# SUPPORT GUIDE 3.0
# FOR EARTH SCIENCE

# SOUTH CAROLINA ACADEMIC STANDARDS
# AND PERFORMANCE INDICATORS FOR SCIENCE

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# INTRODUCTION TO EARTH SCIENCE 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 Earth Science

- Astronomy
- Earth's Geosphere
- Earth's Paleobiosphere
- Earth's Atmosphere
- Earth's Hydrosphere

## Acknowledgements

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## CONTENT SUPPORT GUIDE
## EARTH SCIENCE
## 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.

# Astronomy

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| **Standard H.E.2:** The student will demonstrate an understanding of the structure, properties, and history of the observable universe. | |
| **H.E.2A. Conceptual Understanding:** Earth is a tiny part of a vast universe that has developed over a huge expanse of time. At the center of Earth's solar system is one local star, the Sun. It is just one of a vast number of stars in the Milky Way Galaxy, which is just one of a vast number of galaxies in the observable universe. The study of the light spectra and brightness of stars is used to identify compositional elements of stars, their movements, and their distances from Earth. Nearly all observable matter in the universe formed and continues to form within the cores of stars. The universe began with a period of extreme and rapid expansion and has been expanding ever since. | |
| **Performance Indicator** | **H.E.2A.1:** Construct explanations for how gravity and motion affect the formation and shapes of galaxies (including the Milky Way Galaxy). |
| **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.<br><br>Scale, Proportion, and Quantity<br>Systems and System Models |

**Essential Learning Experiences:**
It is essential that students know the major components of the universe are galaxies consisting of groups of stars bound together by gravitational attraction. Galaxy formation theory is just beginning to be developed. The present view of galaxy formation holds that large systems were built up from smaller ones through collisions and mergers. Galaxies are classified by shape into three main types – spiral (normal and barred), elliptical, and irregular.

It is essential that students use the information from different sources to construct explanations that motion and gravity determine the formation and shapes of galaxies including:

- Spiral galaxies contain a flattened galactic disk of gas, dust, and younger stars in which the spiral arms are found, and a central galactic bulge with a halo of faint, older stars. Gas and stars in the disk move in circular orbits around the galactic center.
  - An example is the Milky Way galaxy, which contains our solar system.
- Elliptical galaxies are made of very old stars with little gas or dust that has no galactic disk with stars distributed throughout the nearly spherical to very flattened shapes. Stars within the galaxy move in random orbits.

- Irregular galaxies contain both young and old stars with ongoing star formation and no obvious structure. Gas and stars move in very irregular orbits.

It is essential that students construct explanations about motion and formation of galaxies by viewing pictures and/or simulations.

**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 use mathematical and computational thinking to explore distances between galaxies, galaxy clusters, or properties of galaxies.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**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..<br>**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.<br>**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.<br>**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.<br><br>**Physics Connections:**<br>**H.P.2D.2:** Use mathematical and computational thinking to predict the relationships among the masses of two objects, the attractive gravitational force between them, and the distance between them (Newton's Law of Universal Gravitation, $F=Gm_1m_2/r^2$).<br>**H.P.2D.3:** Obtain information to communicate how long-term gravitational interactions govern the evolution and maintenance of large-scale structures in the universe (such as the solar system and galaxies) and the patterns of motion within them. |

# Astronomy

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| **Performance Indicator** | **H.E.2A.2:** Develop and use the Hertzsprung-Russell diagram to classify stars and explain the life cycles of stars (including the Sun). |
| **Science and Engineering Practice** | **S.1A.2:** Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others. |
| **Crosscutting Concepts** | The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6.<br><br>Scale, Proportion, and Quantity<br>Systems and System Models |

**Essential Learning Experiences:**
It is essential that students use the Hertzsprung-Russell diagram to classify stars and explain the life cycles of stars (including the Sun). Students should be able to do the following:

- Using the properties of stars to place them on the Hertzsprung-Russell diagram and construct explanations for each star's placement.
- Explain the relationship between a star's mass, absolute magnitude, luminosity, surface temperature, spectral type, and size.

