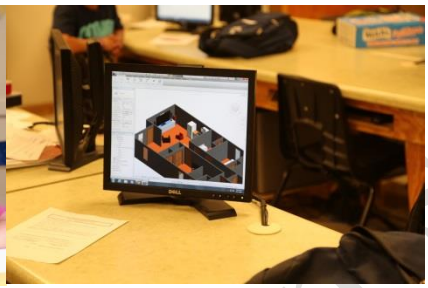
SUPPORT GUIDE FOR GRADE SIX SOUTH CAROLINA ACADEMIC STANDARDS AND PERFORMANCE INDICATORS FOR SCIENCE

Molly M. Spearman
State Superintendent of Education

SOUTH CAROLINA
STATE DEPARTMENT
OF EDUCATION



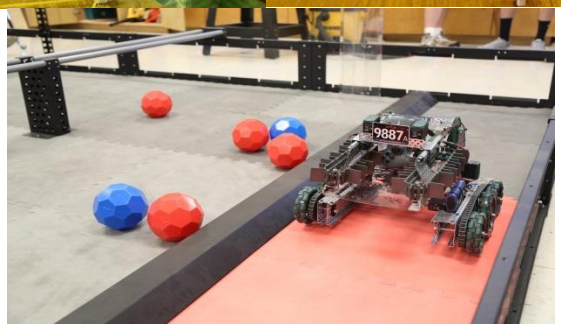
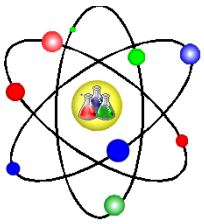


Table of Contents

Standards

Crosswalk

Content Support Guide



INTRODUCTION TO GRADE SIX STANDARDS

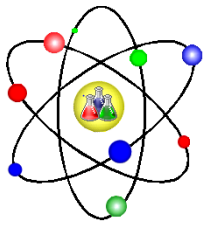
Science is a way of understanding the physical universe using observation and experimentation to explain natural phenomena. Science also refers to an organized body of knowledge that includes core ideas to the disciplines and common themes that bridge the disciplines. This document, *South Carolina Academic Standards and Performance Indicators for Science,* contains the academic standards in science for the state's students in kindergarten through grade twelve.

ACADEMIC STANDARDS

In accordance with the South Carolina Education Accountability Act of 1998 (S.C. Code Ann. § 59-18-110), the purpose of academic standards is to provide the basis for the development of local curricula and statewide assessment. Consensually developed academic standards describe for each grade and high school core area the specific areas of student learning that are considered the most important for proficiency in the discipline at the particular level.

Operating procedures for the review and revision of all South Carolina academic standards were jointly developed by staff at the State Department of Education (SCDE) and the Education Oversight Committee (EOC). According to these procedures, a field review of the first draft of the revised South Carolina science standards was conducted from March through May 2013. Feedback from that review and input from the SCDE and EOC review panels was considered and used to develop these standards.

The academic standards in this document are not sequenced for instruction and do not prescribe classroom activities; materials; or instructional strategies, approaches, or practices. The *South Carolina Academic Standards and Performance Indicators for Science* is not a curriculum.



THE PROFILE OF THE SOUTH CAROLINA GRADUATE

The *2014 South Carolina Academic Standards and Performance Indicators for Science* support the *Profile of the South Carolina Graduate. The Profile of the South Carolina Graduate* has been adopted and approved by the South Carolina Association of School Administrators (SCASA), the South Carolina Chamber of Commerce, the South Carolina Council on Competitiveness, the Education Oversight Committee (EOC), the State Board of Education (SBE), and the South Carolina Department of Education (SCDE) in an effort to identify the knowledge, skills, and characteristics a high school graduate should possess in order to be prepared for success as they enter college or pursue a career. The profile is intended to guide all that is done in support of college- and career-readiness.

Profile of the South Carolina Graduate

World Class Knowledge

- Rigorous standards in language arts and math for career and college readiness
- Multiple languages, science, technology, engineering, mathematics (STEM), arts and social sciences

World Class Skills

- Creativity and innovation
- Critical thinking and problem solving
- Collaboration and teamwork
- Communication, information, media and technology
- Knowing how to learn

Life and Career Characteristics

- Integrity
- Self-direction
- Global perspective
- Perseverance
- Work ethic
- Interpersonal skills

Approved by SCASA Superintendent's Roundtable and SC Chamber of Commerce.

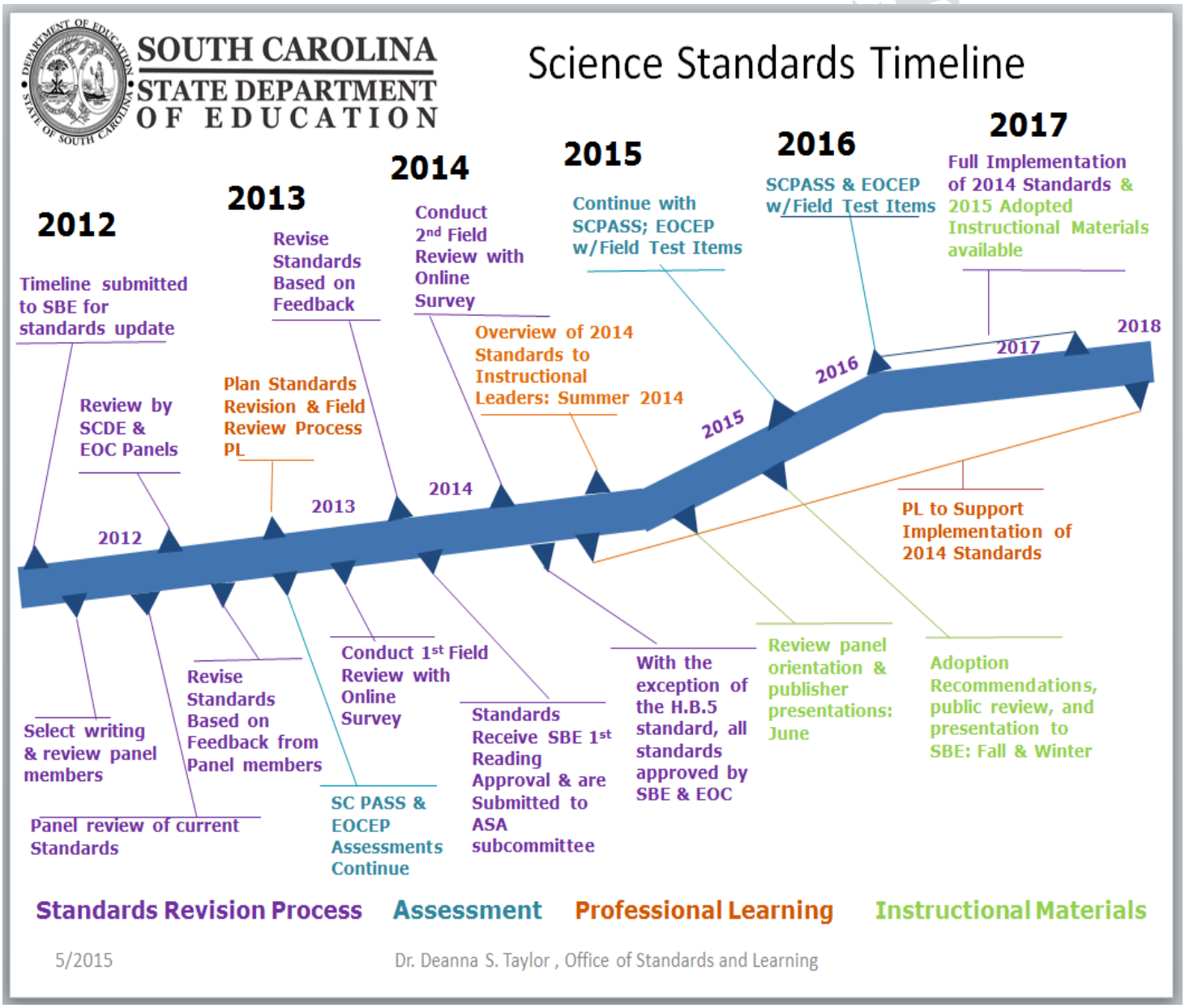
transformSC
tomorrow won't wait for our students

AN INITIATIVE OF SOUTH CAROLINA COUNCIL ON COMPETITIVENESS

SCIENCE STANDARDS TIMELINE

This timeline is used to illustrate the timeline for the standards revisions process, student assessment administration, provision of professional learning and the review and adoption of instructional materials. This timeline may be used with the science academic standards, science and engineering support document, and grade/content support documents to assist local districts, schools and teachers as they construct standards-based science curriculum, allowing them to add or expand topics they feel are important and to organize content to fit their students' needs and match available instructional materials.

The timeline in this document does not offer a sequence for instruction and do not prescribe classroom activities; materials; or instructional strategies, approaches, or practices. The *Science Standards Timeline*, is not a curriculum.



Click HERE to return to the Table of Contents

CROSSCUTTING CONCEPTS

Seven common threads or themes are presented in *A Framework for K-12 Science Education* (2012). These concepts connect knowledge across the science disciplines (biology, chemistry, physics, earth and space science) and have value to both scientists and engineers because they identify universal properties and processes found in all disciplines. These crosscutting concepts are:

1. Patterns
2. Cause and Effect: Mechanism and Explanation
3. Scale, Proportion, and Quantity
4. Systems and System Models
5. Energy and Matter: Flows, Cycles, and Conservation
6. Structure and Function
7. Stability and Change

These concepts should not to be taught in isolation but reinforced in the context of instruction within the core science content for each grade level or course.

SCIENCE AND ENGINEERING PRACTICES

In addition to the academic standards, each grade level or high school course explicitly identifies S*cience and Engineering Practice* standards, with indicators that are differentiated across grade levels and core areas. The term "practice" is used instead of the term "skill," to emphasize that scientists and engineers use skill and knowledge simultaneously, not in isolation. These eight science and engineering practices are:

1. Ask questions and define problems
2. Develop and use models
3. Plan and conduct investigations
4. Analyze and interpret data
5. Use mathematical and computational thinking
6. Construct explanations and design solutions
7. Engage in scientific argument from evidence
8. Obtain, evaluate, and communicate information

Students should engage in scientific and engineering practices as a means to learn about the specific topics identified for their grade levels and courses. It is critical that educators understand that the Science and Engineering Practices are *not* to be taught in isolation. There should *not* be a distinct "Inquiry" unit at the beginning of each school year. Rather, the practices need to be employed *within the content* for each grade level or course.

Additionally, an important component of all scientists and engineers' work is communicating their results both by informal and formal speaking and listening, and formal reading and writing. Speaking, listening, reading and writing is important not only for the purpose of sharing results, but because during the processes of reading, speaking, listening and writing, scientists and engineers continue to construct their own knowledge and understanding of meaning and implications of their research. Knowing how one's results connect to previous results and what those connections reveal about the underlying principles is an important part of the scientific discovery process. Therefore, students should similarly be reading, writing, speaking and listening throughout the scientific processes in which they engage.

For additional information regarding the development, use and assessment of the *2014 Academic Standards and Performance Indicators for Science* please see the official document that is posted on the SCDE science web page--- http://tinyurl.com/2014SCScience.

DECIPHERING THE STANDARDS

KINDERGARTEN

LIFE SCIENCE: EXPLORING ORGANISMS AND THE ENVIRONMENT

Standard K.L.2: The student will demonstrate an understanding of organisms found in the environment and how these organisms depend on the environment to meet those needs.

K.L.2A. Conceptual Understanding: The environment consists of many types of organisms including plants, animals, and fungi. Organisms depend on the land, water, and air to live and grow. Plants need water and light to make their own food. Fungi and animals cannot make their own food and get energy from other sources. Animals (including humans) use different body parts to obtain food and other resources needed to grow and survive. Organisms live in areas where their needs for air, water, nutrients, and shelter are met.

Performance Indicators: Students who demonstrate this understanding can:

K.L.2A.1 Obtain information to answer questions about different organisms found in the environment (such as plants, animals, or fungi).

K.L.2A.2 Conduct structured investigations to determine what plants need to live and grow (including water and light).

Figure 1: Example from the Kindergarten Standards

The code assigned to each performance indicator within the standards is designed to provide information about the content of the indicator. For example, the **K.L.2A.1** indicator decodes as the following--

- **K: The first part of each indicator denotes the grade or subject.** The example indicator is from Kindergarten. The key for grade levels are as follows—

  K: Kindergarten
  1: First Grade
  2: Second Grade
  3: Third Grade
  4: Fourth Grade
  5: Fifth Grade
  6: Sixth Grade
  7: Seventh Grade
  8: Eighth Grade
  H.B: High School Biology 1
  H.C: High School Chemistry 1
  H.P: High School Physics 1
  H.E: High School Earth Science

- **L: After the grade or subject, the content area is denoted by an uppercase letter.** The L in the example indicator means that the content covers Life Science. The key for content areas are as follows—
    - E: Earth Science
    - EC: Ecology
    - L: Life Science
    - P: Physical Science
    - S: Science and Engineering Practices

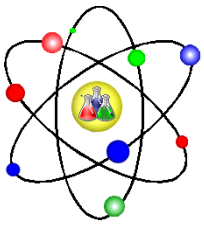
- **2: The number following the content area denotes the specific academic standard.** In the example, the 2 in the indicator means that it is within the second academic standard with the Kindergarten science content.

- **A: After the specific content standard, the conceptual understanding is denoted by an uppercase letter.** The conceptual understanding is a statement of the core idea for which students should demonstrate understanding. There may be more than one conceptual understanding per academic standard. The A in the example means that this is the first conceptual understanding for the standard. Additionally, the conceptual understandings are novel to the *2014 South Carolina Academic Standards and Performance Indicators for Science*.

- **1: The last part of the code denotes the number of the specific performance indicator.** Performance indicators are statements of what students can do to demonstrate knowledge of the conceptual understanding. The example discussed is the first performance indicator within the conceptual understanding.

CORE AREAS OF KINDERGARTEN

- Earth's Weather and Climate
- Energy Transfer and Conservation
- Diversity of Life – Classification and Animals
- Diversity of Life – Protists, Fungi, and Plants



GRADE SIX

SCIENCE AND ENGINEERING PRACTICES

NOTE: Scientific investigations should always be done in the context of content knowledge expected at this grade level. The standard describes how students should learn and demonstrate knowledge of the content outlined in the other standards.

Standard 6.S.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.

6.S.1A. Conceptual Understanding: The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers.

Performance Indicators: Students who demonstrate this understanding can:

6.S.1A.1 Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge claims.

6.S.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.

6.S.1A.3 Plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses, (2) identify materials, procedures, and variables, (3) select and use appropriate tools or instruments to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. Use appropriate safety procedures.

6.S.1A.4 Analyze and interpret data from informational texts, observations, measurements, or investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning or (2) support hypotheses, explanations, claims, or designs.

6.S.1A.5 Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) collect and analyze data, (3) express relationships between variables for models and investigations, or (4) use grade-level appropriate statistics to analyze data.

6.S.1A.6 Construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.

6.S.1A.7 Construct and analyze scientific arguments to support claims, explanations, or designs using evidence from observations, data, or informational texts**.**

6.S.1A.8 Obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of

scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations.

6.S.1B. Conceptual Understanding: Technology is any modification to the natural world created to fulfill the wants and needs of humans. The engineering design process involves a series of iterative steps used to solve a problem and often leads to the development of a new or improved technology.

Performance Indicators: Students who demonstrate this understanding can:

6.S.1B.1 Construct devices or design solutions using scientific knowledge to solve specific problems or needs: (1) ask questions to identify problems or needs, (2) ask questions about the criteria and constraints of the device or solutions, (3) generate and communicate ideas for possible devices or solutions, (4) build and test devices or solutions, (5) determine if the devices or solutions solved the problem and refine the design if needed, and (6) communicate the results.

EARTH SCIENCE: EARTH'S WEATHER AND CLIMATE

Standard 6.E.2: The student will demonstrate an understanding of the interactions within Earth's systems (flow of energy) that regulate weather and climate.

6.E.2A. Conceptual Understanding: Earth's atmosphere, an envelope of gases that surround the planet, makes conditions on Earth suitable for living things and influences weather. Water is always moving between the atmosphere (troposphere) and the surface of Earth as a result of the force of gravity and energy from the Sun. The Sun is the driving energy source for heating Earth and for the circulation of Earth's atmosphere.

Performance Indicators: Students who demonstrate this understanding can:

6.E.2A.1 Develop and use models to exemplify the properties of the atmosphere (including the gases, temperature and pressure differences, and altitude changes) and the relative scale in relation to the size of Earth.

6.E.2A.2 Critically analyze scientific arguments based on evidence for and against how different phenomena (natural and human induced) may contribute to the composition of Earth's atmosphere.

6.E.2A.3 Construct explanations of the processes involved in the cycling of water through Earth's systems (including transpiration, evaporation, condensation and crystallization, precipitation, and downhill flow of water on land).

6.E.2B. Conceptual Understanding: The complex patterns of changes and movement of water in the atmosphere determined by winds, landforms, ocean temperatures and currents, and convection are major determinants of local weather patterns and climate. Technology has enhanced our ability to measure and predict weather patterns.

Performance Indicators: Students who demonstrate this understanding can:

6.E.2B.1 Analyze and interpret data from weather conditions (including wind speed and direction, air temperature, humidity, cloud types, and air pressure), weather maps, satellites, and radar to predict local weather patterns and conditions.

6.E.2B.2 Develop and use models to explain how relationships between the movement and interactions of air masses, high and low pressure systems, and frontal boundaries result in weather conditions and storms (including thunderstorms, hurricanes and tornadoes).

6.E.2B.3 Develop and use models to represent how solar energy and convection impact Earth's weather patterns and climate conditions (including global winds, the jet stream, and ocean currents).

6.E.2B.4 Construct explanations for how climate is determined in an area (including latitude, elevation, shape of the land, distance from water, global winds, and ocean currents).

PHYSICAL SCIENCE: ENERGY TRANSFER AND CONSERVATION

Standard 6.P.3: The student will demonstrate an understanding of the properties of energy, the transfer and conservation of energy, and the relationship between energy and forces.

6.P.3A. Conceptual Understanding: Energy manifests itself in multiple forms, such as mechanical (kinetic energy and potential energy), electrical, chemical, radiant (solar), and thermal energy. According to the principle of conservation of energy, energy cannot be created nor destroyed, but it can be transferred from one place to another and transformed between systems.

Performance Indicators: Students who demonstrate this understanding can:

6.P.3A.1 Analyze and interpret data to describe the properties and compare sources of different forms of energy (including mechanical, electrical, chemical, radiant, and thermal).

