INDIANA DEPARTMENT *of* EDUCATION

ILEARN Science Grade 6
Item and Item Cluster Specifications

Beginning School Year 2023-2024

Introduction

This document presents *cluster specifications* for use with the Next Generation Science Standards (NGSS). These standards are based on the Framework for K-12 Science Education. The present document is not intended to replace the standards, but rather to present guidelines for the development of items and item clusters used to measure those standards.

The remainder of this section provides a very brief introduction to the standards and the framework, an overview of the design and intent of the item clusters, and a description of the cluster specifications that follow. The bulk of the document is composed of cluster specifications, organized by grade and standard.

Background on the framework and standards

The Framework for K-12 Science Education are organized around three core dimensions of scientific understanding. The standards are derived from these same dimensions:

- Disciplinary Core Ideas: The fundamental ideas that are necessary for understanding a given science discipline. The core ideas all have broad importance within or across science or engineering disciplines, provide a key tool for understanding or investigating complex ideas and solving problems, relate to societal or personal concerns, and can be taught over multiple grade levels at progressive levels of depth and complexity.

- Science and Engineering Practices: The practices are what students DO to make sense of phenomena. They are both a set of skills and a set of knowledge to be internalized. The SEPs reflect the major practices that scientists and engineers use to investigate the world and design and build systems.

- Cross-Cutting Concepts: These are concepts that hold true across the natural and engineered world. Students can use them to make connections across seemingly disparate disciplines or situations, connect new learning to prior experiences, and more deeply engage with material across the other dimensions. The NGSS requires that students explicitly use their understanding of the CCCs to make sense of phenomena or solve problems.

- There is substantial overlap between and among the three dimensions. For example, the cross-cutting concepts are echoed in many of the disciplinary core ideas. The core ideas are often closely intertwined with the practices. This overlap reflects the nature of science itself. For example, we often come to understand and communicate causal relationships by employing models to make sense of observations. Even within a dimension, overlap exists. Quantifying characteristics of phenomena is important in developing an understanding of them, so employing computational and mathematical thinking in the construction and use of models is a very common scientific practice, and one of the cross-cutting concepts suggests that scientists often infer causality by observing patterns. In short, the dimensions are not orthogonal.

The framework envisions effective science education as occurring at the intersection of these interwoven dimensions: students learn science by doing science—applying the practices through the lens of the cross-cutting concepts to investigate phenomena that relate to the content of the disciplinary core ideas.

Item clusters

Each item cluster is designed to engage the examinee in a grade-appropriate, meaningful scientific activity aligned to a specific standard.

Each cluster begins with a phenomenon, an observable fact or design problem that engages student interest and can be explained, modeled, investigated, or designed using the knowledge and skill described by the standard in question. What it means to be observable varies across practices. For example, a phenomenon for a performance expectation exercising the a*nalyze data* practice may be observable through regularities in a data set, while standards related to the *development and use of models* might be something that can be watched, seen, felt, smelled, or heard.

What it means to be observable also varies across grade levels. For example, elementary-level phenomena are very concrete and directly observable. At the high school level, an observation of the natural world may be more abstract--for example, “observing” changes in the chemical composition of cells through the observation of macroscopic results of those changes on organism physiology, or through the measurement of system- or organ-level indications.

Content limits refine the intent of the performance expectations and provide limits on what may be asked of items in the cluster to structure the student activity. The content limits also reflect the disciplinary core ideas learning progressions that are present in the K-12 Framework for Science Education.

The task or goal should be explicitly stated in the stimulus or the first item in the cluster: statements such as “In the questions that follow, you will develop a model that will allow you to identify moons of Jupiter,” or “In the questions below, you will complete a model to describe the processes that lead to the steam coming out of the teapot.”

Whereas item clusters have been described elsewhere as “scaffolded,” they are better described as providing structure to the task. For example, some clusters begin with students summarizing data to discover patterns that may have explanatory value. Depending on the grade level and nature of the standard, items may provide complete table shells or labeled graphs to be drawn, or may require the student to choose what to tabulate or graph. Subsequent items may ask the student to note patterns in the tabulated or graphed data and draw on domain content knowledge to posit explanations for the patterns.

These guidelines for clusters do not appear separately in the specifications. Rather, they apply to all clusters.

Structure of the cluster specifications

The item cluster specifications are designed to guide the work of item writers and the review of item clusters by stakeholders.