It is essential that students obtain, evaluate, and communicate information about the life cycle of a star. Students should be able to explain the following:

- Stars are born from the nebula formed from the death of a star and become a protostar. Once nuclear fusion begins, the star enters the main sequence stage where it spends the majority of its life.
- 90% of stars, including our sun, are classified as main sequence stars.
- Death of a star begins with a giant or supergiant phase, and then massive stars may become a supernova or black hole, while medium and small stars may result in dwarfs.

**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.

- Explore internal dynamics of what goes on within the star at various stages of life.
- Temperature data and life cycle time should be relative terms. Some basic study of constellations may spark student's interest.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**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. |

## Astronomy

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|---|---|
| **Standard H.E.2:** The student will demonstrate an understanding of the structure, properties, and history of the observable universe. | |
| **H.E.2A. Conceptual Understanding:** Earth is a tiny part of a vast universe that has developed over a huge expanse of time. At the center of Earth's solar system is one local star, the Sun. It is just one of a vast number of stars in the Milky Way Galaxy, which is just one of a vast number of galaxies in the observable universe. The study of the light spectra and brightness of stars is used to identify compositional elements of stars, their movements, and their distances from Earth. Nearly all observable matter in the universe formed and continues to form within the cores of stars. The universe began with a period of extreme and rapid expansion and has been expanding ever since. | |
| **Performance Indicator** | **H.E.2A.3:** Construct explanations for how elements are formed using evidence from nuclear fusion occurring within stars and/or supernova explosions. |
| **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.<br><br>Matter and Energy<br>Structure and Function |



**Essential Learning Experiences:**
It is essential that students develop a basic understanding of the process of nuclear fusion including:

- A star's size and temperature will govern the rate of nuclear fusion occurring in the core. Stars in main sequence produce energy by fusing hydrogen into helium (same as the Sun) and beyond the main sequence, stars may fuse different elements or not undergo fusion at all. Stars elemental composition depends upon how many times it has gone through nuclear fusion.
- Once a star's core is completely converted to helium, if the temperature is high enough, the helium may fuse to form carbon, oxygen, neon, magnesium, or silicon. Beyond this, when certain stars experience a massive explosion (supernova), elements that are heavier than iron are created and enrich the universe.

**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 compare and contrast nuclear fission and nuclear fusion processes, where they occur, which one we can use on Earth and why.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**7.P.2A.1:** Develop and use simple atomic models to illustrate the components of elements (including the relative position and charge of protons, neutrons, and electrons).<br>**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.<br>**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.<br><br>**Biology Connections:**<br>**H.C.2B.3:** Obtain and communicate information to compare and contrast nuclear fission and nuclear fusion and to explain why the ability to produce low energy nuclear reactions would be a scientific breakthrough.<br><br>**Physics Connections:**<br>**H.P.3G.2:** Develop and use models (such as drawings, diagrams, computer simulations, and demonstrations) to communicate the similarities and differences between fusion and fission. Give examples of fusion and fission reactions and include the concept of conservation of mass-energy.<br>**H.P.3G.3:** Construct scientific arguments to support claims for or against the viability of fusion and fission as sources of usable energy. |

## Astronomy

| **Standard H.E.2:** The student will demonstrate an understanding of the structure, properties, and history of the observable universe. | |
|---|---|
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| **Performance Indicator** | **H.E.2A.4:** Construct and analyze scientific arguments to support claims about the origin of the universe (including the redshift of light from distant galaxies, the measured composition of stars and non-stellar gases, and the cosmic background radiation). |
| **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.<br><br>Patterns<br>Cause and Effect |

**Essential Learning Experiences:**
It is essential that students construct and analyze scientific arguments including:
- The Big Bang Theory states that the universe began as a single concentrated point of matter and energy that was propelled outward and has been expanding ever since.
- Spectral line shifts toward the red end in reference to the Doppler Effect supports galaxies moving away from ours.
- some background radiation, in the form of microwaves, was discovered and is believed to be left over from the initial event.