6.P.3A.2 Develop and use models to exemplify the conservation of energy as it is transformed from kinetic to potential (gravitational and elastic) and vice versa.

6.P.3A.3 Construct explanations for how energy is conserved as it is transferred and transformed in electrical circuits.

6.P.3A.4 Develop and use models to exemplify how magnetic fields produced by electrical energy flow in a circuit is interrelated in electromagnets, generators, and simple electrical motors.

6.P.3A.5 Develop and use models to describe and compare the directional transfer of heat through convection, radiation, and conduction.

6.P.3A.6 Design and test devices that minimize or maximize heat transfer by conduction, convection, or radiation.

6.P.3B. Conceptual Understanding: Energy transfer occurs when two objects interact thereby exerting force on each other. It is the property of an object or a system that enables it to do work (force moving an object over a distance). Machines are governed by this application of energy, work, and conservation of energy.

Performance Indicators: Students who demonstrate this understanding can:

6.P.3B.1 Plan and conduct controlled scientific investigations to provide evidence for how the design of simple machines (including levers, pulleys, inclined planes) helps transfer mechanical energy by reducing the amount of force required to do work.

6.P.3B.2 Design and test solutions that improve the efficiency of a machine by reducing the input energy (effort) or the amount of energy transferred to the surrounding environment as it moves an object.

LIFE SCIENCE: DIVERSITY OF LIFE – CLASSIFICATION AND ANIMALS

Standard 6.L.4: The student will demonstrate an understanding of how scientists classify organisms and how the structures, processes, behaviors, and adaptations of animals allow them to survive.

6.L.4A. Conceptual Understanding: Life is the quality that differentiates living things (organisms) from nonliving objects or those that were once living. All organisms are made up of cells, need food and water, a way to dispose of waste, and an environment in which they can live. Because of the diversity of life on Earth, scientists have developed a way to organize groups of organisms according to their characteristic traits, making it easier to identify and study them.

Performance Indicators: Students who demonstrate this understanding can:

6.L.4A.1 Obtain and communicate information to support claims that living organisms (1) obtain and use resources for energy, (2) respond to stimuli, (3) reproduce, and (4) grow and develop.

6.L.4A.2 Develop and use models to classify organisms based on the current hierarchical taxonomic structure (including the kingdoms of protists, plants, fungi, and animals).

6.L.4B. Conceptual Understanding: The Animal Kingdom includes a diversity of organisms that have many characteristics in common. Classification of animals is based on structures that function in growth, reproduction, and survival. Animals have both structural and behavioral adaptations that increase the chances of reproduction and survival in changing environments.

Performance Indicators: Students who demonstrate this understanding can:

6.L.4B.1 Analyze and interpret data related to the diversity of animals to support claims that all animals (vertebrates and invertebrates) share common characteristics.

6.L.4B.2 Obtain and communicate information to explain how the structural adaptations and processes of animals allow for defense, movement, or resource obtainment.

6.L.4B.3 Construct explanations of how animal responses (including hibernation, migration, grouping, and courtship) to environmental stimuli allow them to survive and reproduce.

6.L.4B.4 Obtain and communicate information to compare and classify innate and learned behaviors in animals.

6.L.4B.5 Analyze and interpret data to compare how endothermic and ectothermic animals respond to changes in environmental temperature.

LIFE SCIENCE: DIVERSITY OF LIFE – PROTISTS, FUNGI AND PLANTS

Standard 6.L.5: The student will demonstrate an understanding of the structures, processes, and responses that allow protists, fungi, and plants to survive and reproduce.

6.L.5A. Conceptual Understanding: The Protist Kingdom is one of the most diverse groups and includes organisms that have characteristics similar to but are not classified as plants, animals, or fungi. These microorganisms live in moist environments and vary in how they obtain energy and move. The Fungi Kingdom consists of organisms that do not make their own food (heterotrophs) but obtain their nutrition through external absorption. Fungi can be grouped by their growth habit or fruiting structure and respond to changes in the environmental stimuli similar to plants.

Performance Indicators: Students who demonstrate this understanding can:

6.L.5A.1 Analyze and interpret data from observations to compare how the structures of protists (including euglena, paramecium, and amoeba) and fungi allow them to obtain energy and explore their environment.

6.L.5A.2 Analyze and interpret data to describe how fungi respond to external stimuli (including temperature, light, touch, water, and gravity).

6.L.5B. Conceptual Understanding: The Plant Kingdom consists of organisms that primarily make their own food (autotrophs) and are commonly classified based on internal structures that function in the transport of food and water. Plants have structural and behavioral adaptations that increase the chances of reproduction and survival in changing environments.

Performance Indicators: Students who demonstrate this understanding can:

6.L.5B.1 Construct explanations of how the internal structures of vascular and nonvascular plants transport food and water.

6.L.5B.2 Analyze and interpret data to explain how the processes of photosynthesis, respiration, and transpiration work together to meet the needs of plants.

6.L.5B.3 Develop and use models to compare structural adaptations and processes that flowering plants use for defense, survival and reproduction.

6.L.5B.4 Plan and conduct controlled scientific investigations to determine how changes in environmental factors (such as air, water, light, minerals, or space) affect the growth and development of a flowering plant.

6.L.5B.5 Analyze and interpret data to describe how plants respond to external stimuli (including temperature, light, touch, water, and gravity).

GRADE SIX CROSSWALK FOR THE 2005 SOUTH CAROLINA SCIENCE ACADEMIC STANDARDS AND THE 2014 SOUTH CAROLINA ACADEMIC STANDARDS AND PERFORMANCE INDICATORS FOR SCIENCE

ACKNOWLEDGEMENTS

SOUTH CAROLINA DEPARTMENT OF EDUCATION

The *Crosswalks for the South Carolina Academic Standards and Performance Indicators for Science* included in this document were developed under the direction of Dr. Julie Fowler, Deputy Superintendent, Division of College and Career Readiness and Cathy Jones Stork, Interim Director, Office of Standards and Learning.

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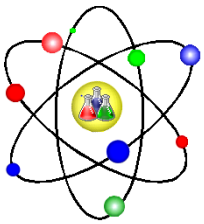
INTRODUCTION

This document, *Crosswalks for the 2005 South Carolina Science Academic Standards and the 2014 South Carolina Academic Standards and Performance Indicators for Science,* contains a comparison of the academic standards in science for the state's students in kindergarten through grade twelve.

HOW TO USE THE CROSSWALKS

This document may be used with the science academic standards, science and engineering support document, and grade/content support documents to assist local districts, schools and teachers as they construct standards-based science curriculum, allowing them to add or expand topics they feel are important and to organize content to fit their students' needs and match available instructional materials. 2005 and 2014 performance indicators that share similar content knowledge and skills that students should demonstrate to meet the grade level or high school course standards have been paired. These pairings have been organized into tables and are sequenced by the 2014 academic standards. The 2005 content indicators that do not match 2014 content have been placed at the end of each table.

The academic standards in this document are not sequenced for instruction and do not prescribe classroom activities; materials; or instructional strategies, approaches, or practices. The *Crosswalks for the 2005 South Carolina Science Academic Standards and the 2014 South Carolina Academic Standards and Performance Indicators for Science,* is not a curriculum.



GRADE SIX SCIENCE CROSSWALK DOCUMENT

(* The 2005 content indicators that do not match 2014 content have been placed at the end of each table.)

2005	2014	Comments
Standard (Science & Engineering Practices)		
6-1: The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.	**6.S.1:** The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	In 2005 this standard and these indicators were referred to as "scientific inquiry"
Conceptual Understanding		
	6.S.1A. The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers.	
Performance Indicators		
	6.S.1A.1 Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge claims.	
	6.S.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.	This is a new expectation in 2014 standards
6-1.1 Use appropriate tools and instruments (including a spring scale, beam balance, barometer, and sling psychrometer) safely and accurately when conducting a controlled scientific investigation. **6-1.5** Use appropriate safety procedures when conducting investigations.	**6.S.1A.3** Plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses, (2) identify materials, procedures, and variables, (3) select and use appropriate tools or instruments to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. Use appropriate safety	

	procedures.
	6.S.1A.4 Analyze and interpret data from informational texts, observations, measurements, or investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning or (2) support hypotheses, explanations, claims, or designs.
	6.S.1A.5 Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) collect and analyze data, (3) express relationships between variables for models and investigations, or (4) use grade-level appropriate statistics to analyze data.
6-1.2 Differentiate between observation and inference during the analysis and interpretation of data.	**6.S.1A.6** Construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.
	6.S.1A.7 Construct and analyze scientific arguments to support claims, explanations, or designs using evidence from observations, data, or informational texts**.**
	6.S.1A.8 Obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations.

Conceptual Understanding	
	6.S.1B. Technology is any modification to the natural world created to fulfill the wants and needs of humans. The engineering design process involves a series of iterative steps used to solve a problem and often leads to the development of a new or improved technology.
Performance Indicators	
6-1.4 Use a technological design process to plan and produce a solution to a problem or a product (including identifying a problem, designing a solution or a product, implementing the design, and evaluating the solution or the product).	**6.S.1B.1** Construct devices or design solutions using scientific knowledge to solve specific problems or needs: (1) ask questions to identify problems or needs, (2) ask questions about the criteria and constraints of the device or solutions, (3) generate and communicate ideas for possible devices or solutions, (4) build and test devices or solutions, (5) determine if the devices or solutions solved the problem and refine the design if needed, and (6) communicate the results.

*6-1.3 Classify organisms, objects, and materials according to their physical characteristics by using a dichotomous key.

2005	2014	Comments
	Standard (Earth Science)	
6-4: The student will demonstrate an understanding of the relationship between Earth's atmospheric properties and processes and its weather and climate.	**6.E.2:** The student will demonstrate an understanding of the interactions within Earth's systems (flow of energy) that regulate weather and climate.	
	Conceptual Understanding	
	6.E.2A. Earth's atmosphere, an envelope of gases that surround the planet, makes conditions on Earth suitable for living things and influences weather. Water is always moving between the atmosphere (troposphere) and the surface of Earth as a result of the force of gravity and energy from the Sun. The Sun is the driving energy source for heating Earth and for the circulation of Earth's atmosphere.	
	Performance Indicators	
6-4.1 Compare the composition and structure of Earth's atmospheric layers (including the gases and differences in temperature and pressure within the layers).	**6.E.2A.1** Develop and use models to exemplify the properties of the atmosphere (including the gases, temperature and pressure differences, and altitude changes) and the relative scale in relation to the size of Earth.	
	6.E.2A.2 Critically analyze scientific arguments based on evidence for and against how different phenomena (natural and human induced) may contribute to the composition of Earth's atmosphere.	
6-4.2 Summarize the interrelationships among the dynamic processes of the water cycle (including precipitation, evaporation, transpiration, condensation, surface-water flow, and groundwater flow).	**6.E.2A.3** Construct explanations of the processes involved in the cycling of water through Earth's systems (including transpiration, evaporation, condensation and crystallization, precipitation, and downhill flow of water on land).	
	Conceptual Understanding	
	6.E.2B. The complex patterns of changes and movement of water in the atmosphere determined by winds, landforms, ocean	

	temperatures and currents, and convection are major determinants of local weather patterns and climate. Technology has enhanced our ability to measure and predict weather patterns.
Performance Indicators	
6-4.3 Classify shapes and types of clouds according to elevation and their associated weather conditions and patterns. **6-4.5** Use appropriate instruments and tools to collect weather data (including wind speed and direction, air temperature, humidity, and air pressure) **6-4.6** Predict weather conditions and patterns based on weather data collected from direct observations and measurements, weather maps, satellites, and radar.	**6.E.2B.1** Analyze and interpret data from weather conditions (including wind speed and direction, air temperature, humidity, cloud types, and air pressure), weather maps, satellites, and radar to predict local weather patterns and conditions.
6-4.4 Summarize the relationship of the movement of air masses, high and low pressure systems, and frontal boundaries to storms (including thunderstorms, hurricanes, and tornadoes) and other weather conditions.	**6.E.2B.2** Develop and use models to explain how relationships between the movement and interactions of air masses, high and low pressure systems, and frontal boundaries result in weather conditions and storms (including thunderstorms, hurricanes and tornadoes).
6-4.7 Explain how solar energy affects Earth's atmosphere and surface (land and water). **6-4.8** Explain how convection affects weather patterns and climate.	**6.E.2B.3** Develop and use models to represent how solar energy and convection impact Earth's weather patterns and climate conditions (including global winds, the jet stream, and ocean currents).
6-4.9 Explain the influence of global winds and the jet stream on weather and climatic conditions.	**6.E.2B.4** Construct explanations for how climate is determined in an area (including latitude, elevation, shape of the land, distance from water, global winds, and ocean currents).

2005	2014	Comments
	Standard (Physical Science)	
6-5: The student will demonstrate an understanding of the law of conservation of energy and the properties of energy and work.	**6.P.3:** The student will demonstrate an understanding of the properties of energy, the transfer and conservation of energy, and the relationship between energy and forces.	
	Conceptual Understanding	
	6.P.3A. Energy manifests itself in multiple forms, such as mechanical (kinetic energy and potential energy), electrical, chemical, radiant (solar), and thermal energy. According to the principle of conservation of energy, energy cannot be created nor destroyed, but it can be transferred from one place to another and transformed between systems.	
	Performance Indicators	
6-5.1 Identify the sources and properties of heat, solar, chemical, mechanical, and electrical energy.	**6.P.3A.1** Analyze and interpret data to describe the properties and compare sources of different forms of energy (including mechanical, electrical, chemical, radiant, and thermal).	
6-5.2 Explain how energy can be transformed from one form to another (including the two types of mechanical energy, potential and kinetic, as well as chemical and electrical energy) in accordance with the law of conservation of energy.	**6.P.3A.2** Develop and use models to exemplify the conservation of energy as it is transformed from kinetic to potential (gravitational and elastic) and vice versa.	
6-5.4 Illustrate energy transformations (including the production of light, sound, heat, and mechanical motion) in electrical circuits.	**6.P.3A.3** Construct explanations for how energy is conserved as it is transferred and transformed in electrical circuits.	
6-5.3 Explain how magnetism and electricity are interrelated by using descriptions, models, and diagrams of electromagnets, generators, and simple electrical motors.	**6.P.3A.4** Develop and use models to exemplify how magnetic fields produced by electrical energy flow in a circuit is interrelated in electromagnets, generators, and simple electrical motors.	
6-5.5 Illustrate the directional	**6.P.3A.5** Develop and use models to	

transfer of heat energy through convection, radiation, and conduction.	describe and compare the directional transfer of heat through convection, radiation, and conduction.
	6.P.3A.6 Design and test devices that minimize or maximize heat transfer by conduction, convection, or radiation.
	Conceptual Understanding
	6.P.3B. Energy transfer occurs when two objects interact thereby exerting force on each other. It is the property of an object or a system that enables it to do work (force moving an object over a distance). Machines are governed by this application of energy, work, and conservation of energy.
	Performance Indicators
6-5.6 Recognize that energy is the ability to do work (force exerted over a distance). **6-5.7** Explain how the design of simple machines (including levers, pulleys, and inclined planes) helps reduce the amount of force required to do work.	**6.P.3B.1** Plan and conduct controlled scientific investigations to provide evidence for how the design of simple machines (including levers, pulleys, inclined planes) helps transfer mechanical energy by reducing the amount of force required to do work.
6-5.8 Illustrate ways that simple machines exist in common tools and in complex machines.	**6.P.3B.2** Design and test solutions that improve the efficiency of a machine by reducing the input energy (effort) or the amount of energy transferred to the surrounding environment as it moves an object.

2005	2014	Comments
	Standard (Life Science)	
6-3: The student will demonstrate an understanding of structures, processes, and responses of animals that allow them to survive and reproduce.	**6.L.4:** The student will demonstrate an understanding of how scientists classify organisms and how the structures, processes, behaviors, and adaptations of animals allow them to survive.	
	Conceptual Understanding	
	6.L.4A. Life is the quality that differentiates living things (organisms) from nonliving objects or those that were once living. All organisms are made up of cells, need food and water, a way to dispose of waste, and an environment in which they can live. Because of the diversity of life on Earth, scientists have developed a way to organize groups of organisms according to their characteristic traits, making it easier to identify and study them.	
	Performance Indicators	
6-2.1 Summarize the characteristics that all organisms share (including the obtainment and use of resources for energy, the response to stimuli, the ability to reproduce, and process of physical growth and development).	**6.L.4A.1** Obtain and communicate information to support claims that living organisms (1) obtain and use resources for energy, (2) respond to stimuli, (3) reproduce, and (4) grow and develop.	
6-2.2 Recognize the hierarchical structure of the classification (taxonomy) of organisms (including the seven major levels or categories of living things—namely, kingdom, phylum, class, order, family, genus, and species).	**6.L.4A.2** Develop and use models to classify organisms based on the current hierarchical taxonomic structure (including the kingdoms of protists, plants, fungi, and animals).	
	Conceptual Understanding	
	6.L.4B. The Animal Kingdom includes a diversity of organisms that have many characteristics in common. Classification of animals is based on structures that function in growth, reproduction, and survival. Animals have both structural and behavioral	

	adaptations that increase the chances of reproduction and survival in changing environments.
Performance Indicators	
6-3.1 Compare the characteristic structures of invertebrate animals (including sponges, segmented worms, echinoderms, mollusks, and arthropods) and vertebrate animals (fish, amphibians, reptiles, birds, and mammals).	**6.L.4B.1** Analyze and interpret data related to the diversity of animals to support claims that all animals (vertebrates and invertebrates) share common characteristics.
6-3.2 Summarize the basic functions of the structures of animals that allow them to defend themselves, to move, and to obtain resources. **6-3.4** Explain how environmental stimuli cause physical responses in animals (including shedding, blinking, shivering, sweating, panting, and food gathering).	**6.L.4B.2** Obtain and communicate information to explain how the structural adaptations and processes of animals allow for defense, movement, or resource obtainment.
6-3.5 Illustrate animal behavioral responses (including hibernation, migration, defense, and courtship) to environmental stimuli.	**6.L.4B.3** Construct explanations of how animal responses (including hibernation, migration, grouping, and courtship) to environmental stimuli allow them to survive and reproduce.
6-3.7 Compare learned to inherited behaviors in animals.	**6.L.4B.4** Obtain and communicate information to compare and classify innate and learned behaviors in animals.
6-3.3 Compare the response that a warm-blooded (endothermic) animal makes to a fluctuation in environmental temperature with the response that a cold-blooded (ectothermic) animal makes to such a fluctuation.	**6.L.4B.5** Analyze and interpret data to compare how endothermic and ectothermic animals respond to changes in environmental temperature.

