Item Specifications for the Delaware Next Generation Science Assessment

Prepared by WestEd for the
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Contents

Introduction

In 2013, Delaware adopted the Next Generation Science Standards (NGSS) as its state science standards. The goal of NGSS is to make certain all students leave Delaware schools able to apply their scientific knowledge and skills to real-world circumstances. Delaware is committed to a science assessment system that honors the principles of three-dimensional science learning while monitoring student readiness for challenging coursework in science and for college and career. The system reflects the state's mission for students to contextualize the crosscutting concepts across science core ideas and science and engineering practices.

The state's science assessment system offers three types of measures for understanding a student's progress in science. The summative assessments provide an evaluative measure in the benchmark years at the end of elementary school (grade 5), middle school (grade 8), and high school (biology). The results of the summative assessment are reported as a singular score of proficiency. The score from the summative assessment is intended to make a broad statement about lasting and pervasive knowledge and skills. More discrete information is collected throughout instruction by the other components of the state's assessment system. End-of-Unit Assessments are designed to provide rich data by measuring student abilities at a finer grain at intervals throughout the school year and across grades three through ten, while classroom assessments provide information throughout ongoing instruction. Other progress measures may include a student's grades, classroom exams, district-wide tests, and more.

Components of Delaware's Science Assessment System

The Next Generation Science Assessment System for Delaware learners is a comprehensive and balanced assessment system with three distinct parts.

- *Embedded Classroom Assessments* are developed by teachers to provide information on learning in real time in every grade from third grade through tenth grade. The assessments are primarily for instructional use and are therefore short and administered at the discretion of each teacher. The development of these has been supported by professional development.

- *End-of-Unit Assessments*, aligned to instructional units in every grade from third through tenth, are administered by teachers after the completion of each instructional unit. Each End-of-Unit Assessment is meant to provide information on student learning of the NGSS content in each unit for the purposes of instruction (e.g., to determine whether additional instruction on previously instructed topics is needed, or to use as a classroom assessment for grading purposes) and evaluation (e.g., to inform curriculum adoption, adaptation, and modification) at classroom, school, and district levels. End-of-Unit Assessments are developed by vendors working with DDOE staff and informed by educator reviews for classroom administration by teachers.

- The *Integrative Transfer Assessment* is administered to students in grade 5, grade 8, and high school biology. The Integrative Transfer Assessment is meant to capture students' learning of the content instructed during the entire year in each of the three grades in greater depth than the End-of-Unit Assessments. The Integrative Transfer Assessment requires students to apply their knowledge of science to grade-level-appropriate situations in order to solve unique, real-life problems. Integrative Transfer Assessments are developed by vendors working with DDOE staff and informed by educator committee reviews. They are administered through an online system in a secure testing environment and used for state accountability purposes.

The PEs assessed on the Integrative Transfer Assessments and End-of-Unit Assessments at each grade level are described in Appendix A.

Item specifications are intended to support item and item cluster development by providing a link between identified standards and the assessment. Item specifications describe how the standards being assessed are applied in the development of assessment items that measure them.

These item specifications are an important component of the item development process for the Delaware summative Integrative Transfer Assessments (ITA) and the End-of-Unit (EoU) Assessments. They play an essential role in ensuring the consistency and quality of items developed for each of these assessments. This document will provide general guidance for each of these assessments.