**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 compare the Big Bang Theory to other theories (such as the Steady-State Theory) to grasp an understanding of critical density and the ultimate fate of the universe based on these theories.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**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.<br><br>**Chemistry Connections:**<br>**H.C.2B.4:** Use mathematical and computational thinking to explain the relationship between mass and energy in nuclear reactions ($E=mc^2$).<br><br>**Physics Connections:**<br>**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).<br>**H.P.3F.5:** Obtain information to communicate the similarities and differences among the different bands of the electromagnetic spectrum (including radio waves, microwaves, infrared, visible light, ultraviolet, and gamma rays) and give examples of devices or phenomena from each band. |

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| **Performance Indicator** | **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. |
| **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.<br><br>Systems and System Models<br>Energy and Matter<br>Structure and Function |

**Essential Learning Experiences:**

It is essential that students obtain, evaluate, and know:

- Objects in space emit radiation in all frequencies of the electromagnetic spectrum which are collected and analyzed via a variety of telescopes that have been developed.
    - X-rays cannot be easily reflected by any surface so a special design for detecting x-rays had to be developed which consists of an arrangement of cylindrical mirrors that allows the x-rays to be guided to a precise focus to form an image.
    - Reflecting telescopes use a concave mirror to focus a large amount of light onto a small area (the larger the mirror, the more light the telescope can collect). A flat mirror reflects the light to the eyepiece lens. The majority of visual telescopes used today are reflecting.

- Refracting telescopes use convex lenses to bring visible light to a focus. The largest lens is called the objective lens; the second lens is the eyepiece lens. When light passes through the objective lens, the lens focuses the light at a certain distance away from the lens. The larger the objective lens, the more light it can collect.
- Radio telescopes have curved, reflecting surfaces that are used to detect radio waves from objects in space. The surface of the telescope concentrates faint radio waves onto small antennas.

**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 also use ray diagrams to trace the path of incoming radiation in the various telescopes.
- Students may also study and describe the contributions of the Hubble Space Telescope to contemporary understanding of astronomy and related science fields.
- Students could compare and contrast ground based versus space based observatories.

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

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|---|---|
| **Learning Connections** | **Previous Connections (6-8):**<br>**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.<br>**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.<br><br>**Chemistry Connections:**<br>**H.C.2A.3:** Analyze and interpret absorption and emission spectra to support explanations that electrons have discrete energy levels.<br><br>**Physics Connections:**<br>**H.P.3F.5:** Obtain information to communicate the similarities and differences among the different bands of the electromagnetic spectrum (including radio waves, microwaves, infrared, visible light, ultraviolet, and gamma rays) and give examples of devices or phenomena from each band. |

# Astronomy

| **Standard H.E.2:** The student will demonstrate an understanding of the structure, properties, and history of the observable universe. | |
|---|---|
| **H.E.2B Conceptual Understanding:** The solar system consists of the Sun and a collection of objects of varying sizes and conditions – including planets and their moons – that have predictable patterns of movement. These patterns can be explained by gravitational forces and conservation laws, and in turn explains many large-scale phenomena observed on Earth. Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the Sun. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. | |
| **Performance Indicator** | **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). |
| **Science and Engineering Practice** | **S.1A.4:** Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions. |
| **Crosscutting Concepts** | The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6.<br><br>Patterns |

**Essential Learning Experiences:**
It is essential that students analyze and interpret the data, looking for conditions necessary for life. Students should identify what makes Earth unique in its support for life.

| Planet | Composition | Density (g/cm$^3$) | Surface Tectonics | Climate | |
|---|---|---|---|---|---|
| | | | | Surface. Temp. (Celsius) | Water |
| Mercury | Terrestrial | 5.427 | Yes | -173 to 427 | No |
| Venus | Terrestrial | 5.243 | No | 462 | No |
| Earth | Terrestrial | 5.513 | Yes | -88 to 58 | Yes |
| Mars | Terrestrial | 3.934 | Yes | -87 to -5 | Yes |
| Jupiter | Gaseous | 1.326 | No | -148 (effective) | No |
| Saturn | Gaseous | 0.687 | No | -178 | traces |
| Uranus | Gaseous | 1.270 | No | -216 | traces |
| Neptune | Gaseous | 1.638 | No | -214 | Yes |

**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 teacher may opt to include an analysis of period of rotation, period of revolution, or atmospheric conditions as extensions of the climatic study.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**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.<br>**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.<br>**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.<br>**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.<br><br>**Physics Connections:**<br>**H.P.2D.2:** Use mathematical and computational thinking to predict the relationships among the masses of two objects, the attractive gravitational force between them, and the distance between them (Newton's Law of Universal Gravitation, $F=Gm_1m^2/r^2$ ).<br>**H.P.2D.3:** Obtain information to communicate how long-term gravitational interactions govern the evolution and maintenance of large-scale structures in the universe (such as the solar system and galaxies) and the patterns of motion within them. |

