Kansas Performance Level Descriptors

Middle School

9/22/2025

Contents

<table>
<tr><td>MS-LS1-1.</td><td colspan="3">Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.

Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.</td></tr>
<tr><td colspan="4">Planning and Carrying Out Investigations

Planning and carrying out investigations in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

• Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.</td></tr>
<tr><td colspan="4">LS1.A: Structure and Function

• All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Identify that the goal of an investigation is to provide evidence that only living things are made of cells.</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Conduct an investigation to provide evidence that living things are made of cells, either one cell or many different numbers and types of cells.</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Refine an experimental design that supports the claim that living things may contain different types of cells within a single organism by improving the quality of the data</td></tr>
</table>

• Identify the tools needed to view cells.		collected (e.g., hand lens to microscope).

<table>
<tr><td>MS-LS1-2.</td><td colspan="3">Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.

Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.

Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.</td></tr>
<tr><td colspan="4">Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

• Develop and use a model to describe phenomena.</td></tr>
<tr><td colspan="4">LS1.A: Structure and Function

• Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Use a given model to describe that cells contain smaller structures that help them survive by performing specific functions.</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Develop a model to describe how the structure of the cell wall and cell membrane contribute to the functions they perform for a cell.</td></tr>
</table>

		• Use a model to investigate the structures within a cell and how they affect the overall function of the cell (e.g., comparing plant cells with and without chloroplasts).

<table>
<tr><td>MS-LS1-3.</td><td colspan="3">Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.

Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.</td></tr>
<tr><td colspan="4">Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

• Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.</td></tr>
<tr><td colspan="4">LS1.A: Structure and Function

• In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.</td></tr>
<tr><td colspan="2">Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Make an argument that the body is composed of independent</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Use argument supported by evidence for how the body is a</td><td>Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Use scientific reasoning describing the hierarchical</td></tr>
</table>

structures, including systems, organs, and cells.	system of interacting subsystems composed of groups of cells.	organization of the body to explain a specific phenomenon.

<table>
<tr><td>MS-LS1-4.</td><td colspan="3">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.

Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.</td></tr>
<tr><td colspan="4">Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

• Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.</td></tr>
<tr><td colspan="4">LS1.B: Growth and Development of Organisms

• Animals engage in characteristic behaviors that increase the odds of reproduction.
• Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.</td></tr>
<tr><td>Level 2</td><td>Level 3</td><td colspan="2">Level 4</td></tr>
</table>

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Identify evidence that animals have unique behaviors that allow them to reproduce (i.e., excludes the probabilistic nature of successful reproduction). • Identify evidence that plants have unique structures that allow them to reproduce (i.e., excludes the probabilistic nature of successful reproduction).	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • 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.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Use scientific reasoning to explain how animal behaviors can affect the probability of successful plant reproduction. • Use scientific reasoning to explain why seemingly counterintuitive behaviors and/or structures for survival can help increase the probability of successful reproduction (e.g., colorful plumage increasing visibility to predators but also making an animal attractive to mates, a plant sacrificing resources to produce nectar).

<table>
<tr><td>MS-LS1-5.</td><td colspan="3">Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.

Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.</td></tr>
<tr><td colspan="4">Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

• Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</td></tr>
<tr><td colspan="4">LS1.B: Growth and Development of Organisms

• Genetic factors as well as local conditions affect the growth of the adult plant.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:</td><td colspan="2">Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:</td><td>Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:</td></tr>
</table>

• Identify which evidence from real-world examples supports a claim about environmental or genetic factors influencing the growth of organisms.	• Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. • Construct a scientific explanation based on evidence for how environmental factors influence the growth of organisms. • Construct a scientific explanation based on evidence for how genetic factors influence the growth of organisms.	• Construct an explanation for how growth can be predicted with changing conditions. • Apply scientific reasoning to explain why data regarding either the environment or genetics alone would not be adequate to explain or predict the growth of an organism with certainty. • Apply scientific reasoning to explain whether a piece of evidence more strongly suggests influence from environmental or genetic factors.

<table>
<tr><td>MS-LS1-6.</td><td colspan="3">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.

Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.

Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.</td></tr>
<tr><td colspan="4">Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

• Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</td></tr>
<tr><td colspan="4">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></tr>
<tr><td colspan="2">Level 2</td><td>Level 3</td><td>Level 4</td></tr>
</table>

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Explain the inputs and outputs of photosynthesis while cycling in and out of organisms in an ecosystem, using a model or representation. • Explain the need for an energy input from light for matter to cycle during photosynthesis.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • 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. • Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter into and out of organisms. • Construct a scientific explanation based on evidence for the role of photosynthesis in the flow of energy into and out of organisms.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Construct an explanation for the direct relationship between photosynthesis and cycling of matter (e.g., a higher rate of photosynthesis leads to more oxygen produced or carbon dioxide used) that describes a phenomenon. • Construct an explanation that photosynthesis cycles matter and transfers energy within plants, allowing them to grow and develop. • Explain that plants and organisms that eat plants rely on photosynthesis for energy, using examples from real-world examples or models.