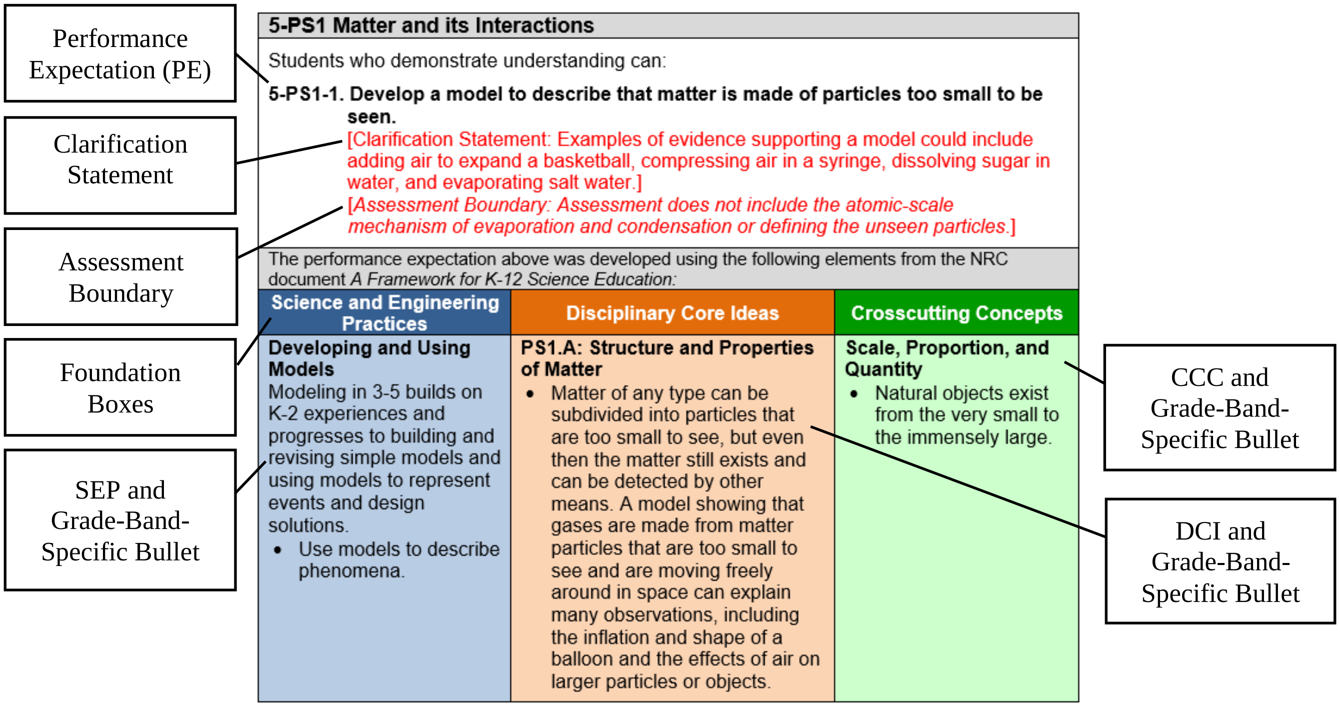
Organization of the NGSS

Science instruction aligned to the NGSS requires students to engage in scientific and engineering practices in the context of disciplinary core ideas and to use crosscutting concepts to make connections across topics. The NGSS set expectations for what students should know by the end of every grade level in elementary school and at the end of grade clusters at middle and high school for each of the three dimensions of science:

- Science and Engineering Practices (SEPs)
- Disciplinary Core Ideas (DCIs)
- Crosscutting Concepts (CCCs)

The goals for science learning are outlined in the NGSS in the form of performance expectations (PEs). PEs are statements about what students should know and be able to do at the end of instruction. Each PE combines an SEP with a DCI and an appropriate CCC. The associated specific dimensions for each PE are further identified through the NGSS foundation boxes (Figure 1). Clarification statements, when present, often provide examples intended to make clear the intent of the PE. Assessment boundaries, when present, describe limits in terms of the Delaware large-scale assessments (ITA and EoU).

Figure 1. Example of Performance Expectation (PE) with Foundation Boxes



Delaware has set the specific grade-level expectations for the PEs in the middle school and high school grade bands. These grade-level decisions are reflected in Appendix A.

The SEPs are grouped into eight categories and describe how students should engage in the practices used by scientists and engineers. Students engage in all eight of the SEPs over each grade band. The SEPs increase in complexity and sophistication, reflecting the progression in students' capabilities to use each of the practices as they progress from the lower to the upper grades. The eight SEPs are listed here:

1. Asking Questions and Defining Problems (Q/P)
2. Developing and Using Models (MOD)
3. Planning and Carrying out Investigations (INV)
4. Analyzing and Interpreting Data (DATA)
5. Using Mathematics and Computational Thinking (MCT)
6. Constructing Explanations and Designing Solutions (E/S)
7. Engaging in Argument from Evidence (ARG)
8. Obtaining, Evaluating, and Communicating Information (INFO)

The CCCs provide a way of linking the different domains of science and have application across all domains of science. Students engage in all seven of the CCCs over each grade band. As students' understanding of the disciplinary core ideas increases, their depth of understanding of the CCCs increases as well. Therefore, like the SEPs, the CCCs increase in complexity and sophistication across the grades. The seven CCCs are listed here:

1. Patterns (PAT)
2. Cause and Effect (C/E)
3. Scale, Proportion, and Quantity (SPQ)

4. Systems and System Models (SYS)
5. Energy and Matter (E/M)
6. Structure and Function (S/F)
7. Stability and Change (S/C)

The organization of the NGSS is structured around three domains (Physical Science; Life Science; Earth and Space Science) in the major fields of natural science, with the addition of one domain focused on Engineering, Technology, and Applications of Science (ETS). The domains are divided into core ideas, and the core ideas are further divided into supporting ideas. Each supporting idea includes a description of what students should understand at the end of instruction for the K–2, 3–5, 6–8, and 9–12 grade bands; together these make up the DCIs in the NGSS.

The DCIs are organized into the following 12 categories of core ideas:

Physical Sciences

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

Life Sciences

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

Earth and Space Sciences

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

Engineering, Technology, and Applications of Science

ETS1: Engineering Design

Integrative Transfer Assessment—Summative

General Guidelines

The Integrative Transfer Assessments in the Delaware Next Generation Science Assessment System are composed of item clusters and standalone (or discrete) items. These general guidelines provide descriptions of common elements of the summative assessments.

PE Bundles, Phenomena, and Stimuli

Item clusters are designed to prompt students to make sense of a phenomenon. The development of an item cluster begins with the selection of the Performance Expectation (PE) bundle and an appropriate phenomenon. PE bundles are selected from the eligible grade-level PEs based on the PEs needed to fulfill the assessment blueprint and the ability of the PE bundle to support a phenomenon that is appropriate for the assessment. A PE bundle may be within a domain or across multiple domains.

A phenomenon is defined as an observable event that occurs in the universe that can be explained through the application of the three dimensions of the NGSS. The stimulus provides the context or setting, including data sets, graphs, tables, models, and/or descriptions of investigations, in which the phenomenon is presented to students. The context should support the use of the intended specific dimensions. For example, the stimulus could describe an investigation if the intended SEP is Planning and Carrying Out Investigations. Stimuli must be scientifically correct and should be sourced from reputable sources.

A standalone item is not adequate for making sense of a phenomenon. Although each standalone item is based on a phenomenon, the item focuses on a single aspect of the phenomenon. The item requires the student to makes sense of only that aspect rather than the entire phenomenon.

Item Types

A variety of item types are available for use in the computer-based ITAs. The item type is deliberately chosen to elicit the evidence most appropriate for the PE and dimensions being assessed by the item. The following list describes the available item types.