## Astronomy

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|---|---|
| **Standard H.E.2:** The student will demonstrate an understanding of the structure, properties, and history of the observable universe. | |
| **H.E.2B Conceptual Understanding:** The solar system consists of the Sun and a collection of objects of varying sizes and conditions – including planets and their moons – that have predictable patterns of movement. These patterns can be explained by gravitational forces and conservation laws, and in turn explains many large-scale phenomena observed on Earth. Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the Sun. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. | |
| **Performance Indicator** | **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. |
| **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.<br><br>System and System Models |



**Essential Learning Experiences:**
It is essential that students obtain, evaluate, and communicate the following information:

- The Moon is Earth's natural satellite and is unique among the moons in the solar system.
- Unique properties of the Moon include:
  - Size: The Moon is one of the largest in the solar system, especially compared to the size of the planet it orbits. The Moon is the only large moon among the inner planets. Mercury and Venus have no moons and the moons of Mars are both small.
  - Orbital radius: The Moon's orbit is relatively far from Earth when compared to most of the other moons in our solar system.
  - Composition: The Moon is a solid, rocky body, in contrast to the icy composition of the moons of the outer planets.
  - Atmosphere: The Moon has no atmosphere.

- Features of the Moon:
    - Craters: All the craters on the Moon are impact craters.
    - Rays: Long trails of material (ejecta) blasted out from impacts on the Moon radiate out from craters.
    - Maria: These are dark, smooth plains of lower elevation on the Moon; they may contain craters and small meandering, valley-like structures.
    - Highlands: These cover most of the lunar surface, are mountainous, and are heavily covered with craters.
- Because of its size and the fact that the same side of the Moon always faces Earth, the illuminated side of the Moon that can be seen from Earth goes through sequential changes called phases. Students can revisit this concept as they study the unique properties and features of Earth's Moon.
- Because of its size and its close proximity to Earth, the Moon's pull of gravity creates bulges of ocean water on both the near and far sides of Earth. As Earth rotates, these bulges remain aligned with the Moon so that the ocean level rises and falls about every 12 hours. The Sun's gravitational pull also has an effect on the formation of tides, but it is about half that of the Moon.
    - Spring and 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.

- Investigate the number of moons of other plants in our solar system and their properties.
- Investigate the possibility of discovering resources or evidence of life on the moons of other planets such as Jupiter and Saturn.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**8.E.4B.2:** Construct explanations for how gravity affects the motion of objects in the solar system and tides on Earth.<br>**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).<br><br>**Physics Connections:**<br>**H.P.2D.3:** Obtain information to communicate how long-term gravitational interactions govern the evolution and maintenance of large-scale structures in |

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| | the universe (such as the solar system and galaxies) and the patterns of motion within them. |

## Astronomy

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| **Standard H.E.2:** The student will demonstrate an understanding of the structure, properties, and history of the observable universe. | |
| **H.E.2B Conceptual Understanding:** The solar system consists of the Sun and a collection of objects of varying sizes and conditions – including planets and their moons – that have predictable patterns of movement. These patterns can be explained by gravitational forces and conservation laws, and in turn explains many large-scale phenomena observed on Earth. Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the Sun. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. | |
| **Performance Indicator** | **H.E.2B.3:** Use mathematical and computational thinking to explain the motion of an orbiting object in the solar system. |
| **Science and Engineering Practice** | **S.1A.5:** Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) 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.<br><br>Cause and Effect |

**Essential Learning Experiences:**
It is essential that students use mathematical and computational thinking and know Kepler's Laws of Planetary Motion.

Please see chart.