<table>
<tr><td>MS-LS1-7.</td><td colspan="3">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.

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

Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.</td></tr>
<tr><td colspan="4">Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

• Develop a model to describe unobservable mechanisms.</td></tr>
<tr><td colspan="4">LS1.C: Organization for Matter and Energy Flow in Organisms

• Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.

PS3.D: Energy in Chemical Processes and Everyday Life

• Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary)</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:</td></tr>
</table>

• Identify components to include in a model showing how organisms get energy and/or matter from food. • Use a given model to identify that matter is rearranged during digestion. • Use a given model to describe the ways an organism can use the matter absorbed from food. • Use a given model to describe the relationship between food and energy.	• Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as the matter moves through an organism.	• Use a model to describe relationships between components and explain changes (e.g., more CO_2 released indicates more oxygen consumed and energy produced). • Use a model to describe how atoms cycle through an organism, and cite examples from the model of matter being conserved as atoms are rearranged to form new molecules.

<table>
<tr><td>MS-LS1-8.</td><td colspan="3">Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.</td></tr>
<tr><td colspan="4">Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods.

• Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.</td></tr>
<tr><td colspan="4">LS1.D: Information Processing

• Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Critically read scientific information to describe patterns in how organisms respond to stimuli in the environment (e.g., different</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Gather and synthesize information that sensory receptors respond to stimuli by sending messages to</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Use a scientific text to describe how the storage of memories allows for predictable behavior responses.</td></tr>
</table>

animals may rely on different senses, but all process signals to determine behavior). • Combine information from scientific texts and visual displays to describe how different sensory receptors respond to different inputs.	the brain for immediate behavior or storage as memories.	• Evaluate a scientific text to determine if there is sufficient evidence to claim a behavior is caused by an external stimulus.

<table>
<tr><td>MS-LS2-1.</td><td colspan="3">Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.</td></tr>
<tr><td colspan="4">Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

• Analyze and interpret data to provide evidence for phenomena.</td></tr>
<tr><td colspan="4">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></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Analyze data to determine changes in resource availability.</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Analyze and interpret data to provide evidence for the effects of</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Use data to support a prediction of how environmental changes may</td></tr>
</table>

• Identify patterns in data that show changes in population size or individual growth.	resource availability on organisms and populations of organisms in an ecosystem. • Analyze and interpret data to provide evidence for the effects of resource availability on organisms in an ecosystem. • Analyze and interpret data to provide evidence for the effects of resource availability on populations of organisms in an ecosystem.	affect population or individual growth. • Analyze data to identify the impact of interactions between populations on resource limitations that affect individual growth or population sizes (e.g., competition, predation).

MS-LS2-2.	**Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.** Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.

LS2.A: Interdependent Relationships in Ecosystems

- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

Level 2	**Level 3**	**Level 4**
Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Identify evidence that supports an explanation for patterns of interactions across multiple ecosystems. • Compare and contrast interactions between organisms, or between organisms and their environments.	• Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.	• Construct an explanation for patterns of interactions among organisms that lead to populations being eliminated or species becoming interdependent across multiple types of ecosystems.

<table>
<tr><td>MS-LS2-3.</td><td colspan="3">Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.

Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.</td></tr>
<tr><td colspan="4">Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

• Develop a model to describe phenomena.</td></tr>
<tr><td colspan="4">LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

• Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Identify components of a given model that show the cycling of</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Develop a model to describe the cycling of matter and flow of</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Revise a model to reflect changes to a system (e.g., change in</td></tr>
</table>

matter or flow of energy between parts of an ecosystem. • Use a given model to identify producers, consumers, or decomposers within an ecosystem that cycle matter or transfer energy.	energy among living and nonliving parts of an ecosystem.	species present, change in nonliving components), and the effects on the cycling of matter and flow of energy. • Describe the limitations of a model in describing the cycling of matter and flow of energy in an ecosystem.

<table>
<tr><td>MS-LS2-4.</td><td colspan="3">Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.</td></tr>
<tr><td colspan="4">Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

• Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.</td></tr>
<tr><td colspan="4">LS2.C: Ecosystem Dynamics, Functioning, and Resilience

• Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Identify evidence that shows how a population may be affected by changes to the ecosystem.</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Evaluate or critique an explanation for the cause of changes to all populations due to a disturbance to the ecosystem (e.g.,</td></tr>
</table>

		introduction of a new species, drought conditions).

MS-LS2-5.	**Evaluate competing design solutions for maintaining biodiversity and ecosystem services.** Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.

Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.