*6-3.6 Summarize how internal stimuli (including hunger, thirst, and sleep) of animals ensure their survival.

2005	2014	Comments
	Standard (Life Science)	
6-2: The student will demonstrate an understanding of structures, processes, and responses of plants that allow them to survive and reproduce.	**6.L.5:** The student will demonstrate an understanding of the structures, processes, and responses that allow protists, fungi, and plants to survive and reproduce.	Includes the protist and fungi kingdoms
	Conceptual Understanding	
	6.L.5A. The Protist Kingdom is one of the most diverse groups and includes organisms that have characteristics similar to but are not classified as plants, animals, or fungi. These microorganisms live in moist environments and vary in how they obtain energy and move. The Fungi Kingdom consists of organisms that do not make their own food (heterotrophs) but obtain their nutrition through external absorption. Fungi can be grouped by their growth habit or fruiting structure and respond to changes in the environmental stimuli similar to plants.	
	Performance Indicators	
	6.L.5A.1 Analyze and interpret data from observations to compare how the structures of protists (including euglena, paramecium, and amoeba) and fungi allow them to obtain energy and explore their environment.	
	6.L.5A.2 Analyze and interpret data to describe how fungi respond to external stimuli (including temperature, light, touch, water, and gravity).	
	Conceptual Understanding	
	6.L.5B. The Plant Kingdom consists of organisms that primarily make their own food (autotrophs) and are commonly classified based on internal structures that function in the transport of food and water. Plants have structural and behavioral adaptations that increase	

	the chances of reproduction and survival in changing environments.
Performance Indicators	
6-2.3 Compare the characteristic structures of various groups of plants (including vascular or nonvascular, seed or spore-producing, flowering or cone-bearing, and monocot or dicot).	**6.L.5B.1** Construct explanations of how the internal structures of vascular and nonvascular plants transport food and water.
6-2.7 Summarize the processes required for plant survival (including photosynthesis, respiration, and transpiration).	**6.L.5B.2** Analyze and interpret data to explain how the processes of photosynthesis, respiration, and transpiration work together to meet the needs of plants.
6-2.4 Summarize the basic functions of the structures of a flowering plant for defense, survival, and reproduction. **6-2.6** Differentiate between the processes of sexual and asexual reproduction of flowering plants.	**6.L.5B.3** Develop and use models to compare structural adaptations and processes that flowering plants use for defense, survival and reproduction.
	6.L.5B.4 Plan and conduct controlled scientific investigations to determine how changes in environmental factors (such as air, water, light, minerals, or space) affect the growth and development of a flowering plant.
6-2.8 Explain how plants respond to external stimuli (including dormancy and the forms of tropism known as phototropism, gravitropism, hydrotropism, and thigmotropism).	**6.L.5B.5** Analyze and interpret data to describe how plants respond to external stimuli (including temperature, light, touch, water, and gravity).

*6-2.5 Summarize each process in the life cycle of flowering plants (including germination, plant development, fertilization, and seed production).
6-2.9 Explain how disease-causing fungi can affect plants.

CONTENT SUPPORT GUIDE
FOR GRADE SIX
2014 SOUTH CAROLINA ACADEMIC STANDARDS AND PERFORMANCE INDICATORS FOR SCIENCE

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SOUTH CAROLINA DEPARTMENT OF EDUCATION

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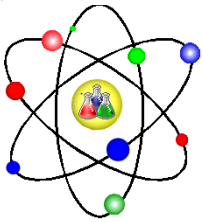

INTRODUCTION

Local districts, schools and teachers may use this document to construct standards-based science curriculum, allowing them to add or expand topics they feel are important and to organize content to fit their students' needs and match available instructional materials. The support document includes essential knowledge, extended knowledge, connections to previous and future knowledge, and assessment recommendations.

FORMAT OF THE CONTENT SUPPORT GUIDE

The format of this document is designed to be structurally uniformed for each of the academic standards and performance indicators. For each, you will find the following sections--

- **Standard**
  - This section provides the standard being explicated.
- **Conceptual Understanding**
  - This section provides the overall understanding that the student should possess as related to the standard. Additionally, the conceptual understandings are novel to the *2014 South Carolina Academic Standards and Performance Indicators for Science*.
- **Performance Indicator**
  - This section provides a specific set of content with an associated science and engineering practice for which the student must demonstrate mastery.
- **Assessment Guidance**
  - This section provides guidelines for educators and assessors to check for student mastery of content utilizing interrelated science and engineering practices.
- **Previous and Future Knowledge**
  - This section provides a list of academic content along with the associated academic standard that students will have received in prior or will experience in future grade levels. Please note that the kindergarten curriculum support document does not contain previous knowledge. Additionally, although the high school support document may not contain future knowledge, this section may list overlapping concepts from other high school science content areas.
- **Essential Knowledge**
  - This section illustrates the knowledge of the content contained in the performance indicator for which it is fundamental for students to demonstrate mastery.
- **Extended Knowledge**
  - This section provides educators with topics that will enrich students' knowledge related to topics learned with the explicated performance indicator.
- **Science and Engineering Practices**
  - This section lists the specific science and engineering practice that is paired with the content in the performance indicator. Educators should reference the chapter on this specific science and engineering practice in the *Science and Engineering Practices Support Guide.*

GRADE 6 SCIENCE CONTENT SUPPORT GUIDE

Standard:
6.E.2 The student will demonstrate an understanding of the interactions within Earth's systems (flow of energy) that regulate weather and climate.

Conceptual Understanding
6.E.2A. Earth's atmosphere, an envelope of gases that surround the planet, makes conditions on Earth suitable for living things and influences weather. Water is always moving between the atmosphere (troposphere) and the surface of Earth as a result of the force of gravity and energy from the Sun. The Sun is the driving energy source for heating Earth and for the circulation of Earth's atmosphere.

Performance Indicator
6.E.2A.1 Develop and use models to exemplify the properties of the atmosphere (including the gases, temperature and pressure differences, and altitude changes) and the relative scale in relation to the size of Earth.

Assessment Guidance

The objective of this indicator is to *develop and use* scale *models* that depict the properties of Earth's atmosphere. Therefore the primary focus of assessment should be for students to construct scaled representations of the layers of Earth's atmosphere that illustrates the similarities and differences between the layers. This could include but is not limited to students analyzing and interpreting data collected from informational text sources to create models.

In addition to *developing and using models*, students should *ask questions, plan and conduct investigations, analyze and interpret data, use mathematical and computational thinking, construct explanations* and *obtain, evaluate and communicate information*.

Previous and Future Knowledge

- H.E.5: The student will demonstrate an understanding of the dynamics of Earth's atmosphere. Key words: Layers of the atmosphere

Essential Knowledge
Earth's atmosphere is divided into several different atmospheric layers extending from Earth's surface outward. The air pressure, the force exerted by the gases pushing on an object, is greatest near the surface of Earth, in the troposphere. As altitude increases the gravitational pull decreases which results in a decrease in air pressure. The two most abundant (common) gases in all the layers of the atmosphere are nitrogen and oxygen. However, trace gases (such as argon) play an insignificant role in the layers. The atmosphere is divided into layers based on whether the temperature in the layer increases or decreases.
Troposphere:

- weather and clouds occur in this layer
- water vapor and carbon dioxide are also found in this layer and are important in the weather conditions in the layer
- as altitude increases temperature decreases
- extends from the surface of the earth up to 6-20km high

Stratosphere:

- where the ozone layer is contained

- ozone is a form of oxygen that is found in this layer
- cold except in its upper region where ozone is located
- extends from 20 km up to 50km

Mesosphere:

- the coldest layer
- extends from 50km up to 85km

Thermosphere:

- the warmest layer
- the air is very thin in this layer
- extends from 86km up to 690km

Exosphere:

- cold regions of outer space extend from this layer
- extends from 691km up to 10,000km

Extended Knowledge

- Weather balloons fly as high as the stratosphere.
- Meteors, or shooting stars, burn up in the mesosphere because of their interaction with Earth's atmosphere.
- Auroras occur in the ionosphere, which is located in the lower portion of the thermosphere.
- Shuttles orbit in thermosphere.
- Airplanes fly in the troposphere.
- Satellites orbit in the exosphere.
- While there is no clear definition of where outer space begins the general guideline is between 80-128 km from Earth.

Science and Engineering Practices

S.1A.2

Standard

6.E.2 The student will demonstrate an understanding of the interactions within Earth's systems (flow of energy) that regulate weather and climate.

Conceptual Understanding

6.E.2A. Earth's atmosphere, an envelope of gases that surround the planet, makes conditions on Earth suitable for living things and influences weather. Water is always moving between the atmosphere (troposphere) and the surface of Earth as a result of the force of gravity and energy from the Sun. The Sun is the driving energy source for heating Earth and for the circulation of Earth's atmosphere.

Performance Indicator

6.E.2A.2 Critically analyze scientific arguments based on evidence for and against how different phenomena (natural and human induced) may contribute to the composition of Earth's atmosphere.

Assessment Guidance

The objective of this indicator is for students to *analyze data* from a variety of sources, including informational text, to provide *arguments based on evidence* for and against natural and human phenomena contributing to the composition of Earth's atmosphere. Therefore, the focus of assessment for students should be to *obtain* data

from various sources and *evaluate and communicate* evidence that supports natural causes for the production of greenhouse gases and evidence that supports human activities as the cause of the increase in greenhouse gases. This would include but is not limited to students 1) examining data reflective of the amount of harmful chemicals released by volcanic eruptions 2) examining data reflective of the various ways that humans contribute to the production of greenhouse gases 3) analyzing data comparing the current composition of Earth's layers to historical data 4) using data collected to predict how the composition of Earth's atmospheric layers could be altered and 5) designing solutions for decreasing the amount of greenhouse gas production.

In addition to *critically analyzing scientific arguments*, students should *ask questions and define problems; develop and use models; plan and conduct investigations; analyze and interpret data; use mathematical and computational thinking; construct explanations and design solutions; engage in scientific argument from evidence; and obtain, evaluate and communicate information.*

Previous and Future Knowledge

- H.E.5 The student will demonstrate an understanding of Earth's atmosphere.

Essential Knowledge

Greenhouse gases in the atmosphere absorb and retain the energy radiated from land and ocean surfaces, thereby regulating Earth's average surface temperature and keeping it habitable (greenhouse effect). This effect can be enhanced by an increase in the gases that trap heat in the atmosphere. Additionally, the composition of Earth's atmosphere has changed over Earth's history, particularly the amount of ozone in the stratosphere. The following evidence can be found to support and refute this phenomenon.

- Volcanic eruptions affect the atmosphere by releasing ashes, which contain harmful chemicals and large amounts of carbon dioxide (a greenhouse gas).
- Human activities, such as the release of greenhouse gases from burning fossil fuels and the use of aerosol sprays also contribute to the change in Earth's atmospheric composition.

Extended Knowledge

Life on Earth could not exist without the protective shield of the ozone layer. This gas absorbs harmful UV rays, which harm plants and animals. Human health problems such as skin cancer and blindness can be attributed to a decrease in the amount of ozone.

Volcanic eruptions and the burning of fossil fuels can cause air pollution. This pollution can cause human health problems such as respiratory diseases. Volcanic ash also contains particulates that can reflect sunlight and result in a decrease in surface temperatures.

Human activities can be harmful or beneficial to the atmosphere. When humans clear cut and burn forests, more carbon dioxide is released into the atmosphere. Planting new plants can help to absorb carbon dioxide from the environment. Students should be able to research and explain the positive and negative effects that we have on our atmosphere and how these changes can affect life on our planet.

Science and Engineering Practices

S.1A.4

Standard

6.E.2: The student will demonstrate an understanding of the interactions within Earth's systems (flow of energy) that regulate weather and climate.

Conceptual Understanding
6.E.2A. Earth's atmosphere, an envelope of gases that surround the planet, makes conditions on Earth suitable for living things and influences weather. Water is always moving between the atmosphere (troposphere) and the surface of Earth as a result of the force of gravity and energy from the Sun. The Sun is the driving energy source for heating Earth and for the circulation of Earth's atmosphere.

Performance Indicator
6.E.2A.3 Construct explanations of the processes involved in the cycling of water through Earth's systems (including transpiration, evaporation, condensation and crystallization, precipitation, and downhill flow of water on land).

Assessment Guidance

The objective of this indicator is to *construct explanations* related to how water cycles through the Earth. Therefore, the primary focus of assessment should be for students to use evidence from a variety of sources (using primary or secondary scientific evidence; models; conclusions from scientific investigations; predictions based on observations; and data communicated in graphs, tables or diagrams) to explain the role of sunlight and gravity in the water cycle (including transpiration, evaporation, condensation and crystallization, precipitation, and downhill flow of water on land). This could include, but is not limited to students articulating the link between their ideas and supporting evidence based on 1) creating models and simulations of water cycle phases and 2) comparing data and images of water cycle phases to explain how thermal energy from the sun and gravity affect the phenomenon.

In addition to *constructing explanations*, students should *ask questions and define problems, develop and use models, plan and conduct investigations, analyze and interpret data, construct explanations and design solutions, engage in scientific argument from evidence and obtain, evaluate and communicate information.*

Previous and Future Knowledge
- 4.E.2: The student will demonstrate an understanding of the water cycle and weather and climate patterns. Key Words: water vapor, water cycle, clouds, precipitation
- H.E.6: The student will demonstrate an understanding of Earth's freshwater and ocean systems.

Essential Knowledge
Water continually cycles between the atmosphere (troposphere), land, and ocean via the water cycle. The following processes are propelled by sunlight and gravity:
Precipitation
- After condensation occurs (forming clouds), water droplets fall in various forms of *precipitation* – rain, snow, freezing rain, sleet, or hail, depending upon weather conditions.
- Temperature variations within clouds and/or within the region between the cloud and Earth allows for the various forms of precipitation.
- Gravity is the driving force for precipitation.

Evaporation/Transpiration
- Water enters the atmosphere as water vapor through the processes of evaporation and transpiration (i.e. plants releasing water vapor).
- Thermal energy from the sun causes water to evaporate and/or transpire.

Condensation/Crystallization
- As water vapor rises in the atmosphere it can turn into water droplets or ice crystals which results in cloud formation.

- Condensation of water vapor into water droplets or ice crystals must occur on a surface.
    - In the atmosphere, dust particles (or any other particulates) serve as a surface for water to condense on.
- These processes can form on Earth's surface in the following forms:
    - *Dew* forms when water vapor condenses directly onto a surface;
    - *Frost* forms when water vapor changes from gas directly to ice crystals on a surface when the temperature at which condensing would take place are at the freezing point or below.
- Increases in thermal temperature causes water vapor to rise (evaporation) while a decrease in thermal temperature triggers condensation (clouds, dew, and frost).

Downhill Flow of Water on Land

- If precipitation falls on land surfaces, it always attempts to move back toward sea level as *surface-water flow* or *groundwater flow*.
- The surface that receives the precipitation determines its flow back towards sea level. Examples are:
    - Water will remain on the surface when the surface is not porous or the precipitation is falling too fast for the water to sink into the ground.
    - Water will sink into the ground when the surface is porous and there is space in the soil to hold the water.
- Gravity is the driving force for downhill flow of water on land

Extended Knowledge

- The amount of water on Earth has not changed over Earth's history. Therefore, pollution can effect this cycle and the organisms that rely on it.
- There are human and natural factors that affect the quality of the water in the water cycle. Students can explore the positive and negative effects that these factors have on organisms that rely on water. These factors can include pollution added to waterways by accidental spills or run-off (from roads and cities).

Science and Engineering Practices
S.1A.6

Standard
6.E.2: The student will demonstrate an understanding of the interactions within Earth's systems (flow of energy) that regulate weather and climate.

Conceptual Understanding
6.E.2B. The complex patterns of changes and movement of water in the atmosphere determined by winds, landforms, ocean temperatures and currents, and convection are major determinants of local weather patterns and climate. Technology has enhanced our ability to measure and predict weather patterns.

Performance Indicator
6.E.2B.1 Analyze and interpret data from weather conditions (including wind speed and direction, air temperature, humidity, cloud types, and air pressure), weather maps, satellites, and radar to predict local weather patterns and conditions.

Assessment Guidance

The objective of this indicator is to *analyze and interpret data* about wind, temperature, humidity cloud types and air pressure from weather maps, satellites and radar to make predictions related to weather. Therefore, the focus of assessment should be for students to use primary and secondary sources including weather maps,

satellite images, and radar to predict local weather conditions. This could include but is not limited to students 1) using weather symbols to interpret a weather map, station model, or hurricane tracking map, and then predict future weather conditions 2) comparing a series of weather maps to provide evidence of patterns or weather system movement to support weather predictions.

In addition to *analyze and interpret data*, students should *ask questions; develop and use models, plan and conduct investigations; use mathematical and computational thinking; construct explanations; engage in scientific argument from evidence; obtain, evaluate and communicate information; and construct devices or design solutions.*

Previous/Future Knowledge

- 4.E.2: The student will demonstrate an understanding of the water cycle and weather and climate patterns. Key Words: water cycle, clouds, precipitation, climate, temperature, wind speed, wind direction, relative humidity, cloud types, thunderstorms, hurricanes, and tornadoes
- H.E.5: The student will demonstrate an understanding of the dynamics of Earth's atmosphere.

Essential Knowledge

Meteorologists can predict the weather by analyzing and interpreting data from observations and tools such as current weather conditions, weather maps, satellites, and radar images.

- Changes in the following weather conditions can indicate a change in the pattern of weather.
    - Wind speed is measured using an anemometer and indicates a change in atmospheric flow patterns
    - Wind direction is measured using a wind vane (also known as a weather vane) and indicates the direction of advancing air masses.
    - Temperature is measured using a thermometer. Changes in the air masses result in changes in the temperature.
    - Humidity can be measured with sling psychrometers or hygrometers. Humidity is a measure of the percentage of water vapor in the air. Increased levels of humidity can be associated with a high probability of precipitation.
    - Air pressure is measured with a barometer. A rise in air pressure indicates fair weather while a fall in pressure indicates stormy weather conditions advancing
    - Basic shapes of clouds are associated with weather patterns.
        - Cirrus clouds are high and wispy and signal fair weather or an approaching warm front
        - Cumulus clouds are puffy with flat bottoms and signal fair weather. However, when they are darker, they may signal rain or thunderstorms, as they develop into cumulonimbus clouds (thunderheads).
        - Stratus clouds are spread over a large area and are layered. As these clouds thicken long periods of precipitation can occur over the area where the clouds are located.
- Weather maps
    - Weather maps can help predict weather patterns by indicating high or low pressure systems (*isobars*), movement of air masses and fronts, or temperature ranges (*isotherms*).
- Satellites
    - Satellite images are used for seeing cloud patterns and movements.
    - For example, hurricane clouds and movement can be observed using satellite images.
- Radar
    - Radar images can be used to detect cloud cover, rainfall, storm location or intensity, and cloud movement, as well as the potential for severe weather (for example, hurricanes or tornadoes).