- Multiple choice (MC): A prompt and four answer options with one correct choice (1 point)
- Multiple select (MS): A prompt and five to seven answer options with two correct choices (1 point)
- Technology-enhanced item (TEI): Designed for online administration only; item types include graphic gap match, match table grid, hot spot, and bar graph (1 or 2 points)
- Two-part dependent (TPD): Two-part item where the answer to Part B is an explanation of, or provides evidence to support, the answer to Part A; the student must get Part A correct to get any credit for Part B; partial credit is possible only if Part A is correct; possible combinations of item types in a TPD are: MC/MC, MC/TEI, and TEI/TEI (2 points)
- Two-part independent (TPI): Two-part item where each part is scored independently, and the student may get credit for Part B even if Part A is incorrect; possible combinations of item types in a TPI are: MC/MC, MC/TEI, and TEI/TEI (2 points)
- Constructed response (CR): Open-ended item that typically requires a 1–3 sentence response, for use in item clusters only (2 points)
- Extended response (ER): Open-ended item that typically requires a 5-sentence or longer response, for use in item clusters only (4 points)

Graphics

Graphics should be purposeful and be included as needed to add clarity, present data, and/or simplify a concept through a visual representation. Graphics may also provide a backdrop for some technology-enhanced items. Graphics for the ITA are developed in color. Colors are chosen to accommodate students with the various forms of color blindness.

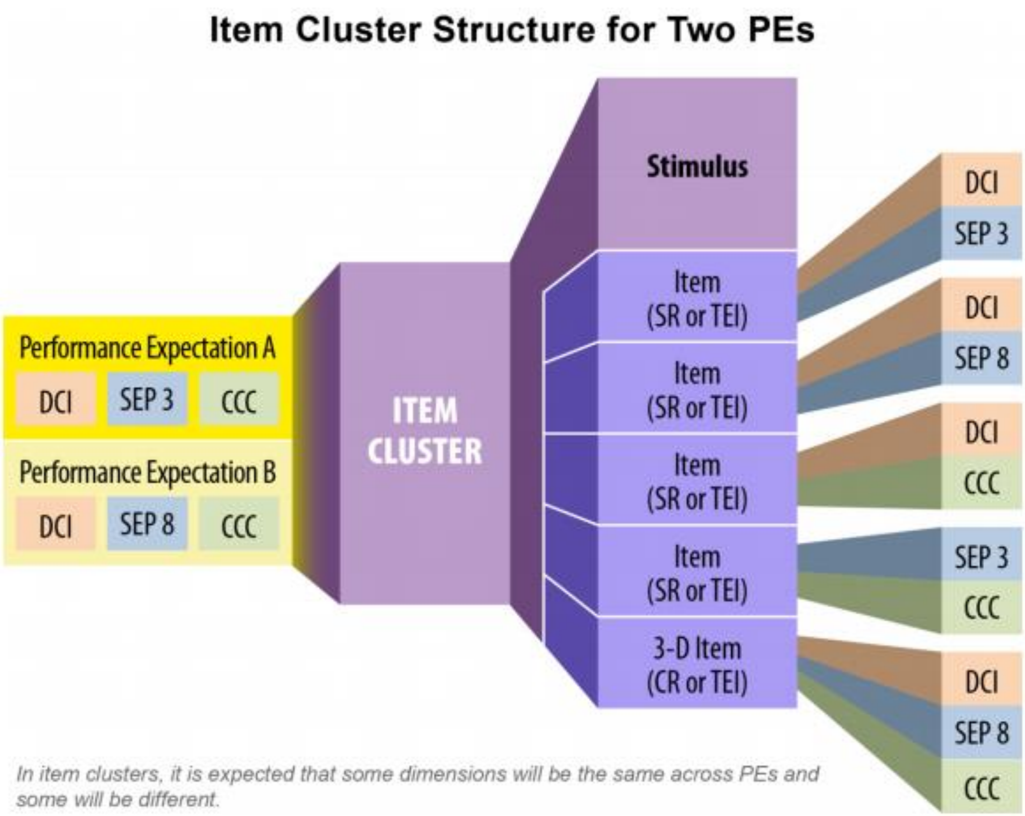
Item Cluster Characteristics

Each item cluster is aligned to a grade-specific performance expectation (PE) bundle and is based on a well-articulated phenomenon. Item clusters must be inclusive of all three dimensions in each of the associated PEs. It is not expected that a single item cluster will fully assess the breadth of the associated PEs. Any given PE may appear in more than one item cluster and in a variety of contexts.

The items in an item cluster share a common stimulus (or stimuli) that provides a realistic context in which to present the phenomenon. The information in the stimulus must be necessary and used along with content knowledge to answer every item. In other words, students must bring their knowledge of the standards in addition to the information in the stimulus in order to answer the items.

The majority of items in the ITA are included as part of an item cluster. Figure 2 shows the general structure of an item cluster. The item cluster represented in the figure is aligned to two PEs, A and B. The stimulus provides the context or setting in which the phenomenon is presented to students and supports the use of the intended specific dimensions. Each item is aligned to at least two of the dimensions from the PEs.

Figure 2. General Structure of an NGSS Item Cluster



There are two types of item clusters in an ITA, Integrative Item Clusters (IICs) and Regular Item Clusters (RICs). Depending on the grade level, an ITA is composed of one Integrative Item Cluster (IIC), either two or three Regular Item Clusters (RICs), and 10–14 Standalone Items (SAIs), as shown in the blueprints in Table 1 and Table 2.

Table 1. Grade 5 ITA Blueprint

RIC 01	SAI	IIC	RIC 02	SAI
5 items	5 items	6 items	5 items	5 items

Table 2. Grade 8 and Biology ITA Blueprint

RIC 01	SAI	IIC	RIC 02	SAI	RIC 03
5 items	7 items	6 items	5 items	7 items	5 items

The characteristics of each type of item cluster, RIC and IIC, are described below.