LS4.D: Biodiversity and Humans

- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary)

ETS1.B: Developing Possible Solutions

- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary)

Level 2	**Level 3**	**Level 4**

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Identify design constraints relevant to solutions for maintaining biodiversity and/or ecosystem services. • Identify evidence of a design solution's effect on biodiversity and/or ecosystem services.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • Evaluate competing design solutions for maintaining biodiversity and ecosystem services. • Evaluate competing design solutions for maintaining biodiversity. • Evaluate competing design solutions for maintaining ecosystem services.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Revise a design solution to better maintain biodiversity and ecosystem services based on new evidence. • Use evidence to predict how a design solution will affect biodiversity and ecosystem services. • Use scientific reasoning to justify why a design solution is best for maintaining biodiversity and ecosystem services.

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.** Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins. *Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.*

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena.

LS3.A: Inheritance of Traits

- Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.

LS3.B: Variation of Traits

- In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.

Level 2	Level 3	Level 4
Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Use a given model to identify that a change to a gene causes structural changes to a protein. • Identify components of a given model that connect changes in genetic material to changes in proteins. • Identify a model that correctly illustrates the relationship among DNA, proteins, and traits.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • 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. • 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 of the organism. • 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 function of the organism.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Revise a model to describe that the multiple chromosomes in cells can explain the neutral effects of mutations. • Use a model to describe the relationship between structure and function for DNA, protein, and 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.** Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena.

LS1.B: Growth and Development of Organisms

- Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary)

LS3.A: Inheritance of Traits

- Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.

LS3.B: Variation of Traits

- In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.

Level 2	**Level 3**	**Level 4**

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Use a given model to identify that sexual reproduction results in more genetic variation than asexual reproduction. • Complete a model to show how genes are passed from parents to offspring and the possible genetic variations of offspring.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • 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.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Revise a model to illustrate what happens if a component of a system (e.g., parent's genes, method of reproduction) changes and how the change affects genetic variation. • Use a model to describe the relationship between the number of chromosomes involved in reproduction and the genetic variation possible in offspring.

<table>
<tr><td>MS-LS4-1.</td><td colspan="3">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.

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

Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.</td></tr>
<tr><td colspan="4">Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

• Analyze and interpret data to determine similarities and differences in findings.</td></tr>
<tr><td colspan="4">LS4.A: Evidence of Common Ancestry and Diversity

• The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Identify similarities and differences between fossils in the fossil record (i.e., comparing two</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Analyze and interpret data for patterns in the fossil record that document the existence, diversity,</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Describe how even though the fossil record is incomplete for certain species, larger</td></tr>
</table>

fossils, but short of identifying large patterns over time). • Organize data from the fossil record to better identify patterns (e.g., chronological order).	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.	conclusions can still be drawn regarding the existence, diversity, extinction, and change of life forms. • Describe how the assumption that natural laws operate today as in the past affects the interpretation of patterns in the fossil record.

<table>
<tr><td>MS-LS4-2.</td><td colspan="3">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.

Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.</td></tr>
<tr><td colspan="4">Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

• Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.</td></tr>
<tr><td colspan="4">LS4.A: Evidence of Common Ancestry and Diversity

• Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Identify anatomical similarities and differences between modern organisms and/or modern and fossil organisms.</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Apply scientific reasoning based in evidence to show why anatomical similarities and differences are adequate evidence to infer evolutionary relationships.</td></tr>
</table>

	modern and fossil organisms to infer evolutionary relationships. • Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms to infer evolutionary relationships. • Apply scientific ideas to construct an explanation for the anatomical similarities and differences between modern and fossil organisms to infer evolutionary relationships.	• Consider limitations of anatomical evidence and explain why relationships can still be inferred and/or what additional data would strengthen inferences.

<table>
<tr><td>MS-LS4-3.</td><td colspan="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.

Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.

Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.</td></tr>
<tr><td colspan="4">Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

• Analyze displays of data to identify linear and nonlinear relationships.</td></tr>
<tr><td colspan="4">LS4.A: Evidence of Common Ancestry and Diversity

• Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Analyze displays of pictorial data to identify similarities in the embryological development of two species.</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Consider limitations of embryological evidence and explain why relationships can still be inferred and/or what additional data would strengthen inferences.</td></tr>
</table>

• Identify patterns of change as an embryo of a single species develops.	relationships not evident in the fully formed anatomy.	

<table>
<tr><td>MS-LS4-4.</td><td colspan="3">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.

Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.</td></tr>
<tr><td colspan="4">Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

• Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.</td></tr>
<tr><td colspan="4">LS4.B: Natural Selection

• Natural selection leads to the predominance of certain traits in a population, and the suppression of others.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Identify evidence that supports that individuals have a different probability of reproducing.</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Construct an explanation based on evidence that predicts how populations with and without genetic variation will respond to a change in environment.</td></tr>
</table>

	and reproducing in a specific environment.	

<table>
<tr><td>MS-LS4-5.</td><td colspan="3">Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.

Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.</td></tr>
<tr><td colspan="4">Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods.

• Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.</td></tr>
<tr><td colspan="4">LS4.B: Natural Selection

• In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Identify information from a scientific text about the way</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Gather and synthesize information about technologies that have changed the way humans</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Gather and synthesize information about technologies that change the way humans influence traits in</td></tr>
</table>

humans influence the inheritance of desired traits in organisms.	influence the inheritance of desired traits in organisms.	organisms, and describe the potential positive and negative impacts of these technologies on a species.

<table>
<tr><td>MS-LS4-6.</td><td colspan="3">Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.

Assessment Boundary: Assessment does not include Hardy Weinberg calculations.</td></tr>
<tr><td colspan="4">Using Mathematics and Computational Thinking

Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.

• Use mathematical representations to support scientific conclusions and design solutions.</td></tr>
<tr><td colspan="4">LS4.C: Adaptation

• Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Identify that mathematical representations can serve as evidence for changes in specific traits in populations over time.</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Use mathematical representations to support explanations of how natural selection may lead to increases</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Use mathematical representations to explain how changes in the frequency of traits</td></tr>
</table>

• Use mathematical representations to identify changes in the frequency of specific traits in populations over time.	and decreases in specific traits in populations over time. • Use mathematical representations to support explanations of how natural selection may lead to increases in specific traits in populations over time. • Use mathematical representations to support explanations of how natural selection may lead to decreases of specific traits in populations over time.	lead to adaptation for survival in the environment. • Use mathematical representations to explain why changes are described in terms of generations and not time.

<table>
<tr><td>MS-ESS1-1.</td><td colspan="3">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.

Clarification Statement: Examples of models can be physical, graphical, or conceptual.</td></tr>
<tr><td colspan="4">Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

• Develop and use a model to describe phenomena.</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Use a model to identify that the sun, Earth, and the moon move in a predictable pattern.</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Develop a model to predict the timing and conditions required</td></tr>
</table>

• Use a model to identify that the moon goes through predictable phases. • Use a model to identify that the movement of Earth around the sun is a partial explanation of the cause of Earth's changing seasons. • Develop a model to show how Earth moves around the sun and how the moon moves around Earth.	lunar phases, eclipses of the sun and moon, or seasons.	for different phases and eclipses.

MS-ESS1-2.	**Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.** Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state). *Assessment Boundary: Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.*

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena.

ESS1.A: The Universe and Its Stars

- Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.

ESS1.B: Earth and the Solar System

- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

Level 2	**Level 3**	**Level 4**

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Use a model to identify that two or more interacting objects are pulled toward each other by the force of gravity (does not include direction or that both bodies are pulling on each other).	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • Develop or use a model to describe the role of gravity in the motions within galaxies and the solar system.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Develop and refine models to demonstrate how gravity caused the formation of the solar system from a disk of dust and gas.

<table>
<tr><td>MS-ESS1-3.</td><td colspan="3">Analyze and interpret data to determine scale properties of objects in the solar system.

Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object’s layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.

Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.</td></tr>
<tr><td colspan="4">Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

• Analyze and interpret data to determine similarities and differences in findings.</td></tr>
<tr><td colspan="4">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></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Analyze graphical displays to determine similarities and</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Analyze and interpret data to determine scale properties of objects in the solar system.</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Analyze and interpret data to compare scale properties, distinguishing patterns in size</td></tr>
</table>

differences of different types of solar system objects. • Analyze and interpret data to describe surface features or orbital distances from the sun of solar system objects.		and orbital dimensions, distance, and surface features.

<table>
<tr><td>MS-ESS1-4.</td><td colspan="3">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.

Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth’s history. Examples of Earth’s major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.

Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.</td></tr>
<tr><td colspan="4">Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

• Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</td></tr>
<tr><td colspan="4">ESS1.C: The History of Planet Earth

• The geologic time scale interpreted from rock strata provides a way to organize Earth’s history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.</td></tr>
<tr><td>Level 2</td><td colspan="2">Level 3</td><td>Level 4</td></tr>
</table>

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Identify evidence to support a claim about patterns in rock strata and fossil records that describe sequences of geologic events.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • 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.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Refine a scientific explanation of Earth's historical changes using newly presented evidence from multiple sources.

<table>
<tr><td>MS-ESS2-1.</td><td colspan="3">Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

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

Assessment Boundary: Assessment does not include the identification and naming of minerals.</td></tr>
<tr><td colspan="4">Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

• Develop and use a model to describe phenomena.</td></tr>
<tr><td colspan="4">ESS2.A: Earth’s Materials and Systems

• All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Identify the aspects of a model that describe the cycling of Earth's materials or show that</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Develop a model to describe how energy flow drives both chemical and physical changes</td></tr>
</table>

energy from the sun or Earth's interior drives Earth's processes.		in Earth's materials and living organisms.

MS-ESS2-2.	**Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.** Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future.

