appendix E p. 2 Appendix E p. 7	Appendix G pp. 10–11
Clarification Statement	Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
HS-ESS1-6.1	SEP-DCI-CCC	Apply scientific reasoning and evidence from ancient Earth materials, meteorites, other planetary surfaces, geologic processes, and/or radioactive decay to construct an explanation of Earth's formation and/or early history .
HS-ESS1-6.2	SEP-DCI	Due to a strong overlap between the DCI and the CCC, items are not coded HS-ESS1-6.2.
HS-ESS1-6.3	DCI-CCC	Connect changes to ancient Earth materials, meteorites, other planetary surfaces, and/or geologic processes to Earth's formation and/or early history .
HS-ESS1-6.4	SEP-CCC	Apply scientific reasoning and evidence to construct an explanation for how things change and how they remain stable.

Details and Clarifications

- **Construct** an **explanation** is expanded to include:
 - making claims about relationships between dependent and independent variables
 - using valid and/or reliable evidence to construct and/or revise an explanation
 - applying scientific ideas, principles, and/or evidence to describe a scientific phenomenon and/or solve a problem
 - using evidence to evaluate how well a solution meets the criteria for success
 - using evidence to evaluate the constraints that may limit the success of a solution
 - using knowledge, evidence, criteria, and/or tradeoffs to evaluate and/or refine a solution
- Types of **Evidence** may include, but are NOT limited to:
 - the age of materials (e.g., Earth rock, moon rock, meteorite) as determined by radiometric dating
 - number of impact craters on Earth compared to other planets
 - the size and/or composition of solar system objects (e.g., meteorites, moon)
- **Earth's formation** and/or **early history** may include, but is NOT limited to:
 - formation of Earth with the rest of the solar system 4.6 billion years ago
 - bombardment of Earth and solar system objects
 - volcanic activity and/or the formation of continents and ocean basins

Performance Expectation	HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.		
Dimensions	Science & Engineering Practice	Disciplinary Core Ideas	Crosscutting Concept
	Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. <ul style="list-style-type: none"> Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. 	ESS2.A: Earth Materials and Systems <ul style="list-style-type: none"> Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. ESS2.D: Weather and Climate <ul style="list-style-type: none"> The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. 	Stability and Change <ul style="list-style-type: none"> Feedback (negative or positive) can stabilize or destabilize a system. Connections to Engineering, Technology, and Applications of Science Influence of Engineering, Technology, and Science on Society and the Natural World <ul style="list-style-type: none"> New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 61–63	pp. 179–182 pp. 186–189	pp. 98–101
NGSS Appendices	Appendix F p. 9	Appendix E p. 2 Appendix E p. 3	Appendix G pp. 10–11 Appendix J pp. 1–6
Clarification Statement	Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
HS-ESS2-2.1	SEP-DCI-CCC	Analyze data to make claims that interactions within and/or between Earth's systems can cause feedback and/or changes that affect the stability of other Earth systems.
HS-ESS2-2.2	SEP-DCI	Analyze data to make claims that interactions within and/or between Earth's systems can cause changes to other Earth systems
HS-ESS2-2.3	DCI-CCC	Connect interactions within and/or between Earth's systems to feedback and/or changes that affect the stability of other Earth systems.
HS-ESS2-2.4	SEP-CCC	Analyze data to make claims that feedback can affect stability and/or cause change in Earth's systems.

Details and Clarifications

- **Analyze data** is expanded to include:
 - organizing and/or interpreting data using tables, graphs, and/or statistical analysis
 - identifying relationships in data using tables and/or graphs
 - identifying limitations (e.g., measurement error, sample selection) in data
 - comparing the consistency in measurements and/or observations in sets of data
 - using analyzed data to support a claim and/or an explanation
- Examples of **interactions** may include, but are NOT limited to:
 - atmospheric phenomena and/or oceanic processes that interact with the land, living things, or each other to influence weather and/or climate
 - energy inputs from the sun interacting with matter in the atmosphere and Earth's surface to influence climate, living things, and/or Earth's surface features
 - energy released from Earth's interior driving changes in Earth's surface features that influence weather, climate, living things, and/or oceans
 - water, ice, wind, or organisms interacting with materials on Earth's surface to shape landforms (i.e., through erosion, weathering, deposition)
- **Feedback** that affects **stability** or **change** may include, but is NOT limited to:
 - examples in which the magnitude or impact of an initial change is counteracted to stabilize a condition in one or more of Earth's systems
 - examples in which the magnitude or impact of an initial change is increased and can destabilize a condition in one or more of Earth's systems
 - examples of effects of a technology that can stabilize or destabilize a condition in one or more of Earth's systems

