SUPPORT GUIDE 3.0
FOR SIXTH GRADE

SOUTH CAROLINA ACADEMIC STANDARDS AND PERFORMANCE INDICATORS FOR SCIENCE

Support Document 3.0

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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.

As science educators we must take a 3 dimensional approach in facilitating student learning. By addressing content standards, science and engineering practices and crosscutting concepts, students are able to have relevant and evidence based instruction that can help solve current and future problems. For more information please see: https://www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts.

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.

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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 Superintendents Roundtable and SC Chamber of Commerce SC Education Oversight Committee, SC State Board of Education, SC Department of Education, SC General Assembly, SC Council on Competitiveness, TransformSC, & SC Arts in Basic Curriculum Steering Committee

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 https://ed.sc.gov/scdoe/assets/file/agency/ccr/Standards-Learning/documents/South_Carolina_Academic_Standards_and_Performance_Indicators_for_Science_2014.pdf.

Support for the guidance, overviews of learning progressions, and explicit details of each SEP can be found in the Science and Engineering Support Document https://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf.

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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.

The link http://www.nap.edu/read/13165/chapter/8 provides support from the framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012) that gives further guidance on each crosscutting concept.

1. **Patterns:** The National Research Council (2012) states that "observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them" (p. 84).
2. **Cause and Effect: Mechanism and Explanation:** The National Research Council (2012) states that "events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts" (p. 84).
3. **Scale, Proportion, and Quantity:** The National Research Council (2012) states that "in considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance" (p. 84).
4. **Systems and Systems Models:** The National Research Council (2012) states that "Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering" (p. 84).
5. **Energy and Matter:** Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. **Structure and Function:** The National Research Council (2012) states that "the way in which an object or living thing is shaped and its substructure determine many of its properties and functions" (p. 84).
7. **Stability and Change:** The National Research Council (2012) states that "For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study" (p. 84).

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DECIPHERING THE STANDARDS

Kindergarten
Life Science: Exploring Organisms and the Environment

Standard K.L.2: The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.

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).

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 I
H.B: High School Chemistry I
H.P: High school Physics I
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

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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 GRADE SIX

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

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

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 standard, conceptual understanding, performance indicator, science and engineering practices, crosscutting concepts, essential learning experiences, extended learning experiences, assessment guidelines, learning connections, and in some cases note to teacher.

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.

Science and Engineering Practices (SEPs)
- This section lists the specific science and engineering practice that are 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.*
- Educators have the freedom to enhance SEPs addressed during instruction.
- SEPs Support Guide https://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf

Crosscutting Concepts (CCCs)
- Cross Cutting Concepts (http://www.nap.edu/read/13165/chapter/8) This link provides support from the Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012).
- Educators have the freedom to enhance CCCs addressed during instruction.

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Essential Learning Experiences

- This section illustrates the knowledge of the content contained in the performance indicator for which it is fundamental for students to demonstrate mastery.

Note to Teacher

- If necessary or appropriate, this section provides additional instructional guidance.

Extended Learning Experiences

- This section provides educators with topics that will enrich students' knowledge related to topics learned with the explicated performance indicator.

Assessment Guidelines

- This section provides guidelines for educators and assessors to check for student mastery of content utilizing interrelated science and engineering practices.

Learning Connections

- 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.

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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 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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Patterns Cause and Effect System and System Models

Essential Learning Experiences:
It is essential that students develop and use models about the composition and layers of the atmosphere, and analyze data about the layers.

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.

While there is no clear definition of where outer space begins the general guideline is between 80-128 km from Earth.

- Troposphere:
  - weather and clouds occur in this layer

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    - 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
- 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
- Mesosphere:
    - the coldest layer
- Thermosphere:
    - the warmest layer
    - the air is very thin in this layer
- Exosphere:
    - cold regions of outer space extend from this layer

Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- 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.