Each item cluster has the following elements:

- The text of the performance expectations, including the practice, core idea, and cross-cutting concept.
- Content limits, which refine the intent of the performance expectations and provide limits of what may be asked of examinees. For example, they may identify the specific formulae that students are expected to know or not know.
- Vocabulary, which identifies the relevant technical words that students are expected to know, and related words that they are explicitly not expected to know. Of course, the latter category should not be considered exhaustive, since the boundaries of relevance are ambiguous, and the list is limited by the imagination of the writers.
- Sample phenomena, which provide some examples of the sort of phenomena that would support effective item clusters related to the standard in question. In general, these should be guideposts, and item writers should seek comparable phenomena, rather than drawing on those within the documents. Novelty is valued when applying scientific practices.
- Task demands comprise the heart of the specifications. These statements identify the types of items and activities that item writers should use, and each item written should be clearly linked to one or more of the demands. The verbs in the demands (e.g., *select, identify, illustrate, describe*) provide guidance on the types of interactions that item writers might employ to elicit the student response. We avoid explicitly identifying interaction types or item formats to accommodate future innovations and to avoid discouraging imaginative work by the item writers.
- For each cluster we present, the printed documentation includes the cluster, the task demands represented by each item, and its linkage to the practice and cross-cutting concept identified in the performance expectation.

Range Performance Level Descriptors (PLDs)

The Grade 6 Science Range PLDs provide content-specific claims across each Performance Expectation to represent the range of expectations for student performance within each proficiency level. These PLDs can be used to inform instructional practices as educators consider proficiency of the content. Additionally, educators may use the content examples to consider how to remediate or extend key instructional concepts to transition students across proficiency levels of performance.

Item cluster specifications follow, organized by domain and standard.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS4-1
Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.</td></tr>
<tr><td>Dimensions</td><td>Using Mathematics and Computational Thinking
• Use mathematical representations to describe and/or support scientific conclusions and design solutions.</td><td>PS4.A: Wave Properties
• A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.</td><td>Patterns
• Graphs and charts can be used to identify patterns in data.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasize describing waves with both quantitative and qualitative thinking.
• Examples could include using graphs, charts, computer simulations, or physical models to demonstrate amplitude and energy correlation.
• All equations and formulas must be provided and be age-appropriate.

Content Limits
• Assessment does not include electromagnetic waves and is limited to standard repeating waves.
• Assessment does not include identifying or knowing characteristics of different types of waves (mechanical, electromagnetic, sonic, etc.).
• <u>Students do not need to know</u>: how two waves carrying the same energy can have different amplitudes when introduced into materials of different densities and elasticities.</td></tr>
<tr><td>Science Vocabulary Students Are Expected to Know</td><td colspan="3">Speed, force, kinetic energy, proportional, sound wave, wavelength, frequency, resting position, medium, crest, trough</td></tr>
<tr><td>Science Vocabulary Students Are Not Expected to Know</td><td colspan="3">Elastic, seismic wave, oscillate.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS4-1:
• The 1896 Sanriku earthquake off the coast of Japan generated ocean waves that reached a height of 100 feet (30 m).
• Compared to a megaphone that sends sound messages up to 300 meters away, a Long Range Acoustic Device (LRAD) sends messages that can be heard up to 5,500 meters away.
• Scientists at the Swiss Federal Institute in Zurich caused a toothpick to levitate using sound waves.
• A wave travels down a rope from one student to another when the first student shakes it.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Compile and analyze data to make an inference about the relationship between amplitude and energy of a wave. This may include sorting out relevant from irrelevant data in the given information.</td></tr>
<tr><td colspan="4">2. Organize and/or arrange (e.g., using illustrations and/or labels) or summarize data to highlight trends, patterns, or correlations that reflect how energy changes with amplitude of a wave and vice versa.</td></tr>
<tr><td colspan="4">3. Identify how wave characteristics correspond to physical observations (e.g., wave amplitude corresponds to sound volume).</td></tr>
</table>

4.	Use relationships identified in the data to predict the energy or amplitude change of a wave if the other parameter is changed.
5.	Based on data, calculate or estimate one property of a wave (energy or amplitude) and the relationships between different properties of a wave.
6.	Use graphs, charts, simulations, or physical models to demonstrate amplitude and energy correlation.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS4-2
Develop and/or use a model to describe that waves are reflected, absorbed, or transmitted through various materials.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop and/or use a model to predict and/or describe phenomena.</td><td>PS4.A: Wave Properties
• A sound wave needs a medium through which it is transmitted.

PS4.B: Electromagnetic Radiation
• When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object’s material and the frequency (color) of the light.
• The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass), where the light path bends.
• A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
• However, because light can travel through space, it cannot be a matter wave, like sound or water waves.</td><td>Structure and Function
• Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statement
• Emphasis is on both light and mechanical waves.
• Examples of models could include drawings, simulations, and written descriptions. This includes amplitudes, frequencies, and wave lengths.