Performance Expectation	HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.		
Dimensions	Science & Engineering Practice	Disciplinary Core Ideas	Crosscutting Concept
	Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). <ul style="list-style-type: none"> • Use a model to provide mechanistic accounts of phenomena. Connections to Nature of Science Scientific Knowledge is Based on Empirical Evidence <ul style="list-style-type: none"> • Science arguments are strengthened by multiple lines of evidence supporting a single explanation. 	ESS1.B: Earth and the Solar System <ul style="list-style-type: none"> • Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary) ESS2.A: Earth Materials and System <ul style="list-style-type: none"> • The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. ESS2.D: Weather and Climate <ul style="list-style-type: none"> • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. 	Cause and Effect <ul style="list-style-type: none"> • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 56–59	pp. 175–176 pp. 179–182 pp. 186–189	pp. 87–89
NGSS Appendices	Appendix F p. 6 Appendix H p. 5	Appendix E p. 3	Appendix G pp. 5–6
Clarification Statement	Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.		
Assessment Boundary	Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.		

Items may ask students to:

Code	Alignment	Item Specification
HS-ESS2-4.1	SEP-DCI-CCC	Develop and/or use a model to describe cause and effect relationships between variations in the flow of energy into and out of Earth's systems and changes in climate over a variety of timescales.
HS-ESS2-4.2	SEP-DCI	Develop and/or use a model to describe the flow of energy into and/or out of Earth's systems and/or changes in climate over a variety of timescales.
HS-ESS2-4.3	DCI-CCC	Use cause and effect relationships to connect variations in the flow of energy into and out of Earth's systems to changes in climate over a variety of timescales.
HS-ESS2-4.4	SEP-CCC	Develop and/or use a model to describe cause and effect relationships in a system.

Details and Clarifications

- **Develop** and/or **use** a **model** is expanded to include:
 - developing, revising, and/or using a model to generate data
 - developing, revising, and/or using a model to show relationships between the components of a system and/or between systems
 - using a given complete or partial model to make predictions and/or to describe phenomena
 - revising a given complete or partial model
 - describing the limitations of a complete or partial model
 - comparing models of a given system
- **Models** may include, but are NOT limited to, a diagram, simulation, or written description of:
 - factors that affect input, output, storage, and/or redistribution of energy
 - factors operating over a variety of timescales
- Factors that affect the **flow** of **energy** may include, but are NOT limited to:
 - Earth's orbit and/or orientations of Earth's axis
 - the sun's energy output
 - configuration of continents resulting from tectonic activity
 - volcanic activity
 - ocean circulation
 - atmospheric composition and/or circulation
 - vegetation cover
 - human activities
- Evidence of **changes** in **climate** may include, but is NOT limited to:
 - significant changes in average global temperature
 - significant rises in sea levels or changes in ocean temperature
 - significant changes in weather (e.g., drought, flooding)
- **Cause and effect** relationships may include, but are NOT limited to:
 - the burning of fossil fuels increases CO₂ in the atmosphere, which traps thermal energy and results in increased global surface temperatures
 - volcanic eruptions release particles into the atmosphere that shade incoming solar radiation, resulting in cooling that can last from months to years
 - ocean currents transport warm water from the equator toward the poles and cold water from the poles toward the equator, regulating global climate and counteracting the uneven distribution of solar radiation reaching Earth's surface