Assessment Guidelines:
Students should engage in multiple science and engineering practices when interacting with the content outlined in this performance indicator. For further information please see SEP Support Guide at:
https://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf

Learning Connections	**Future Learning Connections (7-12):** **H.E.5A.1:** Develop and use models to describe the thermal structures (including the changes in air temperature due to changing altitude in the lower troposphere), the gaseous composition, and the location of the layers of Earth's atmosphere. **H.E.5A.7:** Construct scientific arguments to support claims of past changes in climate caused by various factors (such as changes in the atmosphere, variations in solar output, Earth's orbit, changes in the orientation of Earth's axis of rotation, or changes in the biosphere). **H.E.5A.8:** Analyze scientific arguments regarding the nature of the relationship between human activities and climate change.

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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 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.
Science and Engineering Practice	**6.S.1A.7:** Construct and analyze scientific arguments to support claims, explanations, or designs using evidence from observations, data, or informational texts**.**
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Cause and Effect

Essential Learning Experiences:
It is essential that students analyze and interpret data about how 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 ash and gases, which contain harmful chemicals and large amounts of carbon dioxide.
- Volcanic ash also contains particulates and gases that can reflect sunlight and result in a decrease in surface temperatures.
- 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.
- 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

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Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal, but can be used by teachers to extend the depth and rigor of student engagements.

- 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.

Assessment Guidelines:
Students should engage in multiple science and engineering practices when interacting with the content outlined in this performance indicator. For further information please see SEP Support Guide at:
https://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf

Learning Connections	**Future Learning Connections (7-12):** **H.E.5A.1:** Develop and use models to describe the thermal structures (including the changes in air temperature due to changing altitude in the lower troposphere), the gaseous composition, and the location of the layers of Earth's atmosphere. **H.B.6B.1:** Develop and use models of the carbon cycle, which include the interactions between photosynthesis cellular respiration and other processes that release carbon dioxide, to evaluate the effects of increasing atmospheric carbon dioxide on natural and agricultural ecosystems. **H.B.6B.2:** Analyze and interpret quantitative data to construct an explanation for the effects of greenhouse gases (such as carbon dioxide and methane) on the carbon cycle and global climate.

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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 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).
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Patterns Structure and Function

Essential Learning Experiences:
It is essential that students construct explanations related to how 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.

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- 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.
- 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

NOTE TO TEACHER:
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 cause water vapor to rise (evaporation) while a decrease in thermal temperature triggers condensation (clouds, dew, and frost).

Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal, but can be used by teachers to extend the depth and rigor of student engagements.

- 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).

Assessment Guidelines:
Students should engage in multiple science and engineering practices when interacting with the content outlined in this performance indicator. For further information please see SEP Support Guide at:
https://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf

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Learning Connections	**Previous Learning Connections (3-5):** **4.E.2A.2:** Develop and use models to explain how water changes as it moves between the atmosphere and Earth's surface during each phase of the water cycle (including evaporation, condensation, precipitation, and runoff). **Future Learning Connections (7-12):** **H.E.6A.2:** Obtain and communicate information to explain how location, movement, and energy transfers are involved in making water available for use on Earth's surface (including lakes, surface-water drainage basins, freshwater wetlands, and groundwater zones).

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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.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 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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Patterns Cause and Effect

Essential Learning Experiences:
It is essential that students can analyze and interpret weather data. 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.

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- 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).
    - Weather symbols that are used to indicate current weather and predicted weather conditions.
- 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal, but can be used by teachers to extend the depth and rigor of student engagements. 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 (85ºF), wind direction and speed, prediction, 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.

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Assessment Guidelines:
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Learning Connections	**Previous Learning Connections (3-5)** **4.E.2B.1:** Analyze and interpret data from observations, measurements, and weather maps to describe patterns in local weather conditions (including temperature, precipitation, wind speed/direction, relative humidity, and cloud types) and predict changes in weather over time. **Future Learning Connections (7-12)** **H.E.5A.3:** Analyze and interpret data to predict local and national weather conditions on the basis of the relationship among the movement of air masses, pressure systems, and frontal boundaries. **H.E.5A.4:** Analyze and interpret data of pressure differences, the direction of winds, and areas of uneven heating to explain how convection determines local wind patterns (including land/sea breezes, mountain/valley breezes, Chinook winds, and monsoons).

