SUPPORT GUIDE 3.0
FOR EIGHTH GRADE

SOUTH CAROLINA ACADEMIC STANDARDS
AND PERFORMANCE INDICATORS FOR SCIENCE

Molly M. Spearman
State Department of Education

SOUTH CAROLINA
DEPARTMENT OF EDUCATION

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INTRODUCTION TO GRADE EIGHT 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.

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 *Science 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.

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).

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

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 Eight

- Physical Science: Forces and Motion
- Physical Science: Waves
- Earth Science: Earth's Place in the Universe
- Earth Science: Earth Systems and Resources
- Earth Science: Earth's History and Diversity of Life

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Janet Rizer (Colleton)
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CONTENT SUPPORT GUIDE
FOR GRADE EIGHT
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.

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.

Physical Science: Forces and Motion

Standard 8.P.2: The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.	
8.P.2A. Conceptual Understanding: Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.	
Performance Indicator	**8.P.2A.1:** Plan and conduct controlled scientific investigations to test how varying the amount of force or mass of an object affects the motion (speed and direction), shape, or orientation of an object.
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 Stability and Change

Essential Learning Experiences:
It is essential that students plan and conduct scientific investigations to test:

- Speed
  - Speed is a measure of how fast something moves a particular distance (for example, meters) over a given amount of time (for example, seconds).
  - Therefore, speed is the rate of change of the position of an object, or how far something will move in a given period of time.
  - Speed does not necessarily mean that something is moving fast.
- Force
  - If an object is in motion and more force is applied to it, the object will begin moving faster.
  - If two objects have the same mass and a greater force is applied to one of the objects, the object which receives the greater force will change speeds more quickly. For example if a ball is hit harder, it will speed up faster.

- If an object must be slowed down quickly, the force applied to the object must be greater than what is needed for a gradual slowing down. For example, the greater the force applied to the brakes of a bicycle, the more quickly it will slow down or stop.
- Varying the amount of force applied to a moving object can also change the direction that the object is moving more or less quickly. For example, a baseball pitched toward the batter may quickly change direction and speed if hit very hard, or may change direction and speed more slowly if hit softly as with a bunt.

- Mass
  - If a heavy (more massive) object is in motion, more force must be applied to get the object moving faster.
  - If the same force is applied to two objects, the object with the smaller mass will change speeds more quickly. For example if a baseball and a bowling ball are thrown with the same force the baseball will speed up faster.
  - In order to slow down or stop a heavier (more massive) object, the force on that object must be greater than for a less massive object. For example, if the same braking force is applied to a small car and a large truck, the car will slow down more quickly.
  - It is more difficult to change the direction of a heavy moving object, than one that is lighter in mass.

	Motion	Shape	Orientation
Force	• If an object is in motion and more force is applied to it, the object will begin moving faster. • If two objects have the same mass and a greater force is applied to one of the objects, the object which receives the greater force will change speeds more quickly. For example, if a ball is hit harder, it will speed up faster. • If an object must be slowed down quickly, the force applied to the object must be greater than what is needed for a gradual slowing down. For example, the greater the force applied to the brakes of a bicycle, the more quickly it will slow down or stop.	• Change in the shape of an object depends on the magnitude of the force that is acting on it. For example, two cars that collide traveling at lower speeds will not have as much change in shape as two cars that collide traveling at a faster speed.	• Refers to the relative position of an object. • A force can cause an object's orientation to change. For example, when two cars collide at a faster rate, there will be more change in their orientation.

	• Varying the amount of force applied to a moving object can also change the direction that the object is moving more or less quickly. For example, a baseball pitched toward the batter may quickly change direction and speed if hit very hard, or may change direction and speed more slowly if hit softly as with a bunt.		
Mass	• If a heavy (more massive) object is in motion, more force must be applied to get the object moving faster. • If the same force is applied to two objects, the object with the smaller mass will change speeds more quickly. For example, if a baseball and a bowling ball are thrown with the same force the baseball will speed up faster. • In order to slow down or stop a heavier (more massive) object, the force on that object must be greater than for a less massive object. • It is more difficult to change the direction of a heavy moving object, than one that is lighter in mass.	• Change in the shape of an object depends on the mass of the object colliding with the object. For example, a heavier car collides with a lighter car. The lighter car will sustain more changes in the shape of the car.	• A change in orientation can occur when a heavier object collides with a lighter object. For example, if a heavier car collides with a lighter car, the lighter car will have a more noticeable change in their orientation.

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 specific quantitative relationships among force, mass, and movement of objects (F = ma) or Newton's Laws of Motion.

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 (9-12):** **H.P.2.A.1**: Plan and conduct controlled scientific investigations on the straight-line motion of an object to include an interpretation of the object's displacement, time of motion, constant velocity, average velocity, and constant acceleration.

Physical Science: Forces and Motion

Standard 8.P.2 The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.	
8.P.2A. Conceptual Understanding: Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.	
Performance Indicator	**8.P.2A.2:** Develop and use models to compare and predict the resulting effect of balanced and unbalanced forces on an object's motion in terms of magnitude and direction.
Science and Engineering Practice	**S.1A.2:** Develop and use 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 Systems and System Models

Essential Learning Experiences:
It is essential that students develop and use models to compare and predict the resulting effect of balanced and unbalanced forces.

- Forces have a magnitude (strength) and a direction, and are measured in units called newtons (N).
- Forces can be represented as arrows with the length of the arrow representing the magnitude of the force and the head of the arrow pointing in the direction of the force.
- Using such arrows, the resulting force (net force) and direction can be determined.
- Forces acting on an object can be balanced or unbalanced.

Balanced forces will cause no change in the speed of an object.

- Balanced forces acting on an object in opposite directions and equal in strength, as shown in the arrows below, do not cause a change in the speed of a moving object.
- Objects that are not moving will not start moving if acted on by balanced forces.
  - For example, in arm wrestling where there is no winner, the force exerted by each person is equal, but they are pushing in opposite directions. The resulting force (net force) is zero.

- Or, in a tug of war, if there is no movement in the rope, the two teams are exerting equal, but opposite forces that are balanced. Again, the resulting force (net force) is zero.

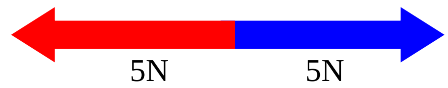

Figure 2. Equal force (SCDE, 2005).

Unbalanced forces are not equal, and they always cause the motion of an object to change the speed and/or direction that it is moving.

- When two unbalanced forces are exerted in opposite directions, their combined force is equal to the difference between the two forces.
- The magnitude and direction of the net force affects the resulting motion
- This combined force is exerted in the direction of the larger force
- For example, if two students push on opposite sides of a box sitting on the floor, the student on the left pushes with less force (small arrow) on the box than the student on the right side of the box (long arrow).
- The resulting action (net force: smaller arrow to the right of the = shows that the box will change its motion in the direction of the greater force as shown below:

Figure 3. Unbalanced force (SCDE, 2005).

- Or, if in a tug of war, one team pulls harder than the other, the resulting action (net force) will be that the rope will change its motion in the direction of the force with the greater strength/magnitude as shown below:

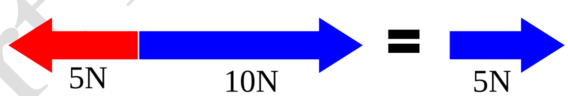

Figure 4. Greater force (SCDE, 20015).

- If unbalanced forces are exerted in the same direction, the resulting force (net force) will be the sum of the forces in the direction the forces are applied.
  - For example, if two people pull on an object at the same time in the same direction, the applied force on the object will be the result of their combined forces (net force or longer arrow to the right of the =) as shown below:

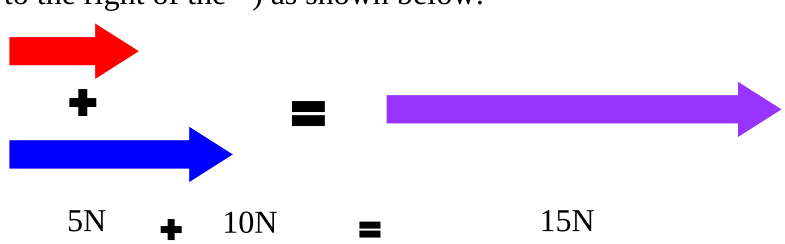

Figure 5. Net force right (SCDE, 2005).

- When forces act in the same direction, their forces are added. When forces act in opposite directions, their forces are subtracted from each other.
- Unbalanced forces also cause a nonmoving object to change its motion
- If there is no net force acting on the object, the motion does not change. If there is net force acting on an object, the speed of the object will change in the direction of the net force.

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 engagement
- Students could investigate pressure. Pressure=force/area

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 (9-12):** **H.P.2B.1**: Plan and conduct controlled scientific investigations involving the motion of an object to determine the relationships among the net force on the object, its mass, and its acceleration, and analyze collected data to construct an explanation of the object's motion using Newton's second law of motion.

Physical Science: Forces and Motion

Standard 8.P.2 The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.

8.P.2A. Conceptual Understanding: Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.

Performance Indicator	**8.P.2A.3:** Construct explanations for the relationship between the mass of an object and the concept of inertia (Newton's First Law of Motion).
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. Cause and Effect

Essential Learning Experiences:
It is essential that students construct explanations for the relationship between the mass of an object and the concept of inertia. Newton's First Law states, "The velocity of an object will remain constant unless a net force acts on it." It is often call the Law of Inertia.

- If an object is moving, it will continue moving with a constant velocity (in a straight line and with a constant speed) unless a net force acts on it.
- If an object is at rest, it will stay at rest unless a net force acts on it.
- Inertia is the tendency of the motion of an object to remain constant in terms of both speed and direction. (Note: Speed with a directional component is known as velocity.)
- The amount of inertia that an object has is dependent on the object's mass. The more mass an object has the more inertia it has.
- If an object has a large amount of inertia (due to a large mass)
    - It will be hard to slow it down or speed it up of it is moving.
    - It will be hard to make it start moving if it is at rest.
    - It will be hard to make it change direction.
- Examples of the effects of inertia might include:
    - Inertia causes a passenger in a car to continue to move forward even though the car stops. This is the reason that seat belts are so important for the safety of passengers.

- Inertia is the reason that it is impossible for vehicles to stop instantaneously.
- Inertia is the reason that it is harder to start pushing a wheelbarrow full of bricks than to start pushing an empty wheelbarrow. The filled wheelbarrow has more mass and therefore, more inertia.
- Inertia is also the reason that it is harder to stop a loaded truck going 55 miles per hour than to stop a car going 55 miles per hour. The truck has more mass resisting the change of its motion and therefore, more inertia.

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 study how momentum relates to inertia or practice how to calculate momentum with real-life data.

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 (9-12):** **H.P.2B.1**: Plan and conduct controlled scientific investigations involving the motion of an object to determine the relationships among the net force on the object, its mass, and its acceleration, and analyze collected data to construct an explanation of the object's motion using Newton's second law of motion. **H.P.2B.2**: Use a free-body diagram to represent the forces on an object

Physical Science: Forces and Motion

Standard 8.P.2 The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.	
8.P.2A. Conceptual Understanding: Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.	
Performance Indicator	**8.P.2A.4:** Analyze and interpret data to support claims that for every force exerted on an object there is an equal force exerted in the opposite direction (Newton's Third Law of Motion).
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 support claims for every force exerted on an object there is an equal force exerted in the opposite direction.
Newton's Third Law of Motion states, "When one object exerts a force on a second object, the second one exerts a force on the first that is equal in magnitude and opposite in direction."

- This law is sometimes called the "Law of Action and Reaction".
- Even though the forces are equal in magnitude and opposite in direction, they do not cancel each other. This law addresses two objects, each with only one force exerted on it.
  - Each object is exerting one force on the other object.
  - Each object is experiencing only one force.
- The action and reaction forces are reciprocal on an object.
  - Examples may include:
  - A swimmer swimming forward:
    - The swimmer pushes against the water (action force), the water pushes back on the swimmer (reaction force) and pushes her forward.
  - A ball is thrown against a wall:

  - The ball puts a force on the wall (action force), and the wall puts a force on the ball (reaction force) so the ball bounces off.
- A person is diving off a raft:
  - The person puts a force on the raft (action force) pushing it, and the raft puts a force on the diver (reaction force) pushing them in the opposite direction.
- A person pushes against a wall (action force), and the wall exerts an equal and opposite force against the person (reaction force).
- The Space Shuttle engines push out hot gases (action force), and the hot gases put a force on the shuttle engines (reaction force) so the shuttle lifts (there is no slingshot doing it!)

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.

- This standard refers to only a pair of forces with Newton's Third Law. Students could examine multiple force pairs in examples such as the multiple forces acting on a ball rolling down a ramp.

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 (9-12)** **H.P.2B.1:** Plan and conduct controlled scientific investigations involving the motion of an object to determine the relationships among the net force on the object, its mass, and its acceleration, and analyze collected data to construct an explanation of the object's motion using Newton's second law of motion. **H.P.2B.2:** Use a free-body diagram to represent the forces on an object. **H.P.2B.3:** Newton's Third Law of Motion to construct explanations of everyday phenomena (such as a hammer hitting a nail, the thrust of a rocket engine, the lift of an airplane wing, or a book at rest on a table) and identify the force pairs in each given situation involving two objects and compare the size and direction of each force.

Physical Science: Forces and Motion

Standard 8.P.2 The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.	
8.P.2A. Conceptual Understanding: Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.	
Performance Indicator	**8.P.2A.5:** Analyze and interpret data to describe and predict the effects of forces (including gravitational and friction) on the speed and direction of an object.
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

Essential Learning Experiences:
It is essential that students analyze and interpret data to describe and predict the effects that forces (including gravity and friction) can have on the speed and direction of an object.

- Gravity
  - Gravity is a force that always attracts or pulls objects toward each other without direct contact or impact.
  - Gravitational attraction depends on the mass of the two objects and the distance they are apart.
  - Objects on Earth are pulled toward the center of Earth.
  - The force of gravity, like all other forces, can cause changes in the speed of objects. As an object falls, its speed will continually increase as Earth's gravity continually pulls it downward. When air resistance is ignored, all objects regardless of mass will speed up at the same rate as they fall.
  - Gravity can also cause an object that is thrown into the air to change its upward motion, slow down, and fall back toward Earth's surface.

    - The pull of Earth's gravity keeps the Moon in orbit; the moon is constantly changing direction because of gravity. (Covered in 8.E.4B.2)
- Friction
    - Friction is a force that occurs when one object rubs against another object. Two factors determine the amount of friction – (1) the kinds of surfaces, and (2) the force pressing the surfaces together.
    - Friction is the force that acts to resist sliding between two surfaces that are touching. It can slow down or stop the motion of an object.
        - The slowing force of friction always acts in the direction opposite to the force causing the motion.
        - For example, friction slows or stops the motion of moving parts of machines.
        - Another example would be athletic shoes with tread grooves to increase friction have better traction for starting or stopping motion than smooth-soled dress shoes.
    - Friction can also be the force that makes it difficult to start an object moving. Enough force must be applied to a nonmoving object to overcome the friction between the touching surfaces.
    - The smoother the two surfaces are, the less friction there is between them; therefore, the moving object will not slow down as quickly.
        - Friction between surfaces can be reduced, in order for objects to move more easily, by smoothing the surfaces, using wheels or rollers between the surfaces, or lubricating/oiling the surfaces.
        - If friction could be removed, an object would continue to move.
    - The greater the force pushing the two surfaces together, the stronger friction prevents the surfaces from moving.
        - As an object gets heavier, the force of friction between the surfaces becomes greater.
        - To move a heavy object, a greater force must be applied to overcome the friction between the surfaces.

