Science Standard-Specific Supports

Grade 6

Revised October 2022

Contents

Science Standard-Specific Supports

Overview

The West Virginia College- and Career-Readiness Standards for Science[1] identify what students should know and be able to do at the end of science instruction. Each standard represents the integration of three "dimensions" of science education: practices of scientists and engineers, core science content, and science connecting concepts. As such, both student learning and assessment around the standards should be "three dimensional." The Science Standard-Specific Supports in this document are intended to show what it looks like for students to fully satisfy the intent of the standard.

The Science Standard-Specific Supports are adapted from the Evidence Statements of the Next Generation Science Standards (NGSS)[2], created when West Virginia was a lead state during the NGSS writing process, and the Framework for K-12 Science Instruction[3], created prior to the development of the NGSS. For more information on the Evidence Statements, please refer to them in their original form.

Purpose

The Science Standard-Specific Supports were designed to articulate how students can use the practices of scientists and engineers to demonstrate their understanding of the core science content through the lens of the science connecting concepts, and thus, demonstrate proficiency on each standard. The Science Standard-Specific Supports do this by clarifying:

- how the three dimensions could be assessed together, rather than in independent units;
- the underlying knowledge required for each core science content;
- the detailed approaches to the practices of scientists and engineers; and
- how science connecting concepts might be used to deepen content- and practice-driven learning.

The Science Standard-Specific Supports are not intended to be used as curriculum or limit or dictate instruction.

Structure

The practices of scientists and engineers are used as the organizing structure for the Science Standard-Specific Supports. However, this does not mean that the practices are more important than the other dimensions. The practices of scientists and engineers form the activities through which students demonstrate understanding of the science content. The proper integration of the practices makes students' thinking visible.

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[1] *West Virginia College- and Career-Readiness Standards for Science* (Policy 2520.3C) https://apps.sos.wv.gov/adlaw/csr/readfile.aspx?DocId=54673&Format=PDF

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

[3] National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Washington, DC: The National Academies Press.

How to Use the Science Standard-Specific Supports

- For instruction:
    - The Science Standard-Specific Supports can be used to aid instructional design, but it is crucial to recognize there are numerous pathways educators may use throughout the sequence of lessons and units to allow students to ultimately be prepared to demonstrate mastery of the standards.
- For assessment:
    - The Science Standard-Specific Supports can be used to inform the development of formative and summative assessments by the classroom educator.

Although supports are listed individually for each standard, this does not indicate that they should be measured individually, or that standards should be taught or assessed individually. Best practices in classroom instruction should be focused on helping students build towards several standards at one time because many concepts and practices are interrelated.

Limitations of the Science Standard-Specific Supports

The science standard supports cannot do the following:

- Provide or prescribe the contexts through which the standards may be taught or assessed.
- Be the rubrics on which levels of student success would be measured.
- Identify the sequence of instruction or assessment.
- Put limits on student learning or student coursework.
- Replace lesson plans or assessment items.
- Serve as complete scoring rubrics.

Science - Grade 6 Introduction

Sixth Grade Science standards build upon students' science understanding from earlier grades and provide deeper understandings in eight major content topics: Weather and Climate; Space Systems; Atoms and Elements; Waves and Electromagnetic Radiation; Matter and Energy in Organisms and Ecosystems; Interdependent Relationships in Ecosystems; Human Impacts, and Engineering Design. The standards blend central ideas with the practices of scientists and engineers and science connecting concepts to support students in developing useable knowledge across the science disciplines. There is a focus on multiple indicators, including developing and using models; analyzing and interpreting data; using mathematical and computational thinking; obtaining, evaluating, and communicating information; and engaging in argument from evidence. Engineering, Technology, and the Application of Science are integrated throughout instruction as students define problems and design solutions related to the course topics. Students will engage in active inquiries, investigations, and hands-on activities at least 50% of the instructional time as they develop and demonstrate conceptual understandings along with research and laboratory skills described in the standards and indicators for science. Safety instruction is integrated into all activities, and students will implement safe procedures and practices when manipulating equipment, materials, organisms, and models. Standards followed by an asterisk (*) denote the integration of traditional science content with an engineering practice.

Within the evidence statements, the words "description" or "describe" followed by an asterisk indicate those descriptions given by students could include but are not limited to written, oral, pictorial, and kinesthetic descriptions unless otherwise specified.

College- and Career-Readiness Indicators for Science Grades 6-8

Nature of Science	
• Scientific knowledge is simultaneously reliable and subject to change based on empirical evidence and interpretation. • Scientific knowledge is obtained through a combination of observations of the natural world and inferences based on those observations. • Science is a creative human endeavor which is influenced by social and cultural biases. • A primary goal of science is the formation of theories and laws. Theories are inferred explanations of some aspect of the natural world based on successfully tested information from evidence and evaluated phenomena. Laws describe relationships among what has been observed in the natural world. • Scientific investigations use a variety of methods to address questions about the natural and material world.	
Practices of Scientists and Engineers	**Science Connecting Concepts**
• Asking questions and defining problems • Developing and using models • Planning and carrying out investigations • Analyzing and interpreting data • Using mathematical and computational thinking • Constructing explanations and designing solutions • Engaging in argument from evidence • Obtaining, evaluating, and communicating information	• Observing patterns • Investigating and explaining cause and effect • Recognizing scale, proportion, and quantity • Defining systems and system models • Tracking energy and matter flows, into, out of, and within systems to understand system behavior • Determining the relationships between structure and function • Studying stability and change
Science Literacy	**Science Lab Safety**
• Producing clear and coherent technical writing in which the development, organization and style are appropriate for the science topic • Correctly utilizing and explaining visually expressed information (e.g., flowchart, diagram, model, graph, table, or digital mapping technology) in a science narrative. • Appropriately using technical terminology or scientific concepts and processes to create visually expressed information • Reading with understanding articles about science in the popular press and engaging in social conversation about the validity of the conclusions • Identifying scientific issues underlying national and local decisions and expressing positions that are scientifically and technologically informed • Evaluating the quality and validity of scientific information on the basis of its source and the methods used to generate it	• Requiring student lab safety training and demonstrating appropriate proficiency before participating in lab activities • Archiving signed student safety contracts documenting lab safety training and medical contraindications (e.g., allergies, contact lenses, medical conditions) • Wearing proper protective gear as needed (e.g., goggles, apron, and gloves) • Requiring grade appropriate lab equipment operation and safety training • Using and following SDS protocols • Storing and disposing of chemical/biological materials properly • Following ethical classroom uses of living materials/organisms • Displaying proper safety signage and laboratory rules in the classroom and lab

Life Science

Topic: Interdependent Relationships in Ecosystems

S.6.1. 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.]