ESS2.A: Earth's Materials and Systems

- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

ESS2.C: The Roles of Water in Earth's Surface Processes

<table>
<tr><td colspan="3">

- Water’s movements—both on the land and underground—cause weathering and erosion, which change the land’s surface features and create underground formations.

</td></tr>
<tr><td>

Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

- Use evidence to describe relationships in geoscience processes that change Earth’s surface (e.g., how water erodes rock).
- Identify evidence that Earth’s surface changes over time (without considering the vast geological timescale).

</td><td>

Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

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

</td><td>

Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

- Construct an explanation using evidence to predict future changes to Earth’s surface based on ongoing geoscience processes.

</td></tr>
</table>

<table>
<tr><td>MS-ESS2-3.</td><td colspan="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.

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

Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed.</td></tr>
<tr><td colspan="4">Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

• Analyze and interpret data to provide evidence for phenomena.</td></tr>
<tr><td colspan="4">ESS1.C: The History of Planet Earth

• Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. (HS.ESS1.C GBE),(secondary)

ESS2.B: Plate Tectonics and Large Scale System Interactions

• Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth’s plates have moved great distances, collided, and spread apart.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:</td></tr>
</table>

• Analyze data from maps that can be used to show the distribution of fossils, rock formations, or continental shapes to recognize patterns in Earth's history.	• Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. • Analyze and interpret data on the distribution of fossils and rocks to provide evidence of the past plate motions. • Analyze and interpret data on the continental shapes to provide evidence of the past plate motions. • Analyze and interpret data on the seafloor structures to provide evidence of the past plate motions.	• Analyze and interpret data to predict the impact of future plate movements on Earth's surface features using current geological and fossil evidence.

<table>
<tr><td>MS-ESS2-4.</td><td colspan="3">Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.

Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.</td></tr>
<tr><td colspan="4">Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

• Develop a model to describe unobservable mechanisms.</td></tr>
<tr><td colspan="4">ESS2.C: The Roles of Water in Earth's Surface Processes

• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
• Global movements of water and its changes in form are propelled by sunlight and gravity.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Use a model to describe that gravity influences precipitation and runoff.</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Develop a model to predict how changes in energy input affect water-cycle processes.</td></tr>
</table>

• Use a model to describe that energy from the sun influences evaporation and cloud formation. • Use a model to describe the general flow of water through Earth's systems.		• Develop a model to compare water-cycle variations in different ecosystems or climates.

MS-ESS2-5.	**Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.** Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation). *Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.*

Planning and Carrying Out Investigations

Planning and carrying out investigations in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

- Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

ESS2.C: The Roles of Water in Earth's Surface Processes

- The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

ESS2.D: Weather and Climate

- Because these patterns are so complex, weather can only be predicted probabilistically.

Level 2	**Level 3**	**Level 4**

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Collect and organize data to observe that air masses move and interact. • Use data to identify basic characteristics of air masses (e.g., temperature and humidity).	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions. • Collect data to provide evidence for how the motions of air masses result in changes in weather conditions. • Collect data to provide evidence for how complex interactions of air masses result in changes in weather conditions.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Analyze collected data to make connections between global atmospheric patterns and local weather changes. • Predict potential weather outcomes based on collected data and known atmospheric patterns.

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.** Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations. *Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.*

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena.

ESS2.C: The Roles of Water in Earth's Surface Processes

- Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.

ESS2.D: Weather and Climate

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

Level 2	Level 3	Level 4
Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Use a model to identify how the angle of sunlight that hits a surface affects the intensity. • Use a model to identify how differences in latitude affect temperature. • Use a model to describe that ocean currents move heat around Earth. • Use a model to show that regional climates are dependent on global circulation of atmospheric and oceanic currents.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • Develop and use a model to describe how unequal heating and rotation of Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. • Develop and use a model to describe how unequal heating and rotation of Earth cause patterns of atmospheric circulation that determine regional climates. • Develop and use a model to describe how unequal heating and rotation of Earth cause patterns of oceanic circulation that determine regional climates.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Use a model to evaluate the influence of geographic land distribution on the direction and energy distribution of ocean and atmospheric circulation patterns.

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

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

ESS3.A: Natural Resources

- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

Level 2	**Level 3**	**Level 4**

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Use evidence to identify the pattern that Earth's natural resources are unevenly distributed. • Identify evidence of limited resource availability due to human activity.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • 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. • Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral resources are the result of past and current geoscience processes. • Construct a scientific explanation based on evidence for how the uneven distributions of Earth's energy resources are the result of past and current geoscience processes. • Construct a scientific explanation based on evidence for how the uneven distributions of Earth's groundwater resources are the result of past	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Construct an explanation that integrates multiple sources of evidence to explain the distribution of resources and the limitations of their availability.

	and current geoscience processes.	