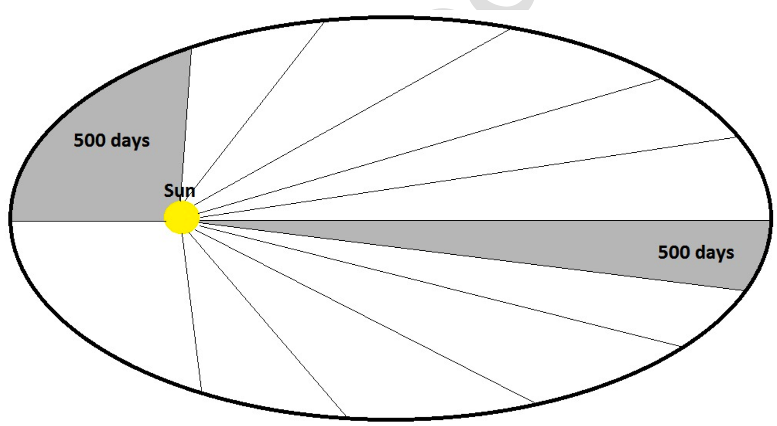
<table>
<tr><th>Concept</th><th>Explanation</th></tr>
<tr><td>Law of Ellipses</td><td>The path of each planet around the Sun is an ellipse. The Sun is at one of the two foci. How round or elliptical a planet's path, or orbit, is measured as eccentricity (e). The value of e for a circular orbit is zero whereas a near perfect elliptical orbit will be just under 100%.<br><br>
<table>
<tr><th>Planet</th><th>Eccentricity (0=circle)</th></tr>
<tr><td>Mercury</td><td>0.205</td></tr>
<tr><td>Venus</td><td>0.007</td></tr>
<tr><td>Earth</td><td>0.017</td></tr>
<tr><td>Mars</td><td>0.94</td></tr>
<tr><td>Jupiter</td><td>0.049</td></tr>
<tr><td>Saturn</td><td>0.057</td></tr>
<tr><td>Uranus</td><td>0.046</td></tr>
<tr><td>Neptune</td><td>0.011</td></tr>
</table></td></tr>
<tr><td>Law of Equal Areas</td><td>This law describes the speed at which planets travel at different points in their orbits. At times, the planet moves more rapidly than others as seen in image below.<br>

</td></tr>
<tr><td>Law of Periods</td><td>The time it takes a planet to revolve around the Sun is proportional to its distance from the Sun. The farther a planet is away from the Sun, the longer its period of revolution. Astronomers use this law to calculate a planet's distance from the Sun.</td></tr>
</table>

*Figure 2.* Laws (SCDE 2005).

<u>It is essential</u> that students use mathematical & computational thinking to explain the Law of Ellipses, Law of Equal Areas, and Law of Periods.

**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.

- Orbital period is calculated by $P^2 = a^3$ where "P" is in years and "a" is in Astronomical Units. Teachers may have students calculate and compare the orbital periods. Eccentricity describes the shape of an orbit. An orbit with the shape of a sphere has an eccentricity of zero (0) and one of a straight line has an eccentricity of one (1).
    - Teachers may extend this to student understanding of galactic shape, eccentricity. A galaxy with the shape of a sphere has an eccentricity of zero (0).

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

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| **Future Learning Experiences** | **Previous Learning Connections (6-8):**<br>**8.E.4B.2:** Construct explanations for how gravity affects the motion of objects in the solar system and tides on Earth.<br><br>**Physics Learning Connections:**<br>**H.P.2D.2:** Use mathematical and computational thinking to predict the relationships among the masses of two objects, the attractive gravitational force between them, and the distance between them (Newton's Law of Universal Gravitation, $F=Gm_1m_2/r^2$ ).<br>**H.P.2D.3:** Obtain information to communicate how long-term gravitational interactions govern the evolution and maintenance of large-scale structures in the universe (such as the solar system and galaxies) and the patterns of motion within them. |

## Astronomy

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|---|---|
| **Standard H.E.2:** The student will demonstrate an understanding of the structure, properties, and history of the observable universe. | |
| **H.E.2B Conceptual Understanding:** The solar system consists of the Sun and a collection of objects of varying sizes and conditions – including planets and their moons – that have predictable patterns of movement. These patterns can be explained by gravitational forces and conservation laws, and in turn explains many large-scale phenomena observed on Earth. Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the Sun. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. | |
| **Performance Indicator** | **H.E.2B.4:** Construct explanations for how the solar system was formed. |
| **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.<br><br>Energy and Matter |



**Essential Learning Experiences:**
It is essential that students construct explanations and know:

- The evident properties within the Solar System that support the Nebular Theory of its formation.
- Stars and planets form from clouds of gas and dust, called interstellar clouds, which exist between the stars. This interstellar cloud material can be observed in regions along the Milky Way. The collapsing of interstellar cloud material along with its rotational motion is the beginning of the flattened rotating disk that became the Solar System.
- Planets near the Sun formed from elements and compounds that could withstand the Sun's heat, such as iron, and formed the terrestrial/rocky planets.
- Outer gas planets formed farther from the Sun where it is cooler.
- Other remnants from the Solar System formation are asteroids, meteoroids, and comets.