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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.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 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).
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Cause and Effect System and System Models

Essential Learning Experiences:
It is essential that students 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.

- 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.

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        - 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal, but can be used by teachers to extend the depth and rigor of student engagements.

- 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.

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    - 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.

Assessment Guidelines:
Students should engage in multiple science and engineering practices when interacting with the content outlined in this performance indicator. For further information please see SEP Support Guide at:
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Learning Connections	**Previous Learning Connections (3-5)** **4.E.2B.2:** Obtain and communicate information about severe weather phenomena (including thunderstorms, hurricanes, and tornadoes) to explain steps humans can take to reduce the impact of severe weather phenomena. **Future Learning Connections (7-12)** **H.E.5A.5:** Construct explanations for the formation of severe weather conditions (including tornadoes, hurricanes, thunderstorms, and blizzards) using evidence from temperature, pressure and moisture conditions.

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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.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 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).
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Cause and Effect Energy and Matter: Flows, Cycles, and Conservation

Essential Learning Experiences:
It is essential that students develop and use models to represent 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 affect the direction of weather systems on Earth
    - Trade winds and westerlies affect the direction of tropical weather systems (hurricanes).
    - Jet streams are fast moving currents of air that move from west to east in the Northern hemisphere.
        - The polar jet stream brings down cold polar conditions from the north.

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- Ocean surface currents circulate warm and cold ocean waters in convection patterns and influence the weather and climates of the land masses 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.

NOTE TO TEACHER:
Earth's winds move in a rotational pattern because of the rotation of Earth around its axis. This phenomenon is called the Coriolis Effect.

Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal, but can be used by teachers to extend the depth and rigor of student engagements.

- The phenomenon called the Coriolis Effect is named after French engineer Gaspard Coriolis who died in 1843.
- Each climate zone has identifying characteristics. Organisms in these regions have adaptations to survive.
- Airplanes ride on jet streams to increase their speed and decrease the amount of fuel they use.

Assessment Guidelines:
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Learning Connections	**Previous Learning Connections (3-5)** **4.E.2B.3:** Construct explanations about regional climate differences using data from the long term weather conditions of the region. **Future Learning Connections (7-12)** **H.E.5A.6:** Develop and use models to exemplify how climate is driven by global circulation patterns.

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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.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 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).
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Patterns Stability and Change

Essential Learning Experiences:
It is essential that students construct explanations for how 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.

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- 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal, but can be used by teachers to extend the depth and rigor of student engagements.

- Agriculture and mariculture in a particular area is determined by the weather conditions.

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (7-12)** **H.E.5A.2:** Develop and use models to predict and explain how the angle of solar incidence and Earth's axial tilt impact (1) the length of daylight, (2) the atmospheric filtration, (3) the distribution of sunlight in any location, and (4) seasonal changes.

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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 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).
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Energy and Matter

Essential Learning Experiences:
It is essential that students analyze and interpret data to describe the properties and compare sources of different forms of energy.

- 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.

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- 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.
        - 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 gravitational 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 TO TEACHER**:** 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

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

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Assessment Guidelines:
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Learning Connections	**Future Learning Connections (7-12)** **H.P.3B.2:** Use mathematical and computational thinking to argue the validity of the conservation of mechanical energy in simple systems and those with periodic motion and on which only conservative forces act.

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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 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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. System and System Models

Essential Learning Experiences:
It is essential that students develop and use models to exemplify 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:

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- 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 due to friction.

Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- 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.

Assessment Guidelines:
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Learning Connections	**Previous Learning Connections (3-5)** **3.P.3A.1:** Obtain and communicate information to develop models showing how electrical energy can be transformed into other forms of energy (including motion, sound, heat, or light). **Future Learning Connections (7-12)**

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	H.P.3A.3: Obtain and use information to communicate how energy is conserved in elastic and inelastic collisions. **H.P.3B.1:** Develop and use models (such as computer simulations, drawings, bar graphs, and diagrams) to exemplify the transformation of mechanical energy in simple systems and those with periodic motion and on which only conservative forces act. **H.P.3B.2:** Use mathematical and computational thinking to argue the validity of the conservation of mechanical energy in simple systems and those with periodic motion and on which only conservative forces act. **H.P.3B.3:** Use drawings or diagrams to identify positions of relative high and low potential energy in a gravitational and electrical field (with the source of the field being positive as well as negative and the charge experiencing the field being positive as well as negative).