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 how to calculate acceleration due to gravity and to calculate weight. Students can differentiate between static, sliding, or rolling friction.

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	**Future Learning Connections (9-12):** **H.P.2.C.1**: Use a free-body diagram to represent the normal, tension (or elastic), applied, and frictional forces on an object. **H.P.2C.2**: Plan and conduct controlled scientific investigations to determine the variables that could affect the kinetic frictional force on an object. **H.P.2C.3**: Obtain and evaluate information to compare kinetic and static friction.

Physical Science: Forces and Motion

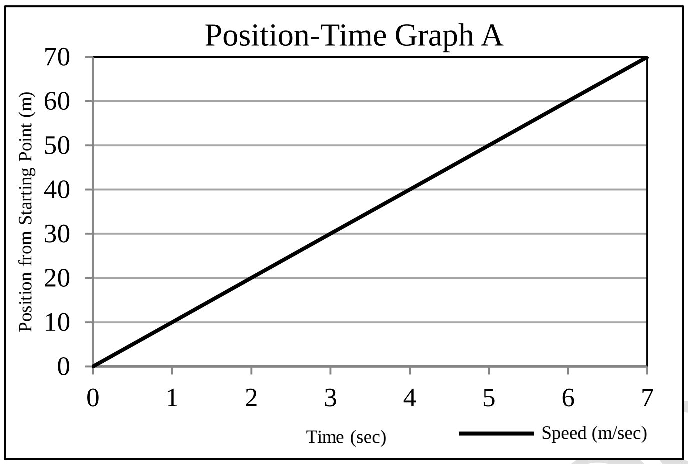
Standard 8.P.2 The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.	
8.P.2A. Conceptual Understanding: Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.	
Performance Indicator	**8.P.2A.6:** Use mathematical and computational thinking to generate graphs that represent the motion of an object's position and speed as a function of time.
Science and Engineering Practice	**S.1A.5:** Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) collect and analyze data, (3) express relationships between variables for models and investigations, or (4) use grade-level appropriate statistics to analyze data.
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

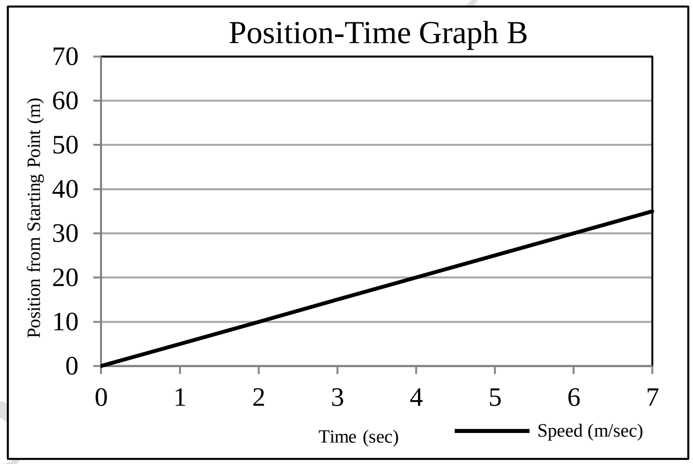
Essential Learning Experiences:
It is essential that students use mathematical and computational thinking to generate graphs:

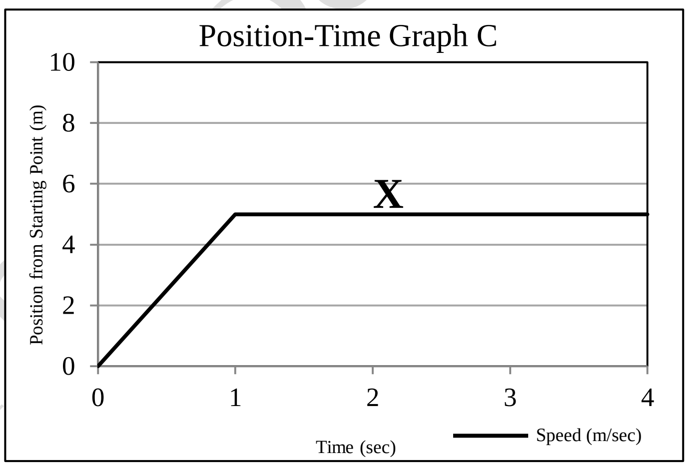
- Motion occurs when there is a change in position of an object with respect to a reference starting point.
- The final position of an object is determined by measuring the change in position and direction of the segments along a trip. The following terms are used to describe and determine motion:
- Position
  - Position is the location of an object. Position represents the distance the object has traveled from the starting point. The change in position is determined by the distance and direction (displacement).
  - An object changes position if it moves relative to a reference point.
- Direction
  - Direction is the line, or path along which something is moving, pointing, or aiming.
  - Direction is measured using a reference point with terms such as up, down, left, right, forward, backward, toward, away from, north, south, east, or west.

- Speed
  - The slope of the line can tell the relative speed of the object.
  - When the slope of the line is steep, the speed is faster (Graph A).
  - When the slope of the line is less steep, the speed is slower (Graph B).
  - When the slope of the line is horizontal to the x-axis, the speed is zero- the object is not moving (segment X on Graph C).

- Position-Time Graphs
  - A graph used to show a change in an object's location over time.
  - For this type of graph, time (the independent variable) is plotted on the x-axis and the position (the dependent variable) is plotted on the y-axis.







NOTE TO TEACHER: Classroom experiments should be designed so that time is being manipulated (the independent variable) and distance is the dependent variable.
It is essential for students to:

- Construct position/time graphs from data showing the distance traveled over time for selected types of motion (rest, constant velocity).
- Compare the shape of these three types of graphs and recognize the type of motion from the shape of the graph.

- Discuss in words the significance of the shapes of the graphs in terms of the motion of the objects.

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 learn about situations and calculate momentum problems.

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (9-12):** **H.P.2.A.1:** Plan and conduct controlled scientific investigations on the straight-line motion of an object to include an interpretation of the object's displacement, time of motion, constant velocity, average velocity, and constant acceleration.

Physical Science: Forces and Motion

Standard 8.P.2 The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.	
8.P.2A. Conceptual Understanding: Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.	
Performance Indicator	**8.P.2A.7:** Use mathematical and computational thinking to describe the relationship between the speed and velocity (including positive and negative expression of direction) of an object in determining average speed (v=d/t).
Science and Engineering Practice	**S.1A.5:** Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) collect and analyze data, (3) express relationships between variables for models and investigations, or (4) use grade-level appropriate statistics to analyze data.
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 Systems and System Models

Essential Learning Experiences:
It is essential that students use mathematical and computational thinking to describe the relationship between the speed and velocity of an object in determining average speed.

Average speed can be calculated by dividing the total distance the object travels by the total amount of time it takes to travel that distance.

- While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken.
- Speed measurements contain a unit of distance divided by a unit of time. Examples of units of speed might include "meters per second" (m/s), "kilometers per hour" (km/h), or "miles per hour" (mph or mi/hr).
- Average speed can be calculated using the formula v=d/t where the variables are:
    - **v** is the average speed of the object with units of m/s
    - **d** is the total distance or length of the path of the object with units of m
    - **t** is the total time taken to cover the path with units of s
    - Speed cannot have a negative value.

- Velocity refers to both the speed of an object and the direction of its motion. (For the intent of this indicator, disregard the direction of the motion.)
- A velocity value should have both speed units and direction units, such as m/sec north, km/h south, cm/s left, or km/min down.
- If an object is moving forward, it has positive velocity. When an object is moving backwards, it has negative velocity.
    - When you throw a ball in the air, it has positive velocity. When it heads back towards you, it has negative velocity.

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 how acceleration is the rate of change in velocity. Students may solve problems for time or distance.

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	**Future Learning Connections (9-12):** **H.P.2A.3:** Use mathematical and computational thinking to apply formulas related to an object's displacement, constant velocity, average velocity and constant acceleration. Interpret the meaning of the sign of displacement, velocity, and acceleration.

Physical Science: Waves

Standard 8.P.3 The student will demonstrate an understanding of the properties and behaviors of waves.	
8.P.3A. Conceptual Understanding Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.	
Performance Indicator	**8.P.3A.1:** Construct explanations of the relationship between matter and energy based on the characteristics of mechanical and light waves.
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

Essential Learning Experiences:
It is essential that students construct explanations of the relationship between matter and energy based on the characteristics of mechanical and light waves.

- A wave is a repeating disturbance or vibration that transfers or moves energy from place to place.
    - Waves are created when a source of energy (force) causes a vibration.
    - A vibration is a repeated back-and-forth or up-and-down motion.
    - Waves carry energy through empty space or through a medium without transporting matter.
    - While all waves can transmit energy through a medium, certain waves can also transmit energy through empty space.
    - A medium is a material through which waves can travel. It can be a solid, liquid, or gas.
    - When waves travel through a medium, the particles of the medium are not carried along with the wave.
    - When there is no medium, certain waves (electromagnetic) can travel through empty space.

Characteristics of mechanical and electromagnetic waves:

- Mechanical waves
  - Mechanical waves require the particles of the medium to vibrate in order for energy to be transferred.
  - For example, water waves, earthquake/seismic waves, sound waves, and the waves that travel down a rope or spring are also mechanical waves.
  - Sound waves, as with all mechanical waves, cannot be transferred or transmitted through empty space (vacuum).
- Light waves
  - Are considered electromagnetic waves which are waves that can travel through matter or empty space where matter is not present.
  - Visible light waves are the only part of the electromagnetic spectrum that the human eye can see. (Covered in 8.P.3A.5)

Another way to classify waves is by how they move:

- Mechanical waves in which the particles of matter in the medium vibrate by pushing together and moving apart parallel to the direction in which the wave travels are called compressional or longitudinal waves.
  - The place on the wave that is pushed together is called the compression and the place that is moving apart is the rarefaction.
  - Examples of mechanical compressional/longitudinal waves might include sound waves, the squeezing and stretching of a spring toy, and some seismic waves.
- Mechanical waves in which the particles of matter in the medium vibrate by moving back and forth and perpendicular (at right angles) to the direction the wave travels are called transverse waves.
  - The highest point of a transverse wave is the crest and the lowest point is called a trough. (Students are required to label these points in 8.P.3A.2)
  - Examples of mechanical transverse waves might include waves on a rope, and some seismic waves.
  - Light waves are transverse waves that can travel without a medium through empty space.

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 explore the mechanisms (the oscillations of the fields) by which energy is transferred through empty space.

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	**Future Learning Connections (9-12):** **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.3D.2:** Use the principle of superposition to explain everyday examples of resonance (including musical instruments and the human voice). **H.P.3D.3**: Develop and use models to explain what happens to the observed frequency of a sound wave when the relative positions of an observer and wave source changes (Doppler Effect). **H.P.3F.1**: Construct scientific arguments that support the wave model of light and the particle model of light. **H.P.3F.2**: Plan and conduct controlled scientific investigations to determine the interaction between the visible light portion of the electromagnetic spectrum and various objects (including mirrors, lenses, barriers with two slits, and diffraction gratings) and to construct explanations of the behavior of light (reflection, refraction, transmission, interference) in these instances using models (including ray diagrams)

Physical Science: Waves

Standard 8.P.3 The student will demonstrate an understanding of the properties and behaviors of waves.	
8.P.3A. Conceptual Understanding Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.	
Performance Indicator	**8.P.3A.2:** Develop and use models to exemplify the basic properties of waves (including frequency, amplitude, wavelength, and speed).
Science and Engineering Practice	**S.1A.2:** Develop and use 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

Essential Learning Experiences:
It is essential that students develop and use models to exemplify the basic properties of waves.

- Frequency
  - Frequency is a measure of how many waves pass a point in a certain amount of time.
  - The higher the frequency, the closer the waves are together and the greater the energy carried by the waves will be.
- Amplitude
  - Amplitude is a measure of the distance between a line through the middle of a wave and a crest or trough.
  - The greater the force that produces a wave, the greater the amplitude of the wave and the greater the energy carried by the wave.
  - In a transverse wave the higher the wave, the higher the amplitude.
  - Sounds with greater amplitude will be louder; light with greater amplitude will be brighter.
- Wavelength
  - Wavelength is a measure of the distance from the crest on one wave to the crest on the very next wave.
  - Shorter wavelengths are influenced by the frequency.
  - A higher frequency causes a shorter wavelength and greater energy.

- Speed
    - Speed is a measure of the distance a wave travels in an amount of time.
    - The speed of a wave is determined by the type of wave and the nature of the medium.
    - As a wave enters a different medium, the wave's speed changes. Waves travel at different speeds in different media.
    - All frequencies of electromagnetic waves travel at the same speed in empty space.

NOTE TO TEACHER: Properties of waves will be modeled using transverse waves.

- The highest point of a transverse wave is the crest and the lowest point is called a trough.