- Integrative Item Clusters (IICs)
    - Multiple stimuli; each stimulus applies to a subset of the six items
    - Aligned to a PE bundle (2–3 PEs)
    - Must include one ER item and may include any of the other item types, with the exception of a CR item

- Regular Item Clusters (RICs)
    - A single stimulus with adequate data and/or information to support up to 10 items (Note: A RIC is developed and field-tested with 8 to 10 items. A RIC in the ITA will appear with 5 of those items.)
    - Aligned to a PE bundle (2–3 PEs)
    - Must include one CR item and may include any of the other item types, with the exception of an ER item

Standalone items in the ITA help to ensure that a broad representation of the PE and dimensions appear on every assessment. Each standalone item is aligned to a single PE. The item must align to at least two of the three dimensions associated with the PE. Alignment to SEPs or CCCs outside of the PE is allowed only if the item also meets the requirement to align to at least two of the dimensions of the PE. All stimulus information is contained within the item itself.

Table 3 summarizes the characteristics of the components of the ITA.

Table 3. Characteristics of Item Clusters and Standalone Items for the ITA

Component	Integrative Item Cluster (IIC)	Regular Item Cluster (RIC)	Standalone Item (SAI)
Stimulus	• Heavy stimuli with a narrative thread or storyline, presented sequentially with items • A mix of text, color graphics, and/or data displays • May include animations and/or simulations	• Light stimulus presented at the beginning of the item set • A mix of text, color graphics, and/or data displays • Does not include animations or simulations	• Very short, as needed, to provide context • May include text, color graphics, and/or data displays • Does not include animations or simulations
Item sequence	Items are connected by a logical thread in the shared stimuli; they are closely linked to each other and have a logical, prescribed sequence, with items progressing in difficulty and complexity	A collection of independent items with a single shared stimulus; items may be presented in any order and include a mix of difficulty levels	Not applicable
Item types	• Multiple choice (MC), 1 point • Multiple select (MS), 1 point • Two-part dependent (TPD), 2 points • Two-part independent (TPI), 2 points • Technology-enhanced items (TEI), 1 or 2 points with partial credit possible • One extended response (ER), 4 points with partial credit possible	• Multiple choice (MC), 1 point • Multiple select (MS), 1 point • Two-part dependent (TPD), 2 points • Two-part independent (TPI), 2 points • Technology-enhanced items (TEI), 1 or 2 points with partial credit possible • One short answer constructed response (CR), 2 points with partial credit possible	• Multiple choice (MC), 1 point • Multiple select (MS), 1 point • Two-part dependent (TPD), 2 points • Two-part independent (TPI), 2 points • Technology-enhanced items (TEI), 1 or 2 points with partial credit possible
Items and points to be developed for FT	• 6 items, 10–13 points • Two 2-point items (e.g., TEIs, two-part items) • One 4-point extended response (ER) item	• 10 items, 13–16 points • Two to five 2-point items (e.g., TEIs, two-part items) • One 2-point short answer constructed response (CR) item	Not applicable
Operational form	• 5–6 items • 10–13 points	• 5 items • 7 points	Not applicable

Component	Integrative Item Cluster (IIC)	Regular Item Cluster (RIC)	Standalone Item (SAI)
Alignment	• PE bundle of 2–3 PEs • May include SEPs and CCCs beyond those associated with the PE	• PE bundle of 2–3 PEs • May include SEPs and CCCs beyond those associated with the PE	• A single PE • Must align to two PE dimensions • May include an additional dimension beyond the two PE-aligned dimensions
Student time to complete	20–24 minutes	13–16 minutes	1–3 minutes
Delivery	Online	Online	Online
Development approach	Develop and field test a full IIC (6 items)	Develop and field test an overage of items, and then select from that bank for operational use; stimulus should be the minimum necessary to support 5 items	Not applicable—Develop and FT an overage of SAIs to allow for operational form flexibility

Alignment

Delaware's assessment system prioritizes the importance of students' abilities to apply scientific content and principles across contexts. The three-dimensional nature of the NGSS PEs means that judging the alignment to these PEs is more complex in nature than judging the alignment to more traditional, one-dimensional standards. An item cluster should achieve alignment to all three dimensions associated with a PE or PE bundle when all items are considered in totality. Additionally, item clusters may include one or two items that are aligned to an SEP and/or a CCC not represented in, but supportive of, the dimensions in the PE bundle. For example, in an item cluster with a PE that includes the SEP of Planning and Carrying Out Investigations, there might be an item aligned to the SEP of Asking Questions and Defining Problems.

Any single item, be it a standalone or part of an item cluster, is unlikely to thoroughly access all three dimensions of a PE. However, responding to an item should require the integration of at least two of the three dimensions specific to a PE or a PE bundle. While individual items may be two- or three-dimensional, that is, addressing SEPs, DCIs, and/or CCCs in the PE or PE bundle, it is not necessary for each item to address the full breadth of a PE or of a dimension. Instead, the items address different aspects of the PE through different combinations of the dimensions. Additionally, the degree of alignment to each dimension may vary. For example, an item should be considered as aligned to the PE if it is strongly aligned to one dimension, partially aligned to another, and not aligned to the third. The fact that an item has some degree of alignment to at least two of the three dimensions of a PE determines the overall alignment of an item, not necessarily the strength of the alignment to each dimension.

Specific details about item and item cluster alignment requirements are summarized below.