Extended Knowledge
Station models from specific locations provide information that can also be used to predict weather patterns. Information found on a station model can include cloud cover, temperature (85°F), wind direction and speed, precipitation (* - snow, ● – rain), or barometric pressure (1002 mb).

Meteorology is based on probability. Therefore, predictions are not always accurate.

The basic shape name of a cloud can be combined with the appropriate prefix or suffix listed below as clues to the weather conditions that may result.

- Combinations of those shapes can be used with nimbus, which means "rain", for example, cumulonimbus or nimbostratus.
- A cumulonimbus cloud, also called a thunderhead, is often part of thunderstorm conditions that may accompany a cold front.
- The prefix alto- may also be used to indicate medium-level clouds formed at about 2-6 kilometers up into the atmosphere, for example, altocumulus or altostratus.

Science and Engineering Practices
S.1A.4

Standard:
6.E.2: The student will demonstrate an understanding of the interactions within Earth's systems (flow of energy) that regulate weather and climate.

Conceptual Understanding:
6.E.2B The complex patterns of changes and movement of water in the atmosphere determined by winds, landforms, ocean temperatures and currents, and convection are major determinants of local weather patterns and climate. Technology has enhanced our ability to measure and predict weather patterns.

Performance Indicator:
6.E.2B.2 Develop and use models to explain how relationships between the movement and interactions of air masses, high and low pressure systems, and frontal boundaries result in weather conditions and storms (including thunderstorms, hurricanes and tornadoes).

Assessment Guidance

The objective of this indicator is to *develop and use models* that depict how air masses, high and low-pressure systems and frontal boundaries cause different weather conditions including thunderstorms, hurricanes and tornadoes. Therefore, the primary focus of assessment should be for students to *create representations* that illustrate the cause and effect relationship between the movements of air masses, high and low pressure systems and frontal boundaries and weather conditions such as thunderstorms, hurricanes and tornadoes. This could include but is not limited to students 1) understanding and representing weather conditions based on data from primary and secondary sources 2) testing devices or solutions that illustrate how thunderstorms, hurricanes, and tornadoes are produced 3) communicating information gathered from the device/solution to predict the weather conditions or storms.

In addition to *analyze and interpret data*, students should *ask questions; plan and conduct investigations; analyze and interpret data; use mathematical and computational thinking; construct explanations; engage in*

scientific argument from evidence; and obtain, evaluate and communicate information; and construct or design solutions.

Previous and Future Knowledge:

- K.E.3: The student will demonstrate an understanding of daily and seasonal weather patterns. Key Words: cloud, wind, snow, rain, temperature, daily, seasonal, patterns, earth, light
- 2.E.2: The student will demonstrate an understanding of the daily and seasonal weather patterns. Key Words: weather, wind, precipitation (such as rain, sleet, snow, and hail), temperature, meteorologist, severe weather, and safety precautions
- 4.E.2: The student will demonstrate an understanding of the water cycle and weather and climate patterns. Key Words: water cycle, clouds, precipitation, climate, temperature, wind speed, wind direction, relative humidity, cloud types, thunderstorms, hurricanes, and tornadoes.
- H.E.5: The student will demonstrate an understanding of the dynamics of Earth's atmosphere. Key Words: Movement of air masses, frontal boundaries, and pressure systems, formation of severe weather

Essential Knowledge:

Air masses

- Huge bodies of air that form over water or land in tropical or polar regions.
- Temperature and humidity conditions (for example, warm or cold air, humid or dry air) within the air masses as they form are important to the resulting weather conditions when air masses move.

Fronts

- As these air masses move and collide with each other, fronts form at the boundaries between the air masses.
- Depending upon the air masses involved, a warm front, cold front, stationary front, or occluded front can develop.
    - When a warm air mass collides and rides over a cold air mass, the resulting warm front may produce long periods of precipitation and warmer temperatures.
    - When a cold air mass collides and slides under a warm air mass, the resulting cold front may produce thunderstorms and sometimes tornadoes and cooler temperatures.
    - When neither a cold air mass nor a warm air mass moves at a frontal boundary, the resulting stationary front may produce long period of precipitation.
    - When a cold air mass pushes into a warm air mass that is behind a cool air mass, the warm air mass is pushed up above the cooler air masses. The resulting occluded front may produce long periods of precipitation.

High/Low Pressure Systems

- Warm air rising or cold air sinking combined with the spinning of the Earth causes the air to spin forming high and low pressure regions.
    - High pressure systems usually signal more fair weather with winds circulating around the system in a clockwise direction.
    - Low pressure systems with counterclockwise circulating winds often result in rainy and/or stormy weather conditions.

Storms

- Severe weather conditions called storms occur when pressure differences cause rapid air movement.
- Conditions that bring one kind of storm can also cause other kinds of storms in the same area.
    - Thunderstorm is a storm with thunder, lightning, heavy rains and strong winds; form within large cumulonimbus clouds; usually form along a cold front but can form within an air mass.

- Tornado is a rapidly whirling, funnel-shaped cloud that extends down from a storm cloud; the very low pressure and strong winds can cause great damage to people and property; are likely to form within the frontal regions where strong thunderstorms are also present.
- Hurricane is a low pressure tropical storm that forms over warm ocean water; winds form a spinning circular pattern around the center, or eye, of the storm; the lower the air pressure at the center, the faster the winds blow toward the center of the storm.

Extended Knowledge:

- Since weather is a condition of Earth's atmosphere at any time, weather conditions may include fair weather, showers or light rain, humid conditions, clear skies with cold conditions, days of clouds and precipitation, or others that do not necessarily involve storms.
- Air masses get their names from where they originate.
  - Continental Polar - originate over cold land masses and bring cold dry air as they move.
  - Continental Tropical - originate over warm land masses and bring warm dry air as they move.
  - Maritime Polar - originate over cold oceans and bring cold moist air as they move.
  - Maritime Tropical - originate over warm oceans and bring warm moist air as they move.
- When air masses remain stationary over land masses for extended periods of time, their presence could impact agriculture through conditions such as floods and droughts.

Science and Engineering Practices
S.1A.2

Standard:
6.E.2: The student will demonstrate an understanding of the interactions within Earth's systems (flow of energy) that regulate weather and climate.

Conceptual Understanding:
6.E.2B The complex patterns of changes and movement of water in the atmosphere determined by winds, landforms, ocean temperatures and currents, and convection are major determinants of local weather patterns and climate. Technology has enhanced our ability to measure and predict weather patterns.

Performance Indicator:
6.E.2B.3 Develop and use models to represent how solar energy and convection impact Earth's weather patterns and climate conditions (including global winds, the jet stream, and ocean currents).

Assessment Guidance

The objective of this indicator is to *develop and use models* that depict the impact of solar energy and convection on Earth's weather patterns and climate conditions including global winds, the jet stream and ocean currents. Therefore, the primary focus of assessment should be for students to use primary and secondary sources to construct cause and effect *models* of how solar energy and convection result in global winds, the jet stream and ocean currents. This could include but is not limited to students using evidence to *develop models* that illustrate 1) how thermal energy is the driving force for convection currents, 2) how convection currents result in the movement of air masses and ocean currents3) and how these convection currents influence global weather conditions (global winds, the jet stream, and ocean currents).

In addition to *developing and using models*, students should *ask questions and define problems, plan and conduct investigations, analyze and interpret data, construct explanations, engage in scientific argument from evidence and obtain, evaluate and communicate information.*

Previous and Future Knowledge:

- 4.E.2: The student will demonstrate an understanding of the water cycle and weather and climate patterns. Key Words: water cycle, clouds, precipitation, climate, temperature, wind speed, wind direction, relative humidity, cloud types, thunderstorms, hurricanes, and tornadoes
- 5.E.3: The student will demonstrate an understanding of how natural processes and human activities affect the features of Earth's landforms and oceans. Key Words: oceans, storms, waves, currents, tides
- H.E.6: The student will demonstrate an understanding of Earth's freshwater and ocean systems. Key Words: Convection currents, ocean circulation

Essential Knowledge:

The driving energy source for heating of Earth is solar energy. The rotation of Earth on its axis along with differences in the heating of Earth impact weather patterns and climate conditions.

- Land absorbs heat energy and releases heat energy quickly. Water absorbs heat energy and releases heat energy slowly. The differences in these heating patterns cause convection currents
- Global convection currents are set up in the atmosphere because of the unequal heating of Earth's surfaces. There are three atmospheric convection areas that influence the climate regions on Earth.
    - the *tropical region* begins at the equator and extends to about 30 degrees latitude;
    - the *temperate region* extends from there to about 60 degrees latitude, and
    - the *polar region* extends from there to the north pole, 90 degrees latitude.
- Global winds occur in each of the climate regions and effect the direction of weather systems on Earth
    - Trade winds and westerlies effect the direction of tropical weather systems (hurricanes).
    - Jet streams are fast moving ribbons of air that move from west to east in the Northern hemisphere.
        - The polar jet stream brings down cold polar conditions from the north.
    - *Ocean surface currents* circulate warm and cold ocean waters in convection patterns and influence the weather and climates of the landmasses nearby.
        - The Gulf Stream influences the eastern Atlantic shoreline of the United States by bringing warm, moist air.
        - The cold California current influences its western Pacific shoreline by bringing cold, moist air.
- Global wind belts occur between climate regions because of the characteristics of the convection currents in those regions. The prevailing direction of the global winds in these large regions affects weather conditions.

Three major climate zones (tropical, temperate, and polar) are a result of these global systems.

Extended Knowledge:

- Earth's winds move in a rotated pattern because of the rotation of Earth around its axis. This phenomenon is called the Coriolis Effect and is named after French engineer Gaspard Coirolis who died in 1843.
- Each climate zone has identifying characteristics. Organisms in these regions have adaptions to survive.
- Airplanes ride on jet streams to increase their speed and decrease the amount of fuel they use.

Science and Engineering Practices

Standard:
6.E.2: The student will demonstrate an understanding of the interactions within Earth's systems (flow of energy) that regulate weather and climate.

Conceptual Understanding:
6.E.2B The complex patterns of changes and movement of water in the atmosphere determined by winds, landforms, ocean temperatures and currents, and convection are major determinants of local weather patterns and climate. Technology has enhanced our ability to measure and predict weather patterns.

Performance Indicator:
6.E.2B.4 Construct explanations for how climate is determined in an area (including latitude, elevation, shape of the land, distance from water, global winds, and ocean currents).

Assessment Guidance
The objective of this indicator is to *construct explanations* to show how latitude, elevation, shape of the land, distance from the water, global winds and ocean currents all determine the climate in an area. Therefore, the primary focus of assessment should be for students to *use evidence obtained* from scientific evidence, models, conclusions, predictions, and data to explain how factors such as latitude, elevation, shape of the land, distance from the water, global winds and ocean currents are all factors that determine climate in an area. This could include but is not limited to students 1) using these factors to determine the climate in a given location and 2) comparing the factors in different locations and use them to explain the differences in regional climates.

In addition to *construct explanations,* students should *ask questions, develop and use models, plan and conduct investigations, analyze and interpret data, use mathematical and computational thinking, engage in scientific argument from evidence and obtain, evaluate and communicate information.*

Previous and Future Knowledge:
- H.E.5: The student will demonstrate an understanding of the dynamics of Earth's atmosphere. Key words: Local wind patterns

Essential Knowledge:
All of the following can affect climate in local regions:
- Latitude
  - The sun's rays directly strike the equator (latitude 0) and cause the regions near the equator to be warmer.
  - Generally, as latitude increases the temperature of the area decreases.
- Elevation
  - Within the troposphere as altitude increases temperature decreases.
- Shape of the Land (Topography)
  - Certain land formations (mountains and valleys) can affect the movement of air masses and therefore affect the weather conditions a region experiences.
- Distance from Water
  - Land and Sea breezes are local convection currents that occur in areas near water because of the unequal heating of Earth materials.
- Global Winds
  - Global winds provide a predictable pattern for the movement of air in a specific region and are

named after the direction they come from.

- Ocean Currents
  - Ocean currents circulate heat energy. Air masses that originate over regions of the ocean are moved with currents and affect the climate of coastal regions.
  -

Extended Knowledge:

- There are three types of global winds.
  - The *trade winds* blow from east to west in the tropical region moving warm tropical air in that climate zone.
  - The prevailing *westerly winds* blow from west to east in the temperate region.
  - The *polar winds* blow northeast to west in the polar region moving cold polar air in that climate zone from the poles toward the west.
- Agriculture and mariculture in a particular area is determined by the weather conditions.

Science and Engineering Practices
S.1A.6

Standard 6.P.3:
The student will demonstrate an understanding of the properties of energy, the transfer and conservation of energy, and the relationship between energy and forces.

Conceptual Understanding 6.P.3A.
Energy manifests itself in multiple forms, such as mechanical (kinetic energy and potential energy), electrical, chemical, radiant (solar), and thermal energy. According to the principle of conservation of energy, energy cannot be created nor destroyed, but it can be transferred from one place to another and transformed between systems.

Performance Indicator 6.P.3A.1
Analyze and interpret data to describe the properties and compare sources of different forms of energy (including mechanical, electrical, chemical, radiant, and thermal).

Assessment Guidance
The objective of this indicator is to *analyze and interpret data to* demonstrate an understanding of the properties of energy, the transfer and conservation of energy, and the relationship between energy and forces. Therefore, the primary focus of assessment should be for students *to analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions to* describe the properties of and compare sources of different forms of energy (including mechanical, electrical, chemical, radiant, solar, and thermal). This could include but is not limited to students organizing data collected from experiments conducted to identify the sources and properties of heat, solar, chemical, mechanical, and electrical energy.

In addition to *analyzing and interpreting data*, students should *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations;*

develop and use models; obtain, evaluate, and communicate information; and construct devices or design solutions.

Previous and Future Knowledge

- H.P.3.A: Work, Work-Energy Theorem, Power, Efficiency
- H.P.3.B: Conservation of Energy, Periodic Motion and Energy, Gravitational Potential Energy

Essential Knowledge

Thermal (Heat) energy

- Thermal energy is the energy that is associated with the motion of the particles in a substance.
- All matter is made up of atoms (particles) that move faster when they heat up. The faster the particles move, the higher the temperature.
- Heat energy is the transfer of thermal energy.
- Heat energy always moves from hotter objects to cooler objects.

Radiant energy

- Energy which is transferred through electromagnetic waves such as visible light, ultraviolet light or X-rays.
- *Solar energy* is a type of radiant energy.
    - Green plants use solar energy during photosynthesis.
    - Most of the energy that we use on Earth originally came from the Sun.
- Sources of radiant energy include, but are not limited to, stars, light bulbs, and microwaves.

Chemical energy

- *Chemical energy* is energy stored within the chemical bonds in matter.
- Chemical energy can be released, for example in batteries or sugar/food, when these substances react to form new substances.

Electrical energy

- *Electrical energy* is the energy flowing in an electric circuit.
- Sources of electrical energy include: stored chemical energy in batteries; solar energy in solar cells; fuels or hydroelectric energy in generators.

Mechanical energy

- *Mechanical energy* is the energy due to the motion (kinetic) and position (potential) of an object. When objects are set in motion or are in a position where they can be set in motion, they have mechanical energy.
    - *Mechanical Potential energy:*
        - *Potential energy* is stored energy.
        - Mechanical potential energy is related to the position of an object.
        - A stretched rubber band has potential energy. This is called *elastic potential energy*.
        - A book on a shelf has potential energy. Since gravity can pull the book to the floor, this is called *gravitational potential energy*. The height and mass of an object affect gravitation potential energy.
            - Gravitational potential energy is greater when the height of an object is greater because more kinetic energy was required to raise the object to the greater height.

- Gravitational potential energy is greater when the mass of the object is greater because more kinetic energy is required to lift the heavier object.
- Examples of this can include, but are not limited to, lifting a book to a height of 2 meters instead of 1 meter; and lifting a basketball to a height of one meter and then lifting a bowling ball to a height of 1 meter.

- *Mechanical Kinetic energy*:
  - *Kinetic energy* is the energy an object has due to its motion.
  - Mechanical kinetic energy increases as an object moves faster.

NOTE: Other types of energy can also be classified as potential and kinetic, but 6th grade students are only responsible for kinetic and potential mechanical energy.

Extended Knowledge

- Chemical reactions or changes for chemical energy
- Electron association with electrical energy
- The concept of nuclear energy.

Science and Engineering Practices

S.1A.4

Standard 6.P.3:

The student will demonstrate an understanding of the properties of energy, the transfer and conservation of energy, and the relationship between energy and forces.

Conceptual Understanding 6.P.3A.

Energy manifests itself in multiple forms, such as mechanical (kinetic energy and potential energy), electrical, chemical, radiant (solar), and thermal energy. According to the principle of conservation of energy, energy cannot be created nor destroyed, but it can be transferred from one place to another and transformed between systems.

Performance Indicator 6.P.3A.2

Develop and use models to exemplify the conservation of energy as it is transformed from kinetic to potential (gravitational and elastic) and vice versa.

Assessment Guidance

The objective of this indicator is to *develop and use models* to exemplify the conservation of energy as it is transformed from kinetic to potential (gravitational and elastic) and vice versa. Therefore, the primary focus of assessment should be for students to construct drawings/diagrams and models that exemplify or simulate how energy changes between kinetic energy and potential energy in a system. The same models may be used to demonstrate the Law of Conservation of Energy. This could include but is not limited to students *developing a model* (interpreting diagrams or illustrations) to illustrate how the presence of gravitational potential energy and kinetic energy in a system supports the Law of Conservation of Energy.

In addition to *developing and using models*, students should *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; obtain, evaluate, and communicate information; and construct devices or design solutions.*

Previous and Future Knowledge

- 3.P.3.A.: 1 Electricity transformed into other forms of energy (including light, heat, and sound)
- H.P.3.A: Work, Work-Energy Theorem, Power, Elastic and Inelastic Collisions, Efficiency
- H.P.3.B: Periodic Motion and Energy, Conservation of Energy, Gravitational Potential Energy

Essential Knowledge

The Law of Conservation of Energy:

- The *Law of Conservation of Energy* states that energy cannot be created nor destroyed.
- Energy can be transformed from one form into another, but the total amount of energy never changes.