Model of a Transverse Wave

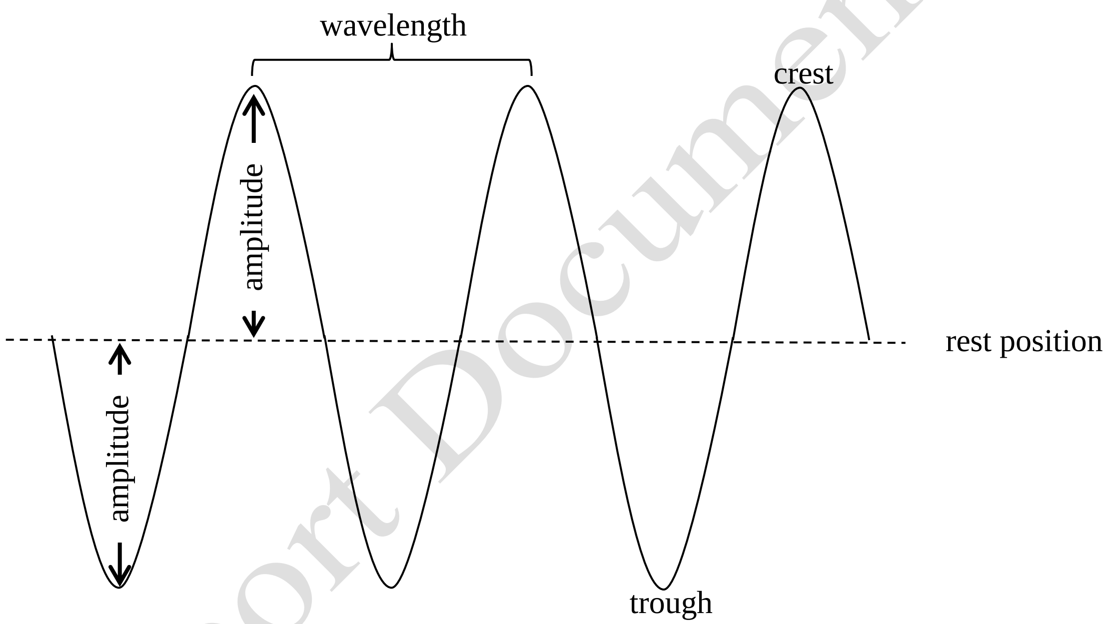
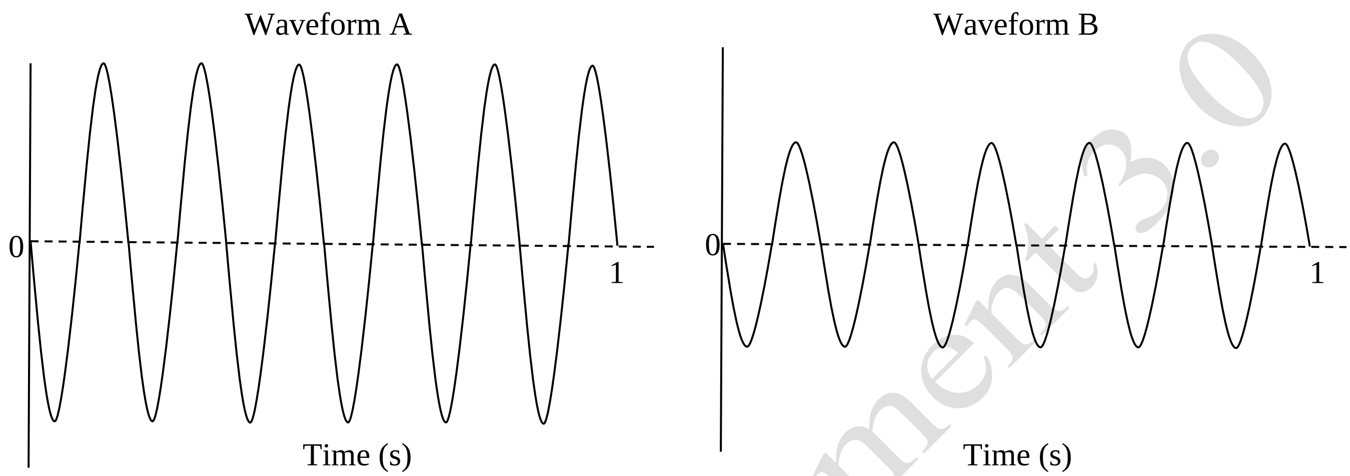
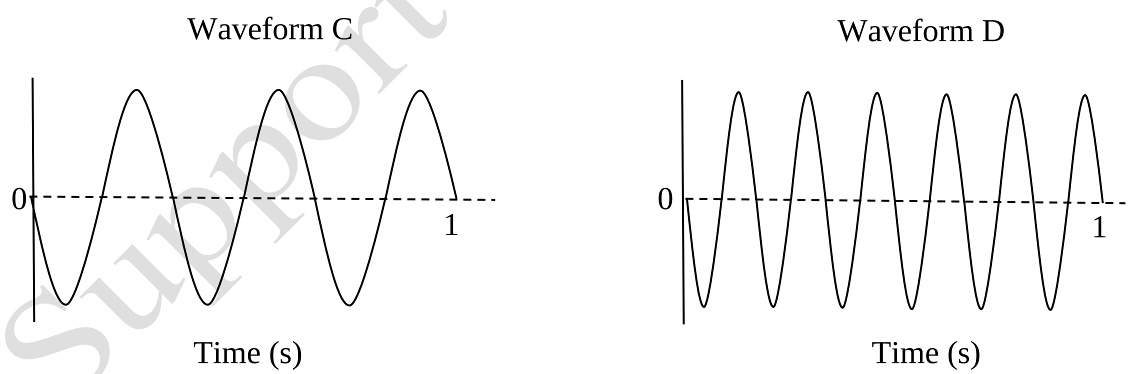


Figure 6. Transverse wave (SCDE, 2018).

- Frequency, amplitude, and wavelength will be modeled using wave forms.
- For example:



Which waveform has a greater amplitude? Waveform A
Which property do Waveforms A and B have in common? Wavelength
Which wave, A or B, carries greater energy? Waveform A: It has a greater amplitude.
What is the frequency shown in the two waveforms? 6 Hz



Which waveform has a greater frequency? Waveform D
Which property do these two waveforms have in common? Amplitude
Which wave carries greater energy? Waveform D: It has a higher frequency.
What is the frequency shown in Waveform C? 3 Hz

Figure 7. Waveforms (SCDE, 2018).

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 investigate how to calculate the speed of a wave or how to diagram these properties on a longitudinal wave.

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (9-12):** **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.3D.2:** Use the principle of superposition to explain everyday examples of resonance (including musical instruments and the human voice). **H.P.3D.3**: Develop and use models to explain what happens to the observed frequency of a sound wave when the relative positions of an observer and wave source changes (Doppler Effect). **H.P.3F.1**: Construct scientific arguments that support the wave model of light and the particle model of light. **H.P.3F.2:** Plan and conduct controlled scientific investigations to determine the interaction between the visible light portion of the electromagnetic spectrum and various objects (including mirrors, lenses, barriers with two slits, and diffraction gratings) and to construct explanations of the behavior of light (reflection, refraction, transmission, interference) in these instances using models (including ray diagrams)

Physical Science: Waves

Standard 8.P.3 The student will demonstrate an understanding of the properties and behaviors of waves.	
8.P.3A. Conceptual Understanding Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.	
Performance Indicator	**8.P.3A.3:** Analyze and interpret data to describe the behavior of waves (including refraction, reflection, transmission, and absorption) as they interact with various materials.
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 Structure and Function

Essential Learning Experiences:
It is essential that students analyze and interpret data to describe the behaviors of waves.
In addition to the properties of waves discussed 8.P.3A.2, waves have the following behaviors:

- Refraction
    - Refraction is the bending of waves caused by a change in their speed as they pass from one medium to another.
    - As waves pass at an angle from one medium to another, they may speed up or slow down.
    - The greater the change in speed of the waves, the more the waves will bend.
    - Refraction of light going from air through a convex lens, for example, can make images appear larger as the light waves bend.
    - Prisms or diffraction gratings separate white light into its different components or colors by bending the light at different angles depending on the frequencies of the light passing through the prism or diffraction grating. Different colors of light have different frequencies.

- Reflection
    - Reflection is the bouncing back of a wave when it meets a surface or boundary that does not absorb the entire wave's energy.
    - All types of waves can be reflected.
    - Reflections of sound waves, for example, are called echoes and help bats and dolphins learn about their environments.
    - Plane mirrors and other smooth surfaces reflect light to form clear images.
- Transmission
    - Transmission of waves occurs when waves pass through a given point or medium.
    - Sound waves are transmitted through solids, liquids, and gases.
    - Light waves are transmitted through transparent materials (may be clear or colored material such as filters) that allow most of the light that strikes them to pass through them.
    - Only a small amount of light is reflected or absorbed.
    - Opaque materials allow no light waves to be transmitted through them.
    - Translucent materials transmit some light, but cause it to be scattered so no clear image is seen.
- Absorption
    - Absorption of certain frequencies of light occurs when the energy is not transferred through, or reflected by, the given medium.
    - Objects or substances that absorb any wavelength of electromagnetic radiation become warmer and convert the absorbed energy to infrared radiation.

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 explore the quantitative relationships in refraction, reflection, absorption, or transmission of waves. Students may investigate the behavior of diffraction and polarization of light. Measuring angles of reflection or refraction can be investigated. Behaviors using concave lenses or convex mirrors and concave mirrors may also be investigated.

Assessment Guidelines:
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Learning Connections	**Previous Learning Connections (3-7):** **4.P.4A.1:** Construct scientific arguments to support the claim that white light is made up of different colors. **4.P.4A.5:** Plan and conduct scientific investigations to explain how light behaves when it strikes transparent, translucent, and opaque materials. **Future Learning Connections (9-12):** **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.3D.2**: Use the principle of superposition to explain everyday examples of resonance (including musical instruments and the human voice). **H.P.3D.3:** Develop and use models to explain what happens to the observed frequency of a sound wave when the relative positions of an observer and wave source changes (Doppler Effect). **H.P.3F.1**: Construct scientific arguments that support the wave model of light and the particle model of light. **H.P.3F.2**: Plan and conduct controlled scientific investigations to determine the interaction between the visible light portion of the electromagnetic spectrum and various objects (including mirrors, lenses, barriers with two slits, and diffraction gratings) and to construct explanations of the behavior of light (reflection, refraction, transmission, interference) in these instances using models (including ray diagrams)

Physical Science: Waves

Standard 8.P.3 The student will demonstrate an understanding of the properties and behaviors of waves.	
8.P.3A. Conceptual Understanding Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.	
Performance Indicator	**8.P.3A.4:** Analyze and interpret data to describe the behavior of mechanical waves as they intersect.
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 Cause and Effect Structure and Function

Essential Learning Experiences:
It is essential that students
- Waves interfere with each other.
- Interference may be constructive:
  - A crest will interfere with another crest constructively to produce a larger crest and a trough will interfere to produce a larger trough.
  - Compressions interfere constructively with each other as do rarefactions.
  - When constructive interference occurs waves are considered “in phase.” (In other words, the crests line up with crests and troughs line up with troughs.)
- Interference may be destructive:
  - A crest will interfere with a trough to lessen or cancel the displacement of each.
  - Compressions interfere with rarefactions to lessen or cancel the displacement of each.
  - When destructive interference occurs waves are considered “out of phase.” (In other words, the crests do not line up with crests and troughs do not line up with troughs.)

- Sound waves interfere with each other changing what you hear.
  - Destructive interference makes sounds quieter; constructive interference makes sounds louder.
  - Sound waves reflect in tubes or some musical instruments to produce standing waves which reinforce sound through constructive interference to make the sound louder.

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.

- This standard references sound, students can research interference in reference to light waves or ocean waves.

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (9-12):** **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.3D.2**: Use the principle of superposition to explain everyday examples of resonance (including musical instruments and the human voice). **H.P.3D.3:** Develop and use models to explain what happens to the observed frequency of a sound wave when the relative positions of an observer and wave source changes (Doppler Effect). **H.P.3F.1**: Construct scientific arguments that support the wave model of light and the particle model of light. **H.P.3F.2:** Plan and conduct controlled scientific investigations to determine the interaction between the visible light portion of the electromagnetic spectrum and various objects (including mirrors, lenses, barriers with two slits, and diffraction gratings) and to construct explanations of the behavior of light (reflection, refraction, transmission, interference) in these instances using models (including ray diagrams)

Physical Science: Waves

Standard 8.P.3 The student will demonstrate an understanding of the properties and behaviors of waves.	
8.P.3A. Conceptual Understanding Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.	
Performance Indicator	**8.P.3A.5:** Construct explanations for how humans see color as a result of the transmission, absorption, and reflection of light waves by various materials.
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. Structure and Function

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

- The interaction between the eye and light emitted or reflected by an object allows sight to occur as follows:
  - Light waves that have been emitted or reflected by an object, enter the eye and first pass through the transparent layer called the cornea where they are refracted.
  - The light rays are then refracted again as they pass through the transparent lens (convex).
  - The lens focuses the light waves on the retina, located on the back of the inside of the eye.
  - The retina is composed of tiny light sensitive nerves that transfer the energy of the light waves to nerve impulses transmitted through the optic nerve to the brain for interpretation as sight.
- The absorption and reflection of light waves by various materials results in human perception of color as follows:
  - Most materials absorb light of some frequencies and reflect the rest.
  - If a material absorbs a certain frequency of light, that frequency will not be reflected, so its color will not be perceived by the observer.

  - If the material does not absorb a certain frequency of light, that frequency will be reflected, so its color will be perceived by the observer.
  - If all colors of light are reflected by a material, it will appear white. If all colors of light are absorbed by a material, it will appear black.
- The color that we see depends on
  - (1) the color of light that is shined on the object and
  - (2) the color of light that is reflected by the object.
  - For example, if an object reflects red wavelengths and absorbs all others, the object will appear red in color.
- Color filters allow only certain colors of light to pass/transmit through them; they absorb or reflect all other colors.
  - For example, a blue filter only transmits blue light.
  - Objects seen through a blue filter will look blue if the objects reflect blue; objects of other colors will appear black because the other color wavelengths are being absorbed by the filter.

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 research knowledge about vision problems, such as being nearsighted or farsighted.
- Students may explore which frequencies of light are perceived as which colors. The mixing of primary colors of light or of primary pigments may also be investigated.

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Learning Connections	**Future Learning Connections (9-12):** **H.P.3F.1**: Construct scientific arguments that support the wave model of light and the particle model of light. **H.P.3F.2:** Plan and conduct controlled scientific investigations to determine the interaction between the visible light portion of the electromagnetic spectrum and various objects (including mirrors, lenses, barriers with two slits, and diffraction gratings) and to construct explanations of the behavior of light (reflection, refraction, transmission, interference) in these instances using models (including ray diagrams)

Physical Science: Waves

Standard 8.P.3 The student will demonstrate an understanding of the properties and behaviors of waves.	
8.P.3A. Conceptual Understanding Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.	
Performance Indicator	**8.P.3A.6:** Obtain and communicate information about how various instruments are used to extend human senses by transmitting and detecting waves (such as radio, television, cell phones, and wireless computer networks) to exemplify how technological advancements and designs meet human needs.
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. Cause and Effect

Essential Learning Experiences:
It is essential that students obtain and communicate information about how the electromagnetic spectrum depicts the range of all possible frequencies of electromagnetic radiation. Radio waves are classed as low frequency, high-wavelength energy waves, and gamma rays are classed as high-frequency, low-wavelength energy waves.

Signals that humans cannot sense directly can be detected through technological advances and designs. Radios, televisions, cell phones and wireless computer networks are examples of such technologies that are beneficial to humans by receiving and transmitting signals through radio waves. These signals are transmitted through a medium (which can include the air or fiber optic cables) and captured by the device. The higher the frequency of the radio wave, the more information it can carry. For example, the radio waves transmitted and received by wireless computer networks are at much higher frequencies than those used by other devices. Radios,

televisions, and cell phones cannot detect these waves that carry the enormous amounts of information required for internet usage.
The signals sent and received by radios, televisions, cell phones and wireless networks are often digitized (sent as wave pulses) as a more reliable way to transmit information. When in digitized form, information can be recorded, stored for future recovery, and transmitted over long distances without substantial loss.

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 develop models of antique and novel types of radios, televisions, cell phones and wireless networks to compare and contrast the parts of these devices that send and receive wave signals. Students may also plan and carry out investigations that determine which materials block and which materials transmit radio waves using a remote control car.

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (9-12):** **H.P.3F.1**: Construct scientific arguments that support the wave model of light and the particle model of light.

Earth Science: Earth's Place in the Universe

Standard 8.E.4: The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.	
8.E.4A Conceptual Understanding: Earth's solar system is part of the Milky Way Galaxy, which is one of many galaxies in the universe. The planet Earth is a tiny part of a vast universe that has developed over a span of time beginning with a period of extreme and rapid expansion.	
Performance Indicator	**8.E.4A.1:** Obtain and communicate information to model the position of the Sun in the universe, the shapes and composition of galaxies, and the measurement unit needed to identify star and galaxy locations.
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 Scale, Proportion and Quantity

Essential Learning Experiences:
It is essential that students obtain and communicate information to model the position of the Sun in the universe, the shapes and composition of galaxies, and the measurement unit needed to identify star and galaxy locations.

- The Sun is a star in the Milky Way galaxy located in a spiral arm about two-thirds of the way from the center of the galaxy.
- Galaxies are made up of gas, dust, and billions of stars and have different shapes
  - elliptical – spherical or flattened disks,
  - spiral – a nucleus of bright stars and two or more spiral arms, or
  - irregular – no definite shape
- Because distances in space are so great that conventional numbers are too large to work with, astronomers use a unit of measurement called light year to measure the distance to stars and galaxies in space. The distance in one light year is equal to the distance light travels in one year.