- Each individual item, whether part of an item cluster or a standalone item, must align to at least two dimensions of a PE. Extended response (ER) items are an exception to this rule. ER items must be three-dimensional. An ER should align to all three dimensions of a PE, or to three of the dimensions across a PE bundle (an SEP, a CCC, and a DCI).
- Items are limited by the assessment boundary statement associated with a PE, when present.
- Item clusters are typically developed to align to a PE bundle of 2–3 PEs. The items that compose an item cluster must, as a set of items, include alignments to all three dimensions of each PE in the PE bundle.
- Additional Science and Engineering Practices (SEPs) and Crosscutting Concepts (CCCs), beyond those specified in the PEs in the PE bundle, may be included in the alignment of items in an item cluster.
- Alignment begins at the PE level. At the dimension level, the sub-bullets of the specific dimensions represented in a PE should be the basis of alignment decisions. However, these decisions should also be informed by the progressions documents (NGSS Lead States, 2013[1]; see, in particular, NGSS appendices E, F, and G), as well as by additional SEPs and CCCs, outside the specified PEs, that can—and, in many cases, should—be included in the alignment. Any additional alignment(s) should be captured as metadata.

Cognitive Complexity

The NGSS are structured in such a way as to expect student understanding beyond recall. The PEs have been written with high levels of cognitive complexity, incorporating knowledge with practice and explicitly identifying and utilizing unifying concepts to develop scientific explanations. A student's demonstration of basic content recognition or usage is not sufficient evidence of meaningful understanding of any PE. As a result, the traditional measures of cognitive complexity (e.g., Webb's Depth of Knowledge rating scale) are insufficient to represent the cognitive challenges embedded in the NGSS. Delaware's approach to cognitive complexity is based on "A Framework for Analyzing Cognitive Demand and Content-Practices Integration: Task Analysis Guide in Science" (Tekkumru-Kisa, Stein, and Schunn, 2015[2]). An item's cognitive complexity is classified according to three levels, or categories, described below.

- <u>Scripted</u>: The item provides heavy scaffolding, or a script, that explicitly tells the student what to do. "Cookbook" lab procedures fall into the scripted category. There is a well-defined set of actions or procedures a student needs to take, usually in a given order. Students can follow those actions and reach the desired answer without knowing how or why the script leads to that answer.

- <u>Guided</u>: The item provides some scaffolding, or suggested pathways, while requiring students to transfer their knowledge to a novel context. Students are expected to explain

[1] NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.
[2] Tekkumru-Kisa, Stein, and Schunn. (2015). "A Framework for Analyzing Cognitive Demand and Content-Practices Integration: Task Analysis Guide in Science." *Journal of Research in Science Teaching*, *52*(5), 659-685.

their reasoning for what they are doing. These items usually include using a model, data, and/or information to develop an explanation or argument.

- Doing Science: The item provides very little to no scaffolding and provides the opportunity for student-designed explorations. The students are required to identify which practices, or which use of practices and/or crosscutting concepts, are most appropriate to develop or deepen understanding of a scientific idea and/or explore a phenomenon. These items may engage a student in developing a model, developing an explanation, or developing an argument from their own analysis of raw data.

This approach to cognitive complexity also accounts for the number of dimensions to which an item is aligned. Every item must be an integration of at least two of the three dimensions (SEP, DCI, and CCC). Therefore, an item's cognitive complexity is a combination of the level of independence required of the student in responding to the item and the level of integration of dimensionality. For example, an item with heavy scaffolding aligned to an SEP and a DCI would have a cognitive complexity designation of Scripted Integration 2 (SI2), whereas an item with somewhat less scaffolding aligned to all three dimensions would have a cognitive complexity designation of Guided Integration 3 (GI3).

The categories of cognitive complexity are summarized in Table 4. The cognitive complexity of an item increases from top to bottom across Table 4, from Scripted to Guided to Doing Science tasks. Cognitive complexity also increases from left to right with the increased integration of the dimensions, from the integration of two dimensions (SI2, GI2, or DI2) to the integration of three dimensions (SI3, GI3, or DI3), as shown in Table 4. Items are developed across the range of cognitive complexity to support the goal of representing a range of cognitive complexity across each assessment.

Table 4. Cognitive Complexity

Increasing complexity →

Increasing complexity ↓

	One Dimension* (SEP or DCI)	Two Dimensions	Three Dimensions
Memorized Tasks	Repeating definitions of practices or content*	N/A	N/A
Scripted Tasks	Following a scripted practice or following a script to utilize content*	Following a script to work on practices or crosscutting concepts tied to content (SI2)	Following a script to work on practices and crosscutting concepts tied to content (SI3)
Guided Tasks	Guided work with a practice or guided to understanding of content*	Guidance for work on practices or crosscutting concepts tied to content (GI2)	Guidance for work on practices and crosscutting concepts tied to content (GI3)
Doing Science Tasks	N/A	Engaging in practices or crosscutting concepts to make sense of content and recognizing how scientific knowledge is developed (DI2)	Identifying appropriate practices or crosscutting concepts and engaging them to make sense of content, and recognizing how scientific knowledge is developed (DI3)

*Not used in assessment development

End of Unit Assessment—Interim

End-of-Unit Assessments are intended to complement the Integrative Transfer Assessments by providing ongoing student and teacher feedback throughout instruction. As assessment is intended to provide educators with tools to inform instruction and intervention, ongoing feedback is an important part of a strong science education system.

Like Integrative Transfer Assessments, End-of-Unit Assessments are designed to prompt students to make sense of a phenomenon. Item clusters are developed from a selection of Performance Expectations aligned with associated curricular units, and assessment is delivered at the end of instruction.

There will be a total of three EoUs per grade (grades 3–10) to align with each curricular unit taught in each grade. The exception is grade 6, which has four units and four EoUs. EoUs are developed and delivered as paper-pencil assessments with ancillary student answer booklets and teacher guides.

The EoU assessments are developed according to the guidelines described for the ITA. Differences between the EoU and the ITA are noted in the following descriptions.