Mechanical energy transformations:

- When water is behind a dam, it has potential energy. The potential energy of the water changes to kinetic energy in the movement of the water as it flows over the dam.
- When a rubber band is stretched, kinetic energy is transformed into potential energy. The further back you stretch the rubber band, the greater potential energy, and the more energy that will be transferred as kinetic energy. When a stretched rubber band is released its potential energy is transformed into kinetic energy as the rubber band moves.
- When a book is lifted to a shelf, kinetic energy is transformed into potential energy. If the book falls off the shelf the potential energy is transformed to kinetic energy.

Energy is conserved during energy transformations:

- Transformations may occur between any of the various types of energy but energy itself is never lost.
- The potential energy that a book on a shelf has is from the kinetic energy it took to lift the book to the shelf.
- A swing pendulum (such as a Newton's cradle) also demonstrates how energy is conserved as it changes forms.
    - Kinetic energy is used to pull a ball back; this energy is transformed into potential energy.
    - The ball is released and the ball swings back toward the other three balls (kinetic energy).
    - The moving ball strikes the stationary ball and the kinetic energy is transferred from one ball to the next.
    - The last ball swings away from the others because of the kinetic energy that was transferred to the ball.
    - If this experiment is repeated by pulling back two balls, then two balls will swing off of the other end.
    - This shows conservation of energy because one ball has enough potential energy to cause one ball to move; two balls cause two to moves, and so on.
- Although energy is not lost during energy transformations, some is transformed into heat and friction. This means that all of the potential energy stored in a book is not going to be transformed into kinetic energy.

Extended Knowledge

- Formulas for potential energy and kinetic energy
- Calculate potential or kinetic energy
- In relationship to a pendulum, the pendulum will eventually stop due to friction.
- The friction transforms the energy that was originally mechanical energy in the swinging pendulum into heat.

Science and Engineering Practices
S.1A.2

Standard 6.P.3:
The student will demonstrate an understanding of the properties of energy, the transfer and conservation of energy, and the relationship between energy and forces.

Conceptual Understanding 6.P.3A.
Energy manifests itself in multiple forms, such as mechanical (kinetic energy and potential energy), electrical, chemical, radiant (solar), and thermal energy. According to the principle of conservation of energy, energy cannot be created nor destroyed, but it can be transferred from one place to another and transformed between systems.

Performance Indicator 6.P.3A.3
Construct explanations for how energy is conserved as it is transferred and transformed in electrical circuits.

Assessment Guidance
The objective of this indicator is to *construct explanations* for how energy is conserved as it is transferred and transformed in electrical circuits*;* therefore the focus of assessment should be for students *to construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams* to describe how energy is conserved when it is transformed and transferred. This could include but is not limited to students constructing a circuit and identifying the conserved energy is transformed within that circuit such as where transformations into mechanical, light, sound, and/or heat energy occur.

This could include, but is not limited to, students constructing a circuit and identifying how energy is conserved and transformed in the circuit. Students should explore circuits that transform electricity in mechanical, light, sound, and/or heat energy.

In addition to *constructing explanations,* students should *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information; develop and use models; and construct devices or design solutions.*

Previous and Future Knowledge

- H.P.3B: Conservation of Energy, Gravitational Potential Energy
- H.P.3E: Ohm's Law, Circuits, Electrical Power, Series and Parallel Circuits, Electromagnetic Induction
- H.P.3D: Mechanical Waves, Wave Interference, Principle of Superposition, Doppler Effect, Properties of Waves
-

Essential Knowledge

An electric circuit contains:

- A source of electrical energy. Examples include:
    - The electrical energy in a battery comes from stored chemical energy.
    - The electrical energy in a solar cell comes from light energy from the sun.
    - The electrical energy in outlets may come from chemical energy (burning fuels) which powers a generator in a power plant.
- A conductor of electrical energy (wire) that connects all parts of the electric circuits.
- A transformer changes the electrical energy into something else (a light bulb changes electrical energy into radiant energy)

An electric circuit must be a complete, unbroken path through which the electricity flows.

- The wire (conductor) must connect the power source to the transformer and then connect back to the power source to create a complete, or closed, circuit. A closed circuit allows the electricity to flow and the transformer to change the electrical energy into another type of energy.
    - A light bulb with two wires attached to it, one going to the negative end of a battery and one going to the positive end of the same battery, is an example of a closed circuit.
- If the circuit is not closed, then electricity cannot flow and the circuit is an open circuit. Since the electricity is not flowing, the transformer cannot change the electrical energy into another type of energy.
- The purpose of a switch is to control whether a circuit is closed (electricity flows) or open (electricity cannot flow).

Electrical energy can be transformed to other forms of energy in a circuit. For example:

Light

- Electrical energy can be transformed into light energy in an electric circuit if a light bulb is included in the circuit.
- The transformation in this case might be that chemical energy in a battery is transformed into electrical energy in the circuit which is transformed into light and heat energy in the light bulb.

Sound

- Electrical energy can be transformed into sound energy in an electric circuit if a bell, buzzer, radio, or TV is included in the circuit.
- The transformation in this case might be that chemical energy in a battery is transformed into electrical energy in the circuit which is transformed into sound energy by the bell or buzzer.

Heat

- Electrical energy can be transformed into heat energy in an electric circuit if a toaster, stove, or heater is included in the circuit.

- The transformation in this case might be that--
    - Chemical energy from the fuel at the power plant is transformed into heat energy.
    - This heat energy is transformed into mechanical energy to turn a generator.
    - The generator transforms the mechanical energy into electrical energy.
    - Then the electrical energy in the circuit is transformed into heat energy in the heater.

Mechanical motion

- Electrical energy can be transformed into the energy of mechanical motion if a fan or motor is added to the circuit.
- Transformation in this case might be that chemical energy in a battery is transformed into electrical energy in the circuit which is transformed into the energy of mechanical motion by the fan or motor.
- A generator in a circuit can change mechanical motion into electrical energy.
    - The transformation in this case might be that chemical energy from the fuel at a power plant is transformed into heat energy which is transformed into mechanical energy to turn a generator.
    - The generator transforms the mechanical energy into electrical energy.
    - This is the source of energy in electric outlets.

Electrical energy is conserved as it flows in the circuit.

- The Law of Conservation of energy states that energy isn't created or destroyed; it only changes forms.
- The reason that batteries eventually lose power is because some of the electrical energy is transformed into another source of energy (radiant energy in a flashlight, for example). Some of the electrical energy is also transformed into heat energy.
- In this example, if the flashlight is left on, more and more of the electrical energy will be transformed into light and heat energy. This will continue until the electrical energy is depleted.

Extended Knowledge

- Construct a generator (water, wind, or solar powered) and connect it to a transformer.
- Measure the voltage before and after a transformer to explore the conservation of electrical energy.
- Compare and/or construct series and parallel circuits

Science and Engineering Practices

S.1A.6

Standard 6.P.3:
The student will demonstrate an understanding of the properties of energy, the transfer and conservation of energy, and the relationship between energy and forces.

Conceptual Understanding 6.P.3A.
Energy manifests itself in multiple forms, such as mechanical (kinetic energy and potential energy), electrical, chemical, radiant (solar), and thermal energy. According to the principle of conservation of energy, energy cannot be created nor destroyed, but it can be transferred from one place to another and transformed between systems.

Performance Indicator 6.P.3A.4
Develop and use models to exemplify how magnetic fields produced by electrical energy flow in a circuit is interrelated in electromagnets, generators, and simple electrical motors.

Assessment Guidance
The objective of this indicator is to *develop and use models* to exemplify how magnetic fields produced by electrical energy flow in a circuit are interrelated in electromagnets, generators, and simple electrical motors. Therefore, the primary focus of assessment should be to model how the flow of electricity allows an electromagnet to generate a magnetic field. Although invisible, this field is observable by how the magnetic field interacts with magnetic materials (changing the direction a compass points, picking up paperclips, etc.). This could require students to interpret diagrams or illustrations related to energy transformations such as those found in simple motors and generators.

In addition to *develop and use models*, students should *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; obtain, evaluate, and communicate information; and construct devices or design solutions.*

Previous and Future Knowledge
- 3.P.3B Properties of magnets and electromagnets.
- Students have not been introduced to the concept of generators and simple electrical motors in previous grade levels.
- H.P.3E: Ohm's Law, Circuits, Electrical Power, Series and Parallel Circuits, Electromagnetic Induction

Essential Knowledge
It is essential for students to:
- Know that *magnetism* is the force of attraction or repulsion of magnetic materials.
- Surrounding a magnet is a *magnetic field* that applies a force, a push or pull, without actually touching an object.
- Evidence of a magnetic field can be found in how the field affects magnetic materials (including, but not limited to, a compass, iron filings, and paper clips).
- An electric current flowing through a wire wrapped around an iron core forms a *magnet*.
- A coil of wire spinning around a magnet or a magnet spinning around a coil of wire can form an *electric current*.

Examples of how magnetism and electricity are interrelated can be demonstrated by the following devices:

Electromagnets

- An *electromagnet* is formed when a wire in an electric circuit is wrapped around an iron core producing a magnetic field.
- The magnet that results loses its *magnetism* if the electric current stops flowing.

Generators

- A *generator* produces an electric current when a coil of wire wrapped around an iron core is rotated near a magnet.
- Generators at power plants produce electric energy for our homes.
- A generator contains coils of wire that are stationary, and rotating magnets are rotated by turbines. Turbines are huge wheels that rotate when pushed by water, wind, or steam.
- Thus mechanical energy is changed to electrical energy by a generator. Smaller generators may be powered by gasoline.

Simple electric motors

- An electric motor changes electrical energy to mechanical energy.
- It contains an electromagnet that rotates between the poles of a magnet.
- The coil of the electromagnet is connected to a battery or other source of electric current.
- When an electric current flows through the wire in the electromagnet, a magnetic field is produced in the coil.
- Like poles of the magnets repel and unlike poles of the magnets attract.
- This causes the coil to rotate and thus changes electrical energy to mechanical energy.
- This rotating coil of wire can be attached to a shaft and a blade in an electric fan.

Extended Knowledge

- Components of generators or motors
- Differences between AC and DC generators
- The function of a transformer
- How a magnetic field is produced

Science and Engineering Practices

S.1A.2

Standard 6.P.3:

The student will demonstrate an understanding of the properties of energy, the transfer and conservation of energy, and the relationship between energy and forces.

Conceptual Understanding 6.P.3A.

Energy manifests itself in multiple forms, such as mechanical (kinetic energy and potential energy), electrical, chemical, radiant (solar), and thermal energy. According to the principle of conservation of energy, energy cannot be created nor destroyed, but it can be transferred from one place to another and transformed between systems.

Performance Indicator 6.P.3A.5
Develop and use models to describe and compare the directional transfer of heat through convection, radiation, and conduction.

Assessment Guidance
The objective of this indicator is *to develop and use models* to describe and compare the directional transfer of heat through convection, radiation, and conduction. Therefore, the primary focus of assessment should be *to develop a model* from sources of evidence and scientific information to show how heat can be transferred through three ways (conduction, convection, or radiation). This could include but is not limited to students using models to communicate information related to the types of heat transfer based on descriptions of how particles behave and inferred direction of heat transfer at various temperature points.

In addition to *develop and use models,* students should *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; obtain, evaluate, and communicate information; and construct devices or design solutions.*

Previous and Future Knowledge
- 3.P.2A students explained how heat moves easily from one object to another through direct contact in some materials (called conductors) and not so easily through other materials (called insulators).
- Students have not been introduced to the concepts of radiation or convection.
- H.P.3C: Heat Transfer, Thermal Conductivity, Conduction, Convection and Radiation.

Essential Understanding
It is essential for students to know that heat energy can transfer in the three ways (i.e. conduction, convection, radiation).
Conduction
- Conduction is the transfer of thermal energy through direct contact.
- The transfer of energy as heat occurs between particles as they collide within a substance or between two objects in contact.
- All materials do not conduct heat energy equally.
- Poor conductors of heat are called insulators.
    - For example, if a plastic spoon and a metal spoon are placed into a hot liquid, the handle of the metal spoon will get hot quicker than the handle of the plastic spoon because the heat is conducted through the metal spoon better than through the plastic spoon.
- The energy transfers from an area of higher temperature to an area of lower temperature.

Convection
- Convection is the transfer of energy as heat by movement of the heated substance itself, as currents in fluids (liquids and gases).
- In convection, particles with higher energy move from one location to another carrying their energy with them.
- Heat transfer occurs when particles with higher energy move from warmer to cooler parts of the fluid.

- Uneven heating can result in convection, both in the air and in water. This causes currents in the atmosphere (wind) and in bodies of water on earth which are important factors in weather and climate.

Radiation

- Radiation is the transfer of energy through space without particles of matter colliding or moving to transfer the energy.
- This radiated energy warms an object when it is absorbed.
- Radiant heat energy moves from an area of higher temperature to an area of cooler temperature.

Extended Knowledge

Students may investigate the difference between areas of higher or lower density in fluids. Students may research how electromagnetic waves are transferred in radiation.

Science and Engineering Practices

S.1A.2

Standard 6.P.3:

The student will demonstrate an understanding of the properties of energy, the transfer and conservation of energy, and the relationship between energy and forces.

Conceptual Understanding 6.P.3A.

Energy manifests itself in multiple forms, such as mechanical (kinetic energy and potential energy), electrical, chemical, radiant (solar), and thermal energy. According to the principle of conservation of energy, energy cannot be created nor destroyed, but it can be transferred from one place to another and transformed between systems.

Performance Indicator 6.P.3A.6

Design and test devices that minimize or maximize heat transfer by conduction, convection, or radiation.

Assessment Guidance

The objective of this indicator *is to design and test devices* to determine the types of materials that minimize or maximize heat transfer by conduction, convection, or radiation. Therefore, the focus of this assessment should be for students *to plan and conduct controlled scientific investigations* related to heat transfer *to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form*. This could include but is not limited to students designing and testing materials that will prevent an object from losing heat as well materials that will allow an object to lose heat quickly. Students should be encouraged to find how such testing can impact their lives (for example, winter clothing compared to exercise clothing).

In addition to *designing and testing devices,* students should *ask questions; develop and use models, plan and carryout investigations, analyze and interpret data, use mathematical and computational thinking, construct explanations, engage in scientific arguments from evidence, and obtain, evaluate and communicate information.*

Previous and Future Knowledge

- H.P.3C: Heat Transfer, Thermal Conductivity, Conduction, Convection and Radiation

Essential Knowledge

Various individual materials and/or combinations of materials affect how quickly heat transfers by conduction, convection, or radiation.

- Conductors are materials that easily carry heat or electric current.
    - Glass and metals are good conductors of heat. When a metal pan is placed on a heat source, it will quickly get hot and conduct the heat to whatever is inside of the pot.
- Insulators are materials that are poor carriers of heat or electric current.
    - Wood and animal fat (blubber) are good insulators; they do not conduct heat very well. A polar bear swims in freezing water but the bear does not freeze to death like a human would. The bear's thick layer of fat insulates the bear and traps heat inside of the bear's body.

Various materials, including but not limited to, water, metal, glass, wood, plastic, air, and reflective and non-reflective substances, should be tested in order to determine how well each conducts heat by conduction, convection, and/or radiation.

Extended Knowledge

- If the device tested (see assessment guidance section) does not minimize or maximize heat transfer, then students could refine designs, propose and communicate successful designs.
- Students could extend their knowledge by designing a material that could minimize or maximize the amount of heat transferred through convection, conduction, or radiation.

Science and Engineering Practices

S.1B.1

Standard 6.P.3:

The student will demonstrate an understanding of the properties of energy, the transfer and conservation of energy, and the relationship between energy and forces.

Conceptual Understanding 6.P.3B.

Energy transfer occurs when two objects interact, thereby exerting force on each other. It is the property of an object or a system that enables it to do work (force moving an object over a distance). Machines are governed by this application of energy, work, and conservation of energy.

Performance Indicator 6.P.3B.1

Plan and conduct controlled scientific investigations to provide evidence for how the design of simple machines (including levers, pulleys, inclined planes) helps transfer mechanical energy by reducing the amount of force required to do work.

Assessment Guidance

The objective of this indicator is *to plan and conduct investigations* to determine how the design of simple machines (including levers, pulleys, inclined planes) helps transfer mechanical energy by reducing the amount of force required to do work. Therefore, the focus of this assessment should be for students to obtain experimentally derived data to illustrate and support claims that the design of simple machines reduces the amount of force required to do work without the simple machine and then with the simple machine. Students *should plan and conduct controlled scientific investigations* about simple machines *to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form.* This could include but is not limited to students planning and conducting a scientific investigation that will show how either a lever, pulley, or inclined plane reduces the amount of force needed to move an object from one place to another place.

In addition to *plan and conduct investigations*, students may be expected *to ask questions; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; and develop and use models; obtain, evaluate, and communicate information; and construct devices or design solutions*.

Previous and Future Knowledge

- 6.P.3A.1 Analyze and interpret data to describe the properties and compare sources of different forms of energy (including mechanical, electrical, chemical, radiant, and thermal).
- H.P.3A: Work, Work-Energy Theorem, Power, Elastic and Inelastic Collisions, Efficiency
- H.P.3B: Periodic Motion and Energy, Conservation of Energy, Gravitational Potential Energy.

Essential Knowledge

It is essential for students to:

- E*nergy* is a property that enables something to do work.
- Work occurs when a force is used to move an object.
- The following conditions must be met for *work* to be done:
    - apply a force to an object over a distance
    - the object moves in response to the force
- When work is done to an object and the object moves, the work is transformed into kinetic energy.
- If an object is lifted to some height, it gains gravitational potential energy equal to the work done against gravity in lifting the object.
    - The work done against gravity is the same whether the object was lifted straight up or rolled up a ramp.
    - The greater the height, the more gravitational potential energy the object has.

- Evidence of work can include, but is not limited to,:
    - When a toy car at rest is pushed, work is done on the car if the car moves.
    - When a fan is connected to an electric circuit, it moves, so work was done on the fan blades.
    - When an object is lifted, it moves, so work is done on the object.
- A *simple machine* is a device that reduces the amount of *effort force* needed to do work by increasing the distance that the force is applied.
- Simple machines can also change the direction of the effort force.

Lever

- A *lever* is a rigid bar or board that is free to move around a fixed point called a *fulcrum*.
- The fulcrum may be placed at different locations along the bar.
- A lever can be used to reduce the amount of force required to move a load in two ways:
    - increasing the distance from the fulcrum to the point where the effort force is applied
    - decreasing the distance the load is from the fulcrum
- By increasing the distance the effort force moves relative to the distance the load moves, a lever can reduce the effort force needed.