Performance Expectation	HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). <ul style="list-style-type: none"> • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. 	ESS2.D: Weather and Climate <ul style="list-style-type: none"> • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. 	Energy and Matter <ul style="list-style-type: none"> • The total amount of energy and matter in closed systems is conserved.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 56–59	pp. 186–189	pp. 94–96
NGSS Appendices	Appendix F p. 6	Appendix E p. 3	Appendix G pp. 8–9
Clarification Statement	Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
HS-ESS2-6.1	SEP-DCI-CCC	Develop and/or use a quantitative model to describe how matter is conserved as carbon cycles among the hydrosphere, atmosphere, geosphere, and/or biosphere.
HS-ESS2-6.2	SEP-DCI	Develop and/or use a quantitative model to describe how carbon cycles among the hydrosphere, atmosphere, geosphere, and/or biosphere.
HS-ESS2-6.3	DCI-CCC	Connect the conservation of matter and the cycling of carbon among the hydrosphere, atmosphere, geosphere, and/or biosphere.
HS-ESS2-6.4	SEP-CCC	Develop and/or use a quantitative model to describe how matter is conserved in a system.
Details and Clarifications		
<ul style="list-style-type: none"> • Develop and/or use a quantitative model is expanded to include: <ul style="list-style-type: none"> ○ developing, revising, and/or using a model to generate data ○ developing, revising, and/or using a model to show relationships between the components of a system and/or between systems ○ using a given complete or partial model to make predictions and/or to describe phenomena ○ revising a given complete or partial model ○ describing the limitations of a complete or partial model ○ comparing models of a given system • Examples of how matter is conserved as carbon cycles may include, but are NOT limited to: <ul style="list-style-type: none"> ○ relative concentrations and/or quantities of carbon stored in Earth systems or reservoirs ○ rates of carbon transfer among Earth systems or reservoirs ○ the effects of natural processes and/or human activities on the concentration of CO₂ in the atmosphere and the subsequent effects on climate ○ measurements or calculations of carbon storage and/or carbon cycling among Earth's systems or reservoirs ○ gradual movement of carbon between the biosphere and the atmosphere during photosynthesis and/or cellular respiration 		

Performance Expectation	HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.		
Dimensions	Science & Engineering Practice	Disciplinary Core Ideas	Crosscutting Concepts
	Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. <ul style="list-style-type: none"> Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations). 	ESS3.A: Natural Resources <ul style="list-style-type: none"> All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. ETS1.B: Developing Possible Solutions <ul style="list-style-type: none"> When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary) 	Connections to Engineering, Technology, and Applications of Science Influence of Science, Engineering, and Technology on Society and the Natural World <ul style="list-style-type: none"> Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. Analysis of costs and benefits is a critical aspect of decisions about technology. Connections to Nature of Science Science Addresses Questions About the Natural and Material World <ul style="list-style-type: none"> Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. Science knowledge indicates what can happen in natural systems — not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.
These item specifications were developed using the following reference materials:			
K–12 Framework	pp. 71–74	pp. 191–192 pp. 206–208	N/A
NGSS Appendices	Appendix F pp. 13–14	Appendix E p. 3 Appendix I pp. 1–7	Appendix H pp. 1–10 Appendix J pp. 1–6
Clarification Statement	Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.		
Assessment Boundary	An assessment boundary is not provided for this PE.		

Items may ask students to:

Code	Alignment	Item Specification
HS-ESS3-2.1	SEP-DCI-CCC	Evaluate competing design solutions for challenges related to energy production and/or resource extraction based on analysis of costs, risks, and/or benefits .
HS-ESS3-2.2	SEP-DCI	Due to strong overlap between the DCI and the CCC, items are not coded HS-ESS3-2.2.
HS-ESS3-2.3	DCI-CCC	Connect the analysis of costs, risks, and/or benefits to energy production and/or resource extraction .
HS-ESS3-2.4	SEP-CCC	Evaluate competing design solutions while analyzing costs, risks, and/or benefits.