Practices of Scientists and Engineers	Core Science Content
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. Students will construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.	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.
Science Connecting Concepts	
Patterns - Patterns can be used to identify cause and effect relationships	

Observable features of the student performance by the end of the course:

1) Articulating the explanation of phenomena
   a) Students articulate a statement that relates the given phenomenon to a scientific idea, including that similar patterns of interactions occur between organisms and their environment, regardless of the ecosystem or the species involved.
   b) Students use evidence and reasoning to construct an explanation for the given phenomenon.
2) Evidence
   a) Students identify and describe* the evidence (e.g., from students' own investigations, observations, reading material, archived data) necessary for constructing the explanation, including evidence that:
      i) Competitive relationships occur when organisms within an ecosystem compete for shared resources (e.g., data about the change in population of a given species when a competing species is introduced).
      ii) Predatory interactions occur between organisms within an ecosystem.
      iii) Mutually beneficial interactions occur between organisms within an ecosystem. Organisms involved in these mutually beneficial interactions can become so dependent upon one another that they cannot survive alone.
      iv) Resource availability, or lack thereof, can affect interactions between organisms (e.g., organisms in a resource-limited environment may have a competitive relationship, while those same organisms may not be in competition in a resource-rich environment).
      v) Competitive, predatory, and mutually beneficial interactions occur across multiple, different, ecosystems
   b) Students use multiple valid and reliable sources for the evidence.

3) Reasoning

a) Students identify and describe* quantitative or qualitative patterns of interactions among organisms that can be used to identify causal relationships within ecosystems, related to the given phenomenon.
b) Students describe* that regardless of the ecosystem or species involved, the patterns of interactions (competitive, mutually beneficial, predator/prey) are similar.
c) Students use reasoning to connect the evidence and support an explanation. In their reasoning, students use patterns in the evidence to predict common interactions among organisms in ecosystems as they relate to the phenomenon, (e.g., given specific organisms in a given environment with specified resource availability, which organisms in the system will exhibit competitive interactions). Students predict the following types of interactions:
    i) Predatory interactions.
    ii) Competitive interactions.
    iii) Mutually beneficial interactions.

S.6.2. 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.]

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). Students will evaluate competing design solutions based on jointly developed and agreed upon design criteria.</td><td rowspan="3">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.

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)

Developing Possible Solutions
There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary)</td></tr>
<tr><th>Science Connecting Concepts</th></tr>
<tr><td>Stability and Change
Small changes in one part of a system might cause large changes in another part.

Influence of Science, Engineering, and Technology on Society and the Natural World
The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time.

Science Addresses Questions About the Natural and Material World
Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.</td></tr>
</table>

Observable features of the student performance by the end of the course:

1) Identifying the given design solution and supporting evidence
    a) Students identify and describe:
        i) The given competing design solutions for maintaining biodiversity and ecosystem services.
        ii) The given problem involving biodiversity and/or ecosystem services that is being solved by the given design solutions, including information about why biodiversity and/or ecosystem services are necessary to maintaining a healthy ecosystem.
        iii) The given evidence about performance of the given design solutions.
2) Identifying any potential additional evidence that is relevant to the evaluation
    a) Students identify and describe the additional evidence (in the form of data, information, or other appropriate forms) that is relevant to the problem, design solutions, and evaluation of the solutions, including:
        i) The variety of species (biodiversity) found in the given ecosystem.
        ii) Factors that affect the stability of the biodiversity of the given ecosystem.
        iii) Ecosystem services (e.g., water purification, nutrient recycling, prevention of soil erosion) that affect the stability of the system.
        iv) Students collaboratively define and describe criteria and constraints for the evaluation of the design solution.
3) Evaluating and critiquing the design solution
    a) In their evaluations, students use scientific evidence to:
        i) Compare the ability of each of the competing design solutions to maintain ecosystem stability and biodiversity.
        ii) Clarify the strengths and weaknesses of the competing designs with respect to each criterion and constraint (e.g., scientific, social, and economic considerations).
        iii) Assess possible side effects of the given design solutions on other aspects of the ecosystem, including the possibility that a small change in one component of an ecosystem can produce a large change in another component of the ecosystem.

Topic: Matter and Energy in Organisms and Ecosystems

S.6.3. 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.]

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.
Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Connections to Nature of Science
Scientific Knowledge is Based on Empirical Evidence
Science knowledge is based upon logical connections between evidence and explanations.</td><td rowspan="3">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.

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><th>Science Connecting Concepts</th></tr>
<tr><td>Energy and Matter
Within a natural system, the transfer of energy drives the motion and/or cycling of matter.</td></tr>
</table>

Observable features of the student performance by the end of the course:

1) Articulating the explanation of phenomena
   a) Students articulate a statement that relates the given phenomenon to a scientific idea, including the idea that photosynthesis results in the cycling of matter and energy into and out of organisms.
   b) Students use evidence and reasoning to construct a scientific explanation for the given phenomenon.
2) Evidence
   a) Students identify and describe evidence (e.g., from students' own investigations, observations, reading material, archived data) necessary to constructing the explanation, including that:
      i) Plants, algae, and photosynthetic microorganisms require energy (in the form of sunlight) and must take in carbon dioxide and water to survive.
      ii) Energy from sunlight is used to combine simple nonfood molecules (e.g., carbon dioxide and water) into food molecules (e.g., sugar) and oxygen, which can be used immediately or stored by the plant.
      iii) Animals take in food and oxygen to provide energy and materials for growth and survival.
      iv) Some animals eat plants, algae, and photosynthetic microorganisms, and some animals eat other animals, which have themselves eaten photosynthetic organisms.
   b) Students use multiple valid and reliable sources of evidence.