Pulley

- A *pulley* is a grooved wheel with a rope running along the groove.
- Pulleys can change the amount and/or the direction of the force applied (*effort force*).
- Movable pulleys are used to reduce the effort force needed to lift a load by increasing the distance of the effort force (length of rope pulled).
- A single fixed pulley changes only the direction of the force (you pull down and the load goes up).
- By combining movable and fixed pulleys, less effort force is needed to move a load. This allows for very heavy loads (like a piano) to be moved.

Inclined plane

- An *inclined plane* is a sloping surface (like a ramp) that reduces the amount of force required to move an object/load.
- An inclined plane can be designed to reduce the force needed to lift an object/load in two ways:
    - increase the length of the ramp
        - in this example, the same amount of work is done as the distance of the effort force is increased but the object/load still is moved to the same height
    - decrease the height of the ramp
        - in this example, less work is done because the object/load is not moved to the same height
- By increasing the distance the effort force moves (length of the ramp) relative to the distance the object/load is moved (height of the ramp); an inclined plane can reduce the effort force needed.

Extended Knowledge

- Students could investigate multiple pulley systems such as a block and tackle system.

Science and Engineering Practices

S.1A.3

Standard 6.P.3:
The student will demonstrate an understanding of the properties of energy, the transfer and conservation of energy, and the relationship between energy and forces.

Conceptual Understanding 6.P.3B.
Energy transfer occurs when two objects interact thereby exerting force on each other. It is the property of an object or a system that enables it to do work (force moving an object over a distance). Machines are governed by this application of energy, work, and conservation of energy.

Performance Indicator 6.P.3B.2
Design and test solutions that improve the efficiency of a machine by reducing the input energy (effort) and the amount of energy transferred to the surrounding environment as it moves an object.

Assessment Guidance
The objective of this indicator is to *design and test solutions* that will improve the efficiency of a machine. Therefore, the primary focus of assessment should be for *students to (1) ask questions to identify* ways to reduce the effort required to use the machine and ways to minimize the amount of energy transferred to the environment by the machine., *(2) ask questions about the criteria and constraints of the devices or solutions, (3) generate and communicate ideas for possible devices or solutions, (4) build and test devices or solutions, (5) determine if the devices or solutions solved the problem, and (6) communicate the results*. This could include but is not limited to students creating various forms of the same type of simple machine and determining how much effort force is required to move a load. By analyzing and interpreting this data, students should be able to determine which form of the simple machine is most efficient.

In addition to *designing solutions*, students should *ask questions; develop and use models; plan and carry out tests; analyze and interpret data; and obtain, evaluate, and communicate information.*

Previous and Future Knowledge
- 6.P.3B.1: Plan and conduct controlled scientific investigations to provide evidence for how the design of simple machines (including levers, pulleys, inclined planes) helps transfer mechanical energy by reducing the amount of force required to do work.
- H.P.3A: Work, Work-Energy Theorem, Power, Elastic and Inelastic Collisions, Efficiency
- H.P.3B: Periodic Motion and Energy, Conservation of Energy, Gravitational Potential Energy

Essential Knowledge
Levers
- Levers are made up of a rigid bar that moves around the fulcrum
- The shape and size of the fulcrum, as well as what it is made of, can change the efficiency of the lever.
- The shape and size of the rigid bar, as well as what it is made of, can change the efficiency of the lever.

Pulleys
- Pulleys are a grooved wheel with a rope running along the groove.
- The type of rope, or cable, that is used can change the efficiency of the pulley.

- The presence of a grooved wheel, and how well that wheel spins, can change the efficiency of the pulley.

Inclined planes

- An inclined plane is a sloping surface.
- The material an inclined plane is made from can change the efficiency of the inclined plane.
- The length of an inclined plane can change the efficiency of the inclined plane.
- Wedges are inclined planes that move; like a knife. How sharp a wedge is can change the efficiency of the wedge.

Mechanical efficiency measures how well a machine converts input energy, work, and power into output energy, work, and power.

The efficiency of an ideal machine is 100% because the input work equals the output work. However, real machines do not achieve an efficiency of 100% because heat may be lost from the system do to the friction between moving parts. An important way to improve the efficiency of a machine is to reduce friction. For example, a pulley with a rope running over a wheel is more efficient than a pulley where the rope only runs over a bar. The spinning wheel in the first example reduces friction and makes the machine more efficient.

Extended Knowledge

- Students can look at how the various simple machines that comprise complex machines work together to make a more efficient machine.
- Students may explore and research which classes of levers are in common tools or complex machines.
- Students may also investigate the difference in mechanical advantage within each class of simple machines (ex. pulley, double pulley, etc.).
- Students could research and apply the formula for calculating mechanical advantage.

Science and Engineering Practices

S.1B.1

Standard

6.L.4: The student will demonstrate an understanding of how scientists classify organisms and how the structures, processes, behaviors, and adaptations of animals allow them to survive.

Conceptual Understanding

6.L.4A. Conceptual Understanding: Life is the quality that differentiates living things (organisms) from nonliving objects or those that were once living. All organisms are made up of cells, need food and water, a way to dispose of waste, and an environment in which they can live. Because of the diversity of life on Earth, scientists have developed a way to organize groups of organisms according to their characteristic traits, making it easier to identify and study them.

Performance Indicator

6.L.4A.1 Obtain and communicate information to support claims that living organisms (1) obtain and use resources for energy, (2) respond to stimuli, (3) reproduce, and (4) grow and develop.

Assessment Guidance
The objective of this indicator is to *obtain and communicate information* to support claims that living organisms (1) obtain and use resources for energy, (2) respond to stimuli, (3) reproduce, and (4) grow and develop. Therefore, the primary focus of assessment should be for students to *obtain and communicate information* (from investigations and primary and secondary sources) that supports claims that living things have special characteristics and processes that are not present in non-living things. This could include but is not limited to students conducting a controlled investigation to obtain data from charting plant growth, observing the environmental preference of earthworm or snails (wet vs. dry soil, well-lit area vs. dark area, etc.), or evaluating how yeast, in warm water, respond to various amounts of sugar.

In addition to *obtaining, evaluating, and communicating information* students should *ask questions, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, engage in argument from evidence, construct explanations, develop and use models, and construct devices or design solutions.*

Previous and Future Knowledge
- 4.L.5B.3 Adaptations of animals (methods for defense, locomotion, obtaining resources, or camouflage)

Essential Knowledge
It is essential for students to know the characteristics that separate living organisms from nonliving things. All living organisms share the following characteristics:
They obtain and use resources for energy
- All organisms must obtain resources, such as food, oxygen, and water, which provide required energy to perform the basic processes of life, such as growing and developing, or repairing injured parts.
- Autotrophs (for example plants) provide their own food for energy through the process of photosynthesis, while heterotrophs (for example animals) must find an external source for food.
- Energy is released from food in most organisms through the process of respiration.

They respond to stimuli
- A stimulus is any change in an organism's surroundings that will cause the organism to react.
- Examples of environmental stimuli may be changes in the following: amount of light, temperature, sound, amount of water, space, amounts or types of food, or other organisms present.
- The reaction to the stimulus is called a response. It can be an action or behavior performed by the organism.

They reproduce
- Organisms have the ability to reproduce, or produce offspring that have similar characteristics as the parent(s). There are two basic types of reproduction:
    - Asexual reproduction - a process that involves only one parent and produces offspring that is identical to the parent.
    - Sexual reproduction - a process that involves two parents. The egg (female reproductive cell) and sperm (male reproductive cell) from these two parents combine to make an offspring that has characteristics of both parents.

They grow and develop
- Growth is the process whereby the organism becomes larger (has an increase in height, mass, and/or overall size).
- Development is the process that occurs in the life of the organism that results in the organism becoming more complex structurally.
- Organisms require energy to grow and develop.

Extended Knowledge
The students can obtain and communicate information about cellular activities that support claims that cells are part of an organism's growth and development process.

Science and Engineering Practices
S.1A.8

Standard
6.L.4: The student will demonstrate an understanding of how scientists classify organisms and how the structures, processes, behaviors, and adaptations of animals allow them to survive.

Conceptual Understanding
6.L.4A. Conceptual Understanding: Life is the quality that differentiates living things (organisms) from nonliving objects or those that were once living. All organisms are made up of cells, need food and water, a way to dispose of waste, and an environment in which they can live. Because of the diversity of life on Earth, scientists have developed a way to organize groups of organisms according to their characteristic traits, making it easier to identify and study them.

Performance Indicator
6.L.4A.2 Develop and use models to classify organisms based on the current hierarchical taxonomic structure (including the kingdoms of protists, plants, fungi, and animals).

Assessment Guidance
The objective of this indicator is to *develop and use models* to classify organisms based on the current hierarchical taxonomic structure (including the kingdoms of protists, plants, fungi, and animals). Therefore, the primary focus of assessment should be for students to *develop and use models* that represent how biologists have devised ways of naming and classifying organisms based on similar structures. This could include but is not limited to students constructing models of a species' taxonomic structure. Students should be able to use a model of the kingdoms to identify the key characteristics of an organism.

In addition to *develop and use models*, students should *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; obtain, evaluate, and communicate information;* and *construct devices or define solutions*

Previous and Future Knowledge
- 5.L.4A.2 Ecosystems, organisms (population and communities)
- 7.L.3A.2 Cells (bacteria, protists, plant and animal)

Essential Knowledge
It is essential for students to know that through studying all of the organisms on Earth, biologists have devised ways of naming and classifying them according to similarities in their structures.
- The study of how scientists classify organisms is known as taxonomy.
- The modern classification system uses a series of levels to group organisms.
- An organism is placed into a broad group and is then placed into more specific groups based on its structures.
- The levels of classification, from broadest to most specific, include: kingdom, phylum, class, order, family, genus, and species.
- The more classification levels an organism shares with another, the more characteristics they have in

common.

Kingdom

- While scientists currently disagree as to how many kingdoms there are, many support a five kingdom (Plants, Animals, Fungi, Protists, Monerans) system.
- Organisms are placed into kingdoms based on their ability to make food and the number of cells in their body.

Phylum (pl. phyla)

- The first major division for each kingdom
- In the Plant Kingdom, phyla are sometimes referred to as divisions.
- Plants are normally divided into two groups: vascular and nonvascular.
- In the Animal Kingdom, there are 35 different phyla. These phyla can be divided into two groups: vertebrates and invertebrates.

Class, Order, Family

- These levels become even more specific and will include fewer organisms that have more in common with each other as they move down the levels.

Genus (pl. Genera)

- Contains closely related organisms.
- The genus is used as the first word in an organism's scientific name.

Species

- Consists of all the organisms of the same type which are able to breed and produce young of the same kind.
- The species is used as the second word in an organism's scientific name.

Scientific name

- The scientific name of an organism is made up of its genus and species.
- It is written in italics (Genus species) with the genus capitalized.
- For example, *Canis lupus* is the scientific name for the wolf and *Pinus taeda* is the scientific name for a loblolly pine.

Extended Knowledge

To extend the student's knowledge, students may develop and use Kingdom models to determine the characteristics associated with each Kingdom:

Protists:

- Protists are mostly single celled organisms (unicellular) but some protists are multicellular.
- Protists cells are eukaryotic (have nuclei).
- Some protists are animal-like (heterotrophs - need to eat other organisms) and some are plant-like (autotrophs - use sunlight to produce food).

Plants:

- All plants are made of many eukaryotic cells.
- Plants are autotrophs - they use sunlight to make their food

Fungi:

- Almost all fungi are multicellular organisms.
- Fungi cells have nuclei (eukaryotic).
- Fungi do not move to get food, but they do need to absorb nutrients from other organisms (either living or dead).

Animals

- Animals are multi-cellular organisms.
- Animal cells have nuclei (eukaryotic).
- Almost all animals move to get food. Animals are heterotrophs - they eat other organisms to get energy

Science and Engineering Practices
S.1A.2

Standard
6.L.4: The student will demonstrate an understanding of how scientists classify organisms and how the structures, processes, behaviors, and adaptations of animals allow them to survive.

Conceptual Understanding
6.L.4B. Conceptual Understanding: The Animal Kingdom includes a diversity of organisms that have many characteristics in common. Classification of animals is based on structures that function in growth, reproduction, and survival. Animals have both structural and behavioral adaptations that increase the chances of reproduction and survival in changing environments.

Performance Indicator
6.L.4B.1 Analyze and interpret data related to the diversity of animals to support claims that all animals (vertebrates and invertebrates) share common characteristics.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to support claims that all animals (vertebrates and invertebrates) share common characteristics. Therefore, the primary focus of assessment should be for students use primary and secondary sources *to (1) reveal patterns and construct meaning or (2) support hypotheses, explanations, claims, or designs* that all animals share common characteristics despite their diversity. This could include, but is not limited to, students analyzing data about animals and grouping them according to similarities. Based on the patterns this reveals, students should be able to determine the key characteristics of all animals including vertebrates and invertebrates.

In addition to *analyzing and interpreting* data, students should *ask questions, plan and carry out investigations, use mathematics and computational thinking, engage in argument from evidence, construct explanations, develop and use models, obtain, evaluate, and communicate information, and construct devices or design solutions.*

Previous and Future Knowledge
- 4.L.5A.1 Physical characteristics of plants (flowering and non-flowering) and animals (vertebrates and invertebrates)
- 4.L.5A.3 Life cycle of animals, metamorphosis

Essential Knowledge
It is essential for students to know that the Animal Kingdom is divided into 35 different phyla.
- These phyla can be classified into two groups (vertebrates or invertebrates) based on external and internal physical characteristics.
- However, all animals share several common characteristics:
    - They are multi-cellular.
    - They are heterotrophs (cannot make their own food) and must get their energy by consuming plants or other animals.
    - Their major functions are to obtain food and oxygen for energy, maintain their internal conditions (ex. body temperature), move, and reproduce.

Only one phylum of animals is comprised of vertebrates which includes fish, amphibians, reptiles, birds, and mammals. Vertebrates share certain physical characteristics:

- Have a backbone, an internal skeleton (endoskeleton), and muscles attached to their bones.
- Have blood that circulates through blood vessels and lungs or gills for the exchanging of gases (oxygen and carbon dioxide).
- Have a protective skin covering.
- Have legs, wings, or fins for movement.
- Have a nervous system with a brain that processes information from their environment through sensory organs.

Vertebrates differ from each other in the way that they control their body temperature.

- Some vertebrates (fishes, amphibians, and reptiles) are ectothermic (cold-blooded).Their body temperature changes in response to temperature changes in their environment.. Other vertebrates (birds and mammals) are endothermic (warm-blooded). Their body temperature remains constant regardless of the temperature of the environment.

Examples of vertebrates include:

Fish

- Are ectothermic, obtain dissolved oxygen in water through gills, most lay eggs, have scales, have fins, and live in water.

Amphibians

- Are ectothermic, most can breathe in water with gills as young, go through metamorphosis and breathe on land with lungs as adults, and lay jelly-like eggs.
- Major groups include amphibians are frogs, toads, and salamanders.
- Frogs and salamanders have smooth, moist skin, through which they can breathe and live part of their life in water and part on land.
- Toads have thicker, bumpy skin and live on land.

Reptiles

- Are ectothermic, breathe with lungs, most lay eggs, although in some the eggs hatch inside the female, and have scales or plates.

Birds

- Are endothermic, breathe with lungs, lay eggs, have feathers, and have a beak, two wings, and two feet.

Mammals

- Are endothermic, breathe with lungs, most have babies that are born live, have fur or hair; and produce milk to feed their young.

Invertebrates comprise the remaining phyla of the Animal Kingdom. They include sponges, segmented worms, echinoderms, mollusks, and arthropods. Invertebrates share certain characteristics:

- Do not have backbones or internal skeletons.
- Some have external skeletons, called exoskeletons.

Examples of invertebrates include:

Sponges

- Very simple animals that have many pores (holes) through which water flows.
- Water moves into a central cavity and out through a hole in the top.
- Sponges obtain their food and eliminate wastes through this passage of water.
- They have specialized cells for obtaining food and oxygen from the water.

Segmented worms

- Have long tube-like bodies that are divided into segments.
- Simplest organisms with a true nervous system and blood contained in vessels.
- A long digestive tube runs down the length of the worm's inner body.
- Take in dissolved oxygen from the water through their skin.
- Examples of segmented worms may be earthworms and leeches.

Echinoderms
- Have arms that extend from the middle body outwards.
- Have tube feet that take in oxygen from the water and spines.
- Examples may be sea stars, brittle stars, sea cucumbers, or sea urchins.

Mollusks
- Have soft bodies; most have a thick muscular foot for movement or to open and close their shells.
- Have more developed body systems than sponges or worms.
- Take in oxygen through gills or lungs, and some have shells.
- Examples may be slugs, snails, clams, and octopuses.

Arthropods
- Have jointed legs, segmented bodies, and some have wings.
- Have hard outer coverings called exoskeletons.
- Obtain oxygen from the air through gills or air tubes.
- Examples may be insects, arachnids, and crustaceans.

Extended Knowledge
- Students should be able to explain how the different characteristics of the vertebrate groups allowed them to adapt to new environments.
- Students can research different animal phyla and describe the characteristics that make that phylum unique.

Science and Engineering Practices
S.1A.4

Standard
6.L.4: The student will demonstrate an understanding of how scientists classify organisms and how the structures, processes, behaviors, and adaptations of animals allow them to survive.

Conceptual Understanding
6.L.4B. Conceptual Understanding: The Animal Kingdom includes a diversity of organisms that have many characteristics in common. Classification of animals is based on structures that function in growth, reproduction, and survival. Animals have both structural and behavioral adaptations that increase the chances of reproduction and survival in changing environments.

Performance Indicator
6.L.4B.2 Obtain and communicate information to explain how the structural adaptations and processes of animals allow for defense, movement, or resource obtainment.

Assessment Guidance
The objective of this indicator is to *obtain and communicate information* to explain how the structural adaptations and processes of animals allow for defense, movement, or resource obtainment. Therefore, the primary focus of assessment should be for students to *obtain and communicate scientific information (from investigations and primary and secondary sources) to explain* how the special structures that animals have enable them to survive in their environment. This could include, but is not limited to, students *obtaining, evaluating, and communicating information* about specific animals and how they can use their various parts of their bodies for defense, movement, and/or resource obtainment. Students can also create an animal of their own design and describe how each body part can be used for defense, movement, and/or resource obtainment.