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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 Indicator	**6.P.3A.3:** Construct explanations for how energy is conserved as it is transferred and transformed in electrical circuits.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Cause and Effect Stability and Change

Essential Learning Experiences:

It is essential that students construct explanation for how energy is conserved as it is transferred and transformed in electrical circuits.

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 lightbulb, fan, or bell, which transform the electrical energy into light, mechanical and sound energy respectively.

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

- The wire (conductor) must connect the power source to the lightbulb, fan, or bell 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 lightbulb, fan, or bell 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.

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- If the circuit is not closed, then electricity cannot flow and the circuit is an open circuit. Since the electricity is not flowing, the lightbulb, fan, or bell 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.

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- 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- 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

Assessment Guidelines:
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Learning Connections	**Previous Learning Connections (3-5)** **3.P.3A.1:** Obtain and communicate information to develop models showing how electrical energy can be transformed into other forms of energy (including motion, sound, heat, or light). **Future Learning Connections (7-12)** **H.P.3A.3:** Obtain and use information to communicate how energy is conserved in elastic and inelastic collisions. **H.P.3B.3:** Use drawings or diagrams to identify positions of relative high and low potential energy in a gravitational and electrical field. **H.P.3D.1:** Develop and use models (such as drawings) to exemplify the interaction of mechanical waves with different boundaries (sound wave interference) including the formation of standing waves and two-source interference patterns. **H.P.3E.1:** Plan and conduct controlled scientific investigations to determine the relationship between the current and potential drop across an Ohmic resistor. Analyze and interpret data to verify Ohm's law, including constructing

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	an appropriate graph in order to draw a line-of-best-fit whose calculated slope will yield R, the resistance of the resistor. **H.P.3E.5:** Plan and conduct controlled scientific investigations to determine how connecting resistors in series and in parallel affects the power (brightness) of light bulbs.

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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 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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. System and System Models Energy and Matter

Essential Learning Experiences:
It is essential that students develop and use models 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.

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- 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

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

Assessment Guidelines:
Students should engage in multiple science and engineering practices when interacting with the content outlined in this performance indicator. For further information please see SEP Support Guide at:
https://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf

Learning Connections	**Previous Learning Connections (3-5)** **3.P.3B.1:** Develop and use models to describe and compare the properties of magnets and electromagnets (including polarity, attraction, repulsion, and strength). **3.P.3B.2:** Plan and conduct scientific investigations to determine the factors that affect the strength of an electromagnet. **Future Learning Connections (7-12)**

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	H.P.3E.6: Obtain and communicate information about the relationship between magnetism and electric currents to explain the roles of magnets and coils of wire in microphones, speakers, generators, and motors. **H.P.3E.7:** Design a simple motor and construct an explanation of how this motor transforms electrical energy into mechanical energy and work.

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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 Indicator	**6.P.3A.5:** Develop and use models to describe and compare the directional transfer of heat through convection, radiation, and conduction.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. System and System Models

Essential Learning Experiences:
It is essential that students develop and use models to describe and compare how 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.

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  - 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

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

Assessment Guidelines:
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https://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf

Learning Connections	**Previous Learning Connections (3-5)** **3.P.2A.3:** Plan and conduct scientific investigations to determine how changes in heat (increase or decrease) change matter from one state to another (including melting, freezing, condensing, boiling, and evaporating). **3.P.2A.5:** Define problems related to heat transfer and design devices or solutions that facilitate (conductor) or inhibit (insulator) the transfer of heat. **Future Learning Connections (7-12)** **H.P.3C.1:** Plan and conduct controlled scientific investigations to determine the variables that affect the rate of heat transfer between two objects. **H.P.3C.2:** Analyze and interpret data to describe the thermal conductivity of different materials. **H.P.3C.3:** Develop and use models (such as drawing or a small-scale greenhouse) to exemplify the energy balance of the Earth (including conduction, convection, and radiation).