PE Bundles and Phenomena

Item clusters that make up an EoU are designed to prompt students to make sense of a phenomenon that is closely related to a curricular unit. PE bundles for each item cluster are selected from the set of grade-level PEs included in that curricular unit. The PEs included across the item clusters that make up an EoU will represent the entire set of PEs for the curricular unit.

Item Types

A variety of item types are available for use on the paper-based EoUs. The item type is deliberately chosen to elicit the evidence most appropriate for the PE and dimensions being assessed by the item. The following list describes the available item types.

- Multiple choice (MC): A prompt and four answer options with one correct choice (1 point)
- Multiple select (MS): A prompt and five to seven answer options with two correct choices (1 point)
- Paper-pencil innovative item (PPI): Technology-enhanced-like item, designed for paper administration; item types include bar graphs, student-drawn models, and tables (1 or 2 points)
- Two-part dependent (TPD): Two-part item where the answer to Part B is an explanation of, or provides evidence to support, the answer to Part A; the student must get Part A correct to get any credit for Part B; partial credit is possible only if Part A is correct; possible combinations of item types in a TPD are: MC/MC, MC/PPI, and PPI/PPI (2 points)
- Two-part independent (TPI): Two-part item where each part is scored independently, and the student may get credit for Part B even if Part A is incorrect; possible combinations of item types in a TPI are: MC/MC, MC/PPI, and PPI/PPI (2 points)

- Constructed response (CR): Open-ended item that typically requires a 1–3 sentence response, for use in item clusters only (2 points)
- Extended response (ER): Open-ended item that typically requires a 5-sentence or longer response, for use in item clusters only (4 points)

Graphics

Graphics should be purposeful and be included as needed to add clarity, present data, and/or simplify a concept through a visual representation. Graphics may also provide a backdrop for some paper-pencil innovative items. Graphics for the EoU are developed in grayscale.

Item Cluster Characteristics

All items in the EoU are included as part of an item cluster. As in the ITA, the stimulus provides the context or setting in which the phenomenon is presented to students and supports the use of the intended specific dimensions. Each item is aligned to at least two of the dimensions from the PEs.

Unlike the ITA that includes two types of item clusters, IICs and RICs, each EoU is composed of two to three IICs, as shown in the blueprints in Table 5 and Table 6.

Table 5. Grades 3–5 EoU Blueprint

IIC 01	IIC 02	Total Items	Time
4–8 items	4–8 items	12	No more than 45 minutes

Table 6. Grades 6–High School EoU Blueprint

IIC 01	IIC 02	IIC 03	Total Items	Time
4–8 items	4–8 items	4–8 items	18	No more than 90 minutes

The composition of the IICs in an EoU varies somewhat from the composition of an IIC in an ITA. The characteristics of IICs in an EoU are described in the list below, and additional details are included in Table 7.

- Each IIC includes multiple stimuli; each stimulus applies to a subset of the items.
- The EoU is aligned to all of the PEs associated with a unit of instruction (5–16 PEs per unit). (Note: Each IIC in an EoU is aligned to a subset of the PEs associated with the unit.)
- Each EoU must include one IIC culminating in an ER item. Other IICs making up an EoU form must culminate with a CR item.
- IICs may include any of the other item types except for TEIs. PPI items will take the place of TEIs.
- Additional dimensions (SEPs and CCCs) are included in items to reflect the way NGSS is taught in classrooms.

Table 7. Characteristics of IICs for the EoU

Component	Description
Stimulus	• Heavy stimuli with a narrative thread or storyline, presented sequentially with items as the student progresses through the cluster • A mix of text, grayscale graphics, and/or data displays
Item sequence	Items are connected by a logical thread in the shared stimuli; they are closely linked to each other and have a logical, prescribed sequence, with items progressing in difficulty and complexity.
Item types	• Multiple choice (MC), 1 point • Multiple select (MS), 1 point • Two-part dependent (TPD), 2 points • Two-part independent (TPI), 2 points • Paper-pencil innovative (PPI), 1 or 2 points with partial credit possible • One extended response (ER) per EoU, 4 points with partial credit possible • Grades 3–5: One short answer constructed response (CR) per EoU, 2 points with partial credit possible • Grades 6–10: Two short answer constructed responses (CRs) per EoU, 2 points each with partial credit possible
Items and points to be developed	• 6–10 items, with an average of 8 per form • 1–3 two-point items (e.g., TEI and two-part items) • 1 four-point extended response (ER) item per EoU • Grades 3–5: One 2-point constructed response (CR) per EoU • Grades 6–10: Two 2-point constructed response (CR) per EoU
Operational form	• 4-8 items per IIC • Grades 3–5: 12 items total • Grades 6–10: 18 items total
Alignment	• PE bundle of typically 2–8 PEs • May include SEPs and CCCs beyond those associated with the PE
Student time to complete	• 18–28 minutes per IIC, 45 minutes per EoU • 22–35 minutes per IIC, 90 minutes per EoU
Delivery	Paper
Development approach	• Grades 3–5: Develop and field test a full EoU form with 2 IICs • Grades 6–10: Develop and field test a full EoU form with 3 IICs

Appendix A

The NGSS were developed and organized by grade level for kindergarten through grade 5. The middle and high school standards were organized by grade band. For the middle and high school grades, Delaware has outlined which standards should be taught each year in grades 8–10. Some standards at the secondary level (indicated by **) are introduced more than once, or only to a certain degree at a given grade or over the course of a grade band. Assessment boundaries for each repeated or limited performance expectation are presented in this document.

Grade 3

Forces and Interactions

Code	Performance Expectation
3-PS2-1	Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
3-PS2-2	Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.
3-PS2-3	Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
3-PS2-4	Define a simple design problem that can be solved by applying scientific ideas about magnets.