In addition to *construct explanations*, students should *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information; develop and use models;* and *construct devices or design solutions.*

Previous/Future Knowledge

- 4.L.5B.3 Adaptations of animals (methods for defense, locomotion, obtaining resources, or camouflage)
- 7.E.5 The student will demonstrate an understanding of how organisms interact with and respond to the biotic and abiotic components of their environments.
- H.B.6 The student will demonstrate an understanding that ecosystems are complex, interactive systems that include both biological communities and physical components of the environment.

Essential Knowledge

It is essential for students to know that animals have special structures that enable them to survive in their environment. These structures allow them to defend themselves, to move, and to obtain resources.

Structures for defense

- Allow an animal to hide from a predator or warn a predator (Examples: camouflage or mimicry (copying the appearance, actions, or sounds of another animal)
- Allow an animal to make a direct, attack painful (Examples: horns, claws, quills, stingers, or venom)
- Allow an animal to prevent a direct attack (Examples: Mechanisms such as having shells, emitting smells or body fluids (ink)
- Allow an animal to change its size (Examples: puffing up fur, inflating body)
- Allow an animal to flee or hide from predators (Examples: Body design that allows for speed or jumping or wings and light-weight skeletons for flying.)Allow an animal to construct holes or tunnels to run into and hide or to climb (Example: paws, toenails or teeth)

Structures for movement

- Allow animals to move to fulfill their needs such as finding food and escaping predators (Examples: legs, feet, arms, tails, fins, wings, , skeleton)

Structures to obtain resources

- Allow an animal to chew, tear, and eat its food or drink (Examples: mouthparts including beaks, teeth, flexible jaws, tongues, shape of the mouth)
- Allow an animal to grab and hold its food (Examples: tentacles, pincers, claws, fangs)
- Allow an animal to consume food found in the water (Examples: filtering structures in sponges, clams and baleen whales used for feeding)

Extended Knowledge

- Students can obtain and communicate information that will explain which structures organisms have to obtain resources.
- Students can predict what environment an animal lives in based on physical structures and it's role (niche) in the ecosystem (i.e. a(n) carnivore, herbivore, or an omnivore).

Science and Engineering Practices

S.1A.8

Standard

6.L.4: The student will demonstrate an understanding of how scientists classify organisms and how the structures, processes, behaviors, and adaptations of animals allow them to survive.

Conceptual Understanding
6.L.4B. Conceptual Understanding: The Animal Kingdom includes a diversity of organisms that have many characteristics in common. Classification of animals is based on structures that function in growth, reproduction, and survival. Animals have both structural and behavioral adaptations that increase the chances of reproduction and survival in changing environments.

Performance Indicator
6.L.4B.3 Construct explanations of how animal responses (including hibernation, migration, grouping, and courtship) to environmental stimuli allow them to survive and reproduce.

Assessment Guidance
The objective of this indicator is to *construct explanations* of how animal responses to environmental stimuli allow them to survive and reproduce. Therefore, the primary focus of assessment should be for students to *construct explanations from primary or secondary sources, predictions based on observations and measurements, and data communicated in graphs, tables, or diagrams* that the ways animals respond to their environment enables them to survive and reproduce. This could include but is not limited to students *obtaining and evaluating* weather data and communicating predictions based upon this evidence of how animals will respond to the changes in the seasons. Students can also *analyze collected data*, from graphs or data tables, and use this evidence to predict whether the animals will respond by hibernating, reproducing, and/or migrating.

In addition to *construct explanations*, students should *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information; develop and use models;* and *construct devices or design solutions.*

Previous and Future Knowledge
- 4.L.5A.3 Life cycle of animals, metamorphosis
- 4.L.5B.1 Sensory organs, senses
- 4.L.5B.3 Adaptations of animals (methods for defense, locomotion, obtaining resources, or camouflage)
- 7.E.5 The student will demonstrate an understanding of how organisms interact with and respond to the biotic and abiotic components of their environments.

Essential Knowledge
It is essential for students to know that a complex set of responses to stimuli is called behavior. Behavioral responses refer to how animals cope with changes in their environments. Animals may respond to environmental stimuli through behaviors that include hibernation, migration, defense, and courtship.
Hibernation
- As a result of cold, winter weather (stimulus) some animals will hibernate.
- Hibernation is a state of greatly reduced body activity, used to conserve food stored in the body.
- Some animals hibernate for part or all of the winter.
- The animal's body temperature drops, its heartbeat and breathing slow down, and it uses very little energy.
- Examples of hibernating animals may be ants, snakes, black bears, beavers, and ground squirrels.

Migration
- Migration is the movement of animals from one place to another in response to seasonal changes. They travel to other places where food is available.
- Migrating animals usually use the same routes year after year.
- The cycle is controlled by changes in the amount of daylight and the weather.
- Examples of animals that migrate are monarch butterflies, orcas, caribou, ducks and salmon

Defense

- Defense mechanisms vary with different types of animals. Some examples are:
  Camouflage: Some animals have protective coloration to survive changes in its environment. Some animals develop their camouflage in response to the weather. For example, the arctic fox and snowshoe hare develop a white coat for the winter to blend in with the snow and a gray coat in the summer to blend in with the forest. Chameleons and other lizards change colors to blend into the environment to avoid predators.
  Smells: Skunks use an offensive odor in response to fear. The skunk turns the predator's sense of smell against it by issuing a stream of oily, foul smelling musk.
  Stingers: Wasps and bees use a stinger for protection when frightened or threatened.
  Ejection: The black ink cloud of an octopus is a defense mechanism because it gives the animal a chance to escape from a predator. When the horned lizard gets really scared, it shoots blood out of its eyes allowing it time to escape.
  Mimicry: When a weaker animal copies stronger animals' characteristics to warn off predators. Some animals may look like another more poisonous or dangerous animal that give it protection, such as a "false" coral snake or hawk moth caterpillar that looks like a snake. Certain moths have markings that look like eyes and some flower flies resemble black and yellow wasps that have a powerful sting and use this disguise to ward off predators.
  Grouping: This social behavior occurs when certain animals travel together in groups to protect individuals within the group or to fool a predator into thinking the group is one large organism. Examples may include herds (buffalo, zebra, cattle), packs (wolves), or schools of fish.

Courtship

- Courtship in animals is usually a behavioral process whereby adults of a species try to attract a potential mate.
- Courtship behaviors ensure that males and females of the same species recognize each other.
- Environmental stimuli, such as seasonal changes, will stimulate courtship.
- Often sensory cues such as chemical odor cues, sounds, or color will serve as courtship attractants in animals.

Extended Knowledge

- The student should be able to obtain and communicate information that describes why a specific animal's defense is particularly effective at discouraging the types of predators that animal encounters in its environment.
- The student may also construct explanations that show how courtship behaviors can increase the chances an animal gets eaten by a predator.

Science and Engineering Practices

S.1A.6

Standard

6.L.4: The student will demonstrate an understanding of how scientists classify organisms and how the structures, processes, behaviors, and adaptations of animals allow them to survive.

Conceptual Understanding

6.L.4B. Conceptual Understanding: The Animal Kingdom includes a diversity of organisms that have many characteristics in common. Classification of animals is based on structures that function in growth, reproduction, and survival. Animals have both structural and behavioral adaptations that increase the chances of reproduction and survival in changing environments.

Performance Indicator
6.L.4B.4 Obtain and communicate information to compare and classify innate and learned behaviors in animals.

Assessment Guidance
The objective of this indicator is to *obtain and communicate information* to compare and classify innate and learned behaviors in animals. Therefore, the primary focus of assessment should be for students to *obtain and communicate* (from investigations and primary and secondary sources) information that supports the claim that animal behaviors can be learned or inherited. This could include but is not limited to students observing an animal's behavior and *arguing from evidence* whether the behavior is innate or learned. Students can also use primary and secondary resources to *construct explanations* to explain why behaviors that are innate in some animals are learned in others (for example, the ability to swim is an innate behavior for animals that are born in water but it is a learned behavior in land animals).

In addition to *obtain information*, students should *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models*; and *construct devices or define solutions.*

Previous and Future Knowledge
- 4.L.5A.4 Inheritance and environmental factors, traits
- 7.E.5 The student will demonstrate an understanding of how organisms interact with and respond to the biotic and abiotic components of their environments.

Essential Knowledge
It is essential for students to know that a behavior is an activity or action, in response to changes in the environment, which helps an organism survive. *Learned behaviors* result from direct observations or experiences.
- *Imprinting* is a behavior in which newborn animals recognize and follow the first moving object they see. Usually, this moving object is the mother. *Conditioni*ng (which includes trial-and-error learning) is a behavior in which an animal learns that a particular stimulus and its response to that stimulus will lead to a good or bad result. For example, chimpanzees learn to use small sticks to dig in the soil for insects, or a child learns that touching a hot object will cause pain.

Inherited behaviors are passed from the parent to offspring and are with the animal from birth. These are also called *instincts*.
- The ability to swim is an inherited behavior for whales and fish.
- Crying in human babies is an inherited behavior that is often a response to hunger, thirst, or sleepiness.
- When a snail digs a hole to lay its eggs, a bird builds a special kind of nest, or when a fiddler crab waves its claw to attract a female, the animals are acting on instinct.

Extended Knowledge
- The students can obtain information about animal behaviors and engage in scientific argumentation from evidence about whether the behavior is inherited or learned and, if it is learned, by what means the animals learns the behavior.
- Students should be able to construct explanations as to why some animals have many inherited behaviors while others have many learned behaviors.

Science and Engineering Practices
S.1A.8

Standard
6.L.4: The student will demonstrate an understanding of how scientists classify organisms and how the structures, processes, behaviors, and adaptations of animals allow them to survive.

Conceptual Understanding
6.L.4B. Conceptual Understanding: The Animal Kingdom includes a diversity of organisms that have many characteristics in common. Classification of animals is based on structures that function in growth, reproduction, and survival. Animals have both structural and behavioral adaptations that increase the chances of reproduction and survival in changing environments.

Performance Indicator
6.L.4B.5 Analyze and interpret data to compare how endothermic and ectothermic animals respond to changes in environmental temperature.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to compare how endothermic and ectothermic animals respond to changes in environmental temperature. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts, observations, measurements, or investigations using a range of methods (such as tabulation, graphing, or statistical analysis)* that explain how the different characteristics of endothermic and exothermic animals allow each group of animals to survive temperature changes in their environments. This could include but is not limited to students collecting data regarding the change in activity rate of ectothermic animals in environments of different temperatures; for example, students could observe the breathing rates of goldfish at different temperatures. Students could also explore how endothermic animals maintain their body temperatures in a variety of environments. For example, students could collect quantitative data of how a variety of substances, including lard (animal fat), insulate a thermometer submerged in cold water; they should use this data to construct an explanation of how some animals, like seals, survive in very cold water.

In addition to *analyze and interpret data*, students should *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information;* and *construct devices or define solutions.*

Previous/Future Knowledge
- 4.L.5B.1 Sensory organs, senses
- 4.L.5B.3 Adaptations of animals (methods for defense, locomotion, obtaining resources, or camouflage)
- 7.E.5 The student will demonstrate an understanding of how organisms interact with and respond to the biotic and abiotic components of their environments.

Essential Knowledge
It is essential for students to know the characteristics of endothermic and ectothermic animals and how these animals respond to changes in their environmental temperatures. Animals that are vertebrates differ in their abilities to regulate body temperature.
Endothermic (warm-blooded)
- Animals, including birds and mammals, maintain a nearly constant internal temperature and do not change with the temperature of the environment.
- When the outside temperature is too hot, an endothermic animal can cool off by sweating, panting, changing position, or changing location. Sweating and panting generate heat loss through evaporating water. Changing position and location allow the animal to find a cooler environment in the shade or

shelter.
- When the outside temperature is too cold, an endothermic animal can generate heat by shivering.
- Endothermic animals must eat much more often than ectothermic animals since it takes energy to maintain a constant body temperature. For example, a lion must eat its weight in food every seven to ten days.

Ectothermic (cold-blooded)
- Animals, including fish, amphibians, and reptiles, which have an internal body temperature that changes with the temperature of the environment.
- They must gain heat to perform internal activities such as digestion).
- If the environment is cold, ectothermic animals become slow moving and sluggish. Some animals must bask in the Sun (for example snakes or lizards) or move to a warmer area (for example some fish) before they can move about to hunt for food.
- If the temperature gets too hot, ectothermic animals will need to find a cooler temperature or burrow in the ground to keep its body cool.
- Ectothermic animals take on the temperature of their surroundings and don't use food energy to keep warm. Therefore, they don't have to eat as often as an endothermic animal.

Extended Knowledge
The students can engage in scientific argument from evidence regarding the merits of being an ectotherm and of being an endotherm. The student should be able to obtain and communicate evidence to support the position they take.

Science and Engineering Practices
S.1A.4

Standard
6.L.5: The student will demonstrate an understanding of the structures, processes, and responses that allow protists, fungi, and plants to survive and reproduce.

Conceptual Understanding
6.L.5A. Conceptual Understanding: The Protist Kingdom is one of the most diverse groups and includes organisms that have characteristics similar to but are not classified as plants, animals, or fungi. These microorganisms live in moist environments and vary in how they obtain energy and move. The Fungi Kingdom consists of organisms that do not make their own food (heterotrophs) but obtain their nutrition through external absorption. Fungi can be grouped by their growth habit or fruiting structure and respond to changes in the environmental stimuli similar to plants.

Performance Indicator
6.L.5A.1 Analyze and interpret data from observations to compare how the structures of protists (including euglena, paramecium, and amoeba) and fungi allow them to obtain energy and explore their environment.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* from observations to compare how the structures of protists (including euglena, paramecium, and amoeba) and fungi allow them to obtain energy and explore their environment. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts, observations, measurements, or investigations* that supports the claim that protists and fungi have specialized structures that allow them to obtain energy and explore their environment. This could include, but is not limited to, students observing videos of protists and constructing 2-D models to

explain how the specialized structures of protists that allow for movement and obtaining energy. Students can also analyze informational text and use that as evidence to argue whether a sample fungus is aprophytic, parasitic, or symbiotic. These fungal examples can be diagrams, images, or live specimens.

In addition to *analyze and interpret data*, students should *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information;* and *construct devices or define solutions.*

Previous/Future Knowledge

- 7.L.3 The student will demonstrate an understanding of how the levels of organization within organisms support the essential functions of life.
- H.B. 2 The Student will demonstrate the understanding that the essential functions of life take place in cells or systems of cells.

Essential Knowledge

It is essential that the student be able to distinguish between specialized structures that allow protists and fungi to obtain energy and explore their environment.

Protists

Protists are organisms that are classified into the Kingdom Protista. Although there is a lot of variety within the protists, they do share some common characteristics.

- Protists are usually single celled organisms.
- Live in moist environments.
- Vary in the ways they move and obtain energy.

Protists obtain their energy in several ways.

- Animal-like protists ingest or absorb food after capturing or trapping it.
- Plant-like protists produce food through photosynthesis.
- Fungus-like protists obtain their food by external digestion either as decomposers or as parasites.
- Some protists have both autotrophic and heterotrophic characteristics.

Protists have three main ways to move (locomotion) :

- *Flagellum* (flagella) - a long whip-like tail used to move and/or catch food. An example of a flagellated protist is the Euglena.
- *Cilia* - small hair-like projections on the surface (cell membrane) of the cell used to sweep food into mouth-like structures and/or beat them in rhythm to move. An example of a ciliated protist is a paramecium.
- *Pseudopod* – (false foot) a finger-like projection of the cell membrane and cytoplasm used to catch food and/or movement. An example of a protist with pseudopod is the amoeba.

Fungi

Fungi are classified into the Kingdom Fungi. This includes microorganisms such as yeast and molds as well as multicellular organisms such as mushrooms.

There are three main ways Fungi obtain energy

- *Saprophytic* - Fungi that get their energy from decaying organic matter.
- *Parasitic* - Fungi that feed on other living organisms (host) and harm the host.
- *Symbiotic* - Fungi that feed on other living organisms (host) but do not harm the host. In many cases the host benefits from the fungi.

In most cases, fungi are not mobile organisms.

Fungi can be categorized based on their fruiting structures (structures for reproduction and spore dispersal).

Extended Knowledge

- There are many other examples of protists that use the various methods mentioned above to move or obtain energy. Euglena, paramecium, and amoeba are only a small sample.
- In order to observe the movement and structure of protists, students could be introduced to basic microscopy and observe the organisms first-hand.
- Other cells outside of Protista that have flagellum (many bacteria or sperm cells), cilia (cells in the trachea), and pseudopods (white blood cells).
- Fungi are a very diverse group of organisms. Students may develop and use models that show the methods of fungal reproduction and spore dispersal.

Science and Engineering Practices
S.1A.4

Standard
6.L.5: The student will demonstrate an understanding of the structures, processes, and responses that allow protists, fungi, and plants to survive and reproduce.

Conceptual Understanding
6.L.5A. Conceptual Understanding: The Protist Kingdom is one of the most diverse groups and includes organisms that have characteristics similar to but are not classified as plants, animals, or fungi. These microorganisms live in moist environments and vary in how they obtain energy and move. The Fungi Kingdom consists of organisms that do not make their own food (heterotrophs) but obtain their nutrition through external absorption. Fungi can be grouped by their growth habit or fruiting structure and respond to changes in the environmental stimuli similar to plants.

Performance Indicator
6.L.5A.2 Analyze and interpret data to describe how fungi respond to external stimuli (including temperature, light, touch, water, and gravity).

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to describe how fungi respond to external stimuli. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts, observations, measurements, or investigations* that supports claims that fungi are able to respond to stimuli from their environment. This could include but is not limited to students analyzing informational text and using that as evidence to argue whether a sample fungus has grown in response to light (phototropism) or away from gravity (gravitropism). These fungal examples can be diagrams, images, or live examples. Students can also use a variety of resources to explain how the hyphae, although not easily observed, are present and how the mycelium is helping the fungus to survive.

In addition to *analyze and interpret data*, students should *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information;* and *construct devices or define solutions.*

Previous/Future Knowledge

- 5.L.4B.1 Producers, consumers (herbivores, carnivores, omnivores), decomposers

Essential Knowledge
It is essential that students understand that fungi are able to respond to information from their environment to ensure survival of the organism. Fungi, like plants, respond to stimuli from the environment.

- In early development, many species will grow in response to light (*phototropism*) or away from gravity (*gravitropism*). However, as the fungal species mature, they tend to display negative gravitropism.

Because fungi lack a root system, they use *hyphae*.

- Hyphae are long fibrous strands that allow the fungus to obtain water and nutrients.
- Hyphal growth is greatly influenced by stimuli and will grow toward a food source, water, or even toward reproductive units of other fungi.
- Collectively, a mass of hyphae are referred to as a *mycelium*.