It is essential that students construct their own explanations for how the solar system was formed.

**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.

- Describe the formation process of the individual bodies within the Solar System.

**Assessment Guidelines:**
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| **Learning Connections** | **Previous Connections (6-8):**<br>**7.P.2A.2:** Obtain and use information about elements (including chemical symbol, atomic number, atomic mass, and group or family) to describe the organization of the periodic table.<br>**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.<br>**8.E.4B.2:** Construct explanations for how gravity affects the motion of objects in the solar system and tides on Earth.<br><br>**Physics Connections:**<br>**H.P.2D.2:** Use mathematical and computational thinking to predict the relationships among the masses of two objects, the attractive gravitational force between them, and the distance between them (Newton's Law of Universal Gravitation, $F=Gm_1m^2/r^2$ ). |

# Earth's Geosphere

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|---|---|
| **Standard H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere. | |
| **H.E.3A. Conceptual Understanding:** Evidence indicates Earth's interior is divided into a solid inner core, a liquid outer core, a solid (but flowing) mantle and solid crust. Although the crust is solid, it is in constant motion and is recycled through time. Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a coherent account of its geological history. Weathering (physical and chemical) and soil formation are a result of the interactions of Earth's geosphere, hydrosphere, and atmosphere. All forms of resource extraction and land use have associated economic, social, environmental, and geopolitical costs, risks, and benefits. Natural hazards and other geological events have shaped the course of human history. | |
| **Performance Indicator** | **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. |
| **Science and Engineering Practice** | **S.1A.4:** Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions. |
| **Crosscutting Concepts** | The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6.<br><br>Energy and Matter<br>Structure and Function |

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

- The layering of Earth into a core, mantle and crust occurred early in Earth's formation because the temperature within the planet steadily increased due to decay of radioactive elements. Earth became so hot that at least some melting of original materials occurred and denser materials (such as iron) were pulled to the core.
- Depending upon the temperature and pressure, a particular Earth material may behave like a solid, or like a putty-like material, or even melt and become a liquid within the Earth.
    - The core is composed of more dense material which sank to become the core. At the extreme pressures found in the core, the iron-rich material in the center forms a solid sphere. The iron-rich material of the liquid outer core has a convective flow which generates Earth's magnetic field.

- The mantle is a zone of rock that makes up almost two-thirds of Earth's mass. It is divided into different regions – the top portion, along with the crust, is mostly igneous rock and is part of the lithosphere. The asthenosphere, below the lithosphere, is partially melted due to increases in pressure and temperature and allows for convection currents to flow, which drives plate tectonic movements. In the lower mantle pressure increases and the rock material strengthens to a more rigid layer. Even so, the rocks are still hot and capable of very gradual flow.
- The crust is Earth's outermost layer: a relatively cool, rigid shell. It makes up only about one percent of Earth's mass. There are two types of crustal material – the thinner, denser oceanic crust and the thicker, less dense continental crust.

- The behavior of seismic waves has allowed scientists to learn much about Earth's interior structure. For instance, S-waves do not move through the liquid outer core.
- Radioactive decay of elements within the Earth contributes to the heat and help drive convection currents.