Content Limits
• Assessment is limited to qualitative applications pertaining to light and mechanical waves, not quantitative.
• Assessment does not include:
  ○ Particle movement and compression waves
  ○ Constructive or destructive interference</td></tr>
<tr><td>Science Vocabulary Students are Expected to Know</td><td colspan="3">Refracted, medium, transparent, frequency, brightness, color, bending, amplitude, sound wave, light wave, path, propagation, filter, barrier, lens, mirror, mechanical waves, electromagnetic, visible light, ray, prism, wavelength.</td></tr>
<tr><td>Science Vocabulary Students are Not Expected to Know</td><td colspan="3">Longitudinal wave, transverse wave, compression wave, seismic waves, radio wave, microwave, infrared, ultraviolet, x-rays, gamma rays, angle of incidence, concave, convex, diffraction, constructive interference, destructive interference</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-PS4-2:
• One part of a straw appears to be broken from the rest of the straw when viewed through the side of a glass of water.
• Music placed near a lake can be heard clearly while sitting on the shore. However, while swimming under the water, the sound cannot be heard as clearly.
• Objects are more visible during a moonlit night when there is snow on the ground vs. when there is no snow on the ground.
• Loud music moves the leaves of a plant.</td></tr>
</table>

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Select from a collection of potential model components including distractors, the components needed to model the phenomenon. Components might include type of wave, properties of the wave, the materials with which the waves interact, the position of the source of the wave, etc.
2. Assemble, from a collection of potential model components, an illustration or flow chart that is capable of representing the movement, transmission, reflection, refraction, and absorption of waves. This does not include labeling an existing diagram.
3. Manipulate the components of a model to demonstrate the changes that cause the observed phenomenon.
4. Manipulate the components of a model to predict the behavior of waves in an alternate scenario.
5. Given models or diagrams of how a wave interacts with different materials, identify the wave properties and how they change in each scenario OR identify the properties of the different materials that cause the wave to behave differently.
6. Identify missing components, relationships, or other limitations of the model.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-PS4-3
Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.</td></tr>
<tr><td>Dimensions</td><td>Obtaining, Evaluating, and Communicating Information
• Integrate qualitative scientific and technical information in written text with information contained in media and visual displays to clarify claims and findings.</td><td>PS4.C: Information Technologies and Instrumentation
• Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information</td><td>Structure and Function
• Structures can be designed to serve particular functions.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
Emphasis is on a basic understanding that waves can be used for communication purposes.
Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.
Examples could also include using vinyl record vs. digital song files, film cameras vs. digital cameras, or alcohol thermometers vs. digital thermometers.
Content Limits
Assessment does not include binary counting.
Assessment does not include the specific mechanism of any given device.
<u>Students do not need to know</u>:
Specifics about binary or any other coding process.
How certain mechanisms work other than the fact that they are either analog or digital.
Students are not responsible for knowing the different parts of mechanisms: hard drives, USB cables, flash drives, and servers.</td></tr>
<tr><td>Science Vocabulary Students Are Expected to Know</td><td colspan="3">Computer, machine, communicate, electricity, device, coded, decode, conversion/convert, digitize, encode, radio wave</td></tr>
<tr><td>Science Vocabulary Students Are Not Expected to Know</td><td colspan="3">Binary, emit, photoelectric, pixel, electromagnetic radiation, radiation, wave packet, wave source, ohm, photon, microwave, ultraviolet, volt, ampere.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for Standard MS-PS4-3:
A digital scale gives better precision on weight measurements than analog.
Digital films are higher quality than analog films (from a film reel).
Digital measurements provide precise values compared to analog measurements
Digital data can be stored in a server and easily retrieved if the hardware breaks, while analog data are lost if the hardware is broken.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Identify evidence that is sufficient to support the claim that digital signals are a more reliable way to store and transmit information than analog signals.</td></tr>
</table>

2.	Citing evidence, identify specific features of digital signals that make them more reliable than analog signals OR identify specific examples of how digitization of a certain technology has advanced science.
3.	Gather, read and synthesize information from multiple sources and assess the credibility, accuracy, and possible bias of each publication; describe how they are supported or not supported by evidence.
4.	Evaluate data and/or conclusions in scientific and technical texts in light of competing information.

<table>
<tr><td>Performance Expectation</td><td colspan="3">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.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</td><td>LS1.C: Organization for Matter and Energy Flow in Organisms
• Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

PS3.D: Energy in Chemical Processes and Everyday Life
• The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen (secondary).</td><td>Energy and Matter
• Within a natural system, the transfer of energy drives the motion and/or cycling of matter.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on tracing movement of matter and flow of energy.
• Students are able to identify relationships between dependent and independent variables.