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 multiple historical figures that have contributed to our current understanding of the Sun's location in the Milky Way. The following are included:

- Johannes Kepler
- Galileo Galilei
- Tycho Brahe

Light travels 9.46 x 10^{12} km (5.88 x 10^{12} miles) in a year. This means that the light that we are seeing from objects in the sky is from the past. The light from our star leaves the surface of the Sun 8 minutes before it reaches us. The light from the nearest large galaxy, Andromeda, was emitted 2.5 million years ago. Therefore, the images we see of these objects are how they looked at the time in the past when their light left them. The further away an object is, the older the light is that we are receiving from it.

The shapes of galaxies can change over time as a result of various factors including collisions with other galaxies and the evolution of the galaxy itself.

Astronomers use a method called parallax to determine how far away stars are. Stars seem to shift their position when viewed from Earth because of Earth's revolution about the Sun. This is referred to as a parallax shift. Astronomers use the diameter of Earth's orbit to determine the parallax angle across the sky.

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Learning Connections	**Future Learning Connections (9-12):** **H.E.2A.1:** Construct explanations for how gravity and motion affect the formation and shapes of galaxies (including the Milky Way Galaxy).

Earth Science: Earth's Place in the Universe

Standard 8.E.4: The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.	
8.E.4A Conceptual Understanding: Earth's solar system is part of the Milky Way Galaxy, which is one of many galaxies in the universe. The planet Earth is a tiny part of a vast universe that has developed over a span of time beginning with a period of extreme and rapid expansion.	
Performance Indicator	**Performance Indicator** **8.E.4A.2** Construct and analyze scientific arguments to support claims that the universe began with a period of extreme and rapid expansion using evidence from the composition of stars and gases and the motion of galaxies in the universe.
Science and Engineering Practice	**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. Stability and Change Scale, Proportion and Quantity

Essential Learning Experiences:
It is essential that students construct scientific arguments to support claims that the universe began with a period of extreme and rapid expansion using evidence from the composition of stars and gases and the motion of galaxies in the universe.
The universe is composed of matter and energy. All of the matter in the universe now was in the universe when it formed. There is evidence to support that scientists are able to estimate the age of the universe in two ways

- by looking for the oldest stars
  - Nebula (gas and dust) exist in space and are remnants from the formation of the universe.
  - Stars undergo a life cycle based on the composition of the gases within them. As stars age the amount of hydrogen in the star changes, therefore changing the color and brightness of the star.
- by measuring the rate of expansion of the universe
  - Astronomers determined the galaxy is expanding based on the color of light emitted from galaxies and stars.
  - As the universe expands and galaxies move apart, the wavelength of light emitted from those galaxies is stretched. This shifts the light toward the red end of the spectrum and is called "red-shift". The more distance or faint a galaxy the more

rapidly it is moving away from Earth. As the galaxy moves away "red- shift" occurs.
    - Evidence from spectrometers can be used to demonstrate "red-shift."

NOTE TO TEACHER: "Blue shift" occurs when a galaxy moves toward the observer.

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.

- Knowledge of the movement of galaxies and stars has advanced as we have made developments in space technology.
- Students can develop models to show how expansion results in an increase in wavelength which produces red-shift.
- Students can research additional resources regarding the evidence scientists use to support the argument that the universe is expanding as well as the age of the universe.

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (9-12): H.E.2A.4:** Construct and analyze scientific arguments to support claims about the origin of the universe (including the red-shift of light from distant galaxies, the measured composition of stars and nonstellar gases, and the cosmic background radiation).

Earth Science: Earth's Place in the Universe

Standard 8.E.4 The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.	
8.E.4B: Conceptual Understanding: Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.	
Performance Indicator	**8.E.4B.1:** Obtain and communicate information to model and compare the characteristics and movements of objects in the solar system (including planets, moons, asteroids, comets, and meteors).
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. Systems and System Models

Essential Learning Experiences:
It is essential that students obtain and communicate information to model and compare the characteristics and movements of objects in the solar system (including planets, moons, asteroids, comets, and meteors).

Objects found in the solar system have characteristics based on surface features and atmosphere (if there is one). These objects move via orbit/revolution and/or rotation.

- Planets
  - There are 8 unique planets (Mercury, Venus, Earth, Mars, Jupiter, Uranus, Saturn, Neptune) in our solar system.
  - Planets may have either a terrestrial/rocky surface or a gaseous surface. Gaseous planets are considerably larger than terrestrial planets.
  - Planets may have rings or other unique surface characteristics.
  - Movement of planets is based on revolution around the Sun and rotation on the planet's axis.
- Moons
  - Moons are studied in relation to the planet they orbit. Not all planets have moons.
  - Most are rocky bodies covered with craters, but some have unique characteristics.

    - Movement of moons is based on revolution around their planets and rotation on their axis.
- Asteroids
    - Most asteroids are rocky bodies that orbit in a region in the solar system known as the Asteroid Belt between Mars and Jupiter.
    - They vary in size and shape.
    - Movement is based on their revolution around the Sun.
    - Some asteroids outside the asteroid belt have orbits that cross Earth's orbit, which require scientists to monitor their positions.
- Comets
    - Comets have a main body or head (ice, methane and ammonia and dust) and a tail that emerges as the comet gets closer to the Sun during its orbit.
    - The effects of the solar winds result in the tail always points away from the Sun.
    - Comets have long, narrow, elliptical orbits that cause them to cross paths with other objects in the solar system.
    - Most comets originate from regions of the solar system that lie beyond the orbit of Neptune.
- Meteors
    - Meteors are chunks of rock that burn upon entering a planet's atmosphere.
    - Prior to entering the atmosphere the chunks of rock move about within the solar system and are known as meteoroids.
    - When the chunk of rock strikes the surface of a planet or moon it is known as a meteorite.

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.

- Factors affecting the appearance of impact craters include the size, mass, speed and angle of the falling object.
- Planetary motions around the Sun can be predicted using Kepler's three empirical laws, which can be explained based on Newton's theory of gravity.
- Students can research the likelihood that Earth will be struck by a large object from space, what might be the outcome of such a collision (students can look at historical impacts as well as predict the results of future impacts), what we are doing to identify those objects, and what we might be able to do to avoid such collisions.
- Students can research dwarf planets and argue from scientific information as to whether or not this new classification is needed.

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Learning Connections	**Previous Learning Connections (3-7):** **4.E.3A.1:** Develop and use models of Earth's solar system to exemplify the location and order of the planets as they orbit the Sun and the main composition (rock or gas) of the planets. **Future Learning Connections (9-12):** **H.E.2B.1:** Analyze and interpret data to compare the properties of Earth and other planets (including composition, density, surface expression of tectonics, climate, and conditions necessary for life). **H.E.2B.2:** Obtain, evaluate, and communicate information about the properties and features of the moon to support claims that it is unique among other moons in the solar system in its effects on the planet it orbits.

Earth Science: Earth's Place in the Universe

Standard 8.E.4: The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.	
8.E.4B Conceptual Understanding: Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.	
Performance Indicator	**8.E.4B.2:** Construct explanations for how gravity affects the motion of objects in the solar system and tides on Earth.
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 Cause and Effect

Essential Learning Experiences:
It is essential that students construct explanations for how gravity affects the motion of objects in the solar system and tides on Earth.

- Tides and planetary orbits are caused by the pull of gravity.
- Effects of Mass and Distance on Gravitational Force
  - The more massive an object, the greater its gravitational pull.
  - The closer the distance between objects, the greater the gravitational pull
  - The gravitational pull between the Sun and the planets and between Earth and its Moon cause distinct motions between and among these bodies
- Effects of Gravity on Planetary Orbits
  - The Sun's gravitational attraction, along with the planet's inertia (continual forward motion), keeps the planets moving in elliptical orbits (Earth's orbit is slightly oval) and determines how fast they orbit.
  - Planets nearer the Sun move/orbit faster than planets farther from the Sun because the gravitational attraction is greater.
  - When a planet is farther from the Sun, the gravitational attraction between them decreases and the planet moves/orbits slower.
- Effects of Gravity on Tides
  - Since the Moon is closer to Earth than the Sun (distance), the Moon has the greatest pulling effect on tides, the rise and fall of Earth's waters.
  - The Sun also pulls on Earth

- The sun can combine its gravitational force with the Moon causing even higher tides, spring tides. Spring tides are seen at full and new moon phases.
- Neap tides, small differences between high and low tide, are seen when the moon is in the first quarter and third quarter phases and the Moon and the Sun are perpendicular to one another (with respect to the Earth).

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.

- Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.

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Learning Connections	**Future Learning Connections (9-12):** **H.E.2B.2:** Obtain, evaluate, and communicate information about the properties and features of the moon to support claims that it is unique among other moons in the solar system in its effects on the planet it orbits.

Earth Science: Earth's Place in the Universe

Standard 8.E.4 The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.	
8.E.4B Conceptual Understanding: Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.	
Performance Indicator	**8.E.4B.3:** Develop and use models to explain how seasons, caused by the tilt of Earth's axis as it orbits the Sun, affects the length of the day and the amount of heating on Earth's surface.
Science and Engineering Practice	**S.1A.2:** Develop and use 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

Essential Learning Experiences:
It is essential that students develop and use models to explain how seasons, caused by the tilt of Earth's axis as it orbits the Sun, affects the length of the day and the amount of heating on Earth's surface.

- The Earth's axis remains pointed in the same direction at all times as the Earth revolves around the Sun.
- The combination of the revolution around the Sun and the fixed angle of the Earth's axis result in the following seasonal changes: temperature changes, angle of sunlight, number of daylight hours.
- As Earth revolves around the Sun, the tilt of its axis (23½ degrees) determines the amount of time that the Sun is shining on a specific portion of Earth. The tilt remains at the same angle and points in the same direction as Earth revolves around the Sun. This difference in the amount of time that an area receives sunlight results in changes in the length of day.
- When the tilt of Earth is toward the Sun in a particular hemisphere, there is a longer length of day and the season is summer.
- When both hemispheres are receiving the same amount of sunlight, the length of day and night is equal. This occurs in fall/autumn and spring.
- When the tilt of Earth is away from the Sun in a particular hemisphere, there is a shorter length of day and the season is winter.

- The combination of direct rays from the Sun that strike Earth at higher angles (closer to 90 degrees) and more daylight hours causes the hemisphere of Earth tilted toward the Sun to have warmer temperatures.
- The combination of indirect rays from the Sun that strike Earth at lower angles and less hours of daylight in the hemisphere of Earth angled away from the Sun have cooler temperatures.

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.

- At latitudes beyond 66.5 degrees north and south (the Arctic Circle and Antarctic Circle), there are "days" and "nights" that last for a month or for months. During the "day" period, the Sun never fully sets and during the "night" period the Sun never fully rises.
- The only region of the Earth that ever receives sunlight at 90 degrees is between the Tropics of Cancer (23.5 degrees north) and Capricorn (23.5 degrees south).
- The changes in seasons affect living things in many different ways. These changes can stimulate living things to enter dormancy or hibernation, enter into courtship behaviors, develop structures for reproduction, and/or many other responses.
- Over the course of Earth's history, the Earth's axis has wobbled. This means that the Earth's axis has not always been pointed in the same direction. When combined with variations in the tilt of the Earth's axis and the distance the Earth is from the Sun, the result is an approximately 100,000 year cycle of ice ages.
- Migratory animals sense the change in the amount of daylight (photoperiod) and respond by migrating.

Assessment Guidelines:
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Learning Connections	**Previous Learning Connections (3-7):** **4.E.3B.2:** Construct explanations of how day and night result from Earth's rotation on its axis. **4.E.3B.4:** Develop and use models to describe the factors (including tilt, revolution, and angle of sunlight) that result in Earth's seasonal changes. **Future Learning Connections (9-12):** **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).

Earth Science: Earth's Place in the Universe

Standard 8.E.4 The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.	
8.E.4B Conceptual Understanding: Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.	
Performance Indicator	**8.E.4B.4:** Develop and use models to explain how motions within the Sun-Earth-Moon system cause Earth phenomena (including day and year, Moon phases, solar and lunar eclipses, and tides).
Science and Engineering Practice	**S.1A.2:** Develop and use 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

Essential Learning Experiences:
It is essential that students develop and use models to explain how motions within the Sun-Earth-Moon system cause Earth phenomena (including day and year, Moon phases, solar and lunar eclipses, and tides).

All bodies in the solar system are in constant motion.

- Day
  - The Earth rotates on its axis as it revolves around the Sun. It takes approximately 24 hours, a day, for a complete rotation to occur. This counterclockwise motion occurs from west to east, causing the Sun to appear to rise in the east and set in the west.
- Year
  - While the Earth rotates on its axis, it is also revolving around the Sun. It takes 365 ¼ days, a year, for this motion/orbit to occur.
  - The Earth revolves around the Sun in an elliptical orbit.
- Lunar Movement
  - The Moon rotates on its axis and revolves around the Earth as the Earth revolves around the Sun.
  - It takes about 27 Earth days for the Moon to rotate on its axis and about 29 ½ Earth days (month) for it to revolve around the Earth.
  - Because the Moon's period of rotation on its axis and period of revolution around the Earth are nearly the same, the same side of the Moon always faces Earth.

  - Changes in the Moon's position as it revolves around the Earth results in more or less of the sunlight reflected from the Moon being visible when observing the Moon from the Earth. This causes the Moon to appear to change shape.
- Phases of the Moon
  - New Moon - The Moon is positioned between the Sun and the Earth so that the side of the Moon that is viewed from Earth is cannot be seen. Because of this, there appears to be no Moon in the night sky.
  - Full Moon - The Sunlit portion of the Moon is facing the Earth while the Earth is positioned between the Sun and Moon. The Moon is visible in the sky.
  - The Sunlit portion of the Moon that is visible from Earth appears to either increases (waxes) or decreases (wanes), as the Moon orbits the Earth.
  - Crescent Moon-either waxing or waning; less than ½ of the Sunlit portion of the Moon is visible.
  - Gibbous Moon-either waxing or waning; Greater than ½ of the Sunlit portion of the Moon is visible.
  - First/Third Quarter-1/2 of the sunlit portion of the Moon is visible.
    - A first quarter follows the waxing crescent.
    - A third quarter occurs when ½ of the Moon is visible.
- Eclipses
  - Eclipses occur when an object in space passes directly between two other objects or between the object and the viewer.
  - A solar eclipse occurs when the Moon passes directly between the Sun and Earth, blocking the Sun's light and casting a shadow over a certain area on Earth. This can only occur during a New Moon.
  - A lunar eclipse occurs when Earth passes directly between the Sun and the Moon, blocking the Sun's light so that Earth's shadow hits the Moon casting a shadow over the Moon. This can only occur during a Full Moon.
  - An eclipse does not occur at every New Moon and Full Moon because of the angle of the Moon's orbit around the Earth.
- Tides
  - Tides are the rise and fall of the surface levels of Earth's ocean water caused by the gravitational effects of the Sun and Moon on Earth. The effects of tides are most noticeable along ocean shorelines.
  - As the Moon orbits Earth, the waters of Earth closest to the Moon bulge outward toward the Moon. This bulge is the high tide. Another high tide occurs on the opposite side of Earth. Low tides occur in the areas between the two high tides.
  - As the Earth rotates on its axis, any given location will rotate into and out of the tidal bulge. This results in the changes between high and low tides over the course of 24 hours.
  - When the Sun and the Moon are aligned so that the Moon is between the Sun and the Earth (New Moon) or the Earth is between the Sun and the Moon (Full Moon) high tides are higher and the low tides are lower. These are called spring tides. When the Sun and the Moon are at right angles to each other (first and last quarter), lower high tides and higher low tides are experienced. These tides are called neap tides.