3) Reasoning
   a) Students use reasoning, along with 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, to connect the evidence and support an explanation for energy and matter cycling during photosynthesis. Students describe a chain of reasoning for their explanation, including:
      i) Plants, algae, and photosynthetic microorganisms take in matter (in the form of carbon dioxide and water) and use energy from the sun to produce carbon-based organic molecules (food), which they can use immediately or store, and release oxygen into the environment through photosynthesis.
      ii) Plants use the food they have made for energy, growth, and other necessary functions (e.g., repair, seed production).
      iii) Animals depend on matter from plants for growth and survival, including:
         (1) Eating photosynthetic organisms (or other organisms that have eaten photosynthetic organisms), thus acquiring the matter they contain, the production of which was driven by photosynthesis.
         (2) Breathing in oxygen, which was released when plants used energy to rearrange carbon dioxide and water during photosynthesis.
      iv) Because animals acquire their food from photosynthetic organisms (or from other animals that have eaten those organisms) and their oxygen from the products of photosynthesis, all food and most of the oxygen animals use for life processes are the results of energy from the sun driving matter flows through the process of photosynthesis.
      v) The process of photosynthesis has an important role in energy and matter cycling within plants (i.e., the conversion of carbon dioxide and water into complex carbon-based molecules (sugars) and oxygen, the contribution of sugars to plant growth and internal processes) as well as from plants to other organisms.

S.6.4. 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.]

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Developing and Using Models
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. Students will develop a model to describe unobservable mechanisms.</td><td rowspan="3">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.

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>Science Connecting Concepts</td></tr>
<tr><td>Energy and Matter
Matter is conserved because atoms are conserved in physical and chemical processes.</td></tr>
</table>

Observable features of the student performance by the end of the course:

1) Components of the model
   a) To make sense of a phenomenon, students develop a model in which they identify the relevant components for describing how food molecules are rearranged as matter moves through an organism, including:
      i) Molecules of food, which are complex carbon-containing molecules.
      ii) Oxygen.
      iii) Energy that is released or absorbed during chemical reactions between food and oxygen.
      iv) New types of molecules produced through chemical reactions involving food.
2) Relationships
   a) In the model, students identify and describe the relationships between components, including:
      i) During cellular respiration, molecules of food undergo chemical reactions with oxygen, releasing stored energy.
      ii) The atoms in food are rearranged through chemical reactions to form new molecules.
3) Connections
   a) Students use the model to describe:
      i) The number of each type of atom being the same before and after chemical reactions, indicating that the matter ingested as food is conserved as it moves through an organism to support growth.
      ii) That all matter (atoms) used by the organism for growth comes from the products of the chemical reactions involving the matter taken in by the organism.
      iii) Food molecules taken in by the organism are broken down and can then be rearranged to become the molecules that comprise the organism (e.g., the proteins and other molecules in a hamburger can be broken down and used to make a variety of tissues in humans).
      iv) As food molecules are rearranged, energy is released and can be used to support other processes within the organism.

S.6.5. 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.]

Practices of Scientists and Engineers	Core Science Content
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. Student will analyze and interpret data to provide evidence for phenomena.	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
Science Connecting Concepts	
Cause and Effect Cause and effect relationships may be used to predict phenomena in natural or designed systems.	

Observable features of the student performance by the end of the course:
1) Organizing data
   a) Students organize the given data (e.g., using tables, graphs, and charts) to allow for analysis and interpretation of relationships between resource availability and organisms in an ecosystem, including:

      i) Populations (e.g., sizes, reproduction rates, growth information) of organisms as a function of resource availability.
      ii) Growth of individual organisms as a function of resource availability.
2) Identifying relationships
   a) Students analyze the organized data to determine the relationships between the size of a population, the growth and survival of individual organisms, and resource availability.
   b) Students determine whether the relationships provide evidence of a causal link between these factors.
3) Interpreting data
   a) Students analyze and interpret the organized data to make predictions based on evidence of causal relationships between resource availability, organisms, and organism populations. Students make relevant predictions, including:
      i) Changes in the amount and availability of a given resource (e.g., less food) may result in changes in the population of an organism (e.g., less food results in fewer organisms).
      ii) Changes in the amount or availability of a resource (e.g., more food) may result in changes in the growth of individual organisms (e.g., more food results in faster growth).
      iii) Resource availability drives competition among organisms, both within a population as well as between populations.
      iv) Resource availability may have effects on a population's rate of reproduction.

S.6.6. 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.]

Practices of Scientists and Engineers	Core Science Content
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. Student will develop a model to describe phenomena.	**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.
Science Connecting Concepts	
Energy and Matter The transfer of energy can be tracked as energy flows through a natural system. **Connections to Nature of Science** Scientific Knowledge Assumes an Order and Consistency in Natural Systems	

Observable features of the student performance by the end of the course:

1) Components of the model
   a) To make sense of a given phenomenon, students develop a model in which they identify the relevant components, including:
      i) Organisms that can be classified as producers, consumers, and/or decomposers.
      ii) Nonliving parts of an ecosystem (e.g., water, minerals, air) that can provide matter to living organisms or receive matter from living organisms.
      iii) Energy

   b) Students define the boundaries of the ecosystem under consideration in their model (e.g., pond, part of a forest, meadow; a whole forest, which contains a meadow, pond, and stream).
2) Relationships
   a) In the model, students describe relationships between components within the ecosystem, including:
      i) Energy transfer into and out of the system.
      ii) Energy transfer and matter cycling (cycling of atoms):
         (1) Among producers, consumers, and decomposers (e.g., decomposers break down consumers and producers via chemical reactions and use the energy released from rearranging those molecules for growth and development).
         (2) Between organisms and the nonliving parts of the system (e.g., producers use matter from the nonliving parts of the ecosystem and energy from the sun to produce food from nonfood materials).
3) Connections
   a) Students use the model to describe the cycling of matter and flow of energy among living and nonliving parts of the defined system, including:
      i) When organisms consume other organisms, there is a transfer of energy and a cycling of atoms that were originally captured from the nonliving parts of the ecosystem by producers.
      ii) The transfer of matter (atoms) and energy between living and nonliving parts of the ecosystem at every level within the system, which allows matter to cycle and energy to flow within and outside of the system.
   b) Students use the model to track energy transfer and matter cycling in the system based on consistent and measurable patterns, including:
      i) That the atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
      ii) That matter and energy are conserved through transfers within and outside of the ecosystem.