Content Limits
• Assessment does not include the biochemical mechanisms of photosynthesis.
• Assessment does not include the carbon cycle or nitrogen fixation.
• <u>Students do not need to know:</u> how to balance chemical equations.</td></tr>
<tr><td>Science Vocabulary Students are Expected to Know</td><td colspan="3">Glucose, algae, consumer, product, transformation, conservation, convert, decomposer, aquatic, organic, phytoplankton, producer, reaction, carbon, carbon dioxide, chemical process, chemical reaction, molecule, nutrient, moisture, structure, organic matter, stimulus, tissue, hydrogen</td></tr>
<tr><td>Science Vocabulary Students are Not Expected to Know</td><td colspan="3">Biomass, biological molecule, compound, flow of matter, hydrocarbon, net transfer, photosynthesizing organism, carbon cycle, efficient, excitatory molecule, molecular synthesis, organic compound synthesis, stomata</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-LS1-6:
• A plant is kept in a clear, closed container that allows sunlight to pass through. After one week, the plant is dead. A mouse kept alone in the same container also dies. However, a plant and mouse kept together in the same container after one week are alive.
• The plant Elodea releases bubbles at an increased rate when an aquatic animal is added to the same aquarium.
• A plant grows in a pot of soil for one month. Only water is added to the pot. After one month, the plant has gained mass, while the mass of the soil has barely changed.
• A plant leaf kept in the light contains large amounts of starch, while a leaf kept in the dark does not.</td></tr>
</table>

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or features of the reactants and products.
2. Express or complete a description of the flow of energy and/or matter among organisms. This may include indicating directions of causality in an incomplete model (including food webs), such as a flow chart or diagram.
3. Identify evidence that photosynthesis cycles matter and energy through an ecosystem.
4. Select, identify, or describe the predicted effect of a change of conditions on the flow of energy and matter among organisms.
5. Describe, identify, and/or select information needed to support an explanation.

<table>
<tr><td>Performance Expectation</td><td colspan="3">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.</td></tr>
<tr><td>Dimensions</td><td>Analyzing and Interpreting Data
• Analyze and interpret data to provide evidence of phenomena.</td><td>LS2.A: Interdependent Relationships in Ecosystems
• Organisms, and populations of organisms, are dependent on their environmental interactions, both with other living things and with nonliving factors.
• In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
• Growth of organisms and population increases are limited by access to resources.</td><td>Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on cause and effect relationships between resources and growth of individual organisms, and the numbers of organisms in ecosystems during periods of abundant and scarce resources.
• Examples could include water, food, and living space

Content Limits
• Assessment does not include mathematical and/or computational representations of factors related to carrying capacity of ecosystems of different sizes (including deriving mathematical equations to make comparisons).</td></tr>
<tr><td>Science Vocabulary Students are Expected to Know</td><td colspan="3">Resource, competition, ecosystem, nutrient, food chain/web, producer, consumer</td></tr>
<tr><td>Science Vocabulary Students are Not Expected to Know</td><td colspan="3">Biotic component, abiotic component, exponential (AKA “logistic”) growth, ecological niche, resource partitioning, fundamental niche, realized niche, carrying capacity, interspecific competition, intraspecific competition, biomass, carrying capacity</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">The phenomena for this performance expectation are the given data. Samples of phenomena should describe the data set(s) to be given in terms of patterns or relationships to be found in the data, and the columns and rows of a hypothetical table presenting the data, even if the presentation is not tabular. The description of the phenomenon should describe the presentation format of the data (e.g., maps, tables, graphs, etc.).

Some example phenomena for MS-LS2-1:
• On the north Atlantic coastline, two species of barnacles live at different depths
• Cheetahs and leopards in the savannah use the same watering holes.
• After a drought period, the population of grasshoppers is halved.
• A garden is cleared of aphids. After a few days, the ladybirds in the surrounding trees are gone.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
</table>

1.	Organize and/or arrange (e.g., using illustrations and/or labels), or summarize data to highlight trends, patterns, or correlations between resource availability and the growth of a population or populations of organisms.
2.	Generate or construct graphs, tables, or assemblages of illustrations and/or labels of data that document patterns, trends, or correlations between resource availability and the growth of a population or populations of organisms. This may include sorting out distractors.*
3.	Use relationships identified in resource/population data to predict the change in a population or populations or the change in resources that resulted in a change in populations.**
4.	Identify patterns or evidence in the data that supports inferences and explanations about how resource availability affects a population of organisms.*
5.	Construct or identify testable questions that can be asked to collect data about how resource availability may affect the growth of a population or populations of organisms.
6.	Identify, describe, or select from a collection characteristics to be manipulated or held constant while gathering information to answer a well-articulated question.*
7.	Select or describe inferences relevant to the question posed and supported by the data, especially inferences about causes and effects.
8.	Select, identify, or describe predicted outcomes when specific changes in resource availability occur, using inferences about cause and effect relationships involving those resources.**

*denotes those task demands which are deemed appropriate for use in stand-alone item development
**TD3 and TD8 must be used together.

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS2-2
Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.</td></tr>
<tr><td>Dimensions</td><td>Constructing Explanations and Designing Solutions
• Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.</td><td>LS2.A: Interdependent Relationships in Ecosystems
• Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.</td><td>Patterns
• Patterns can be used to identify cause and effect relationships.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statement
• Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between living organisms and nonliving components of ecosystems.
• Examples of types of interactions could include competitive, predatory, and mutually beneficial.