<table>
<tr><td>MS-ESS3-2.</td><td colspan="3">Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).</td></tr>
<tr><td colspan="4">Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

• Analyze and interpret data to determine similarities and differences in findings.</td></tr>
<tr><td colspan="4">ESS3.B: Natural Hazards

• Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:</td><td colspan="2">Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:</td><td>Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:</td></tr>
</table>

• Identify similarities and differences of different types of natural hazards and the effects they have on the environment.	• Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.	• Analyze data to propose improvements to existing hazard monitoring or mitigation technologies. • Analyze data to determine the relationship between geologic forces and the effects of natural hazards.

<table>
<tr><td>MS-ESS3-3.</td><td colspan="3">Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).</td></tr>
<tr><td colspan="4">Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

• Apply scientific principles to design an object, tool, process or system.</td></tr>
<tr><td colspan="4">ESS3.C: Human Impacts on Earth Systems

• Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things.
• Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.</td></tr>
<tr><td>Level 2</td><td>Level 3</td><td>Level 4</td></tr>
</table>

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Describe how designed solutions for conservation and sustainability efforts can help reduce negative impacts.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Justify how a designed solution effectively reduces human impact on the environment based on evidence, by analyzing positive and negative characteristics.

<table>
<tr><td>MS-ESS3-4.</td><td colspan="3">Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth’s systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.</td></tr>
<tr><td colspan="4">Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

• Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.</td></tr>
<tr><td colspan="4">ESS3.C: Human Impacts on Earth Systems

• Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Make a claim, supported by evidence, that an increasing</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Construct an argument supported by evidence for how increases in</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Use evidence to construct an argument evaluating the</td></tr>
</table>

population leads to more resource consumption.	human population and per-capita consumption of natural resources impact Earth's systems. • Construct an argument supported by evidence for how increases in human population impact Earth's systems. • Construct an argument supported by evidence for how increases in per-capita consumption of natural resources impact Earth's systems.	sustainability of human activities based on resource-management strategies. • Construct an argument focused on how human activities and technologies impact Earth's systems, and evaluate how engineered solutions can modify these effects to reduce negative environmental impacts.

<table>
<tr><td>MS-ESS3-5.</td><td colspan="3">Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.</td></tr>
<tr><td colspan="4">Asking Questions and Defining Problems

Asking questions and defining problems in 6–8 builds on K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

• Ask questions to identify and clarify evidence of an argument.</td></tr>
<tr><td colspan="4">ESS3.D: Global Climate Change

• Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.</td></tr>
<tr><td colspan="2">Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:</td><td>Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:</td></tr>
</table>

• Ask questions about how human actions might affect Earth's climate.	• Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.	• Ask questions that critically evaluate claims distinguishing between human and natural climate-change factors. • Ask questions that challenge assumptions in arguments about the causes of global temperature rise.

<table>
<tr><td>MS-PS1-1.</td><td colspan="3">Develop models to describe the atomic composition of simple molecules and extended structures.

Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.

Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.</td></tr>
<tr><td colspan="4">Developing and Using Models

Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.

● Develop a model to predict and/or describe phenomena.</td></tr>
<tr><td colspan="4">PS1.A: Structure and Properties of Matter

● Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
● Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).</td></tr>
<tr><td>Level 2</td><td colspan="2">Level 3</td><td>Level 4</td></tr>
</table>

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Identify components of models that represent atoms and molecules (e.g. atoms of carbon, hydrogen, and oxygen can combine to form a sugar molecule). • Use models to describe that atoms combine to form molecules.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • Develop models to describe the atomic composition of simple molecules and extended structures.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Refine models to clarify differences between molecules and extended structures. • Modify models to improve representation of atomic composition (e.g., difference between H_20 and H_2O_2).

<table>
<tr><td>MS-PS1-2.</td><td colspan="3">Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.

Assessment boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.</td></tr>
<tr><td colspan="4">Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

• Analyze and interpret data to determine similarities and differences in findings.</td></tr>
<tr><td colspan="4">PS1.A: Structure and Properties of Matter

• Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

PS1.B: Chemical Reactions

• Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.</td></tr>
<tr><td>Level 2</td><td colspan="2">Level 3</td><td>Level 4</td></tr>
</table>

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Use data to compare properties before or after substance interactions. • Identify basic properties (e.g., density, melting point) used to describe substances.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Interpret data of properties that indicate a chemical change and the recombination of the atoms in structures that were not present before the chemical reaction.

MS-PS1-3.	**Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.** Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels. *Assessment Boundary: Assessment is limited to qualitative information.*

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods.

- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or now supported by evidence.

PS1.A: Structure and Properties of Matter

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

PS1.B: Chemical Reactions

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

Level 2	**Level 3**	**Level 4**

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Gather and make sense of information on synthetic materials and their uses. • Use information to identify that synthetic materials originate from natural resources.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Gather information to describe both benefits and drawbacks of synthetic materials, including the allocation of natural resources.

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.** Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.