S.6.7. 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.]

Practices of Scientists and Engineers	Core Science Content
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). Students will construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. Connections to Nature of Science Scientific Knowledge is Based on Empirical Evidence Science disciplines share common rules of obtaining and evaluating empirical evidence.	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.
Science Connecting Concepts	
Stability and Change Small changes in one part of a system might cause large changes in another part.	

Observable features of the student performance by the end of the course:

1) Supported claims
   a) Students make a claim to be supported about a given explanation or model for a phenomenon. In their claim, students include the idea that changes to physical or biological components of an ecosystem can affect the populations living there.
2) Identifying scientific evidence
   a) Students identify and describe the given evidence (e.g., evidence from data, scientific literature) needed for supporting the claim, including evidence about:
      i) Changes in the physical or biological components of an ecosystem, including the magnitude of the changes (e.g., data about rainfall, fires, predator removal, species introduction).
      ii) Changes in the populations of an ecosystem, including the magnitude of the changes (e.g., changes in population size, types of species present, and relative prevalence of a species within the ecosystem).
      iii) Evidence of causal and correlational relationships between changes in the components of an ecosystem with the changes in populations.
   b) Students use multiple valid and reliable sources of evidence.
3) Evaluating and critiquing the evidence
   a) Students evaluate the given evidence, identifying the necessary and sufficient evidence for supporting the claim.
   b) Students identify alternative interpretations of the evidence and describe why the evidence supports the student's claim.
4) Reasoning and synthesis
   a) Students use reasoning to connect the appropriate evidence to the claim and construct an oral or written argument about the causal relationship between physical and biological components of an ecosystem and changes in organism populations, based on patterns in the evidence. In the argument, students describe a chain of reasoning that includes:
      i) Specific changes in the physical or biological components of an ecosystem cause changes that can affect the survival and reproductive likelihood of organisms within that ecosystem (e.g., scarcity of food or the elimination of a predator will alter the survival and reproductive probability of some organisms).
      ii) Factors that affect the survival and reproduction of organisms can cause changes in the populations of those organisms.
      iii) Patterns in the evidence suggest that many different types of changes (e.g., changes in multiple types of physical and biological components) are correlated with changes in organism populations.
      iv) Several consistent correlational patterns, along with the understanding of specific causal relationships between changes in the components of an ecosystem and changes in the survival and reproduction of organisms, suggest that many changes in physical or biological components of ecosystems can cause changes in populations of organisms.
      v) Some small changes in physical or biological components of an ecosystem are associated with large changes in a population, suggesting that small changes in one component of an ecosystem can cause large changes in another component.

Physical Science

Topic: Waves and Electromagnetic Radiation

S.6.10. 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.]

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Using Mathematics and Computational Thinking
Mathematical and computational thinking at the 6–8 level builds on K–5 and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. Students will use mathematical representations to describe and/or support scientific conclusions and design solutions.

Connections to Nature of Science
Scientific Knowledge is Based on Empirical Evidence
Science knowledge is based upon logical and conceptual connections between evidence and explanations.</td><td rowspan="3">Wave Properties
A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.</td></tr>
<tr><td>Science Connecting Concepts</td></tr>
<tr><td>Patterns
Graphs and charts can be used to identify patterns in data.</td></tr>
</table>

Observable features of the student performance by the end of the course:

1) Representation
   a) Students identify the characteristics of a simple mathematical wave model of a phenomenon, including:
      i) Waves represent repeating quantities.
      ii) Frequency, as the number of times the pattern repeats in a given amount of time (e.g., beats per second).
      iii) Amplitude, as the maximum extent of the repeating quantity from equilibrium (e.g., height or depth of a water wave from average sea level).
      iv) Wavelength, as a certain distance in which the quantity repeats its value (e.g., the distance between the tops of a series of water waves).
2) Mathematical modeling
   a) Students apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations (e.g., frequency corresponds to sound pitch, amplitude corresponds to sound volume).
3) Analysis
   a) Given data about a repeating physical phenomenon that can be represented as a wave, and amounts of energy present or transmitted, students use their simple mathematical wave models to identify patterns, including:
      i) That the energy of the wave is proportional to the square of the amplitude (e.g., if the height of a water wave is doubled, each wave will have four times the energy).
      ii) That the amount of energy transferred by waves in a given time is proportional to frequency (e.g., if twice as many water waves hit the shore each minute, then twice as much energy will be transferred to the shore).
   b) Students predict the change in the energy of the wave if any one of the parameters of the wave is changed.

S.6.11. 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.]

Practices of Scientists and Engineers	Core Science Content
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. Students will develop and use a model to describe phenomena.	**Wave Properties** A sound wave needs a medium through which it is transmitted. **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.
Science Connecting Concepts	
Structure and Function Structures can be designed to serve particular functions by taking into account the properties of different materials, and how materials can be shaped and used.	