Content Limits
• Analysis may include recognizing patterns in data, specifying and explaining relationships, making logical predictions from data, retrieving information from a table, graph or figure and using it to explain relationships, generating hypotheses based on observations or data, and generalizing a pattern.
• Analysis should not include relating mathematical or scientific concepts to other content areas.</td></tr>
<tr><td>Science Vocabulary Students are Expected to Know</td><td colspan="3">relative, disperse, ecological role, host, infection, mutualism, mutually beneficial, parasite, evolve, genetic, interdependent</td></tr>
<tr><td>Science Vocabulary Students are Not Expected to Know</td><td colspan="3">abiotic</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">For this performance expectation, the phenomena are sets of data. Those are the observed facts that the students will look at to discover patterns. Below, we enumerate some of the patterns that might comprise the data sets (phenomena) to be analyzed. Patterns should be observed across at least two different environments/habitats.

Patterns that describe the data sets for MS-LS2-2:
• The tongue of the alligator snapping turtle looks like a small worm. The turtle uses this tongue to lure prey close to its mouth. (Predation)—also angler fish.
• Higher density of squirrels in oak environment than in maple environment.</td></tr>
</table>

	• Hippopotamuses spend time in both aquatic and savannah ecosystems. When found in aquatic environments, they're often surrounded by carp. When found in a savannah environment, they're often surrounded by oxpeckers. • In Ecuador's Andean Cloud Forest, a hummingbird feeds on the nectar of an orchid flower (*Epidendrum secundum*). In the Madagascar, a similar orchid flower (*Angraecum sesquipedale*) is seen, but no hummingbirds are found.

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Articulate, describe, illustrate, or select the relationships or interactions to be explained. This may entail sorting relevant from irrelevant information or features.
2. Express or complete a causal chain common or distinct across organisms or environments. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram or completing cause and effect chains.*
3. Identify evidence supporting the inference of causation of patterns of interactions among organisms across multiple ecosystems expressed in a causal chain.*
4. Use an explanation to predict interactions among different organisms or in different environments.
5. Describe/Identify/Select information needed to support an explanation of patterns of interactions among organisms across multiple ecosystems.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

Performance Expectation	**MS-LS2-3** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.		
Dimensions	**Developing and Using Models** • Develop a model to describe phenomena.	**LS2.B: Cycle of Matter and Energy Transfer in Ecosystems** • Food webs are models that demonstrate how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a natural system.

Clarifications and Content Limits	**Clarification Statements**
	• Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems.
	• Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.
	
	Content Limits
	• Students do not need to identify biomes or to know information about specific biomes.
	• Assessment does not include
	  ○ The use of chemical reactions to describe the processes.
	  ○ Identification of trophic levels, understanding of the relative energies of the trophic levels, nor the knowledge of the 10% energy transfer between trophic levels.
	  ○ The process of bioaccumulation.		

Science Vocabulary Students Are Expected to Know	Producer, consumer, decomposer, herbivore, omnivore, carnivore, algae, fungi, microbe, microorganism, organic matter, organic waste, photosynthesis, atom, molecule, sugar, carbon, carbon dioxide, nitrogen, oxygen, predator, prey, aquatic, interdependent, chemical reaction, reactant, product		
Science Vocabulary Students Are Not Expected to Know	Biotic, abiotic, trophic level, energy pyramid, nitrogen fixation, exothermic/endothermic, detritivores, biomass, bioaccumulation/biomagnification, autotroph/heterotroph, biosphere, hydrosphere, geosphere, aerobic, anaerobic, phosphorous, phytoplankton.		
Phenomena			
Context/ Phenomena	Some example phenomena for MS-LS2-3: • In the Alaskan tundra, more grass and wildflowers grow on top of underground fox dens than elsewhere. • In July, a colony of lava crickets is found to inhabit lava flows from a May eruption, but the first plant does not appear in the area until November. • Fox-inhabited islands in the Aleutian Islands have less vegetation than islands not inhabited by foxes. • Giant clams and tube worms are found in the darkest parts of the oceans in the hot water near hydrothermal vents.		
This Performance Expectation and associated Evidence Statements support the following Task Demands.			
Task Demands			

1.	Identify, assemble, or complete from a collection of potential model components, including distractors, components of a food-web model that describe transfers of matter and/or energy among producers, consumers, decomposers, or some subsets of those, potentially including transfers between living and nonliving organisms.
2.	Describe, select, or identify the relationships among components of a food-web model that describes how parts of the food web (producers, consumers, and decomposers) interact to continually cycle matter and to transfer energy among living and nonliving parts of an ecosystem.
3.	Manipulate the components of a food-web model to demonstrate how the interactions among producers, consumers, and/or decomposers result in changes to the cycling of matter and/or transfer of energy among living and nonliving parts of an ecosystem.
4.	Select, describe, or illustrate predictions about the effects of changes in the organisms or nonliving components of the environment on the cycling of matter, transfer of energy, and/or other organisms in the environment. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors.
5.	Select or identify missing components or relationships of a food web model that describes the transfers of matter and/or energy among living and nonliving parts of an ecosystem.