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.

- Scientists can study the top layer of the Sun during some solar eclipses. The Moon blocks the brightest rays of sunlight. This makes it easier for scientists to see the top layer of the Sun.
- If the Earth had no atmosphere, then the Moon would be completely black during a total eclipse. Instead, the Moon can take on a range of colors from dark brown and red to bright orange and yellow. The exact appearance depends on how much dust and clouds are present in Earth's atmosphere. Total eclipses tend to be very dark after major volcanic eruptions since these events dump large amounts of volcanic ash into Earth's atmosphere.
- The orbit of the Moon around the Earth is inclined about 5.1 degrees when compared to the Earth's orbit around the Sun. This is the reason that eclipses do not occur with every New and Full Moon; the shadows do not line up.
- The Moon orbiting the Earth affects the timing of high and low tides. This results in these tides occurring at different times every day.

Assessment Guidelines:
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Learning Connections	**Previous Learning Connections (3-7):** **4.E.3B.1:** Analyze and interpret data from observations to describe patterns in the (1) location, (2) movement, and (3) appearance of the Moon throughout **Future Learning Connections (9-12):** **H.E.2B.2:** Obtain, evaluate, and communicate information about the properties and features of the moon to support claims that it is unique among other moons in the solar system in its effects on the planet it orbits.

Earth Science: Earth's Place in the Universe

Standard 8.E.4 The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.	
8.E.4B Conceptual Understanding: Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.	
Performance Indicator	**8.E.4B.5:** Obtain and communicate information to describe how data from technologies (including telescopes, spectroscopes, satellites, space probes) provide information about objects in the solar system and the universe.
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

Essential Learning Experiences:
It is essential that students obtain and communicate information to describe how data from technologies (including telescopes, spectroscopes, satellites, space probes) provide information about objects in the solar system and the universe.

Astronomers use telescopes, satellites, space probes, and spectroscopes to make observations and collect data about objects inside the solar system and outside the solar system. These tools and the associated technology that allow astronomers to analyze and interpret the data help scientists learn about the solar system and about the universe.

- Telescopes
  - Refractor telescopes use convex lenses to bend and focus light rays to produce images of objects in space.
  - Reflector telescopes use mirrors to focus light rays to produce images of objects in space.
  - Radio telescopes receive radio waves emitted from objects in space, including waves from very distant stars and galaxies. Then the radio waves are used to produce images of the objects from sound waves. Radio telescopes receive information in any weather and during day or night.

- Other telescopes “read” infrared or x-ray signals but have to be placed where Earth’s atmosphere does not block or absorb the signals.
- Satellites and Space Observatories
  - Satellites are placed in orbit around Earth with special instruments and telescopes that collect information from space. The information is sent back to Earth where it is interpreted.
  - Space Observatories are telescopes or other instruments that have been launched into outer space to collect data on distant planets, galaxies, and other celestial bodies. The Hubble Space Telescope is an example of a space observatory.
  - Data gathered from satellites and space observatories are not hampered by Earth’s atmosphere.
- Space probes
  - Space probes contain instruments to collect data and travel out of Earth’s orbit to explore places that would be too dangerous for astronomers; the instruments that a probe contains depends upon the space mission.
- Spectroscopes
  - Spectroscopes collect the light from distant stars and separate that light into bands of different colors; by studying these bands, astronomers identify the elements in a star.

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.
- Remote sensing data is used to provide information about bodies in space. Students can review this data to determine how scientists use it to refine our understanding of the universe. One area of current research is the search for exoplanets. Data is collected from a variety of sources to determine the location of planets outside of our solar system. As more accurate data is collected, planets of smaller sizes are being located.

Assessment Guidelines:
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Learning Connections	**Previous Learning Connections (3-7):** **4.E.3A.3:** Construct scientific arguments to support claims about the importance of astronomy in navigation and exploration (including the use of telescopes, astrolabes, compasses, and sextants). **Future Learning Connections (9-12):** **H.E.2A.5:** Obtain and evaluate information to describe how the use of x-ray,

	gamma-ray, radio, and visual (reflecting, refracting, and catadioptric) telescopes and computer modeling have increased the understanding of the universe.

Earth Science: Earth's Place in the Universe

Standard 8.E.4: The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.	
8.E.4B Conceptual Understanding: Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.	
Performance Indicator	**8.E.4B.6:** Analyze and interpret data from the surface features of the Sun (including photosphere, corona, sunspots, prominences, and solar flares) to predict how these features may affect Earth.
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 Energy and matter Structure and function Cause and effect

Essential Learning Experiences:
It is essential that students analyze and interpret data from the surface features of the Sun (including photosphere, corona, Sunspots, prominences, and solar flares) to predict how these features may affect Earth.

- The photosphere is the visible surface of the Sun that emits the light that we see. It is the lowest layer of the Sun's atmosphere.
- The corona, the outermost layer of the Sun's atmosphere, also emits light but is only visible as a white halo during a solar eclipse.
- Sunspots appear as dark spots on the photosphere. They are actually moving areas of magnetic activity with temperatures that are cooler than the area of the photosphere in which they are located. Astronomers study Sunspot cycles to learn how changes in solar activity affect life on Earth.
- Prominences are bright arch-like loops that may erupt from the photosphere into the corona. Often associated with Sunspot activity, they release large amounts of energy into outer space.
- Solar flares occur near Sunspots and are sudden, intense explosions that result in changes in brightness when magnetic energy is released. The charged particles released by solar flares are often detected in Earth's atmosphere. The energy released from solar flares

can cause damage to the International Space Station, disrupt radio and electrical transmissions on Earth, and cause displays of bright lights, auroras, that appear to "dance" in the skies near the North and South Poles.

- Solar wind occurs when the corona sends out electrically charged particles. Most of these particles do not reach Earth's surface because of the atmosphere and magnetic field around Earth.
- Near the poles, the auroras can form when these charged particles cause gases in the atmosphere to glow.
- Solar flares and prominences increase the particles in the solar wind that in turn affect magnetic storms in Earth's atmosphere.
- Magnetic storms often disrupt radio, telephone, and television signals.

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 describe how these activities can release energies and particles that can interact with living things and man-made objects.

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Learning Connections	**Previous Learning Connections (3-7):** **4.E.3B.3:** Construct explanations of how the Sun appears to move throughout the day using observations of shadows.

Earth Science: Earth Systems and Resources

Standard 8.E.5: The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.	
8.E.5A Conceptual Understanding : All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. Because Earth's processes are dynamic and interactive in nature, the surface of Earth is constantly changing. Earth's hot interior is a main source of energy that drives the cycling and moving of materials. Plate tectonics is the unifying theory that explains the past and current crustal movements at the Earth's surface. This theory provides a framework for understanding geological history.	
Performance Indicator	**8.E.5A.1:** Develop and use models to explain how the process of weathering, erosion, and deposition change surface features in the environment.
Science and Engineering Practice	**S.1A.2:** Develop and use 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 Stability and Change

Essential Learning Experiences:
It is essential that students develop and use models to explain how the processes of weathering, erosion, and deposition change surface features in the environment.
Weathering, erosion, and deposition are processes that act together to wear down and builds up Earth's surface. These processes have occurred for billions of years.

- Weathering is any process that breaks down rocks and creates sediments.
  - There are two forms of weathering, chemical and mechanical (physical).
    - Chemical weathering is decomposition of rock caused by chemical reactions resulting in formation of new compounds.
    - Mechanical (physical) weathering is the breakdown of rock into smaller pieces.
- Erosion is the process by which natural forces move weathered rock and soil from one place to another.
  - Gravity, running water, glaciers, waves, and wind all cause erosion. The material moved by erosion is sediment.
- Deposition occurs when the agents (wind or water) of erosion lay down sediment.
- Deposition changes the shape of the land.

Erosion, weathering, and deposition are at work everywhere on Earth. Gravity pulls everything toward the center of Earth causing rock and other materials to move downhill. Water's movements (both on land and underground) cause weathering and erosion, which change the land's surface features and create underground formations. The effects of these processes are as follows:

- Changes in shape, size, and texture of landforms (i.e. mountains, riverbeds, and beaches).
- Landslides
- Buildings, statues, and roads wearing away.
- Soil formation
- Washes soil, pollutants, harmful sediments into waterways.
- Causes metals to rust
- Reduces beaches, shorelines.
- Creates new landforms.

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 research the effects of beach renourishment or clear cutting for development. They could pose arguments for or against these practices, or problems and solutions related to these.

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Learning Connections	**Previous Learning Connections (3-7):** **3.E.4B.2:** Plan and conduct scientific investigations to determine how natural processes (including weathering, erosion, and gravity) shape Earth's surface. **5.E.3B.1:** Analyze and interpret data to describe and predict how natural processes (such as weathering, erosion, deposition, earthquakes, tsunamis, hurricanes, or storms) affect Earth's surface. **Future Learning Connections (9-12):** **H.E.3A.6:** Develop and use models to explain how various rock formations on the surface of Earth result from geologic processes (including weathering, erosion, deposition, and glaciation). **H.E.3A.7**: Plan and conduct controlled scientific investigations to determine the factors that affect the rate of weathering.

Earth Science: Earth Systems and Resources

Standard 8.E.5: The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.	
8.E.5A Conceptual Understanding: All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. Because Earth's processes are dynamic and interactive in nature, the surface of Earth is constantly changing. Earth's hot interior is a main source of energy that drives the cycling and moving of materials. Plate tectonics is the unifying theory that explains the past and current crustal movements at the Earth's surface. This theory provides a framework for understanding geological history.	
Performance Indicator	**8.E.5A.2:** Use the rock cycle model to describe the relationship between the processes and forces that create igneous, sedimentary, and metamorphic rocks.
Science and Engineering Practice	**S.1A.2:** Develop and use 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 Stability and Change

Essential Learning Experiences:
It is essential that students to use models to describe the relationship between the processes and forces that create igneous, sedimentary, and metamorphic rocks.

There are three large classifications of rocks – igneous, metamorphic, and sedimentary. Each type of rock is formed differently and can change from one type to another over time. The way rocks are formed determines how we classify them.

- Igneous
  - Forms when molten rock (magma or lava) cools and hardens, or solidifies.
  - If cooling takes place slowly beneath Earth's surface, the igneous rock is called intrusive.
  - If the cooling takes place rapidly on Earth's surface, the igneous rock is called extrusive.
- Metamorphic
  - Forms when rocks are changed into different kinds of rocks by great heat and/or pressure – they are heated, squeezed, folded, or chemically changed by contact with hot fluids and/or tectonic forces.
  - When heat and pressure reach the rock's melting point, it melts into magma.

- Sedimentary
  - Forms from the compaction and/or cementation of rock pieces, mineral grains, or shell fragments called sediments.
  - Sediments are formed through the processes of weathering and erosion of rocks exposed at Earth's surface.
  - Sedimentary rocks can also form from the chemical depositing of materials that were once dissolved in water.

The rock cycle is an ongoing process. The sample diagram illustrates the series of natural processes that can change rocks from one kind to another:

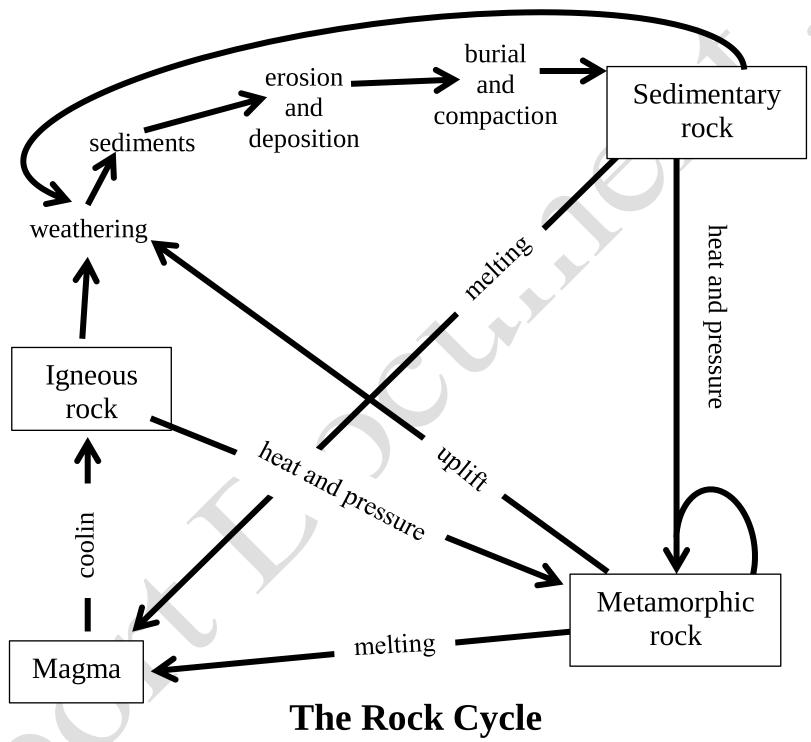

Figure 8. Rock Cycle (SCDE, 2018).

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.

- Rocks are used for building and construction based on their properties.
- When slow cooling magma is ejected before it has completely cools, the resulting igneous rock will have a mixture of macroscopic and microscopic mineral crystals (porphyritic texture: both intrusive and extrusive features).

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Learning Connections	**Previous Learning Connections (3-7): 3.E.4A.1:** Analyze and interpret data from observations and measurements to describe and compare different Earth materials (including rocks, minerals, and soil) and classify each type of material based on its distinct physical **Future Learning Connections (9-12):** **H.E.3A.5:** Analyze and interpret data to describe the physical and chemical of minerals and rocks and classify each based on the properties and environment in which they were formed.

Earth Science: Earth Systems and Resources

Standard 8.E.5 The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.	
8.E.5A Conceptual Understanding: All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. Because Earth's processes are dynamic and interactive in nature, the surface of Earth is constantly changing. Earth's hot interior is a main source of energy that drives the cycling and moving of materials. Plate tectonics is the unifying theory that explains the past and current crustal movements at the Earth's surface. This theory provides a framework for understanding geological history.	
Performance Indicator	**8.E.5A.3:** Obtain and communicate information about the relative position, density, and composition of Earth's layers to describe the crust, mantle, and core.
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

Essential Learning Experiences:
It is essential that students to obtain and communicate information about the relative position, density, and composition of Earth's layers (crust, mantle and core).

The Earth is approximately 6,400 kilometers (4,000 miles) from surface to center. Earth has layers that have specific conditions and composition.

Layer	Relative Position	Density	Composition
Crust	• Outermost layer • Oceanic crust is thinner than continental crust • Crust and top of mantle are called the lithosphere	• Least dense layer of all • Oceanic crust (basalt) is more dense than continental crust (granite)	• Solid rock made of mostly silicon and oxygen • Oceanic crust- basalt • Continental crust- granite
Mantle	• Middle layer • Thickest layer • Top portion called the asthenosphere	• Density increases with depth due to increasing pressure	• Hot softened rock • Contains iron and magnesium
Core	• Inner layer • Two parts - outer core and inner core	• Most dense layer	• Mostly iron and nickel • Outer core - slow flowing liquid • Inner core- a spinning solid

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.