Extended Knowledge

- Students can explore how tropisms in fungi and plants are similar and obtain, evaluate, and communicate information regarding how these two different kingdoms have similarities in early development and growth.
- Students may also develop and use models to explain how various types of fungi reproduce.

Science and Engineering Practices
S.1A.4

Standard
6.L.5: The student will demonstrate an understanding of the structures, processes, and responses that allow protists, fungi, and plants to survive and reproduce.

Conceptual Understanding
6.L.5B. Conceptual Understanding: The Plant Kingdom consists of organisms that primarily make their own food (autotrophs) and are commonly classified based on internal structures that function in the transport of food and water. Plants have structural and behavioral adaptations that increase the chances of reproduction and survival in changing environments.

Performance Indicator
6.L.5B.1 Construct explanations of how the internal structures of vascular and nonvascular plants transport food and water.

Assessment Guidance
The objective of this indicator is to *construct explanations* related to how the internal structures of vascular and nonvascular plants transport food and water. Therefore, the primary focus of assessment should be for students to *construct explanations* regarding how the internal structures of nonvascular and vascular plants enable plants to transport food and water. This could include but is not limited to students developing models to describe how xylem and phloem move water, nutrients, sugars, and other key compounds throughout the body of the vascular plant and compare these structures to the way nonvascular plants pass food and water from cell to cell.

In addition to *construct explanations*, students should *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information; develop and use models;* and *construct devices or design solutions.*

Previous/Future Knowledge

- 4.L.5A.1 Physical characteristics of plants (flowering and non-flowering) and animals (vertebrates and

invertebrates)
- (4.L.5B.2 Structural adaptations of plants (roots, stems, leaves, flowers, fruit, seeds)

Essential Knowledge
It is essential that students be familiar with internal structures of nonvascular and vascular plants and how those structures transport food and water within the plant.
Plants are classified into two major groups based on their internal structures. These two groups are vascular and nonvascular.
Vascular Plants
- Largest group in the Plant Kingdom.
- Have a well-developed system for transporting water and food; therefore, they have true roots, stems, and leaves.
- Have tube-like structures that provide support and help circulate water and food throughout the plant.
- *Xylem* transport water and minerals from the roots to the rest of the plant.
- *Phloem* transport food from the leaves to the rest of the plant.
- Examples include trees and many shrubs with woody stems that grow very tall and grasses, dandelions, and tomato plants with soft stems.

Nonvascular Plants
- Do not have a well-developed system for transporting water and food; therefore, do not have true roots, stems, or leaves.
- Must obtain nutrients directly from the environment and distribute it from cell to cell throughout the plant. As a result, these plants are small in size and grow close to the ground
- Examples include mosses, liverworts, and hornworts.

Extended Knowledge
Students can develop and use models to describe how essential processes (movement of water and food) can be different in vascular and non-vascular plants.
Non-vascular
- Water movement by osmosis
- Solutes move by diffusion
- Plants not very large, all parts must be near their water source

Vascular
- Plants can be 300' tall and parts can be distant from water source
- Basic structure of the xylem and phloem
- Adhesion/cohesion of water in the xylem tissue
- Transpiration from leaves as the driving force for water going up
- Diffusion of water from environment to roots
- Vascular tissue provides stiffness and allows some plants such as sequoias to grow to great heights

Science and Engineering Practices
S.1A.6

Standard
6.L.5: The student will demonstrate an understanding of the structures, processes, and responses that allow protists, fungi, and plants to survive and reproduce.

Conceptual Understanding
6.L.5B. Conceptual Understanding: The Plant Kingdom consists of organisms that primarily make their own food (autotrophs) and are commonly classified based on internal structures that function in the transport of food and water. Plants have structural and behavioral adaptations that increase the chances of reproduction and survival in changing environments.

Performance Indicator
6.L.5B.2 Analyze and interpret data to explain how the processes of photosynthesis, respiration, and transpiration work together to meet the needs of plants.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to explain how the processes of photosynthesis, respiration, and transpiration work together to meet the needs of plants. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts, observations, measurements, and investigations to support claims* that photosynthesis, transpiration, and respiration are processes that are necessary for plants to survive. This could include but is not limited to students using data from informational texts to describe how photosynthesis and respiration are inverse processes that help to ensure survival of the plant. Students can also conduct experiments in order to collect data that shows that photosynthesis or respiration are occurring (increasing amounts of carbon dioxide for photosynthesis or the presence of water for transpiration). Students to should use this data to show how these processes are helping the plant to survive.

In addition to *analyze and interpret data*, students should *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information;* and *construct devices or define solutions.*

Previous/Future Knowledge
- 4.L.5A.1 Physical characteristics of plants (flowering and non-flowering) and animals (vertebrates and invertebrates)
- 4.L.5B.2 Structural adaptations of plants (roots, stems, leaves, flowers, fruit, seeds)
- 5.L.4B.1 Producers, consumers (herbivores, carnivores, omnivores), decomposers
- H.B. 3 The student will demonstrate the understanding that all essential processes within organisms require energy which in most ecosystems is ultimately derived from the Sun and transferred into chemical energy by the photosynthetic organisms in that ecosystem.

Essential Knowledge
It is essential for students to know that plants are organisms that perform certain processes necessary for survival.
Photosynthesis
- Plants are organisms that make their own food, a simple sugar, for survival.
- The process by which they make this sugar is called *photosynthesis*.
-
- Plant cells require sunlight, carbon dioxide and water to undergo photosynthesis.
- *Chloroplasts*, found in the cells of the leaf, contain *chlorophyll*, a green pigment that absorbs light energy from the sun.
- Carbon dioxide is taken in through openings, or *pores*, in the leaf called *stomata* and water is absorbed through the roots
- Simple sugar (glucose) and oxygen gas are produced. The plant uses the glucose for food and the

oxygen gas released into the air through the stomata.

Photosynthesis provides the oxygen gas in the atmosphere that most living organisms need

Respiration

- The glucose created through photosynthesis is used to provide energy needed by the plants to perform life functions such as growing and repairing.
- To obtain the energy from the food it produces, plants must break down the sugar in the cells throughout the plant in a cellular process called *respiration*.
- Cells require glucose and oxygen gas to undergo respiration.
- Oxygen gas from the air (taken in through the stomata) combines with the glucose, which is then broken down producing carbon dioxide and water.
- During this process, energy is released. This energy will be used by the plant to perform life functions such as growth and repair.
- The carbon dioxide gas and water that are formed are then given off through the stomata in the leaves.

Note: All organisms undergo respiration to release energy from food.

Transpiration

- Some of the water taken in through the roots of plants is used in the process of photosynthesis.
- Plants store water inside of their cells.
- Plants lose water through the leaves. This process is called *transpiration*.
- Without a way to control transpiration, plants would wither up and die.
- *Guard cells*, mostly on the underside of the leaf, open and close the stomata and allow plants to control transpiration.
- When the stomata are closed, water cannot escape from the leaf.

Extended Knowledge

- The chemical equation for photosynthesis is $6CO_2 + 6H_2O + \text{energy} \rightarrow C_6H_{12}O_6 + 6O_2$.
- The chemical equation for respiration is $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$.
- Photosynthesis and respiration are chemical reactions that have chemical equations.
- The reactants are at the beginning of the reaction (left side of the arrow) and the products are the substances that are formed (right side of the arrow).
- Students may want to analyze the overall chemical equations for photosynthesis and cellular respiration so they are able to see the complementary relationship between the two processes.

Science and Engineering Practices

S.1A.4

Standard

6.L.5: The student will demonstrate an understanding of the structures, processes, and responses that allow protists, fungi, and plants to survive and reproduce.

Conceptual Understanding

6.L.5B. Conceptual Understanding: The Plant Kingdom consists of organisms that primarily make their own food (autotrophs) and are commonly classified based on internal structures that function in the transport of food and water. Plants have structural and behavioral adaptations that increase the chances of reproduction and survival in changing environments.

Performance Indicator

6.L.5B.3 Develop and use models to compare structural adaptations and processes that flowering plants use for defense, survival and reproduction.

Assessment Guidance
The objective of this indicator is to *develop and use models* to compare structural adaptations and processes that flowering plants use for defense, survival and reproduction. Therefore, the primary focus of assessment should be for students to *construct models that represent (or use simulations to investigate),* compare, and contrast structural adaptations and processes flowering plants use for survival. This could include but is not limited to students creating models to describe how various structures of flowering plants help them to grow, develop, reproduce, and survive.

In addition to *develop and use models*, students should *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; obtain, evaluate, and communicate information;* and *construct devices or define solutions*

Previous/Future Knowledge
- 4.L.5A.1 Physical characteristics of plants (flowering and non-flowering) and animals (vertebrates and invertebrates)
- 4.L.5A.2 Life cycle of plants
- 4.L.5B.2 Structural adaptations of plants (roots, stems, leaves, flowers, fruit, seeds)

Essential Knowledge
It is essential that students be able to compare and contrast structural adaptations and processes flowering plants use for survival.

Structural Adaptations for Defense
Structures for defense protect plants from threats that could potentially kill the plant. Examples of natural defenses that plants have developed over time may be:
- thorns that defend the plant from being eaten by some animals
- fruits and leaves with poisons so that they are not eaten by animals
- the ability to close its leaves when touched (*thigmotropism*)

Structural Adaptations for Survival
Plants have structures that allow them to survive in their habitats when the conditions are not suitable. Examples of parts of flowering plants that function for survival may be:
- Leaves function as the site of photosynthesis, respiration, and transpiration in plants.
- Stems support the plant and hold the leaves up to the light. Stems also function as food storage sites.
    - The *xylem* in the stems transports water from the roots to the leaves and other plant parts.
    - The *phloem* in the stems transport food made in the leaves to growing parts of the plant.
- Roots help anchor the plant in the ground.
    - They also absorb water and nutrients from the soil and store extra food for the plants.
    - The more surface area on the root that is available, the more water and nutrients it can absorb.
    - Root hairs help to increase this surface area.
- There are two types of roots: fibrous roots and taproots.
    - *Fibrous roots* consist of several main roots that branch off to form a mass of roots. Examples are grass, corn, and some trees.
    - *Taproots* consist of one large, main root with smaller roots branching off. Examples are carrots, dandelions, or cacti.
- Seeds have special structures that allow them to be dispersed by wind, water, or animals.
- The seed coat helps protect the embryo from injury and also from drying out.

Structural Adaptations for Reproduction
Parts of the flowering plant that function in reproduction include:
Flowers

- Flowers produce seeds.
- Many flowers contain both male and female organs needed to produce new flowers.
- Flower petals are often colorful or have a scent to attract insects and other animals.

Stamen

- The male organ of a flower that has an *anther* on a stalk (filament).
- The anther produces the *pollen* that contains the sperm cells.

Pistil

- The female organ of the flower that contains
    - The *ovary*, which contains the *ovules* where the egg cells are produced,
    - The *stigma*, which is the sticky top where pollen grains land, and
    - The *style*, which is a stalk down which the pollen tube grows after pollination has taken place

Seed

- The ovule that contains the fertilized egg (*embryo*) from which new plants are formed.
- A fruit that is formed from the ovary often protects them.

Extended Knowledge
Plants use a variety of parts to produce new plants such as:
Tubers, bulbs

- These are all types of underground stems.
- The "eyes" or buds of tubers, for example potatoes, grow into roots and shoots to produce a new plant.
- Bulbs, for example onions, are big buds made of a stem and special types of leaves.

Runners

- These are all types of stems that run along the ground.
- New strawberries or some ivy grow from the tips of runners.
- Many lawn grasses grow from runners.

Stem Cuttings

- When a piece of cut stem is planted, roots may form from the cutting, and then a full plant develops.
- Sugar cane and pineapple are examples of plants grown from stem cuttings.

Roots

- Some fruit trees and bushes send up "suckers" or new shoots from the roots.
- Some plants have roots that can produce new plants from root pieces, such as a sweet potato.

Plant cells have larger vacuoles compared to animal cells to store more food and water. This helps plants to store up the water they need in order to perform the process of photosynthesis.

Science and Engineering Practices
S.1A.2

Standard
6.L.5: The student will demonstrate an understanding of the structures, processes, and responses that allow protists, fungi, and plants to survive and reproduce.

Conceptual Understanding
6.L.5B. Conceptual Understanding: The Plant Kingdom consists of organisms that primarily make their own food (autotrophs) and are commonly classified based on internal structures that function in the transport of food

and water. Plants have structural and behavioral adaptations that increase the chances of reproduction and survival in changing environments.

Performance Indicator
6.L.5B.4 Plan and conduct controlled scientific investigations to determine how changes in environmental factors (such as air, water, light, minerals, or space) affect the growth and development of a flowering plant.

Assessment Guidance
The objective of this indicator is to *plan and conduct controlled scientific investigations* to determine how changes in environmental factors (such as air, water, light, minerals, or space) affect the growth and development of a flowering plant. Therefore, the primary focus of assessment should be for students to *plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses, (2) identify materials, procedures, and variables, (3) select and use appropriate tools or instruments to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form* in order to demonstrate the effects of environmental factors on plants. This could include but is not limited to an experiment to determine which key environmental factor (air, water, light, minerals, or space) has the greatest effect on the growth and development of a flowering plant.

In addition to *planning and conducting scientific investigations*, students should be asked to *ask questions, analyze and interpret data, use mathematics and computational thinking, engage in argument from evidence, construct explanations, develop and use models, obtain, evaluate, and communicate information, and construct devices or design solutions.*

Previous/Future Knowledge
- 4.L.5A.1 Physical characteristics of plants (flowering and non-flowering) and animals (vertebrates and invertebrates)
- 4.L.5A.2 Life cycle of plants
- 4.L.5B.2 Structural adaptations of plants (roots, stems, leaves, flowers, fruit, seeds)
- 5.L.4A.1 Ecosystems (terrestrial and aquatic), biotic and abiotic factors
- 7.E.5 The student will demonstrate an understanding of how organisms interact with and respond to the biotic and abiotic components of their environments.
- H.B.3 The student will demonstrate the understanding that all essential processes within organisms require energy which in most ecosystems is ultimately derived from the Sun and transferred into chemical energy by the photosynthetic organisms in that ecosystem.
- H.B.6 The student will demonstrate an understanding that ecosystems are complex, interactive systems that include both biological communities and physical components of the environment.

Essential Knowledge
It is essential for students to plan and carry out the investigation of the effect of environmental factors on plant. Therefore, students should be conducting investigations to determine ways that air, water, light, minerals, or space affect flowering plants. Students should select one factor in order to determine an *independent variable*. For example, a student could choose to change the amount of water given to a certain species of plant.
For the teacher - due to limits in the amount of class time available, it is not essential that every student tests each factor. Students can test one factor and share data with others in the class. This should provide all students with an opportunity to make direct observations as well as draw conclusions from the data collected by others.

Extended Knowledge

- The students can review collected data to predict the ideal growth conditions for a variety of plants. Students can compare those predicted conditions with the actual conditions that the plant experiences in its natural environment.

Science and Engineering Practices
S.1A.3

Standard
6.L.5: The student will demonstrate an understanding of the structures, processes, and responses that allow protists, fungi, and plants to survive and reproduce.

Conceptual Understanding
6.L.5B. Conceptual Understanding: The Plant Kingdom consists of organisms that primarily make their own food (autotrophs) and are commonly classified based on internal structures that function in the transport of food and water. Plants have structural and behavioral adaptations that increase the chances of reproduction and survival in changing environments.

Performance Indicator
6.L.5B.5 Analyze and interpret data to describe how plants respond to external stimuli (including temperature, light, touch, water, and gravity).

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to describe how plants respond to external stimuli. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts, observations, measurements, or investigations* to construct scientific explanations describing how plants respond to changes in their environments. This could include but is not limited to students observing growing plants and describing how they have grown in response to light, touch, water, and gravity. Students may also be able to gather evidence that would support the hypothesis that plants grow in response to light, tough, water, and gravity (see 6.L.5B.4).

In addition to *analyze and interpret data*, students should be asked to *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information;* and *construct devices or define solutions.*

Previous/Future Knowledge

- 4.L.5A.1 Physical characteristics of plants (flowering and non-flowering) and animals (vertebrates and invertebrates)
- 4.L.5A.2 Life cycle of plants
- 4.L.5B.2 Structural adaptations of plants (roots, stems, leaves, flowers, fruit, seeds)
- 5.L.4A.1 Ecosystems (terrestrial and aquatic), biotic and abiotic factors
- 7.E.5 The student will demonstrate an understanding of how organisms interact with and respond to the biotic and abiotic components of their environments.
- H.B.3 The student will demonstrate the understanding that all essential processes within organisms require energy which in most ecosystems is ultimately derived from the Sun and transferred into chemical energy by the photosynthetic organisms in that ecosystem.
- H.B.6 The student will demonstrate an understanding that ecosystems are complex, interactive systems

that include both biological communities and physical components of the environment.

Essential Knowledge

It is essential for students to know that plants respond to changes in their environments. These responses (the reply to the change in the environment) vary depending on the specific environmental *stimulus* (a change in the environment that causes a response or a reaction).

Temperature

- Temperature, along with day length, can be used to manipulate flowering.
- Temperature alone can also influence flowering in some plants.
- For example, many bulb plants (like daffodils) must be exposed to cold temperature to force the bulb to mature.
- Many plants require a daily change of temperature between night and day to ensure photosynthesis and respiration reactions occur at optimal temperatures which will result in maximum plant growth.
- Under certain conditions (frequent temperature changes), when a mature plant or seed becomes or remains *dormant* (inactive).
    - *Dormancy* is a period of time when the growth or activity of a plant or seed stops due to changes in temperature or amount of water.
    - Dormancy allows various species to survive in particular environments. It helps to ensure that seeds will germinate when conditions are favorable for survival of the small seedlings.
    - For example, leaves fall from trees prior to the conditions of winter and the leaf buds do not open again until conditions are favorable in the spring.

Tropisms

- Plants respond to changes in the environment by growing their stems, roots, or leaves toward or away from the stimulus. This response, or behavior, is called a *tropism*.
- Examples of plant tropisms include:
    - *Phototropism* - The way a plant grows or moves in response to light
    - *Gravitropism* - The way a plant grows or moves in response to gravity; also called geotropism
    - *Hydrotropism* - The way a plant grows or moves in response to water
    - *Thigmotropism* - The way a plant grows or moves in response to touch

Extended Knowledge

- Students can analyze and interpret weather data to see how similar species of plants respond to changes in temperature in different regions of the state and country.
- Students can conduct an experiment where seeds are placed in different directions in order to see how roots and stems respond to gravity.

Science and Engineering Practices

S.1A.4