Performance Expectation	**MS-LS2-4** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.		
Dimensions	**Engaging in Argument from Evidence** • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature: their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.	**Stability and Change** • Small changes in one part of a system might cause large changes in another part.
Clarifications and Content Limits	**Clarification Statements** • Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems. **Content Limits** • Assessment does not include the use of chemical reactions to describe the processes.		
Science Vocabulary Students are Expected to Know	Predator, prey, mutually beneficial interactions, competition, consumers, producers, decomposers, biodiversity.		
Science Vocabulary Students are Not Expected to Know	Carrying capacities, anthropogenic changes, biomass		
Phenomena			
Context/ Phenomena	Example Phenomena for MS-LS2-4: • After a beaver builds a dam, the amount and diversity of fish life in a stream increases. • After wolves were reintroduced to Yellowstone, there were more willows. • The number of willows has increased in Yellowstone. (Give two competing hypotheses: wolf introduction; beaver population increase). • As the Aral Sea declined in size since the 1960s, salinity has increased and the Aral trout is no longer present in the lake.		
This Performance Expectation and associated Evidence Statements support the following Task Demands.			
Task Demands			
1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or information supporting/refuting one or more competing hypotheses.			
2. Predict outcomes when changes to an ecosystem occur, given the inferred cause and effect relationships.*			
3. Identify, select, and/or describe information or evidence needed to support one or more potentially competing explanations.			
4. Identify patterns of information/evidence in the data that support correlative/causative inferences about the relationships among the pertinent parts of an ecosystem.*			

5. Organize and/or arrange (e.g., using illustrations and/or labels) or summarize population data to highlight trends, patterns, or correlations.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-LS2-5
Evaluate competing design solutions for maintaining biodiversity and ecosystem services.</td></tr>
<tr><td>Dimensions</td><td>Engaging in Argument from Evidence
• Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.</td><td>LS2.C: Ecosystem Dynamics, Functioning, and Resilience
• Biodiversity describes the variety of species found in Earth’s terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem’s biodiversity is often used as a measure of its health.

LS4.D: Biodiversity and Humans
• Changes in biodiversity can influence humans’ resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, fresh air and water (secondary).

ETS1.B: Developing Possible Solutions
• There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem (secondary).</td><td>Stability and Change
• Small changes in one part of a system may cause a large change in another part.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion.
• Examples of design solution constraints could include scientific, economic, and social considerations.

Content Limits
• <u>Students do not need to know:</u> specific policies or specific details of organisms.</td></tr>
<tr><td>Science Vocabulary Students Are Expected to Know</td><td colspan="3">Habitats, niche, native species, non-native or invasive species</td></tr>
<tr><td>Science Vocabulary Students Are Not Expected to Know</td><td colspan="3">Specific species names, specific resource or habitat requirements for any species.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Engineering performance expectations are built around meaningful design problems rather than phenomena. In this case, the design problems involve preserving ecosystems and protecting biodiversity. For this performance expectation, the design problem and competing solutions replace phenomena.

Some example design problems for MS-LS2-5:
• Giant African Land Snails were brought to Florida by a boy who smuggled three snails into Florida. His grandmother released these into a garden and the snail population exploded. The snails eat over 500 plant species, tree bark, paint, and even stucco. Florida has implemented four solutions:
  ○ Trained dogs that sniff out snails for capture.
  ○ Chemicals applied to plants that the snails feed upon.
  ○ Predatory species to eat the snails.</td></tr>
</table>

- The brown tree snake was accidentally brought to the island of Guam by ships during World War II, fed on native birds until the Guam rail, a native bird, nearly went extinct in 1984. Guam has implemented two solutions:
    - Feed rats acetaminophen and drop them into wooded areas.
    - Bring in predatory species to eat the snakes.
- Cheatgrass, a type of weed that was brought to the United States in the late 1800s, has spread all over Utah from the desert valleys to the mountains, growing faster than most native plants. Utah has implemented two solutions:
    - Use genetically modified seeds for certain native seeds that are heartier than the Cheatgrass to push out the Cheatgrass seeds.
    - Controlled application of herbicides.
- Asian carp is an aggressive fish species introduced in 1960 to control weed populations in waterways in southern fish farm ponds. The population was sterilized but a few fertile fish escaped into the Mississippi River and migrated north towards the Great Lakes. Asian carp are an invasive species that compete with native fish in the Great Lakes and threaten the ecosystem balance. Regions around the Great Lakes are implementing strategies:
    - Launch a campaign to encourage and incentivize fishing of Asian carp for human consumption
    - Use a system of electric barriers to prevent Asian carp from entering Lake Michigan from the Mississippi River.
    - Use nets to block paths to popular spawning sites during Asian carp reproduction season.
    - Introduce a botanic pesticide used for fish eradications in water areas known to have large Asian carp populations.