Observable features of the student performance by the end of the course:

1) Components of the model
   a) Students develop a model to make sense of a given phenomenon. In the model, students identify the relevant components, including:
      i) Type of wave.
         (1) Matter waves (e.g., sound or water waves) and their amplitudes and frequencies.
         (2) Light, including brightness (amplitude) and color (frequency).
      ii) Various materials through which the waves are reflected, absorbed, or transmitted.
      iii) Relevant characteristics of the wave after it has interacted with a material (e.g., frequency, amplitude, wavelength).
      iv) Position of the source of the wave.
2) Relationships
   a) In the model, students identify and describe the relationships between components, including:
      i) Waves interact with materials by being:
         (1) Reflected.
         (2) Absorbed.
         (3) Transmitted.
      ii) Light travels in straight lines, but the path of light is bent at the interface between materials when it travels from one material to another.
      iii) Light does not require a material for propagation (e.g., space), but matter waves do require a material for propagation.
3) Connections
   a) Students use their model to make sense of given phenomena involving reflection, absorption, or transmission properties of different materials for light and matter waves.
   b) Students use their model about phenomena involving light and/or matter waves to describe the differences between how light and matter waves interact with different materials.
   c) Students use the model to describe why materials with certain properties are well-suited for particular functions (e.g., lenses and mirrors, sound absorbers in concert halls, colored light filters, sound barriers next to highways).

S.6.12. 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.]

Practices of Scientists and Engineers	Core Science Content
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. Students will integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.	**Information Technologies and Instrumentation** Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.
Science Connecting Concepts	
Structure and Function Structures can be designed to serve particular functions. **Connections to Engineering, Technology, and Applications of Science** Influence of Science, Engineering, and Technology on Society and the Natural World - Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. **Connections to Nature of Science** Science is a Human Endeavor - Advances in technology influence the progress of science and science has influenced advances in technology.	

Observable features of the student performance by the end of the course:

1) Obtaining information
   a) Given materials from a variety of different types of sources of information (e.g., texts, graphical, video, digital), students gather evidence sufficient to support a claim about a phenomenon that includes the idea that using waves to carry digital signals is a more reliable way to encode and transmit information than using waves to carry analog signals.
2) Evaluating information
   a) Students combine the relevant information (from multiple sources) to support the claim by describing:
      i) Specific features that make digital transmission of signals more reliable than analog transmission of signals, including that, when in digitized form, information can be:
         (1) Recorded reliably.
         (2) Stored for future recovery.
         (3) Transmitted over long distances without significant degradation.
      ii) At least one technology that uses digital encoding and transmission of information. Students should describe how the digitization of that technology has advanced science and scientific investigations (e.g., digital probes, including thermometers and pH probes; audio recordings).

Earth and Space Science

Topic: Space Systems

S.6.13. 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.]

Practices of Scientists and Engineers	Core Science Content
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. Students will develop and use a model to describe phenomena.	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. Earth and the Solar System This model of the solar system can explain the 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.
Science Connecting Concepts	
Patterns Patterns can be used to identify cause-and-effect relationships. Connections to Nature of Science Scientific Knowledge Assumes an Order and Consistency in Natural Systems - Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.	

Observable features of the student performance by the end of the course:

1) Components of the model
   a) To make sense of a given phenomenon involving, students develop a model (e.g., physical, conceptual, graphical) of the Earth-moon-sun system in which they identify the relevant components, including:
      i) Earth, including the tilt of its axis of rotation.
      ii) Sun.
      iii) Moon.
      iv) Solar energy.
   b) Students indicate the accuracy of size and distance (scale) relationships within the model, including any scale limitations within the model.
2) Relationships
   a) In their model, students describe the relationships between components, including:
      i) Earth rotates on its tilted axis once an Earth day.
      ii) The moon rotates on its axis approximately once a month.
      iii) Relationships between Earth and the moon:
         (1) The moon orbits Earth approximately once a month.
         (2) The moon rotates on its axis at the same rate at which it orbits Earth so that the side of the moon that faces Earth remains the same as it orbits.
         (3) The moon's orbital plane is tilted with respect to the plane of the Earth's orbit around the sun.
      iv) Relationships between the Earth-moon system and the sun:
         (1) Earth-moon system orbits the sun once an Earth year.
         (2) Solar energy travels in a straight line from the sun to Earth and the moon so that the side of Earth or the moon that faces the sun is illuminated.

(3) Solar energy reflects off of the side of the moon that faces the sun and can travel to Earth.
(4) The distance between Earth and the sun stays relatively constant throughout the Earth's orbit.
(5) Solar energy travels in a straight line from the sun and hits different parts of the curved Earth at different angles — more directly at the equator and less directly at the poles.
(6) The Earth's rotation axis is tilted with respect to its orbital plane around the sun. Earth maintains the same relative orientation in space, with its North Pole pointed toward the North Star throughout its orbit.

3) Connections
- a) Students use patterns observed from their model to provide causal accounts for events, including:
  - i) Moon phases:
    - (1) Solar energy coming from the sun bounces off of the moon and is viewed on Earth as the bright part of the moon.
    - (2) The visible proportion of the illuminated part of the moon (as viewed from Earth) changes over the course of a month as the location of the moon relative to Earth and the sun changes.
    - (3) The moon appears to become more fully illuminated until "full" and then less fully illuminated until dark, or "new," in a pattern of change that corresponds to what proportion of the illuminated part of the moon is visible from Earth.
  - ii) Eclipses:
    - (1) Solar energy is prevented from reaching the Earth during a solar eclipse because the moon is located between the sun and Earth.
    - (2) Solar energy is prevented from reaching the moon (and thus reflecting off of the moon to Earth) during a lunar eclipse because Earth is located between the sun and moon.
    - (3) Because the moon's orbital plane is tilted with respect to the plane of the Earth's orbit around the sun, for a majority of time during an Earth month, the moon is not in a position to block solar energy from reaching Earth, and Earth is not in a position to block solar energy from reaching the moon.
  - iii) Seasons:
    - (1) Because the Earth's axis is tilted, the most direct and intense solar energy occurs over the summer months, and the least direct and intense solar energy occurs over the winter months.
    - (2) The change in season at a given place on Earth is directly related to the orientation of the tilted Earth and the position of Earth in its orbit around the sun because of the change in the directness and intensity of the solar energy at that place over the course of the year.
      - (a) Summer occurs in the Northern Hemisphere at times in the Earth's orbit when the northern axis of Earth is tilted toward the sun. Summer occurs in the Southern Hemisphere at times in the Earth's orbit when the southern axis of Earth is tilted toward the sun.
      - (b) Winter occurs in the Northern Hemisphere at times in the Earth's orbit when the northern axis of Earth is tilted away from the sun. Summer occurs in the Southern Hemisphere at times in the Earth's orbit when the southern axis of Earth is tilted away from the sun.
- b) Students use their model to predict:
  - i) The phase of the moon when given the relative locations of the Earth, sun, and moon.
  - ii) The relative positions of the Earth, sun, and moon when given a moon phase.
  - iii) Whether an eclipse will occur, given the relative locations of the Earth, sun, and moon and a position on Earth from which the moon or sun can be viewed (depending on the type of eclipse).
  - iv) The relative positions of the Earth, sun, and moon, given a type of eclipse and a position on Earth from which the moon/sun can be viewed.