- Scientists have been able to identify the composition of inner and outer core based on the movement of seismic waves through the Earth's layers.
- Scientists have been able to identify the composition of the mantle based on the movement of seismic waves through the earth's layers as well as materials ejected from volcanic activity. Most lava that erupts during volcanic activity is actually just melted crust and is not material from the mantle and/or the core.
- The reason that the inner core is solid, despite being at very high temperatures, is because of the weight of all of the other materials above it (crust, mantle, and outer core). The pressure of these layers keeps the inner core solid.
- The movement of the inner and outer core results in Earth's magnetic field.

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Learning Connections	**Future Learning Connections (9-12):** **H.E.3A.1:** Analyze and interpret data to explain the differentiation of Earth's internal structure using (1) the production of internal heat from the radioactive decay of unstable isotopes, (2) gravitational energy, (3) data from seismic waves, and (4) Earth's magnetic field.

Earth Science: Earth Systems and Resources

Standard 8.E.5: The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.	
8.E.5A Conceptual Understanding: All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. Because Earth's processes are dynamic and interactive in nature, the surface of Earth is constantly changing. Earth's hot interior is a main source of energy that drives the cycling and moving of materials. Plate tectonics is the unifying theory that explains the past and current crustal movements at the Earth's surface. This theory provides a framework for understanding geological history.	
Performance Indicator	**8.E.5A.4:** Construct explanations for how the theory of plate tectonics accounts for (1) the motion of lithospheric plates, (2) the geologic activities at plate boundaries, and (3) the changes in landform areas over geologic time.
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. Cause and Effect Stability and Change

Essential Learning Experiences:
It is essential that students construct explanations for how the theory of plate tectonics accounts for (1) the motion of lithospheric plates, (2) the geologic activities at plate boundaries, and (3) the changes in landform areas over geologic time.

The theory of plate tectonics explains the past and current movements of the rocks at Earth's surface (lithospheric plates) and provides a framework for understanding its geological history. Plate movements are responsible for most continental and ocean floor features and for the distribution of most rocks and minerals within Earth's crust. Evidence that supports the theory of plate tectonics includes distribution of rock formation and fossils, shapes of existing continents, ocean floor features, and seismic and volcanic activity. This evidence shows how Earth's plates have moved great distances, collided, and spread apart throughout Earth's history

- Motion of the Lithospheric Plates
    - Plates float on the upper part of the mantle called the asthenosphere.
    - Convection currents can cause the asthenosphere to flow slowly carrying with it the plates of the lithosphere.

  - This movement of plates changes the sizes, shapes, and positions of Earth's continents and oceans.
- Geologic Activities at Plate Boundaries
  - Divergent boundary—where two plates are moving apart
    - Typically located along mid-ocean ridges although they can also be found on land
    - New crust forms because magma pushes up and hardens in the rift zone between separating plates (seafloor spreading).
    - Volcanoes and other types of volcanic activity occur along these boundaries.
    - Earthquakes occur as the plates spread apart.
  - Convergent boundary—where two plates come together and collide
    - Activity depends upon the types of crust that meet.
    - more dense oceanic plate slides under less dense continental plate or another oceanic plate forming a trench at the subduction zone where crust is melted and recycled
    - along these trenches, island arcs and volcanic arcs can be created
    - two continental plates converge, both plates buckle and push up into a mountain range
    - earthquakes occur as the plates collide
  - Transform boundary—where two plates slide past each other
    - crust is neither created nor destroyed;
    - earthquakes occur frequently as plates slide past each other
- Changes in Landform areas over Geologic Time
  - Plates move at very slow rates, averaging about one to ten centimeters per year
  - At one time in geologic history the continents were joined together in one large landmass that was called Pangaea.
  - As the plates continued to move and split apart, oceans were formed, landmasses collided and split apart until the Earth's landmasses came to be in the positions they are now.
  - Evidence of these landmass collisions and splits includes identical fossil formations found on separate continents, landform shapes and features, identical rock formations found on separate continents, and paleoclimate evidence (for example, evidence of warmer climates found in Antarctic fossils).
  - Landmass changes can occur at hot spots within lithospheric plates. Volcanic activity occurs as magma rises and leaks through the crust.
  - Earth's plates will continue to move.
  - Landforms of Earth can be created or changed by volcanic eruptions and mountain-building forces.

NOTE TO TEACHER:
Teachers can use examples such as but not limited to:
- East African Rift (Great Rift Valley) or Mid-Atlantic Ridge for examples of divergent boundaries.
- Japan, the Aleutians, and the Marianas for examples of convergence

of oceanic plates.

- The Andes and the Cascades as examples of convergence of oceanic and continental plates.
- The Himalayas and the Appalachians as examples of convergence of continental plates.

Students may find it helpful to summarize the characteristics of these boundaries:

Plate Boundaries

Type of Boundary	Movement and Crust Formation	Volcanic Activity	Earthquakes	Landforms Created	Examples
Divergent	Rifting, or spreading apart of oceanic or continental plates creates new crust	Yes	Yes	Rift valleys and mid-ocean ridges	Mid-Atlantic Ridge East African Rift
Convergent: Oceanic and Oceanic	Subduction of older, colder oceanic plate destroys crust	Yes	Yes	Volcanic island arcs and deep sea trenches	Philippines, Japan, Mariana Islands, Aleutian Islands
Convergent: Continental and Oceanic	Subduction of denser oceanic plate destroys crust	Yes	Yes	Volcanic mountain ranges along coast and deep sea trenches	Cascade Range in northwestern US; Andes on the western coast of South America
Convergent: Two continental plates collide	Plates are the same density so mountain ranges are pushed upward; crust not created or destroyed	No	Yes	Continental mountain ranges	Himalayas, Appalachians, European Alps
Transform	Plates slide laterally beside each other; crust not created or destroyed	No	Yes	No characteristic landforms	San Andreas Fault in California

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 pressure is applied slowly, folded mountains form.
- If normal faults uplift a block of rock, a fault-block mountain forms.

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	**Future Learning Connections (9-12):** **H.E.3A.2:** Analyze and interpret data from ocean topography, correlation of rock assemblages, the fossil record, the role of convection current, and the action at plate boundaries to explain the theory of plate tectonics. **H.E.3A.3:** Construct explanations of how forces cause crustal changes as evidenced in sea floor spreading, earthquake activity, volcanic eruptions, and mountain building using evidence of tectonic environments (such as mid-ocean ridges and subduction zones).

Earth Science: Earth Systems and Resources

Standard 8.E.5: The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.	
8.E.5A Conceptual Understanding: All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. Because Earth's processes are dynamic and interactive in nature, the surface of Earth is constantly changing. Earth's hot interior is a main source of energy that drives the cycling and moving of materials. Plate tectonics is the unifying theory that explains the past and current crustal movements at the Earth's surface. This theory provides a framework for understanding geological history.	
Performance Indicator	**8.E.5A.5:** Construct and analyze scientific arguments to support claims that plate tectonics accounts for (1) the distribution of fossils on different continents, (2) the occurrence of earthquakes, and (3) continental and ocean floor features (including mountains, volcanoes, faults and trenches).
Science and Engineering Practice	**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. Patterns Cause and Effect

Essential Learning Experiences:
It is essential that students construct and analyze scientific arguments to support claims that plate tectonics accounts for (1) the distribution of fossils on different continents, (2) the occurrence of earthquakes, and (3) continental and ocean floor features (including mountains, volcanoes, faults and trenches).

There is a variety of evidence that supports the claims that plate tectonics accounts for (1) the distribution of fossils on different continents, (2) the occurrence of earthquakes, and (3) continental and ocean floor features (including mountains, volcanoes, faults and trenches).

- Distribution of fossils on different continents
  - The continents fit together almost like puzzle pieces forming Pangaea (one supercontinent).
  - Fossils on different continents are similar to fossils on continents that were once connected. When the continents split, different life forms developed.

- Occurrence of earthquakes
  - Earthquakes tend to form at plate boundaries. Earthquakes occur as a result of a release of energy as the plates move. Seismic energy in the form of waves is released.
- Continental and ocean floor features (including mountains, volcanoes, faults and trenches).
  - Most continental and oceanic floor features are the result of geological activity and earthquakes along plate boundaries. The exact patterns depend on whether the plates are converging (being pushed together) to create mountains or deep ocean trenches, (diverging) being pulled apart to form new ocean floor at mid-ocean ridges, or sliding past each other along surface faults.
  - Most distributions of rocks within Earth's crust, including minerals, fossil fuels, and energy resources, are a direct result of the history of plate motions and collisions and the corresponding changes in the configurations of the continents and ocean basins.
  - This history is still being written. Continents are continually being shaped and reshaped by competing constructive and destructive geological processes.

Example: North America has gradually grown in size over the past 4 billion years through a complex set of interactions with other continents, including the addition of many new crustal segments.

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.

- During the time of Pangaea most of the dry land on Earth was joined into one huge landmass that covered nearly a third of the planet's surface. The giant ocean that surrounded the continent is known as Panthalassa.
- Pangaea existed during the Permian and Triassic geological time periods, which were times of great change.
- Most distributions of rocks within Earth's crust, including minerals, fossil fuels, and energy resources, are a direct result of the history of plate motions and collisions and the corresponding changes in the configurations of the continents and ocean basins.
- North America has gradually grown in size over the past 4 billion years through a complex set of interactions with other continents, including the addition of many new crustal segments.

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (9-12):** **H.E.3A.2:** Analyze and interpret data from ocean topography, correlation of rock assemblages, the fossil record, the role of convection current, and the action at plate boundaries to explain the theory of plate tectonics. **H.E.3A.3:** Construct explanations of how forces cause crustal changes as evidenced in sea floor spreading, earthquake activity, volcanic eruptions, and mountain building using evidence of tectonic environments (such as mid-ocean ridges and subduction zones).

Earth Science: Earth Systems and Resources

Standard 8.E.5: The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.	
8.E.5B Conceptual Understanding: Natural processes can cause sudden or gradual changes to Earth's systems. Some may adversely affect humans such as volcanic eruptions or earthquakes. Mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihoods of future events.	
Performance Indicator	**8.E.5B.1:** Analyze and interpret data to describe patterns in the location of volcanoes and earthquakes related to tectonic plate boundaries, interactions, and hot spots.
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 Cause and effect

Essential Learning Experiences:
It is essential that students analyze and interpret data to describe patterns in the location of volcanoes and earthquakes in relation to tectonic plate boundaries, interactions, and hot spots. Scientists study and record seismic data and volcanic activity in order to support the theory of plate tectonics. The evidence proves that there is a distinct relationship between seismic activity, volcanic activity, and the lithospheric plate boundaries.

- Seismic Data and Plate Tectonics:
  - The interaction along plate boundaries results in an increased frequency of earthquakes at those locations. Additionally, stronger earthquakes are more likely to occur along active plate boundaries.
  - Strong earthquakes are more common at transform and convergent plate boundaries.
    - The San Andreas Fault in California is an example of an active transform plate boundary.
- Volcanic Activity and Plate Tectonics:
  - The interaction of plate boundaries results in an increased frequency of volcanic activity at these locations.

  - Volcanoes occur at convergent plate boundaries where subducting oceanic crust is melted. This magma rises through the crust to form volcanoes and volcanic island arcs.
  - Volcanoes occur at divergent plate boundaries where upwelling magma pushes between plates (rift zones) as the plates move apart.
- The Pacific Ring of Fire is a region of high volcanic and seismic activity that surrounds the majority of the Pacific Ocean Basin. The Pacific Ring of Fire is made up of subduction zones that border the Pacific Ocean basin. Scientists use volcanic activity data from this area to show the relationship between volcanic activity and lithospheric plate motion.
- Hot Spots and Plate Tectonics:
  - A volcanic hotspot is an area in the mantle from which heat rises in the form of a thermal plume from deep within the Earth. Higher heat and lower pressure at the base of the lithosphere melts rock and forms magma. The magma rises through the cracks in the lithosphere and erupts to form volcanoes. As the tectonic plates continue to move over a stationary hotspot, the volcanoes break away and move along with the plate allowing new volcanoes to form in their place. This plate tectonic movement over a hotspot results in chains of volcanoes, such as the Hawaiian Islands.

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.

- At a hot spot, higher heat and lower pressure at the base of the lithosphere melts rock and forms magma. The magma rises through the cracks in the lithosphere and erupts to form volcanoes.
- Students can trace the Hawaiian island chain and the Emperor Sea Mounts to not only show the stationary nature of the hot spot versus the movement of the Pacific plate, but can also see where the plate itself changed the direction it is moving.

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Learning Connections	**Learning Connections (3-7):** **3.E.4B.1:** Develop and use models to describe the characteristics of Earth's continental landforms and classify landforms as volcanoes, mountains, valleys, canyons, plains, and islands. **3.E.4B.3:** Obtain and communicate information to explain how natural events (such as fires, landslides, earthquakes, volcanic eruptions, or floods) and human activities (such as farming, mining, or building) impact the environment. **Future Learning Connections (9-12):** **H.E.3A.4:** Use mathematical and computational thinking to analyze seismic graphs to (1) triangulate the location of an earthquake's epicenter and magnitude, and (2) describe the correlation between frequency and magnitude of an earthquake. **H.E.3B.3:** Analyze and interpret data to explain how natural hazards and other geologic events have shaped the course of human history. **H.E.3B.4:** Obtain and evaluate available data on a current controversy regarding human activities which may affect the frequency, intensity, or consequences of natural hazards. **H.E.3B.5:** Define problems caused by the impacts of locally significant natural hazards and design possible devices or solutions to reduce the impacts of such natural hazards on human activities.

Earth Science: Earth Systems and Resources

Standard 8.E.5: The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.	
8.E.5B Conceptual Understanding: Natural processes can cause sudden or gradual changes to Earth's systems. Some may adversely affect humans such as volcanic eruptions or earthquakes. Mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihoods of future events.	
Performance Indicator	**8.E.5B.2:** Construct explanations of how forces inside Earth result in earthquakes and volcanoes.
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 Cause and Effect Stability and Change

Essential Learning Experiences:
It is essential that students construct explanations of how forces inside Earth result in earthquakes and volcanoes.
Convection currents in the mantle result in the movement of lithospheric plates. The motion and interactions of the plates can create patterns in the location of volcanoes and earthquakes that result along the plate boundaries.

The resulting activity that happens along the plate boundaries depends on the type of plate boundary being created (divergent, convergent, and transform) and the forces associated with those boundaries (compression, tension, and shearing). For example:

- Tectonic forces
    - Forces, or stresses, that cause rocks to break or move are:
        - Tension - pulls rock apart
            - Can cause normal faults.
        - Compression - pushes or squeezes rock together
            - Can cause reverse faults.
        - Shearing - causes rock on either side of faults to move in opposite directions
            - Can cause strike-slip faults.

  - Forces or stresses (for example, tension and compression) on rocks in the lithosphere can cause them to bend and stretch.
    - This bending and stretching can produce mountain ranges.

NOTE TO TEACHER: The stresses involved with plate boundaries and the three types of faults are synonymous. Some plate boundaries, like the San Andreas Fault are actually identified as a fault.