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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 Indicator	**6.P.3A.6:** Design and test devices that minimize or maximize heat transfer by conduction, convection, or radiation.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Scale, Proportion, and Quantity

Essential Learning Experiences:
It is essential that students design and test devices to show how 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.

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Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- 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.

Assessment Guidelines:
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https://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf

Learning Connections	**Previous Learning Connections (3-5)** **3.P.2A.5:** Define problems related to heat transfer and design devices or solutions that facilitate (conductor) or inhibit (insulator) the transfer of heat. **Future Learning Connections (7-12)** **H.P.3C.2:** Analyze and interpret data to describe the thermal conductivity of different materials.

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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.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 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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Patterns Systems and System Models Stability and Change

Essential Learning Experiences:
It is essential that students plan and conduct controlled scientific investigations to provide evidence of:

- Energy 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.

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- 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.
- Simple Machines:
    - 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 angle of 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.

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Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

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

Assessment Guidelines:
Students should engage in multiple science and engineering practices when interacting with the content outlined in this performance indicator. For further information please see SEP Support Guide at:
https://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf

Learning Connections	**Future Learning Connections (7-12)** **H.P.3A.1:** Use mathematical and computational thinking to determine the work done by a constant force (W=Fd). **H.P.3A.2:** Use mathematical and computational thinking to analyze problems dealing with the work done on or by an object and its change in energy. **H.P.3A.5:** Obtain and communicate information to describe the efficiency of everyday machines (such as automobiles, hair dryers, refrigerators, and washing machines). **H.P.3B.1:** Develop and use models (such as computer simulations, drawings, bar graphs, and diagrams) to exemplify the transformation of mechanical energy in simple systems and those with periodic motion and one which only conservative forces act.

Support Document 3.0

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.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 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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Cause and Effect Scale, Proportion, and Quantity

Essential Learning Experiences:
It is essential that students design and tests solutions that improve the efficiency of a machine to:

- 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.

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- 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.

NOTE TO TEACHER:
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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- 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.

Assessment Guidelines:
Students should engage in multiple science and engineering practices when interacting with the content outlined in this performance indicator. For further information please see SEP Support Guide at:
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Future Learning Experiences	**Future Learning Connections (7-12)** **H.P.3A.1:** Use mathematical and computational thinking to determine the work done by a constant force (W=Fd). **H.P.3A.2:** Use mathematical and computational thinking to analyze problems dealing with the work done on or by an object and its change in energy. **H.P.3A.5:** Obtain and communicate information to describe the efficiency of everyday machines (such as automobiles, hair dryers, refrigerators, and washing machines).

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	H.P.3B.1: Develop and use models (such as computer simulations, drawings, bar graphs, and diagrams) to exemplify the transformation of mechanical energy in simple systems and those with periodic motion and one which only conservative forces act.

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Life Science: Diversity of Life-Classification of 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 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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Cause and Effect Energy and Matter Structure and Function Stability and Change

Essential Learning Experiences:
It is essential that students obtain and communicate 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.

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- 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- 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.

Assessment Guidelines:
Students should engage in multiple science and engineering practices when interacting with the content outlined in this performance indicator. For further information please see SEP Support Guide at:
https://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf

Learning Connections	**Previous Learning Connections (3-5)** **4.L.5A.3:** Develop and use models to compare the stages of growth and development in various animals. **4.L.5B.1:** Develop and use models to compare how humans and other animals use their senses and sensory organs to detect and respond to signals from the environment.

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	Future Learning Connections (7-12) **H.B.2B.3:** Obtain and information to contrast the structure of viruses with that of cells and to explain, in general, why viruses must use living cells to reproduce. **H.B.5.2:** Explain how genetic processes result in the continuity of life-forms over time.