v) The season on Earth, given the relative positions of Earth and the sun (including the orientation of the Earth's axis) and a position on Earth.
vi) The relative positions of Earth and the sun when given a season and a relative position (e.g. far north, far south, equatorial) on Earth.

S.6.14. 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.]

Practices of Scientists and Engineers	Core Science Content
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. Students will develop and use a model to describe phenomena.	**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. **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.
Science Connecting Concepts	
Systems and System Models Models can be used to represent systems and their interactions. **Connections to Nature of Science** Scientific Knowledge Assumes an Order and Consistency in Natural Systems - Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.	

Observable features of the student performance by the end of the course:

1) Components of the model
   a) To make sense of a given phenomenon, students develop a model in which they identify the relevant components of the system, including:
      i) Gravity.
      ii) The solar system as a collection of bodies, including the sun, planets, moons, and asteroids.
      iii) The Milky Way galaxy as a collection of stars (e.g., the sun) and their associated systems of objects.
      iv) Other galaxies in the universe
   b) Students indicate the relative spatial scales of solar systems and galaxies in the model.
2) Relationships
   a) Students describe the relationships and interactions between components of the solar and galaxy systems, including:
      i) Gravity as an attractive force between solar system and galaxy objects that:
         (1) Increases with the mass of the interacting objects increases.
         (2) Decreases as the distances between objects increases.
            (i) The orbital motion of objects in our solar system (e.g., moons orbit around planets, all objects within the solar system orbit the sun).
      ii) The orbital motion, in the form of a disk, of vast numbers of stars around the center of the Milky Way.

        iii) That our solar system is one of many systems orbiting the center of the larger system of the Milky Way galaxy.
        iv) The Milky Way is one of many galaxy systems in the universe.

3) Connections
    a) Students use the model to describe that gravity is a predominantly inward-pulling force that can keep smaller/less massive objects in orbit around larger/more massive objects.
    b) Students use the model to describe that gravity causes a pattern of smaller/less massive objects orbiting around larger/more massive objects at all system scales in the universe, including that:
        i) Gravitational forces from planets cause smaller objects (e.g., moons) to orbit around planets.
        ii) The gravitational force of the sun causes the planets and other bodies to orbit around it, holding the solar system together.
        iii) The gravitational forces from the center of the Milky Way cause stars and stellar systems to orbit around the center of the galaxy.
        iv) The hierarchy pattern of orbiting systems in the solar system was established early in its history as the disk of dust and gas was driven by gravitational forces to form moon-planet and planet-sun orbiting systems.
    c) Students use the model to describe that objects too far away from the sun do not orbit it because the sun's gravitational force on those objects is too weak to pull them into orbit.
    d) Students use the model to describe what a given phenomenon might look like without gravity (e.g., smaller planets would move in straight paths through space, rather than orbiting a more massive body).

S.6.15. 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.]

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Students will analyze and interpret data to determine similarities and differences in findings</td><td rowspan="3">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>Science Connecting Concepts</td></tr>
<tr><td>Scale, Proportion, and Quantity
Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Connections to Engineering, Technology, and Applications of Science
Interdependence of Science, Engineering, and Technology • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.</td></tr>
</table>

Observable features of the student performance by the end of the course:

1) Organizing data
    a) Students organize given data on solar system objects (e.g., surface features, object layers, orbital radii) from various Earth- and space-based instruments to allow for analysis and interpretation (e.g., transforming tabular data into pictures, diagrams, graphs, or physical models that illustrate changes in scale).
    b) Students describe that different representations illustrate different characteristics of objects in the solar system, including differences in scale.
2) Identifying relationships
    a) Students use quantitative analyses to describe similarities and differences among solar system objects by describing patterns of features of those objects at different scales, including:
        i) Distance from the sun.
        ii) Diameter.
        iii) Surface features (e.g., sizes of volcanoes).
        iv) Structure.
        v) Composition (e.g., ice versus rock versus gas).
    b) Students identify advances in solar system science made possible by improved engineering (e.g., knowledge of the evolution of the solar system from lunar exploration and space probes) and new developments in engineering made possible by advances in science (e.g., space-based telescopes from advances in optics and aerospace engineering).
3) Interpreting data
    a) Students use the patterns they find in multiple types of data at varying scales to draw conclusions about the identifying characteristics of different categories of solar system objects (e.g., planets, meteors, asteroids, comets) based on their features, composition, and locations within the solar system (e.g., most asteroids are rocky bodies between Mars and Jupiter, while most comets reside in orbits farther from the sun and are composed mostly of ice).
    b) Students use patterns in data as evidence to describe that two objects may be similar when viewed at one scale (e.g., types of surface features) but may appear to be quite different when viewed at a different scale (e.g., diameter or number of natural satellites).
    c) Students use the organization of data to facilitate drawing conclusions about the patterns of scale properties at more than one scale, such as those that are too large or too small to directly observe.

Topic: Weather and Climate

S.6.16. Collect data to provide evidence for how the motions and complex interactions of air masses results 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.]

Practices of Scientists and Engineers	Core Science Content
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. Students will 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.	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.
Science Connecting Concepts	Weather and Climate Because these patterns are so complex, weather can only be predicted probabilistically.
Cause and Effect Cause and effect relationships may be used to predict phenomena in natural or designed systems.	