- Lithospheric Plate Motion and Seismic Activity:
  - Earthquakes occur along plate boundaries where tectonic forces result in the buildup of pressure and formation of faults.
    - Earthquakes form when rocks break, faults fail, magma moves, or even with fracking. When this built up pressure is released, an earthquake results along this fault line.
  - Earthquakes can also occur along faults.
    - Scientists can specifically identify the type of boundary and fault that occurs along the edges of the plates by examining plate boundary maps. Scientists can also use seismic data to understand the ways in which the plates are moving and the relationship between seismic activity and lithospheric plate motion
- Lithospheric Plate Motion and Volcanic Activity:
  - There is scientific data supporting abundant volcanism occurrences at divergent and convergent plate boundaries and a lack of volcanism associated with transform plate boundaries.
    - Volcanic activity at divergent plate boundaries occurs as the plates pull apart which allows magma to fill the rift zone between the separating plates.
    - Volcanic activity at convergent plate boundaries occurs as the two plates converge on one another. The leading edge of the subducted plate melts and rises through the overlying crust resulting in the formation of a volcanic chain of mountains. The most volcanically active belt on Earth is known as the Ring of Fire, a region of volcanic activity that happens at subduction zones surrounding the Pacific Ocean.
    - Volcanic eruptions are constructive in that they add new rock to existing land and form new islands. Volcanic eruptions can be destructive when an eruption is explosive and changes the landscape of and around the volcano.
    - Magma that reaches Earth's surface is known as lava.

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 specific types of volcanism that happens at divergent and convergent plate boundaries are called spreading center volcanism and subduction zone volcanism

- Intraplate volcanism is another term to describe the presence of volcanic activity over hot spots

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Learning Connections	**Learning Connections (3-7):** **3.E.4B.1:** Develop and use models to describe the characteristics of Earth's continental landforms and classify landforms as volcanoes, mountains, valleys, canyons, plains, and islands. **3.E.4B.3:** Obtain and communicate information to explain how natural events (such as fires, landslides, earthquakes, volcanic eruptions, or floods) and human activities (such as farming, mining, or building) impact the environment. **Future Learning Connections (9-12):** **H.E.3A.4:** Use mathematical and computational thinking to analyze seismic graphs to (1) triangulate the location of an earthquake's epicenter and magnitude, and (2) describe the correlation between frequency and magnitude of an earthquake. **H.E.3B.3:** Analyze and interpret data to explain how natural hazards and other geologic events have shaped the course of human history. **H.E.3B.4:** Obtain and evaluate available data on a current controversy regarding human activities which may affect the frequency, intensity, or consequences of natural hazards. **H.E.3B.5:** Define problems caused by the impacts of locally significant natural hazards and design possible devices or solutions to reduce the impacts of such natural hazards on human activities.

Earth Science: Earth Systems and Resources

Standard 8.E.5: The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.	
8.E.5B Conceptual Understanding: Natural processes can cause sudden or gradual changes to Earth's systems. Some may adversely affect humans such as volcanic eruptions or earthquakes. Mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihoods of future events.	
Performance Indicator	**8.E.5B.3:** Define problems that may be caused by a catastrophic event resulting from plate movements and design possible devices or solutions to minimize the effects of that event on Earth's surface and/or human structures.
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 Structure and Function

Essential Learning Experiences:
It is essential that students define problems that may be caused by catastrophic events resulting from plate movements and design possible solutions to minimize the effects of those events on Earth's surface and/or human structures.
Most earthquakes and volcanic eruptions do not strike randomly but occur in specific areas such as along plate boundaries. For example, the Ring of Fire where the Pacific Plate interacts with many surrounding plates, is known as one of the most seismically and volcanically active zones in the world.

- Earthquakes and People:
  - Many population centers are located near active fault zones and/or active plate boundaries, such as the San Andreas Fault. Millions of people in these population centers have suffered personal and economic losses due to volcanic and earthquake activity.

- Defining problems associated with earthquakes:
  - There is evidence to support the idea that tectonic activity contributed to the demise of ancient civilizations. Based on the locations of current population centers, scientists have developed models that show that populations today may be just as vulnerable to the aftereffects of powerful earthquakes.
  - When exposed to sudden lateral forces produced by seismic waves buildings and bridges can fail completely and collapse, crushing the people in and around them.
  - Modern population centers tend to be more densely packed with large numbers of tall buildings. The complex infrastructure of modern cities also poses a danger in case of a major earthquake.
  - Over the past few decades, architects and engineers have developed a number of innovative technologies to ensure houses, multi-dwelling units, and skyscrapers bend instead of break. Making these buildings more pliable, less brittle, and better able to move with the earthquake waves has made it possible for inhabitants to survive extremely destructive earthquakes.
- Defining problems associated with volcanoes:
  - Most of the world's active above-sea volcanoes are located near convergent plate boundaries, an area of subduction. Subduction-zone volcanoes typically erupt with an extremely explosive force. There are many large population centers that are within areas that may be affected by explosive volcanic eruptions. These powerful eruptions can affect people in many different ways:
  - Local effects – personal property damage, personal injuries or possible death, destruction of urban and suburban areas, disruption of local water supplies, contamination of food sources, acid rain, landslides, and lack of breathable air.
  - The 1980 eruption of Mount St. Helens and after effects illustrate the local hazards.
  - Global effects – changes in weather and climate, aviation safety hazards, tsunamis if volcanic activity is under or near oceans, seismic activity in accompaniment with volcanic activity, and production of acid rain
- Minimization Efforts of Volcanic Effects:
  - Predicting exactly when an eruption occurs is difficult, but scientists can observe the effects of past eruptions by studying landforms and geologic deposits. Monitoring seismic activity, gas chemistry, and land deformation can help scientists warn that an eruption might occur soon. This provides enough warning for people in the potentially affected areas to be evacuated.
  - Scientists suggest the following for structures where volcanic activity may occur:
    - Houses should be constructed in a manner that will allow for all vents to be closed.
    - Windows and doors should be properly insulated.

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 following major earthquakes and volcanic eruptions may be studied in further detail:

- Volcanic Eruptions of Interest:
  - Mount Pinatubo in Philippines (1991-1996)
  - Rabaul in Papua New Guinea (1994)
  - Lake Nyos in Cameroon (1986)
  - Nevado del Ruiz in Columbia (1985)
  - El Chichon in Mexico (1982)
  - Mount Tambora (1815) that resulted in the year without a summer
- Earthquakes of Interest:
  - Great San Francisco Earthquake – 1906 (8.3 magnitude)
  - Loma Prieta Earthquake – 1989 (7.1 magnitude)
  - Kobe, Japan Earthquake – 1995 (7.2 magnitude)
  - Northridge Earthquake – 1994 (6.6 magnitude)
  - Charleston, South Carolina Earthquake – 1886 (7.0 magnitude)
  - Haiti Earthquake – 2010 (7.0 magnitude)
  - Indian Ocean Earthquake (9.0 magnitude)
- Further exploration of the "temblor thwarting technologies" for earthquake prevention and sustaining buildings may also studied
- Students can also research the locations of, and history of, super volcanoes. From this information, students can explore the past effects of these types of eruptions and extrapolate the potential effects of a modern eruption of a supervolcano.

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Learning Connections	**Learning Connections (3-7):** **3.E.4B.1:** Develop and use models to describe the characteristics of Earth's continental landforms and classify landforms as volcanoes, mountains, valleys, canyons, plains, and islands. **3.E.4B.3:** Obtain and communicate information to explain how natural events (such as fires, landslides, earthquakes, volcanic eruptions, or floods) and human activities (such as farming, mining, or building) impact the environment. **Future Learning Connections (9-12):** **H.E.3A.4:** Use mathematical and computational thinking to analyze seismic

	graphs to (1) triangulate the location of an earthquake's epicenter and magnitude, and (2) describe the correlation between frequency and magnitude of an earthquake. **H.E.3B.3:** Analyze and interpret data to explain how natural hazards and other geologic events have shaped the course of human history. **H.E.3B.4:** Obtain and evaluate available data on a current controversy regarding human activities which may affect the frequency, intensity, or consequences of natural hazards. **H.E.3B.5:** Define problems caused by the impacts of locally significant natural hazards and design possible devices or solutions to reduce the impacts of such natural hazards on human activities.

Earth Science: Earth Systems and Resources

Standard 8.E.5: The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.	
8.E.5C Conceptual Understanding: Humans depend upon many Earth resources – some renewable over human lifetimes and some nonrenewable or irreplaceable. Resources are distributed unevenly around the planet as a result of past geological processes.	
Performance Indicator	**8E.5C.1:** Obtain and communicate information regarding the physical and chemical properties of minerals, ores, and fossil fuels to describe their importance as Earth resources.
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

Essential Learning Experiences:
It is essential that students obtain, evaluate, and communicate information from a variety of sources (informational texts, observations, data collected or discussions) to describe how the physical and chemical properties of minerals, ores, and fossil fuels make them important Earth resources.

Earth's resources (minerals, ores, and fossil fuels) have properties that make them important and useful. Properties that determine the usefulness of an ore or mineral may be identified using a chart, diagram, or dichotomous key. Two types of properties used to determine the usefulness and value of a resource include:

- Physical properties: characteristics that can be observed or measured without changing the matter's identity
- Chemical properties: characteristics that describe matter based on its ability to change into new materials that have different properties
- Three common Earth resources that have importance based on their properties are:
    - Minerals: natural, solid materials found on Earth that are the building blocks of rock.

    - Each mineral has a certain chemical composition and set of properties that determine their use and value such as hardness, luster, color, texture, cleavage/fracture, flammability, reactivity to acids, and density
    - One such valuable mineral is gypsum. It is used in the production of cement.
  - Ores: minerals that are mined because they contain useful metals or nonmetals
    - One such valuable ore is bauxite. It is a primary source of aluminum.
  - Fossil fuels: natural fuels that come from the remains of living things
    - Fuels give off energy when they are burned
    - One such valuable fossil fuel is natural gas. It is a cleaner-burning fuel source.

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.

- Minerals can be classified and identified using their physical and chemical properties. Some minerals have specific identifying features that are key indicators used to identify the mineral. Using mineral identification kits to test a mineral's hardness, observe its luster, reactivity to acid, and cleavage/fracture (the way it breaks) to identify a mineral is an important classification strategy.
- There are positive and negative consequences of the removal and use of these non-renewable resources.

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Learning Connections	**Learning Connections (3-7):** **3.E.4A.1:** Analyze and interpret data from observations and measurements to describe and compare different Earth materials (including rocks, minerals, and soil) and classify each type of material based on its distinct physical properties. **Future Learning Connections (9-12):** **H.E.3B.1:** Obtain and communicate information to explain how the formation, availability, and use of ores and fossil fuels impact the environment. **H.E.3B.2:** Construct scientific arguments to support claims that responsible management of natural resources is necessary for the sustainability of human societies and the biodiversity that supports them.

Earth Science: Earth's History and Diversity of Life

Standard 8.E.6: The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.	
8.E.6A: Conceptual Understanding: The geologic time scale interpreted from rock strata provides a way to organize major historical events in Earth's history. Analysis of rock strata and the fossil record, which documents the existence, diversity, extinction, and change of many life forms throughout history, provide only relative dates, not an absolute scale. Changes in life forms are shaped by Earth's varying geological conditions.	
Performance Indicator	**8.E.6A.1:** Develop and use models to organize Earth's history (including era, period, and epoch) according to the geologic time scale using evidence from rock layers.
Science and Engineering Practice	**S.1A.2:** Develop and use 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

Essential Learning Experiences:
It is essential that students develop and use models to organize Earth's history (including eras, periods, and epochs) according to the geologic time scale using evidence from rock layers.

The geologic time scale is a record of the major events and diversity of life forms present in Earth's history. The geologic time scale began when Earth was formed and goes on until the present. It divides Earth's long history into units of time.

- Precambrian is the name given to the earliest span of time in Earth history.
- Geologists divide the time between Precambrian and the present into three long units called eras (Paleozoic, Mesozoic, Cenozoic).
  - eras are divided into periods
  - periods can be further divided into epochs
  - these subdivisions are based on large scale events in Earth's history that are identified in the fossil record and rock layers
- At the end of each era a major mass extinction occurred, many kinds of organisms died out, although there were other extinctions going on during each period of geologic time.

The layers of rock on Earth serve as evidence when identifying the geologic time scale. Using the fossil record, paleontologists have created a picture of the different types of common organisms in each geologic period.
Cambrian being the first period is important. The Cambrian Explosion was a time where there was a relatively rapid appearance of most major animal phyla as evidenced by the fossil record.

- Paleozoic Era
  - Began with the early invertebrates, such as trilobites and brachiopods; continued to develop early vertebrate fish, then arachnids and insects; later came the first amphibians, and near the era's end the reptiles became dominant.
  - Early land plants included simple mosses, ferns, and then cone-bearing plants.
  - By the end of the era, seed plants were common.
  - The mass extinction that ended the era caused most marine invertebrates as well as amphibians to disappear.
  - A major geologic event of the Paleozoic was the formation of the super continent of Pangaea.
- Mesozoic Era
  - Reptiles were the dominant animals of this era, including the various dinosaurs.
  - Small mammals and birds also appeared.
  - Toward the end of the era, flowering plants appeared and the kinds of mammals increased.
  - The mass extinction that ended the era caused the dinosaurs to become extinct.
  - A major geologic event of the Mesozoic was the break-up of the super continent of Pangaea into several large continents.
- Cenozoic Era
  - New mammals appeared while others became extinct.
  - The diversity of life forms increased.
  - Flowering plants became most common.
  - Humans are also part of the most recent period of this era.
  - Present day Earth is in this era.
  - A major geologic event of the Cenozoic is the further splitting and moving of continents to their current positions.

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.

- With a more complete fossil record available, the periods of the Cenozoic era are subdivided further into epochs.
- Present day Earth is in the Quaternary period in the Holocene epoch.
- About 95 percent of marine species and 70 percent of land animals were wiped out after the Permian mass extinction. It is suspected that periods of rapid global warming and cooling that happened so quickly most organisms were not able to adjust. Students can research the effect that this extinction had on the evolution of species.
- Students can research additional geologic events, such as periods of increased volcanism and the effect on world-wide climate, mountain formation, climate changes and ice ages, large scale impacts of asteroids and meteorites, and the effect of rising and falling sea levels on early human migrations.

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 (9-12):** **H.E.4A.5:** Develop and use models of various dating methods (including fossils, ordering of rock layers, and radiometric dating) to estimate geologic time.

Earth Science: Earth's History and Diversity of Life

Standard 8.E.6: The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.	
8.E.6A Conceptual Understanding: Conceptual Understanding: The geologic time scale interpreted from rock strata provides a way to organize major historical events in Earth's history. Analysis of rock strata and the fossil record, which documents the existence, diversity, extinction, and change of many life forms throughout history, provide only relative dates, not an absolute scale. Changes in life forms are shaped by Earth's varying geological conditions.	
Performance Indicator	**8.E.6A.2:** Analyze and interpret data from index fossil records and the ordering of rock layers to infer the relative age of rocks and fossils.
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

Essential Learning Experiences:
It is essential that students analyze and interpret data from the fossil record and the ordering of rock layers to infer the relative age of rocks and fossils.
Relative age means the age of one object compared to the age of another object. Relative age does not tell the exact age of an object. The relative age of rocks and fossils can be determined using two basic methods: ordering of rock layers and index fossils:

- Ordering of Rock Layers
  - Scientists read the rock layers knowing that each layer is deposited on top of other layers.
  - The law of superposition states that each rock layer is older than the one above it. So, the relative age of the rock or fossil in the rock is older if it is farther down in the rock layers.
  - Relative dating can be used only when the rock layers have been preserved in their original sequence.
- Index Fossils
  - Certain fossils, called index fossils, can be used to help find the relative age of rock layers.
    - Index fossils
      - must have lived only during a short part of Earth's history.