Support Document 3.0

Life Science: Diversity of Life-Classification of 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 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).
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Systems and System Models Patterns

Essential Learning Experiences:
It is essential that students develop and use models to show 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.

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- 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

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 Learning Experiences:

The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

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

Assessment Guidelines:
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Future Learning Experiences	**Previous Learning Connections (3-5)** **5.L.4A.2:** Obtain and communicate information to describe and compare the biotic factors (including individual organisms, populations, and communities) of different terrestrial and aquatic ecosystems. **Future Learning Connections (7-12)** **7.L.3A.2:** Analyze and interpret data from observations to describe different types of cells and classify cells as plant, animal, protist, or bacteria. **H.B.2B.2:** Collect and interpret descriptive data on cell structure to compare and contrast different types of cells (including prokaryotic versus eukaryotic, and animal versus plant versus fungal) **H.B.5.3:** Explain how diversity within a species increases the chances of survival. **H.B.5.7:** Use a phylogenetic tree to identify the evolutionary relationships among different groups of organisms.

Support Document 3.0

Life Science: Diversity of Life-Classification of 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.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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Patterns

Essential Learning Experiences:

It is essential that students analyze and interpret data 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 include 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.

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- 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 might 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 might 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.

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    - 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- Students could 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.

Assessment Guidelines:
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https://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf

Learning Connections	**Previous Learning Connections (3-5)** **4.L.5A.1:** Obtain and communicate information about the characteristics of plants and animals to develop models which classify plants as flowering or non-flowering and animals as vertebrate or invertebrate. **4.L.5A.3:** Develop and use models to compare the stages of growth and development in various animals.

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Life Science: Diversity of Life-Classification of 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.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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Structure and Function Stability and Change

Essential Learning Experiences:
It is essential that students obtain and communicate information to explain 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

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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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- 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).

Assessment Guidelines:
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Learning Connections	**Previous Learning Connections (3-5)** **4.L.5B.3:** Construct explanations for how structural adaptations (such as methods for defense, locomotion, obtaining resources, or camouflage) allow animals to survive in the environment. **Future Learning Connections (7-12)** **7.EC.5A.3** Analyze and interpret data to predict changes in the number of organisms within a population when certain changes occur to the physical environment (such as changes due to natural hazards or limiting factors). **H.B.5.1:** Summarize the process of natural selection.

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Life Science: Diversity of Life-Classification of 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.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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Stability and Change

Essential Learning Experiences:
It is essential that students construct explanations to justify 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.

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    - Examples of animals that migrate are monarch butterflies, orcas, caribou, ducks and salmon
- Defense (will vary with different types of animals)
    - 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- The student could 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.

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Future Learning Experiences	**Previous Learning Connections (3-5)** **4.L.5A.3:** Develop and use models to compare the stages of growth and development in various animals. **4.L.5B.1:** Develop and use models to compare how humans and other animals use their senses and sensory organs to detect and respond to signals from the environment. **4.L.5B.3:** Construct explanations for how structural adaptations (such as methods for defense, locomotion, obtaining resources, or camouflage) allow animals to survive in the environment. **Future Learning Connections (7-12)** **7.EC.5A.3** Analyze and interpret data to predict changes in the number of organisms within a population when certain changes occur to the physical environment (such as changes due to natural hazards or limiting factors).

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Life Science: Diversity of Life-Classification of 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.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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Patterns Structure and Function

Essential Learning Experiences:

It is essential that students obtain and communicate information 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.
- Conditioning (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. Examples of conditioning may include:
    - Chimpanzees learn to use small sticks to dig in the soil for insects
    - A child learns that touching a hot object will cause pain.

Inherited behaviors are passed from the parent to offspring.

- These may be referred to as instincts.
- These are with the animal from birth.
- Examples may include:
    - The ability to swim is an inherited behavior for whales and fish.

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- Human babies cry in response to hunger, thirst, or sleepiness.
- A turtle may dig a hole to lay its eggs on a moonlit night.
- A bird may build a special kind of nest to lay its eggs.
- A male fiddler crab may waves its claw to attract a female mate.

Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- 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 could construct explanations as to why some animals have many inherited behaviors while others have many learned behaviors.

Assessment Guidelines:
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https://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf

Learning Connections	**Previous Learning Connections (3-5)** **4.L.5A.4:** Construct scientific arguments to support claims that some characteristics of organisms are inherited from parents and some are influenced by the environment. **Future Learning Connections (7-12)** **7.EC.5A.3** Analyze and interpret data to predict changes in the number of organisms within a population when certain changes occur to the physical environment (such as changes due to natural hazards or limiting factors).

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Life Science: Diversity of Life-Classification of 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.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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Cause and Effect Stability and Change

Essential Learning Experiences:
It is essential that students analyze and interpret data 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.

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- 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- The students can engage in scientific argument from evidence regarding the merits of being an ectotherm and of being an endotherm. The student could obtain and communicate evidence to support the position they take.

Assessment Guidelines:
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Learning Connections	**Previous Learning Connections (3-5)** **4.L.5B.1:** Develop and use models to compare how humans and other animals use their senses and sensory organs to detect and respond to signals from the environment. **4.L.5B.3:** Construct explanations for how structural adaptations (such as methods for defense, locomotion, obtaining resources, or camouflage) allow animals to survive in the environment. **Future Learning Connections (7-12)** **7.EC.5A.3** Analyze and interpret data to predict changes in the number of organisms within a population when certain changes occur to the physical environment (such as changes due to natural hazards or limiting factors).

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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 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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Patterns Structure and Function

Essential Learning Experiences:
It is essential that the student analyze and interpret data 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.
  - Protists live in moist environments.
  - Protists 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.

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        - 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 which include:
        - Saprophytic - Fungi that get their energy from decaying organic matter.
        - Parasitic - Fungi that feed on other living organisms (host) and harm the host.
        - Mutualistic - Fungi that feed on other living organisms (host) but do not harm the host. Both organisms benefit from the relationship.
          *Both parasitic and mutualistic are types of symbiotic relationships
    - In most cases, fungi are not mobile organisms.
    - Fungi can be categorized based on their structures of reproduction and dispersal.

Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- 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.

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (7-12)** **7.L.3A.4:** Construct scientific arguments to support claims that bacteria are both helpful and harmful to other organisms and their environment. **H.B.2B.2:** Collect and interpret descriptive data on cell structure to compare and contrast different types of cells (including prokaryotic versus eukaryotic, and animal versus plant versus fungal).

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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 Indicator	**6.L.5A.2:** Analyze and interpret data to describe how fungi respond to external stimuli (including temperature, light, touch, water, and gravity).
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Cause and Effect Stability and Change

Essential Learning Experiences:

It is essential that students analyze and interpret data to 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.

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Extended Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- 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.

Assessment Guidelines:
Students should engage in multiple science and engineering practices when interacting with the content outlined in this performance indicator. For further information please see SEP Support Guide at:
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Learning Connections	**Previous Learning Connections (3-5)** **5.L.4B.1:** Analyze and interpret data to explain how organisms obtain their energy and classify organisms as producers, consumers (including herbivore, carnivore, and omnivore), or decomposers (such as fungi and bacteria).

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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.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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Patterns Structure and Function

Essential Learning Experiences:
It is essential that students construct explanations to 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.

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- 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements. 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

Assessment Guidelines:
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Learning Connections	**Previous Learning Connections (3-5)** **4.L.5A.1:** Obtain and communicate information about the characteristics of plants and animals to develop models which classify plants as flowering or non-flowering and animals as vertebrate or invertebrate. **4.L.5B.2:** Construct explanations for how structural adaptations (such as the types of roots, stems, or leaves; color of flowers; seed dispersal) allow plants to survive and reproduce. **Future Learning Connections (7-12)** **H.B.2C.1:** Develop and use models to exemplify how the cell membrane serves to maintain homeostasis of the cell through both active and passive transport processes.

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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.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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Systems and System Models Energy and Matter

Essential Learning Experiences:
It is essential that students analyze and interpret data to explain 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

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- 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: 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- 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.