Observable features of the student performance by the end of the course:

1) Identifying the phenomenon under investigation
   a) From the given investigation plan, students describe the phenomenon under investigation, which includes the relationships between air mass interactions and weather conditions.
   b) Students identify the purpose of the investigation, which includes providing evidence to answer questions about how motions and complex interactions of air masses result in changes in weather conditions [note: expectations of students regarding mechanisms are limited to relationships between patterns of activity of air masses and changes in weather].
2) Identifying the evidence to address the purpose of the investigation
   a) From a given investigation plan, students describe the data to be collected and the evidence to be derived from the data that would indicate relationships between air mass movement and changes in weather, including:
      i) Patterns in weather conditions in a specific area (e.g., temperature, air pressure, humidity, wind speed) over time.
      ii) The relationship between the distribution and movement of air masses and landforms, ocean temperatures, and currents.
      iii) The relationship between observed, large-scale weather patterns and the location or movement of air masses, including patterns that develop between air masses (e.g., cold fronts may be characterized by thunderstorms).
   b) Students describe how the evidence to be collected will be relevant to determining the relationship between patterns of activity of air masses and changes in weather conditions.
   c) Students describe that because weather patterns are so complex and have multiple causes, weather can be predicted only probabilistically.
3) Planning the investigation
   a) Students describe the tools and methods used in the investigation, including how they are relevant to the purpose of the investigation.

4) Collecting the data
   a) According to the provided investigation plan, students make observations and record data, either firsthand and/or from professional weather monitoring services.

S.6.17. 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.]

Practices of Scientists and Engineers	Core Science Content
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. Students will develop and use a model to describe phenomena.	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. 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.
Science Connecting Concepts	
Systems and System Models Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.	

Observable features of the student performance by the end of the course:

1) Components of the model
   a) To make sense of a phenomenon, students develop a model in which they identify the relevant components of the system, with inputs and outputs, including:
      i) The rotating Earth.
      ii) The atmosphere.
      iii) The ocean, including the relative rate of thermal energy transfer of water compared to land or air.
      iv) Continents and the distribution of landforms on the surface of Earth.
      v) Global distribution of ice.
      vi) Distribution of living things.
      vii) Energy.
         (1) Radiation from the sun as an input.
         (2) Thermal energy that exists in the atmosphere, water, land, and ice (as represented by temperature).
2) Relationships
   a) In the model, students identify and describe the relationships between components of the system, including:
      i) Differences in the distribution of solar energy and temperature changes, including:
         (1) Higher latitudes receive less solar energy per unit of area than do lower latitudes, resulting in temperature differences based on latitude.

(2) Smaller temperature changes tend to occur in oceans than on land in the same amount of time.
(3) In general, areas at higher elevations have lower average temperatures than do areas at lower elevations.
(4) Features on the Earth's surface, such as the amount of solar energy reflected back into the atmosphere or the absorption of solar energy by living things, affect the amount of solar energy transferred into heat energy.

ii) Motion of ocean waters and air masses (matter):
(1) Fluid matter (i.e., air, water) flows from areas of higher density to areas of lower density (due to temperature or salinity). The density of a fluid can vary for several different reasons (e.g., changes in salinity and temperature of water can each cause changes in density). Differences in salinity and temperature can, therefore, cause fluids to move vertically and, as a result of vertical movement, also horizontally because of density differences.

iii) Factors affecting the motion of wind and currents:
(1) The Earth's rotation causes oceanic and atmospheric flows to curve when viewed from the rotating surface of Earth (Coriolis force).
(2) The geographical distribution of land limits where ocean currents can flow.
(3) Landforms affect atmospheric flows (e.g., mountains deflect wind and/or force it to higher elevation).

iv) Thermal energy transfer:
(1) Thermal energy moves from areas of high temperature to areas of lower temperature either through the movement of matter, via radiation, or via conduction of heat from warmer objects to cooler objects.
(2) Absorbing or releasing thermal energy produces a more rapid change in temperature on land compared to in water.
(3) Absorbing or releasing thermal energy produces a more rapid change in temperature in the atmosphere compared to either on land or in water so the atmosphere is warmed or cooled by being in contact with land or the ocean.

3) Connections
a) Students use the model to describe:
i) The general latitudinal pattern in climate (higher average annual temperatures near the equator and lower average annual temperatures at higher latitudes) caused by more direct light (greater energy per unit of area) at the equator (more solar energy) and less direct light at the poles (less solar energy).
ii) The general latitudinal pattern of drier and wetter climates caused by the shift in the amount of air moisture during precipitation from rising moisture-rich air and the sinking of dry air.
iii) The pattern of differing climates in continental areas as compared to the oceans. Because water can absorb more solar energy for every degree change in temperature compared to land, there is a greater and more rapid temperature change on land than in the ocean. At the centers of landmasses, this leads to conditions typical of continental climate patterns.
iv) The pattern that climates near large water bodies, such as marine coasts, have comparatively smaller changes in temperature relative to the center of the landmass. Land near the oceans can exchange thermal energy through the air, resulting in smaller changes in temperature. At the edges of landmasses, this leads to marine climates.
v) The pattern that climates at higher altitudes have lower temperatures than climates at lower altitudes. Because of the direct relationship between temperature and pressure, given the same amount of thermal energy, air at lower pressures (higher altitudes) will have lower temperatures than air at higher pressures (lower altitudes).
vi) Regional patterns of climate (e.g., temperature or moisture) related to a specific pattern of water or air circulation, including the role of the following in contributing to the climate pattern:

(1) Air or water moving from areas of high temperature, density, and/or salinity to areas of low temperature, density, and/or salinity.
(2) The Earth's rotation, which affects atmospheric and oceanic circulation.
(3) The transfer of thermal energy with the movement of matter.
(4) The presence of landforms (e.g., the rain shadow effect).

b) Students use the model to describe the role of each of its components in producing a given regional climate.

S.6.18. 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.]

Practices of Scientists and Engineers	Core Science Content
Asking Questions and Defining Problems Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables and clarifying arguments and models. Students will ask questions to identify and clarify evidence of an argument.	Global Climate Change 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.
Science Connecting Concepts	
Stability and Change Stability might be disturbed either by sudden events or gradual changes that accumulate over time.	