- are widely distributed.
- are unique.

NOTE TO TEACHER:
Students should be interpreting geologic columns to identify index fossils.

Fossils that are found in many rock layers, therefore living long periods of time, do not qualify as index fossils.

Index fossils can be any size.

A key example of an organism used as an index fossil are certain trilobites, a group of hard-shelled animals whose body had three sections, lived in shallow seas, and became extinct about 245 million years ago. Therefore, if a trilobite is found in a particular rock layer, it can be compared with trilobites from other layers to estimate the age of the layer in which it was found.

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.

- Complex layering due to intrusions and extrusions, faults, or unconformities can make dating rocks and fossils challenging.
- Radioactive element decay can also be used to tell the age of fossils and rocks.

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (9-12):** **H.E.4A.5** Develop and use models of various dating methods (including index fossils, ordering of rock layers, and radiometric dating) to estimate geologic time.

Earth Science: Earth's History and Diversity of Life

Standard 8.E.6: The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.	
8.E.6A Conceptual Understanding: Conceptual Understanding: The geologic time scale interpreted from rock strata provides a way to organize major historical events in Earth's history. Analysis of rock strata and the fossil record, which documents the existence, diversity, extinction, and change of many life forms throughout history, provide only relative dates, not an absolute scale. Changes in life forms are shaped by Earth's varying geological conditions.	
Performance Indicator	**8.E.6A.3:** Construct explanations from evidence for how catastrophic events (including volcanic activities, earthquakes, climatic changes, and the impact of an asteroid/comet) may have affected the conditions on Earth and the diversity of its life forms.
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 Cause and Effect

Essential Learning Experiences:
It is essential that students construct explanations of how catastrophic events in Earth's history may have affected the conditions on Earth and the diversity of its life forms.

There is evidence to support the changes in life forms over Earth's history (additions and extinctions) are often accompanied by changes in environmental conditions on Earth. Impacts, climate changes, and volcanism can produce sudden and rapid changes to environmental conditions. Many organisms cannot adapt to these sudden and rapid changes resulting in the extinction of those species. When these events are global in nature then mass extinctions can occur.

- Impact of an asteroid or comet
  - Earth's atmosphere protects the planet from many of the meteors that enter it, resulting in their burning up before striking the surface.
  - There is evidence to support the claim that numerous impacts have occurred throughout Earth's history. These impacts have had both local and large-scale effects on the environment and biodiversity.
  - There is evidence to support that at the end of the Mesozoic Era a large asteroid or comet impacted with Earth. This impact caused dust and smoke to rise into the

atmosphere and cause climatic changes, as well as the dying of many forms of plant life and animals that depended on those plants for food.
    - At the end of the Mesozoic Era, when reptiles, early birds and mammals thrived, many groups of animals disappeared suddenly.
    - A major life form that disappeared at this time was the dinosaur.

- Climatic changes
  Earth's environments have many different climates even today. Climate is an ever-changing condition on Earth.
  - Earliest life forms were influenced by the climates produced by the forming atmosphere and oceans of Earth.
  - Life on land developed and flourished in the tropical climates and warm shallow seas during the Paleozoic Era. Throughout this era as different land environments formed and sea levels changed, new life forms developed. Other life forms that could not adapt or find suitable conditions, especially many marine species, disappeared.
  - During the Mesozoic era, many climate changes occurred due to plate tectonics and the movement of landmasses. Plants and animals that survived through this time had structures and systems that allowed for greater adaptations, such as seed coverings for plant seeds and protective body coverings or constant internal temperature for animals.
  - During the present Cenozoic era, climate conditions continue to change. Major ice ages caused the climate to become much cooler as ice sheets and glaciers covered many areas of Earth. Many mountain ranges formed causing climate differences due to elevation and due to location near those ranges.
- Volcanic activity
  - From the earliest days while Earth was forming to present day, volcanic activity has been part of the nature of this changing planet.
    - During the Precambrian time volcanic activity was one of the most natural events, but lava flows, ash clouds in the atmosphere, and heat made conditions for life forms extremely difficult. Those simple life forms often did not survive these conditions.
    - As continents collided and mountains built up due to plate tectonics, volcanoes also formed. Volcanic activity continued to be common in the Paleozoic era.
    - During the rapid movement of plates in the Mesozoic era, collisions and subduction produced extensive volcanic activity around plate boundaries. Plate boundaries are still the location of much of Earth's volcanic activity.
    - Very explosive volcanic activity can send ash and dust high into the atmosphere where it is carried great distances around the Earth. The Sun can be blocked for long periods of time. This violent type of activity can disrupt many of Earth's processes and ultimately the life forms that depend on those processes.

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.

- Paleoseismology is the study of the timing, location, and size of prehistoric earthquakes.
- A huge crater off Mexico's Yucatán Peninsula is dated to about 65 million years ago, coinciding with the Cretaceous extinction.
- Massive floods of lava erupting from the central Atlantic magmatic province about 200 million years ago may explain the Triassic-Jurassic extinction.
- More than 90 percent of all species perished during the Permian-Triassic extinction event about 250 million years ago.
- Ordovician-Silurian extinction, about 440 million years ago, involved massive glaciations that locked up much of the world's water as ice.

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (9-12):** **H.E.4A.3:** Construct explanations of how changes to Earth's surface are related to changes in the complexity and diversity of life using evidence from the geologic time scale.

Earth Science: Earth's History and Diversity of Life

Standard 8.E.6: The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.	
8.E.6A Conceptual Understanding: Conceptual Understanding: The geologic time scale interpreted from rock strata provides a way to organize major historical events in Earth's history. Analysis of rock strata and the fossil record, which documents the existence, diversity, extinction, and change of many life forms throughout history, provide only relative dates, not an absolute scale. Changes in life forms are shaped by Earth's varying geological conditions.	
Performance Indicator	**8.E.6A.4:** Construct and analyze scientific arguments to support claims that different types of fossils provide evidence of (1) the diversity of life that has been present on Earth, (2) relationships between past and existing life forms, and (3) environmental changes that have occurred during Earth's history.
Science and Engineering Practice	**S.1A.2:** 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 number 6. Patterns Cause and Effect Stability and Change

Essential Learning Experiences:
It is essential that students construct and analyze scientific arguments to support claims that different types of fossils provide evidence of (1) the diversity of life that has been present on Earth (2) relationships between past and existing life forms and (3) environmental changes that have occurred during Earth's history.
Fossils are mineral replacements, preserved remains, or traces of organisms that lived in the past. The collection of fossils and their placement in chronological order is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms and environmental changes throughout the history of life on Earth.

- Thousands of layers of sedimentary rock not only provide evidence of the history of Earth itself but also of changes in organisms whose fossil remains have been found in those layers.
    - Erosion and weathering of sedimentary rock layers can cause the destruction of fossils and result in gaps in the fossil record.

- Certain environmental conditions favor certain fossil formations. Therefore, the type of fossils found in an area can explain the environmental changes that have occurred.
    - The rapid burial of organisms, which is more likely to occur in marine environments, results in a greater likelihood that the remains of marine organisms will be preserved. Flash floods and volcanic ash falls help preserve land organisms.
- Certain fossilized organisms could only live in specific environments or under particular climate conditions.
- Extinction of life forms as well as how and when new life forms appeared is part of the fossil record.
- Fossils can show structural similarities and differences in organisms over time revealing the vast diversity of life forms that have and continue to exist on Earth.
- Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record enable the understanding of the diversity of life that has been present on Earth.
- Comparisons between living organisms and fossils also allow scientists to make inferences about the lines of descent.

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.

- Mold fossil – forms when sediments bury an organism and the sediments change into rock; the organism decays leaving a cavity in the shape of the organism.
- Cast fossil – forms when a mold is filled with sand or mud that hardens into the shape of the organism.
- Petrified fossil (permineralized fossil) – forms when minerals soak into the buried remains, replacing the remains, and changing them into rock.
- Preserved fossil – forms when entire organisms or parts of organisms are prevented from decaying by being trapped in rock, ice, tar, or amber.
- Carbonized fossil – forms when organisms or parts, like leaves, stems, flowers, fish, are pressed between layers of soft mud or clay that hardens squeezing almost all the decaying organism away leaving the carbon imprint in the rock.
- Trace fossil – forms when the mud or sand hardens to stone where a footprint, trail, or burrow of an organism was left behind.

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (9-12):** **H.E.4A.3** Construct explanations of how changes to Earth's surface are related to changes in the complexity and diversity of life using evidence from the geologic time scale.

Earth Science: Earth's History and Diversity of Life

Standard 8.E.6 The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.	
8.E.6A Conceptual Understanding: The geologic time scale interpreted from rock strata provides a way to organize major historical events in Earth's history. Analysis of rock strata and the fossil record, which documents the existence, diversity, extinction, and change of many life forms throughout history, provide only relative dates, not an absolute scale. Changes in life forms are shaped by Earth's varying geological conditions.	
Performance Indicator	**8.E.6A.5:** Construct explanations for why most individual organisms, as well as some entire taxonomic groups of organisms, that lived in the past were never fossilized.
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. Cause and Effect Structure and Function

Essential Learning Experiences:
It is essential that students construct explanations for why most individual organisms, as well as some entire taxonomic groups of organisms that have lived in the past were never fossilized.

Because of the conditions necessary for their preservation, not all types of organisms that existed in the past have left fossils that can be retrieved.

- In order for a fossil to form, the organism's remains must not be significantly disturbed by a scavenger/decomposer or destroyed by erosion and other natural forces. Therefore, organisms or parts of organisms that make up fossils are most likely buried quickly and deeply.
  - Example: woolly mammoth found in ice, insects found in amber, animals found in peat bogs, mass burials from flash floods or volcanic ash falls
- Soft body parts, such as skin, muscle, fat, and internal organs, deteriorate rapidly and leave no trace. Casts of such tissues are rarely found. Similarly, organisms that are soft-bodied creatures, like jellyfish, are very uncommon fossils while hard body parts (such as teeth and shells) fossilize easier.
- In order for some fossils to be formed, the organism must be buried in sediment after which its tissues dissolve and are replaced by dissolved minerals which make it a solid. Without the correct minerals this process cannot take place.

- The fact that extremely few living things are preserved long enough after death to become fossils makes the large collections of fossils in the museums of the world quite remarkable

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.

- Taphonomy is the study of the conditions under which plants, animals, and other organisms become altered after death and sometimes preserved as fossils.
- With molds, sometimes the rock has the appearance of the organism. Sometimes, all traces of the organism are lost but an external mold is formed around the body and is preserved. Sometimes an internal mold forms when material is precipitated inside an organism (ex: a marine shell or the hollow stem of a plant).

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (9-12):** **H.E.4A.4:** Obtain and evaluate evidence from rock and fossil records and ice core samples to support claims that Earth's environmental conditions have changed over time.

Earth Science: Earth's History and Diversity of Life

Standard 8.E.6: The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.	
8.E.6B Conceptual Understanding: Adaptation by natural selection acting over generations is one important process by which species change in response to changes in environmental conditions. The resources of biological communities can be used within sustainable limits, but if the ecosystem becomes unbalanced in ways that prevent the sustainable use of resources, then ecosystem degradation and species extinction can occur.	
Performance Indicator	**8.E.6B.1:** Construct explanations for how biological adaptations and genetic variations of traits in a population enhance the probability of survival in a particular environment.
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. Cause and Effect Stability and Change

Essential Learning Experiences:
It is essential that students construct explanations of how biological adaptations and genetic variations of traits in a population enhance the probability of survival in a particular environment.

Populations in a particular environment that have adapted to living conditions in that specific area are therefore better able to meet their survival needs and are more likely to survive and reproduce offspring with those key survival traits.

- An adaptation is a trait or behavior that helps an organism survive and reproduce
  - Traits are genetic differences that occur in a species. Traits are developed as a species adapts to its environment.
  - Organisms of a species differ from one another in many of their traits
- There can also be variations among species of similar populations. Variations are changes in the genes among members of the same species.
  - Variations can occur both randomly and as a result of a trait being more fit for an environment.

- Natural selection is the process that explains this survival and shows how species can change over time.
    - For example, certain traits or adaptations involving color, camouflage, food gathering (beaks and claws) and other physical traits, sensory abilities, or behaviors enhance the survival of a species.
    - Natural selection over a long period of time can lead to beneficial variations while unfavorable variations tend to disappear.
    - Studying "Darwin's Finches" is a prime example of natural selection based on physical traits that help an animal with food gathering.

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 theory of evolution is used by scientists to explain the genetic variations seen among different species. The theory of evolution is used to explain the gradual change in a species over time. Charles Darwin was an English naturalist and geologist who was the originator of the biological theory of evolution.

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (9-12):** **H.E.4A.3** Construct explanations of how changes to Earth's surface are changes in the complexity and diversity of life using evidence from the geologic time scale.

Earth Science: Earth's History and Diversity of Life

Standard 8.E.6 The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.	
8.E.6B Conceptual Understanding: Adaptation by natural selection acting over generations is one important process by which species change in response to changes in environmental conditions. The resources of biological communities can be used within sustainable limits, but if the ecosystem becomes unbalanced in ways that prevent the sustainable use of resources, then ecosystem degradation and species extinction can occur.	
Performance Indicator	**8.E.6B.2:** Obtain and communicate information to support claims that natural and human-made factors can contribute to the extinction of species.
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. Cause and Effect

Essential Learning Experiences:
It is essential that students obtain and communicate information to support claims that natural and human-made factors can contribute to the extinction of species.

A species is extinct if no members of that species are living. Most organisms that have ever lived on Earth are now extinct.

- Natural factors can cause extinctions and have thus been documented and studied over the course of Earth's history.
  - Organisms that could not survive changes due to volcanic eruptions and global warming, global cooling during ice ages, changes in oxygen levels in seawater, or a massive impact from an asteroid or comet became extinct
  - Natural extinctions due to competition for resources or inability to adapt to the environment have occurred throughout geologic history
    - When species become extinct, the opportunity exists for another species to fill that ecological niche.

  - Not all extinctions that have occurred naturally throughout Earth's history have had a negative impact. Some of these extinctions have often cleared the way for new kinds of life to emerge.
- Man-made factors have caused extinctions in more recent times, such as the cutting of the rainforest regions, removing natural habitats, over-harvesting, and pollution.
  - Scientists have evidence to support claims that humans have contributed to the extinction of many species throughout human history, including the woolly mammoth.
  - Scientists have evidence to support the claims that many plants and animals are likely to become extinct in the near future as a result of the negative impact of human activities (clear-cutting, water and air pollution, etc.) on the environment.
  - Scientists have evidence to support the claims that human effects on the environment could threaten some biological resources that organisms, including humans, may need for survival.

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.

- Extinctions of specific species may be studied. Debates between what man has or has not done in regards to extinction or endangerment of species may be explored. A key species to study may include the Bald Eagle.

Assessment Guidelines:
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Learning Connections	**Future Learning Connections (9-12):** **H.E.4A.3:** Construct explanations of how changes to Earth's surface are related to changes in the complexity and diversity of life using evidence from the geologic time scale. **H.E.4A.4:** Obtain and evaluate evidence from rock and fossil records and ice core samples to support claims that Earth's environmental conditions have changed over time.

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