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Learning Connections	**Previous Learning Connections (3-5)** **4.L.5A.1:** Obtain and communicate information about the characteristics of plants and animals to develop models which classify plants as flowering or non-flowering and animals as vertebrate or invertebrate. **4.L.5B.2:** Construct explanations for how structural adaptations (such as the types of roots, stems, or leaves; color of flowers; seed dispersal) allow plants to survive and reproduce. **5.L.4B.1:** Analyze and interpret data to explain how organisms obtain their energy and classify organisms as producers, consumers (including herbivore, carnivore, and omnivore), or decomposers (such as fungi and bacteria). **Future Learning Connections (7-12)** **H.B.3A.1:** Develop and use models to explain how chemical reactions among ATP, ADP, and inorganic phosphate act to transfer chemical energy within cells. **H.B.3A.2:** Develop and use models to describe how photosynthesis transforms light energy into stored chemical energy. **H.B.3A.3:** Construct scientific arguments to support claims that chemical elements in the sugar molecules produced by photosynthesis may interact with other elements to form amino acids, lipids, nucleic acids or other large organic molecules. **H.B.3A.4:** Develop and use models of the major inputs and outputs of cellular respiration (aerobic and anaerobic) to exemplify the chemical process in which the bonds of molecules are broken, the bonds of new compounds are formed and a net transfer of energy results. **H.B.3A.5:** Plan and conduct scientific investigations or computer simulations to determine the relationship between variables that affect the processes of fermentation and/or cellular respiration in living organisms and interpret the data in terms of real-world phenomena.

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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.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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Structure and Function

Essential Learning Experiences:
It is essential that students develop and use models 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.

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        - 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.
        - Fibrous roots
            - Fibrous roots consist of several main roots that branch off to form a mass of roots. Examples are grass, corn, and some trees.
        - Taproots
            - Taproots consist of one large, main root with smaller roots branching off. Examples are carrots, dandelions, or cacti.
        - Seeds
            - Seeds have special structures that allow them to be dispersed by wind, water, or animals.
            - Seeds have a seed coat helps protect the embryo from injury and also from drying out.
- Structural Adaptations for Reproduction of flowering plants 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 pistil 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 Learning Experiences:
Plants use a variety of parts to produce new plants such as: tubers, bulbs, runners, stem cuttings, etc. 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.

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Learning Connections	**Previous Learning Connections (3-5)** **4.L.5A.1:** Obtain and communicate information about the characteristics of plants and animals to develop models which classify plants as flowering or non-flowering and animals as vertebrate or invertebrate. **4.L.5B.2:** Construct explanations for how structural adaptations (such as the types of roots, stems, or leaves; color of flowers; seed dispersal) allow plants to survive and reproduce. **4.L.5A.2:** Analyze and interpret data from observations and measurements to compare the stages of development of different seed plants.

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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.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.
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Scale, Proportion, and Quantity

Essential Learning Experiences:
It is essential that students 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- 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.

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Learning Connections	**Previous Learning Connections (3-5)** **4.L.5A.1:** Obtain and communicate information about the characteristics of plants and animals to develop models which classify plants as flowering or non-flowering and animals as vertebrate or invertebrate. **4.L.5B.2:** Construct explanations for how structural adaptations (such as the types of roots, stems, or leaves; color of flowers; seed dispersal) allow plants to survive and reproduce. **4.L.5A.2:** Analyze and interpret data from observations and measurements to compare the stages of development of different seed plants. **5.L.4A.1:** Analyze and interpret data to summarize the abiotic factors (including quantity of light and water, range of temperature, salinity, and soil composition) of different terrestrial ecosystems and aquatic ecosystems.

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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.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).
Science and Engineering Practice	**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.
Crosscutting Concepts	The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6. Cause and Effect Systems and System Models Stability and Change

Essential Learning Experiences:
It is essential for students to analyze and interpret data to determine 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.

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        - 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.
- 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 Learning Experiences:
The following knowledge and learning experiences are not essential to the success of this learning goal but can be used by teachers to extend the depth and rigor of student engagements.

- 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.

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