Observable features of the student performance by the end of the course:

1) Addressing phenomena of the natural world
   a) Students examine a given claim and the given supporting evidence as a basis for formulating questions. Students ask questions that would identify and clarify the evidence, including:
      i) The relevant ways in which natural processes and/or human activities may have affected the patterns of change in global temperatures over the past century.
      ii) The influence of natural processes and/or human activities on a gradual or sudden change in global temperatures in natural systems (e.g., glaciers and arctic ice, and plant and animal seasonal movements and life cycle activities).
      iii) The influence of natural processes and/or human activities on changes in the concentration of carbon dioxide and other greenhouse gases in the atmosphere over the past century.
2) Identifying the scientific nature of the question
   a) Student's questions can be answered by examining evidence for:
      i) Patterns in data that connect natural processes and human activities to changes in global temperatures over the past century.
      ii) Patterns in data that connect the changes in natural processes and/or human activities related to greenhouse gas production to changes in the concentrations of carbon dioxide and other greenhouse gases in the atmosphere.

Topic: Human Impacts

S.6.19. 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 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).]

Practices of Scientists and Engineers	Core Science Content
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. Students will analyze and interpret data to determine similarities and differences in findings	**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.
Science Connecting Concepts	
Patterns Graphs, charts, and images can be used to identify patterns in data. **Influence of Science, Engineering, and Technology on Society and the Natural World** The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time.	

Observable features of the student performance by the end of the course:

1) Organizing data
   a) Students organize given data that represent the type of natural hazard event and features associated with that type of event, including the location, magnitude, frequency, and any associated precursor event or geologic forces.
   b) Students organize data in a way that facilitates analysis and interpretation.
   c) Students describe what each dataset represents.
2) Identifying relationships
   a) Students analyze data to identify and describe patterns in the datasets, including:
      i) The location of natural hazard events relative to geographic and/or geologic features.
      ii) Frequency of natural hazard events.
      iii) Severity of natural hazard events.
      iv) Types of damage caused by natural hazard events.
      v) Location or timing of features and phenomena (e.g., aftershocks, flash floods) associated with natural hazard events.
   b) Students describe similarities and differences among identified patterns.
3) Interpreting data
   a) Students use the analyzed data to describe:
      i) Areas that are susceptible to natural hazard events, including areas designated as at the greatest and least risk for severe events.

    ii) How frequently areas, including areas experiencing the highest and lowest frequency of events, are at risk.
    iii) What type of damage each area is at risk of during a given natural hazard event.
    iv) What features, if any, occur before a given natural hazard event that can be used to predict the occurrence of the natural hazard event and when and where they can be observed.
b) Using patterns in the data, students make a forecast for the potential of a natural hazard event to affect an area in the future, including information on the frequency and/or probability of event occurrence; how severe the event is likely to be; where the event is most likely to cause the most damage; and what events, if any, are likely to precede the event.
c) Students give at least three examples of the technologies that engineers have developed to mitigate the effects of natural hazards (e.g., the design of buildings and bridges to resist earthquakes, warning sirens for tsunamis, storm shelters for tornados, levees along rivers to prevent flooding).

Engineering, Technology, and Applications of Science

Topic: Engineering Design

S.6.20. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

<table>
<tr><th>Practices of Scientists and Engineers</th><th>Core Science Content</th></tr>
<tr><td>Asking Questions and Defining Problems
Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables and clarifying arguments and models. Students will define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.</td><td rowspan="3">Defining and Delimiting Engineering Problems

The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.</td></tr>
<tr><td>Science Connecting Concepts</td></tr>
<tr><td>Influence of Science, Engineering, and Technology on Society and the Natural World

All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.</td></tr>
</table>

Observable features of the student performance by the end of the course:

1) Identifying the problem to be solved
   a) Students describe a problem that can be solved through the development of an object, tool, process, or system.
2) Defining the process or system boundaries and the components of the process or system
   a) Students identify the system in which the problem is embedded, including the major components and relationships in the system and its boundaries, to clarify what is and is not part of the problem. In their definition of the system, students include:
      i) Which individuals or groups need this problem to be solved.
      ii) The needs that must be met by solving the problem.
      iii) Scientific issues that are relevant to the problem.
      iv) Potential societal and environmental impacts of solutions.
      v) The relative importance of the various issues and components of the process or system.
3) Defining criteria and constraints
   a) Students define criteria that must be taken into account in the solution that:
      i) Meet the needs of the individuals or groups who may be affected by the problem (including defining who will be the target of the solution).
      ii) Enable comparisons among different solutions, including quantitative considerations when appropriate.
   b) Students define constraints that must be taken into account in the solution, including:
      i) Time, materials, and costs.
      ii) Scientific or other issues that are relevant to the problem.
      iii) Needs and desires of the individuals or groups involved that may limit acceptable solutions.

iv) Safety considerations.
v) Potential effect(s) on other individuals or groups.
vi) Potential negative environmental effects of possible solutions or failure to solve the problem.

S.6.21. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Practices of Scientists and Engineers	Core Science Content
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. Students will analyze and interpret data to determine similarities and differences in findings	Developing Possible Solutions There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Optimizing the Design Solution Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
Science Connecting Concepts	

Observable features of the student performance by the end of the course:

1) Organizing data
    a) Students organize given data (e.g., via tables, charts, or graphs) from tests intended to determine the effectiveness of three or more alternative solutions to a problem.
2) Identifying relationships
    a) Students use appropriate analysis techniques (e.g., qualitative or quantitative analysis; basic statistical techniques of data and error analysis) to analyze the data and identify relationships within the datasets, including relationships between the design solutions and the given criteria and constraints.
3) Interpreting data
    a) Students use the analyzed data to identify evidence of similarities and differences in features of the solutions.
    b) Based on the analyzed data, students make a claim for which characteristics of each design best meet the given criteria and constraints.
    c) Students use the analyzed data to identify the best features in each design that can be compiled into a new (improved) redesigned solution.

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