This Performance Expectation and associated Evidence Statements support the following Task Demands.
Task Demands
1. Identify or assemble from a collection, including distractors, the relevant aspects of the problem that, given design solutions if implemented, will resolve/improve maintaining biodiversity and ecosystem services.
2. Using given information for maintaining biodiversity and ecosystem services, select or identify constraints that the device or solution must meet.
3. Using the given information for maintaining biodiversity and ecosystem services, select or identify the criteria against which the device or solution should be judged.
4. Compare, rank, or otherwise evaluate the different design solutions for maintaining biodiversity and ecosystem services against the identified criteria.
5. Select or propose a recommended course of action supported by the design solution's ability to meet identified criteria.

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 the seasons.		
Dimensions	**Developing and Using Models** • Develop and use a model to describe phenomena.	**ESS1.A The Universe and Its Stars** • Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. **ESS1.B Earth and the Solar System** • This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	**Patterns** • Patterns can be used to identify cause and effect relationships.
Clarifications and Content Limits	**Clarification Statements** • Examples of models can be physical, graphical, or conceptual. **Content Limits** • <u>Students do not need to know</u> Earth's exact tilt; sidereal and synodic periods; umbra and penumbra (the term "shadow" should be used); times of moonrise and moonset; precession; exact dates of equinoxes and solstices (but knowledge of the months in which they occur is reasonable to assess).		
Science Vocabulary Students are Expected to Know	Shadow, orbit, axis, planet, satellite, full moon, new moon, half moon		
Science Vocabulary Students are Not Expected to Know	Perigee, apogee, sidereal period, sidereal month, synodic period, synodic month, umbra, penumbra, precession, equinox, solstice, ecliptic, waxing, waning, gibbous, first quarter moon, last quarter moon		
Phenomena			
Context/ Phenomena	Some example phenomena for MS-ESS1-1: • When observed from Earth over the course of a month, the appearance of the moon changes. • A full moon occurs in every calendar month. However, an eclipse of the moon does not occur in every calendar month. • A new moon occurs in every calendar month. However, a total eclipse of the sun is a rare event. • In the northern hemisphere, July is a summer month. In the southern hemisphere, July is a winter month.		
This Performance Expectation and associated Evidence Statements support the following Task Demands.			
Task Demands			
1. Select or identify from a collection of potential model components, including distractors, components needed for a model that can explain lunar phases, eclipses of the sun, eclipses of the moon, *or* seasons on Earth.			

	Components might include the sun, moon, Earth, solar energy, the moon's orbital trace, Earth's orbital trace, the angle of the moon's orbital trace, the angle of Earth's orbital trace, Earth's axis, or the tilt of Earth's axis.
2.	Assemble or complete, from a collection of potential model components, an illustration or flow chart that is capable of representing the causes of lunar phases, eclipses of the sun, eclipses of the moon, *or* seasons on Earth. This <u>does not</u> include labeling a simple diagram of the Earth-sun-moon system.
3.	Describe, select, or identify the relationships among components of a model that can explain lunar phases, eclipses of the sun, eclipses of the moon, *or* seasons on Earth. Components might include the sun, moon, Earth, solar energy, the moon's orbital trace, Earth's orbital trace, the angle of the moon's orbital trace, the angle of Earth's orbital trace, Earth's axis, or the tilt of Earth's axis.
4.	Manipulate the components of a model to demonstrate how the relationships among the sun, the moon, Earth, and solar energy change to result in lunar phases, eclipses of the sun, eclipses of the moon, *or* seasons on Earth. *****
5.	Make predictions about the effects of changes in the relationships among the sun, the moon, Earth, and solar energy as they relate to lunar phases, eclipses of the sun, eclipses of the moon, *or* seasons on Earth. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors. *****
6.	Identify missing components, relationships, or other limitations of a model that can explain lunar phases, eclipses of the sun, eclipses of the moon, *or* seasons on Earth.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS-ESS1-2
Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.</td></tr>
<tr><td>Dimensions</td><td>Developing and Using Models
• Develop and use a model to describe phenomena.</td><td>ESS1.A: The Universe and Its Stars
• Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.

ESS1.B: Earth and the Solar System
• The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
• The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.</td><td>Systems and System Models
• Models can be used to represent systems and the interactions in a system.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy, and controls orbital motions within them.
• Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state).
• Focus should be on qualitative comparisons, not quantitative.