Environmental Impacts on Organisms and Life Cycles and Traits

Code	Performance Expectation
3-LS2-1	Construct an argument that some animals form groups that help members survive.
3-LS4-1	Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.
3-LS4-3	Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
3-LS4-4	Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.
3-LS1-1	Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.
3-LS3-1	Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.

3-LS3-2	Use evidence to support the explanation that traits can be influenced by the environment.
3-LS4-2	Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.

Weather and Climate

Code	Performance Expectation
3-ESS2-1	Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.
3-ESS2-2	Obtain and combine information to describe climates in different regions of the world.
3-ESS3-1	Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.

Engineering Design—Bundled as Appropriate

Code	Performance Expectation
3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Grade 4

Energy and Waves

Code	Performance Expectation
4-PS3-1	Use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-2	Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

4-ESS3-1	Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
4-PS4-1	Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.
4-PS4-3	Generate and compare multiple solutions that use patterns to transfer information.

Structure/Function and Information Processing

Code	Performance Expectation
4-PS4-2	Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.
4-LS1-1	Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
4-LS1-2	Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

Processes that Shape the Earth

Code	Performance Expectation
4-ESS1-1	Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.
4-ESS2-1	Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.
4-ESS2-2	Analyze and interpret data from maps to describe patterns of Earth's features.
4-ESS3-2	Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Engineering Design—Bundled as Appropriate

Code	Performance Expectation
3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Grade 5

Structures and Properties of Matter

Code	Performance Expectation
5-PS1-1	Develop a model to describe that matter is made of particles too small to be seen.
5-PS1-2	Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.
5-PS1-3	Make observations and measurements to identify materials based on their properties.
5-PS1-4	Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

Ecosystems and Earth Systems

Code	Performance Expectation
5-PS3-1	Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.
5-LS1-1	Support an argument that plants get the materials they need for growth chiefly from air and water.
5-LS2-1	Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
5-ESS2-1	Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
5-ESS2-2	Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.
5-ESS3-1	Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Stars and the Solar System

Code	Performance Expectation
5-PS2-1	Support an argument that the gravitational force exerted by Earth on objects is directed down.
5-ESS1-1	Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth.

5-ESS1-2	Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Engineering Design—Bundled as Appropriate

Code	Performance Expectation
3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Grade 6

Earth History

Code	Performance Expectation
MS-ESS1-4	Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.
MS-LS4-1	Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
MS-ESS2-1	Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
MS-ESS3-1	Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.
MS-ESS3-2	Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
MS-ESS2-2	Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
MS-ESS2-3	Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

Solar System

Code	Performance Expectation
MS-ESS1-1	Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

MS-ESS1-2	Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
MS-ESS1-3	Analyze and interpret data to determine scale properties of objects in the solar system.

Force and Motion

Code	Performance Expectation
MS-PS2-1	Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
MS-PS2-2	Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-PS2-3	Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
MS-PS2-4	Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
MS-PS2-5	Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

Structure/Function (Body Systems)

Code	Performance Expectation
****MS-LS1-3**	Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. (*Evidence Statements 2.a.iii and 2.a.iv*) *Students identify and describe the given evidence that supports the claim (e.g., evidence from data and scientific literature), including evidence that:* • *Different organs can work together as subsystems to form organ systems that carry out complex functions (e.g., the heart and blood vessels work together as the circulatory system to transport blood and materials throughout the body).* • *The body contains organs and organ systems that interact with each other to carry out all necessary functions for survival and growth of the organism (e.g., the digestive, respiratory, and circulatory systems are involved in the breakdown and transport of food and the transport of oxygen throughout the body to cells, where the molecules can be used for energy, growth, and repair).*
****MS-LS1-7**	Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

	• *Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, support growth, or release energy.*
MS-LS1-8	Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Engineering Design—Bundled as Appropriate

Code	Performance Expectation
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Grade 7

Diversity of Life/Cell Structure/Function

Code	Performance Expectation
MS-LS1-1	Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
MS-LS1-2	Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
****MS-LS1-3**	Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. (*Evidence Statement 1.a*) • *Students make a claim to be supported, related to a given explanation or model of a phenomenon. In the claim, students include the idea that the body is a system of interacting subsystems composed of groups of cells.*
MS-LS1-4	Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
MS-LS1-5	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

MS-LS3-1	Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.
MS-LS3-2	Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

Our Genes Ourselves/Genetics-Natural Selection

Code	Performance Expectation
MS-LS4-1	Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
MS-LS4-2	Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
MS-LS4-3	Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.
MS-LS4-4	Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
MS-LS4-5	Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.
MS-LS4-6	Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. (*Evidence Statements 1.a.i, 1.a.ii, and 1.a.iii*) *Students identify the explanations for phenomena that they will support, which include:* • *i. Characteristics of a species change over time (i.e., over generations) through adaptation by natural selection in response to changes in environmental conditions.* • *ii. Traits that better support survival and reproduction in a new environment become more common within a population within that environment.* • *iii. Traits that do not support survival and reproduction as well become less common within a population in that environment.*

Properties of Matter

Code	Performance Expectation
MS-PS1-1	Develop models to describe the atomic composition of simple molecules and extended structures.
MS-PS1-2	Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
MS-PS1-3	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-PS1-4	Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
MS-PS1-5	Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.
MS-PS1-6	Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

Engineering Design—Bundled as Appropriate

Code	Performance Expectation
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Grade 8

Transformation of Energy

Code	Performance Expectation
MS-PS3-1	Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
MS-PS3-2	Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

****MS-PS3-3**	Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. • *Generalized context*
****MS-PS3-4**	Plan an investigation to determine the relations among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. • *Generalized context*
MS-PS3-5	Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
MS-PS4-1	Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.
MS-PS4-2	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