Developing and Using Models

Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to predict and/or describe phenomena.

PS1.A: Structure and Properties of Matter

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

PS3.A: Definitions of Energy

- The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this

<table>
<tr><td colspan="3">second meaning; it refers to the energy transferred due to the temperature difference between two objects. (secondary)
• The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (secondary)</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Use a model to describe particle motion in a substance.
• Identify a model of solids, liquids, and/or gases based on particle motion.</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Develop a model that predicts and describes changes in the particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
• Develop a model that predicts and describes changes in particle motion and temperature when thermal energy is added or removed.
• Develop a model that predicts and describes changes in the</td><td>Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Refine a model to predict how pressure can affect the state of matter.</td></tr>
</table>

	state of a pure substance when thermal energy is added or removed.	

<table>
<tr><td>MS-PS1-5.</td><td colspan="3">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.

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

Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.</td></tr>
<tr><td colspan="4">Developing and Using Models

Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.

• Develop a model to describe unobservable mechanisms.</td></tr>
<tr><td colspan="4">PS1.B: Chemical Reactions

• Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
• The total number of each type of atom is conserved, and thus the mass does not change.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:</td><td>Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:</td></tr>
</table>

• Use a model to identify the total number of atoms in a chemical reaction.	• 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.	• Refine a model that shows when properties change the exact number and types of atoms remain the same and recombine in new ways.

MS-PS1-6.	**Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*** Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride. *Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.*

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.

PS1.B: Chemical Reactions

- Some chemical reactions release energy, others store energy.

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (secondary)

ETS1.C: Optimizing the Design Solution

<table>
<tr><td colspan="3">

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (secondary)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (secondary)

</td></tr>
<tr><td>

Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

- Identify a design that can test the thermal energy changes during a chemical reaction.

</td><td>

Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

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

</td><td>

Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

- Identify the limitations of a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

</td></tr>
</table>

<table>
<tr><td>MS-PS2-1.</td><td colspan="3">Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects.*

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

Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.</td></tr>
<tr><td colspan="4">Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

• Apply scientific ideas or principles to design an object, tool, process or system.</td></tr>
<tr><td colspan="4">PS2.A: Forces and Motion

• For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law).</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Construct an explanation of the motion before and after two objects collide.</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Apply Newton's Third Law to design a solution to a problem</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Apply Newton’s Third Law to design a solution to quantitatively</td></tr>
</table>

	involving the motion of two colliding objects.	predict 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.** Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units. *Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.

- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

PS2.A: Forces and Motion

- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

Level 2	Level 3	Level 4
Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Observe how different unbalanced forces can affect the overall motion of different objects of different masses.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • 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.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Refine investigations to examine how the change in the motion and mass of interacting objects can predict the resulting observed motion of the objects.

<table>
<tr><td>MS-PS2-3.</td><td colspan="3">Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.

Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.</td></tr>
<tr><td colspan="4">Asking Questions and Defining Problems

Asking questions and defining problems in 6–8 builds from K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

• Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.</td></tr>
<tr><td colspan="4">PS2.B: Types of Interactions

• Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.</td></tr>
<tr><td>Level 2</td><td colspan="2">Level 3</td><td>Level 4</td></tr>
</table>

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Make observations on factors that can affect the strength of electric or magnetic forces.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Ask questions that can be investigated about the strength and similarities of electric and magnetic forces.

<table>
<tr><td>MS-PS2-4.</td><td colspan="3">Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.

Assessment Boundary: Assessment does not include Newton’s Law of Gravitation or Kepler’s Laws.</td></tr>
<tr><td colspan="4">Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds from K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

• Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.</td></tr>
<tr><td colspan="4">PS2.B: Types of Interactions

• Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Construct an argument using evidence to describe how the</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Construct and present arguments using evidence to support the claim</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Construct and present arguments using evidence to</td></tr>
</table>

force of gravity is always attractive.	that gravitational interactions are attractive and depend on the masses of interacting objects.	support the claim that larger masses experience and exert proportionally larger gravitational forces.

<table>
<tr><td>MS-PS2-5.</td><td colspan="3">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.

Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.

Assessment Boundary: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.</td></tr>
<tr><td colspan="4">Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.

• Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.</td></tr>
<tr><td colspan="4">PS2.B: Types of Interactions

• Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:</td><td>Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:</td></tr>
</table>

• Plan an investigation to show forces acting at a distance (e.g., magnets pushing against each other).	• 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.	• Conduct an investigation and evaluate the strength of fields of objects that interact at a distance to predict the patterns of the interactions.

<table>
<tr><td>MS-PS3-1.</td><td colspan="3">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.

Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.</td></tr>
<tr><td colspan="4">Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

• Construct and interpret graphical displays of data to identify linear and nonlinear relationships.</td></tr>
<tr><td colspan="4">PS3.A: Definitions of Energy

• Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Analyze data to describe the relationships between the motion of an object and its kinetic energy.</td><td colspan="2">Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.</td><td>Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Construct and interpret graphical displays of data to describe the quantitative proportional relationships among kinetic</td></tr>
</table>

		energy, the mass of an object, and the speed of an object.