Details and Clarifications

- **Evaluate** competing design solutions is expanded to include:
 - identifying criteria used to critique claims
 - using evidence to compare and/or evaluate competing arguments and/or solutions
 - determining the merit of an explanation
 - using evidence to construct and/or support an argument
 - using evidence to construct and/or support a claim
- **Solutions** for challenges related to **energy production** and/or **resource extraction** may include, but are NOT limited to, technologies or methods for:
 - enhancing renewable energy as a source of energy production
 - improving benefits or decreasing costs of renewable energy sources
 - decreasing costs and/or risks associated with the extraction of metal, mineral, and/or fossil fuel resources
 - decreasing costs and/or risks associated with the use of natural resources
 - increasing the availability of natural resources through conservation, recycling, and/or reuse
 - determining locations where resource extraction is viable and impact is minimal
- Examples of **costs, risks, and/or benefits** may include, but are NOT limited to:
 - economic (e.g., cost of extracting resources or developing energy, value of resources)
 - social (e.g., resource locations correlated to size of human populations, societal needs for resources)
 - environmental (e.g., earthquakes after extracting resources, displacement of organisms, habitat destruction)
 - geopolitical (e.g., international trade of resources, collaborative design solutions)
- **Solutions** related to **costs, risks, and/or benefits** may include, but are NOT limited to:
 - conserving, recycling, and/or reusing resources (e.g., minerals, metals) to increase cost-benefit ratios
 - suggesting new tools or technology for resource production or usage
 - proposing technology/engineering designs or practices that reduce risks and/or costs
 - identifying improvements for a component of a current design solution

Performance Expectation	HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. <ul style="list-style-type: none"> Analyze data using computational models in order to make valid and reliable scientific claims. Connections to Nature of Science Scientific Investigations Use a Variety of Methods <ul style="list-style-type: none"> Science investigations use diverse methods and do not always use the same set of procedures to obtain data. New technologies advance scientific knowledge. Scientific Knowledge is Based on Empirical Evidence <ul style="list-style-type: none"> Science knowledge is based on empirical evidence. Science arguments are strengthened by multiple lines of evidence supporting a single explanation 	ESS3.D: Global Climate Change <ul style="list-style-type: none"> Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. 	Stability and Change <ul style="list-style-type: none"> Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 61–63	pp. 196–198	pp. 98–101
NGSS Appendices	Appendix F p. 9 Appendix H p. 5	Appendix E p. 4	Appendix G pp. 10–11
Clarification Statement	Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition)		
Assessment Boundary	Assessment is limited to one example of a climate change and its associated impacts.		

Items may ask students to:

Code	Alignment	Item Specification
HS-ESS3-5.1	SEP-DCI-CCC	Analyze geoscience data and/or the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems .
HS-ESS3-5.2	SEP-DCI	Analyze geoscience data and/or the results from global climate models to describe how the human ability to model, predict, and manage impacts to Earth's systems has changed over time.
HS-ESS3-5.3	DCI-CCC	Connect evidence of the current rate of global or regional climate change to associated future impacts to Earth's systems .
HS-ESS3-5.4	SEP-CCC	Analyze data and/or the results from models to make evidence-based forecasts about changes to a system.
Details and Clarifications		
<ul style="list-style-type: none"> • Analyze data is expanded to include: <ul style="list-style-type: none"> ○ organizing and/or interpreting data using tables, graphs, and/or statistical analysis ○ identifying relationships in data using tables and/or graphs ○ identifying limitations (e.g., measurement error, sample selection) in data ○ comparing the consistency in measurements and/or observations in sets of data ○ using analyzed data to support a claim and/or an explanation • Data may include, but are NOT limited to: <ul style="list-style-type: none"> ○ temperature ○ precipitation ○ sea level ○ glacial and/or sea ice volume ○ atmosphere, geosphere, or hydrosphere composition • Models may include, but are NOT limited to: <ul style="list-style-type: none"> ○ a simulation ○ a mathematical equation ○ a graphical display of data (e.g., map, chart, table, graph) • Climate change may include, but is NOT limited to: <ul style="list-style-type: none"> ○ change in a physical parameter (e.g., CO₂ concentration, temperature, precipitation) of Earth's atmosphere over time ○ change in a chemical characteristic (e.g., pH) of Earth's oceans over time • Impacts to Earth's systems may include, but are NOT limited to: <ul style="list-style-type: none"> ○ an increase in average global temperatures ○ an increase in changes in average sea level ○ an increase in extreme weather events (e.g., hurricanes, flooding) ○ a decrease in arctic sea ice ○ reversible and/or irreversible changes 		