Weather and Climate

Code	Performance Expectation
****MS-PS3-3**	Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. • *In context of assessing, illustrating, or explaining weather patterns, water cycle, convection currents or weather systems.*
****MS-PS3-4**	Plan an investigation to determine the relations among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. • *In context of assessing, illustrating, or explaining weather patterns, water cycle, convection currents or weather systems.*
MS-ESS2-5	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
MS-ESS2-6	Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
MS-ESS2-1	Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
MS-ESS2-4	Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

****MS-ESS3-2**	Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. *(related to severe weather events)*
MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS3-4	Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Ecosystems

Code	Performance Expectation
MS-LS1-6	Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
MS-LS2-1	Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-2	Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
MS-LS2-3	Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
MS-LS2-4	Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-LS2-5	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
****MS-LS1-7**	Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. • *Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.*

Engineering Design—Bundled as Appropriate

Code	Performance Expectation
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Grade 9

Foundational Chemistry—Structure and Properties of Matter and Chemical Reactions

Code	Performance Expectation
HS-PS1-1	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
****HS-PS1-2**	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. (*Evidence statements 1ai, ii, iii*) *Students construct an explanation of the outcome of the given reaction, including:* • *i. The idea that the total number of atoms of each element in the reactant and products is the same;* • *ii. The numbers and types of bonds (i.e., ionic, covalent) that each atom forms, as determined by the outermost (valence) electron states and the electronegativity;* • *iii. The outermost (valence) electron state of the atoms that make up both the reactants and the products of the reaction is based on their position in the periodic table.*
****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. (*Evidence statement 1a*) *a) Students construct an explanation that includes the idea that as the kinetic energy of colliding particles increases and the number of collisions increases, the reaction rate increases.*
****HS-PS1-7**	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. (*Evidence statements 1aiii, iv-conceptual*)

	Students identify and describe the relevant components in the mathematical representations: • *iii. Use of balanced chemical equation(s); and* • *iv. Identification of the claim that atoms, and therefore mass, are conserved during a chemical reaction.*

Forces and Interactions/Energy Transfer and Conservation

Code	Performance Expectation
HS-PS2-3	Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
****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. (*Evidence statements 1a & b conceptual*) *Observable features of the student performance by the end of the course:* • *a) Students clearly define the system of the interacting objects that is mathematically represented.* • *b) Using the given mathematical representations, students identify and describe* the gravitational attraction between two objects as the product of their masses divided by the separation distance squared (Fg = −G m1m2 d2), where a negative force is understood to be attractive.*
HS-PS2-5	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
****HS-PS3-1**	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. (*Evidence statements ai, ii, iii, iv*) *Observable features of the student performance by the end of the course:* • *a Students identify and describe* the components to be computationally modeled, including:* *i. The boundaries of the system and that the reference level for potential energy = 0 (the potential energy of the initial or final state does not have to be zero);* *ii. The initial energies of the system's components (e.g., energy in fields, thermal energy, kinetic energy, energy stored in springs — all expressed as a total amount of Joules in June 2015 Page 1 of 2 each component), including a quantification in an algebraic description to calculate the total initial energy of the system;*

	iii. The energy flows in or out of the system, including a quantification in an algebraic description with flow into the system defined as positive; and *iv. iv. The final energies of the system components, including a quantification in an algebraic description to calculate the total final energy of the system.*
HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
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.
HS-PS3-4	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
HS-PS3-5	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
HS-PS4-1	Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).

Earth Systems

Code	Performance Expectation
HS-ESS1-2	Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.
HS-ESS1-3	Communicate scientific ideas about the way stars, over their life cycle, produce elements.
HS-ESS1-5	Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.
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.

HS-ESS2-1	Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.
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.
HS-ESS2-3	Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
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.
HS-ESS2-5	Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
HS-ESS2-6	Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
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 systems.

Engineering Design—Bundled as Appropriate

Code	Performance Expectation
HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
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.
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

High School Biology

Cellular Foundation of Life/ Structure and Function

Code	Performance Expectation
HS-LS1-1	Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.
HS-LS1-2	Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1-3	Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
HS-LS1-4	Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

Matter and Energy and Interdependent Relationships in Ecosystems

Code	Performance Expectation
HS-LS1-5	Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
HS-LS1-6	Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.
HS-LS1-7	Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.
HS-LS2-3	Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
HS-LS2-4	Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
HS-LS2-5	Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
HS-ESS2-6	Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
HS-ESS2-7	Construct an argument based on evidence about the simultaneous coevolution of Earth’s systems and life on Earth.
HS-LS2-1	Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
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.
HS-LS2-6	Evaluate the 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.
HS-LS2-7	Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

HS-LS2-8	Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.
HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
HS-PS1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Inheritance and Variation of Traits and Natural Selection and Evolution

Code	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.
HS-LS3-2	Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
HS-LS3-3	Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
HS-LS4-1	Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
HS-LS4-2	Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
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.
HS-LS4-4	Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
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.

HS-LS4-6	Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Engineering Design—Bundled as Appropriate

Code	Performance Expectation
HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
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.
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Appendix B

Table B-1. Writing and Review Checklist

Content
• Alignment with PE dimensions • Content relevancy • Grade-level appropriateness • Clearly formulated item stems • Clear and accurately drawn graphics • Correct answers are defensible • Distracters are plausible and logical
Language
• Wording is clear and focused • Vocabulary is grade-appropriate • Sentences are simple rather than complex • Only essential information is included • Grammar, spelling, and punctuation are correct
Structure
• All graphics are introduced or referred to in the text • Frame of reference is positive • Answer choices are concise; of similar length, complexity, and detail; and grammatically parallel • Balanced use (or no use) of words from stem or "cue" words • Answer choices are logically ordered
Bias/Sensitivity Issues
• Stimuli and items provide equal opportunity and access for all students • Portrayal of groups (e.g., racial, ethnic, religious, cultural, gender, social, regional) is appropriate • Potentially sensitive issues are avoided (e.g., violence, religious holidays, death, divorce, alcoholism)