Content Limits
• Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.
• Assessment does not include specific facts about any planets or moons.</td></tr>
<tr><td>Science Vocabulary Students are Expected to Know</td><td colspan="3">Inertia, force, mass, weight, orbit, names of planets</td></tr>
<tr><td>Science Vocabulary Students are Not Expected to Know</td><td colspan="3">Names of specific moons, names of space shuttles, moment of inertia, Kepler's laws of planetary motion, black hole</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">Some example phenomena for MS-ESS1-2:
• Satellites orbit Earth but can fall out of orbit (Skylab, UART satellite).
• Halley's Comet can be seen as it travels past Earth every 75–76 years.
• Rings are present around some planets.
• Mars has two moons, Phobos and Deimos, which orbit the planet.</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
<tr><td colspan="4">Task Demands</td></tr>
<tr><td colspan="4">1. Select or identify from a collection of potential model components, including distractors, the components needed for a model that describes the role of gravity in celestial bodies.</td></tr>
</table>

2.	Assemble or complete, from a collection of potential model components, an illustration, diagram or description that is capable of representing forces and their influences on the motion of celestial bodies and/or man-made objects in orbit. This does not include labeling an existing diagram.
3.	Describe, select or identify the relationships among components of a model that can explain the role of gravity in the motions of galaxies and the solar system. Components might include the sun, the moon, Earth, Milky Way galaxy, other planets and their moons.
4.	Manipulate the components of a model to demonstrate how the relationships among the sun, the Earth, the moon, planets in the solar system, and galaxies change the resulting gravitational force between/or motions of those bodies.*
5.	Make predictions about the effects of changes in mass/distance/how fast an object travels in a given model on other objects in the system. Predictions can be based on manipulating model components, completing illustrations, or selecting from a list including distractors.
6.	Identify missing components, relationships, or other limitations of a model that can explain the role of gravity.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

<table>
<tr><td>Performance Expectation</td><td colspan="3">MS ESS1-3
Analyze and interpret data to determine scale properties of objects in the solar system.</td></tr>
<tr><td>Dimensions</td><td>Analyzing and Interpreting Data
• Analyze and interpret data to determine similarities and differences in findings.</td><td>ESS1.B: Earth and the Solar System
• The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.</td><td>Scale, Proportion, and Quantity
• Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.</td></tr>
<tr><td>Clarifications and Content Limits</td><td colspan="3">Clarification Statements
• Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes and spacecraft to determine similarities and differences among solar system objects.
• Examples of scale properties include the sizes of an object’s layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius.
• Examples of data include statistical information, drawings and photographs, and models.

Content Limits
• Assessment does not include recalling facts about properties of the planets and other solar system bodies.
• <u>Students do not need to know</u>: Facts about properties of the planets and other solar system bodies, scientific notation.</td></tr>
<tr><td>Science Vocabulary Students are Expected to Know</td><td colspan="3">Satellite, terrestrial planet, gas giant, planetary rings, dwarf planet, sun, inner planet, outer planet, comet,</td></tr>
<tr><td>Science Vocabulary Students are Not Expected to Know</td><td colspan="3">Density, ecliptic, solar wind, interstellar medium, main sequence, synchronous rotation, protostar, protoplanetary disc, accretion.</td></tr>
<tr><td colspan="4">Phenomena</td></tr>
<tr><td>Context/ Phenomena</td><td colspan="3">The phenomena for this performance expectation are the given data. Samples of phenomena should describe the data set(s) to be given in terms of patterns or relationships to be found in the data, and the columns and rows of a hypothetical table presenting the data, even if the presentation is not tabular. The description of the phenomenon should describe the presentation format of the data (e.g., maps, tables, graphs, etc).

Some example phenomena for MS-ESS1-3:
• Four of Jupiter’s moons can be clearly seen through a small telescope under low magnification. These moons appear as tiny dots arranged around Jupiter.
• Close-up pictures from the New Horizons mission provided new evidence about the dwarf planet, Pluto, which was not able to be gathered by distant observations and calculations (surface features, scale).
• The sun and the moon appear as approximately the same size in the sky, but the sun is vastly larger than the moon (scale).
• Even though the moon is infinitesimally smaller than the sun, the entire sun is blocked from view on Earth during a solar eclipse (scale).</td></tr>
<tr><td colspan="4">This Performance Expectation and associated Evidence Statements support the following Task Demands.</td></tr>
</table>

Task Demands
1. Make simple calculations using given data to estimate the properties (e.g., mass, surface temp., diameter) and locations of different solar system objects relative to a given reference point/object.
2. Illustrate, graph, or identify relevant features or data that can be used to estimate properties of objects or relationships in our solar system.
3. Calculate, estimate or identify properties of objects or relationships among objects in the solar system, based on data from one or more sources.*
4. Compile, from given information, the data needed for a particular inference about scale or other properties of an object.
5. Given a partial model of objects in the solar system, identify objects or relationships that can be represented in the model or the reasons why they cannot be represented in the model.

*denotes those task demands which are deemed appropriate for use in stand-alone item development