Engineering, Technology, and Applications of Science

Disciplinary Core Ideas:

- ETS1 Engineering Design

The item specifications that follow represent a **sample** of PEs. The sample will continue to expand until this document contains all the PEs. The sample of PEs represents only a part of what could be assessed on the WCAS. The inclusion of a PE in this document does not indicate that PE will be assessed by an item on the WCAS, nor does the absence of a PE from this document indicate that the PE will not be assessed on the WCAS.

Future item specifications drafts will include modification logs that will be updated at each subsequent publication.

Performance Expectation	HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.		
Dimensions	Science & Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. • Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	ETS1.C: Optimizing the Design Solution • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	
These item specifications were developed using the following reference materials:			
K-12 Framework	pp. 67–71	pp. 208–210	
NGSS Appendices	Appendix F pp. 11–12	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
HS-ETS1-2.1	SEP-DCI-CCC	Due to the lack of a CCC, items are not coded HS-ETS1-2.1.
HS-ETS1-2.2	SEP-DCI	Design a solution to a complex real-world problem by breaking the problem down into smaller, more manageable problems that can be evaluated systematically using prioritized criteria and/or tradeoff considerations .
HS-ETS1-2.3	DCI-CCC	Due to the lack of a CCC, items are not coded HS-ETS1-2.3.
HS-ETS1-2.4	SEP-CCC	Due to the lack of a CCC, items are not coded HS-ETS1-2.4.
Details and Clarifications		
<ul style="list-style-type: none"> • Design a solution is expanded to include: <ul style="list-style-type: none"> ○ making claims about relationships between dependent and independent variables ○ using valid and/or reliable evidence to construct and/or revise an explanation ○ applying scientific ideas, principles, and/or evidence to describe a scientific phenomenon and/or solve a problem ○ using evidence to evaluate how well a solution meets the criteria for success ○ using evidence to evaluate the constraints that may limit the success of a solution ○ using knowledge, evidence, criteria, and/or tradeoffs to evaluate and/or refine a solution • Prioritized criteria may include, but are NOT limited to: <ul style="list-style-type: none"> ○ relatively low impact on the environment and/or the health of organisms ○ relative availability of technology ○ relatively high effectiveness in solving specific aspects of the given problem ○ relatively high reliability ○ relative use of materials with desired and/or required properties • Tradeoff considerations may include, but are NOT limited to: <ul style="list-style-type: none"> ○ describing advantages and/or disadvantages for a solution ○ comparing the benefits of several solutions • Evaluated systematically may include, but is NOT limited to: <ul style="list-style-type: none"> ○ comparing the tradeoffs for several solutions ○ using a numerical weighting system to prioritize criteria ○ evaluating and comparing a top criterion (e.g., safety) with impacts on other criteria (e.g., cost) ○ describing the interconnectedness of criteria, solutions, and/or tradeoffs for the sub-problems of a complex problem 		

SEP, DCI, and CCC Vocabulary Used in Assessment Items at Grade 11

The following list is based on the item specifications included in the December 2018 draft of the Test Design and Item Specifications document. The list will be updated in the next draft of the document which is expected to be published late spring 2019.