<table>
<tr><td>MS-PS3-2.</td><td colspan="3">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.

Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate’s hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.

Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.</td></tr>
<tr><td colspan="4">Developing and Using Models

Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.

• Develop a model to describe unobservable mechanisms.</td></tr>
<tr><td colspan="4">PS3.A: Definitions of Energy

• A system of objects may also contain stored (potential) energy, depending on their relative positions.

PS3.C: Relationship Between Energy and Forces

• When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.</td></tr>
<tr><td colspan="2">Level 2</td><td>Level 3</td><td>Level 4</td></tr>
</table>

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Develop a model to show that some objects can interact at a distance (e.g., a rollercoaster going down a hill, a comb bending a stream of water).	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • 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.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Develop a model to make predictions about the stored potential energy of an object (e.g., a coil of wires around a magnet or a mass at some distance above Earth's surface).

MS-PS3-3.	**Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*** Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup. *Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.*

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.

PS3.A: Definitions of Energy

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

PS3.B: Conservation of Energy and Energy Transfer

- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

ETS1.A: Defining and Delimiting an Engineering Problem

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary)

ETS1.B: Developing Possible Solutions • A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary)		
Level 2 Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Apply scientific ideas to explain how thermal energy transfers across the boundary of a system.	**Level 3** Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.	**Level 4** Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Revise a design that either minimizes or maximizes thermal energy transfer.

MS-PS3-4.	**Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.** Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added. *Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred*.

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.

- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

PS3.A: Definitions of Energy

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

PS3.B: Conservation of Energy and Energy Transfer

• The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.		
Level 2 Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Identify the variables that can be measured to determine the average kinetic energy of particles in a sample.	**Level 3** Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.	**Level 4** Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Determine the amount of data needed to support a claim for which sample would have the greatest change in temperature or average kinetic energy.

<table>
<tr><td>MS-PS3-5.</td><td colspan="3">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.

Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.

Assessment Boundary: Assessment does not include calculations of energy.</td></tr>
<tr><td colspan="4">Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds.

• Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon.</td></tr>
<tr><td colspan="4">PS3.B: Conservation of Energy and Energy Transfer

• When the motion energy of an object changes, there is inevitably some other change in energy at the same time.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Construct an argument that energy is transferred across the</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Construct, use, and present arguments to support the claim that when the kinetic energy of an</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Construct and present arguments to support the claim that conservation of energy</td></tr>
</table>

boundary of a system when an object speeds up or slows down.	object changes, energy is transferred to or from the object.	applies to kinetic energy changes within the boundary of a system.

<table>
<tr><td>MS-PS4-1.</td><td colspan="3">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.

Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.]

Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.</td></tr>
<tr><td colspan="4">Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 6–8 level builds on K–5 and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.

• Use mathematical representations to describe and/or support scientific conclusions and design solutions.</td></tr>
<tr><td colspan="4">PS4.A: Wave Properties

• A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:

• Use mathematical representations to identify that waves have properties such as amplitude and wavelength.</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:

• Use mathematical representations to describe a simple model for waves that includes how the amplitude of a</td><td colspan="2">Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:

• Use mathematical representations to describe the proportional relationship between amplitude and energy.</td></tr>
</table>

	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.** Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions. *Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.*

Developing and Using Models

Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena.

PS4.A: Wave Properties

- A sound wave needs a medium through which it is transmitted.

PS4.B: Electromagnetic Radiation

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Level 2	Level 3	Level 4
Students at level 2 show a basic ability to demonstrate their knowledge and skills such as: • Use a model to identify the differences in how mechanical and light waves interact with mediums (e.g., a sound wave needs a medium). • Use a model to identify that all light waves travel in straight lines when not interacting with a material.	Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as: • Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.	Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as: • Develop and use a model to compare different materials and predict their effects on wave behavior (i.e., identify how a change in material may affect how a wave is reflected, absorbed, or transmitted).

<table>
<tr><td>MS-PS4-3.</td><td colspan="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.

Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.

Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.</td></tr>
<tr><td colspan="4">Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods.

• Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.</td></tr>
<tr><td colspan="4">PS4.C: Information Technologies and Instrumentation

• Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.</td></tr>
<tr><td>Level 2

Students at level 2 show a basic ability to demonstrate their knowledge and skills such as:</td><td>Level 3

Students at level 3 show a proficient ability to demonstrate their knowledge and skills such as:</td><td>Level 4

Students at level 4 show an advanced ability to demonstrate their knowledge and skills such as:</td></tr>
</table>

• Evaluate how information can be transmitted using analog and digital signals.	• 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.	• Communicate how different signals are transmitted, and compare transmission methods and their effectiveness in real-world applications.