Items on the grade 11 exam use language targeted to an eighth grade or lower reading level with the exception of the required science terms in the following list. Appropriate science vocabulary allowed for the grades 5 and 8 WCAS may also be used on the grade 11 WCAS. Vocabulary words from the earlier grade levels are included in the list.

a	characteristic	demonstration
<u>Used in grade 5:</u>	charge	describe
advantage	claim	design
amplitude	classify	diagram
angle	climate	disadvantage
atmosphere	collide	disease
attract	collision	distance
axis	compare	
	conclusion	<u>Used in grade 8:</u>
<u>Used in grade 8:</u>	conserve	density
absorb	constraint	digital
adaptation	criteria	
acceleration		<u>Used in grade 11:</u>
allele	<u>Used in grade 8:</u>	differentiate
analog	cell	DNA
artificial selection	cellular respiration	
asexual reproduction	chemical reaction	e
atom	chromosome	<u>Used in grade 5:</u>
	condensation	earthquake
<u>Used in grade 11:</u>	conservation	ecosystem
aerobic	consumer	effect
amino acid	continental crust	electric current
anaerobic	correlation	electric force
	crystallization	electricity
b		electromagnet
<u>Used in grade 5:</u>	<u>Used in grade 11:</u>	energy
balanced force	carrying capacity	energy transfer
behavior	chemical energy	engineer
biosphere	chemical property	environment
	combustion	erosion
<u>Used in grade 8:</u>	concentration (of a solution)	evaporate
biodiversity	conduction	evidence
boundary	convection	exert
	core (of Earth)	extinct
<u>Used in grade 11:</u>		
biomass	d	<u>Used in grade 8:</u>
bond	<u>Used in grade 5:</u>	eclipse
	device	electric circuit
c	data	electric field
<u>Used in grade 5:</u>	decomposer	embryo
camouflage	decrease	evolution
cause	defend	

Used in grade 11:
electromagnetic radiation
electronegativity
equilibrium

f

Used in grade 5:
factor
food web
force
fossil
fossil fuel
function

Used in grade 8:
frequency

Used in grade 11:
fission
fusion

g

Used in grade 5:
gas
geosphere
glacier
graph
gravity
groundwater

Used in grade 8:
gene
genetic variation
geologic process
gravitational force

Used in grade 11:
gravitational field

h

Used in grade 5:
habitat
hazard
heat energy
hydrosphere

i

Used in grade 5:
impact
increase

inherited
input
interaction
investigation

Used in grade 8:
identical

Used in grade 11:
interference (of light)

k

Used in grade 8:
kinetic energy

l

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

Used in grade 8:
lava
light intensity
lunar

m

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

Used in grade 8:
magma
magnetic field
medium (of a wave)
molecule
mutation
mutually beneficial

Used in grade 11:
mantle
molar mass
mole
momentum

n

Used in grade 5:
nonrenewable

Used in grade 8:
natural selection
nutrient

Used in grade 11:
negative feedback

o

Used in grade 5:
object
observation
offspring
orbit
organism
output

Used in grade 8:
orbital radius

Used in grade 11:
oceanic crust
orbital period

p

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

Used in grade 8:
percentage
photosynthesis

pixel
prey
probability
producer
product
protein

Used in grade 11:

polarity
positive feedback
proportion

q

Used in grade 5:

quantity

r

Used in grade 5:

recycle
reduce
relationship
renewable
repel
reproduction
research
resource
result
rock formation
rock layer
rotate
runoff

Used in grade 8:

reactant
reflect
refract
reservoir

Used in grade 11:

radiation
radioactive decay
radioactive isotope
radiometric dating
resilience

s

Used in grade 5:

scientist
sediment
similarity
simulation
solar energy
solid
solution (to a problem)
sound energy
species
speed
stability
state (of matter)
structure
substance
subsystem
support
surface
survive
system

Used in grade 8:

scale
sexual reproduction
solar system
solution (chemical)

Used in grade 11:

selective advantage

t

Used in grade 5:

technology
temperature
trait
tsunami

Used in grade 8:

tectonic plate
thermal energy
transform
transmit
transpiration
trend

Used in grade 11:

tradeoff

u

Used in grade 5:

unbalanced force

Used in grade 11:

ultraviolet light

v

Used in grade 5:

variable
volcanic eruption
volume

w

Used in grade 5:

wave
wavelength
weathering
wetland
wind energy