**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.

- Teachers may elect to explore the temperatures or distances for each of Earth's layers.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**6.P.3A.4:** Develop and use models to exemplify how magnetic fields produced by electrical energy flow in a circuit is interrelated in electromagnets, generators, and simple electrical motors.<br>**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.<br>**8.P.3A.1:** Construct explanations of the relationship between matter and energy based on the characteristics of mechanical and light waves.<br><br>**Chemistry Connections:**<br>**H.C.2B.2:** Develop models to exemplify radioactive decay and use the models to explain the concept of half-life and its use in determining the age of materials (such as radiocarbon dating or the use of radioisotopes to date rocks)<br><br>**Physics Connections:**<br>**H.P.2D.5:** Construct explanations for how the non-contact forces of gravity, |

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| | electricity, and magnetism can be modeled as fields by sketching field diagrams for two given charges, two massive objects, or a bar magnet and use these diagrams to qualitatively interpret the direction and magnitude of the force at a particular location in the field. |

# Earth's Geosphere

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|---|---|
| **Standard H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere. | |
| **H.E.3A. Conceptual Understanding:** Evidence indicates Earth's interior is divided into a solid inner core, a liquid outer core, a solid (but flowing) mantle and solid crust. Although the crust is solid, it is in constant motion and is recycled through time. Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a coherent account of its geological history. Weathering (physical and chemical) and soil formation are a result of the interactions of Earth's geosphere, hydrosphere, and atmosphere. All forms of resource extraction and land use have associated economic, social, environmental, and geopolitical costs, risks, and benefits. Natural hazards and other geological events have shaped the course of human history. | |
| **Performance Indicator** | **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. |
| **Science and Engineering Practice** | **S.1A.4:** Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions. |
| **Crosscutting Concepts** | The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6.<br><br>Cause and Effect<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students analyze and interpret the following:

- The Theory of Plate Tectonics states that Earth's crust and rigid upper mantle (lithosphere) are broken into enormous sections called plates. Tectonic plates move in different directions and at different rates over Earth's surface. The plates are continually changing in shape and size.
- The movement of Earth's plates is explained in a hypothesis that proposes convection currents within the mantle are driven by the unequal distribution of heat. Hot material found deep in the mantle moves slowly upward and serves as one part of Earth's internal convection system. Also cooler, denser sections of oceanic lithosphere descend into the mantle, setting the outer crust into motion. Convection currents in the asthenosphere are thus set in motion by the transfer of energy between Earth's hot interior and the cooler exterior.

- When tectonic plates move, they interact at places called plate boundaries. Each type of boundary has certain geologic characteristics and processes associated with it.
    - Divergent Boundaries are places where two plates are moving apart (separating). Most are found on the seafloor and form ocean ridges, creating new crust and accounts for high heat flow, volcanic eruptions, and earthquakes. On continents, when continental crust begins to separate, the stretched crust forms a long, narrow depression called a rift valley.
    - Convergent Boundaries are places where two plates are moving toward each other. There are three types, which are classified by the type and density of crust involved: (1) Oceanic crust converging with oceanic crust – one of the two plates is denser (and usually older) and descends beneath the other in a process called subduction. Subduction creates a deep trench and because the plate melts, creates a volcanic arc of islands. (2) Oceanic crust converging with less dense continental crust – subduction also occurs, causes a trench, and a volcanic arc on the edge of the continent. (3) Continental plates collide – both plates are too buoyant to be subducted, so the colliding edges of the continents are crumpled and uplifted to form a mountain range.
    - Transform Boundaries are places where two plates slide horizontally past each other. At these boundaries crust is only deformed or fractured. Most are found along the mid-ocean ridges; a famous exception is the San Andreas Fault in southwest California.
- The Continental Drift Hypothesis was developed by Alfred Wegener when he proposed that all Earth's continents once formed a supercontinent called Pangaea. Evidence he used to support this included the shape of the continents fitting together, similar rock types and formations across continents, similar fossils of plants and animals on different continents, and evidence of glaciers. This hypothesis was ultimately rejected because he could not explain how the continents had moved.
- In the 20th century, further evidence was developed to support the concept of continents moving. Paleomagnetic signatures of oceanic crust and the ages of rocks led Harry Hess to the concept of seafloor spreading. This discovery, along with earthquake data, etc. led to the Theory of Plate Tectonics where convection currents within the asthenosphere were the driving force of plate movement.

**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.

- Explore Pangaea Ultima and the potential effects of plate tectonics on the face of our planet.

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| **Learning Connections** | **Previous Connections (6-8):**<br>**6.P.3A.5:** Develop and use models to describe and compare the directional transfer of heat through convection, radiation, and conduction.<br>**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.<br>**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). |

# Earth's Geosphere

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| **Standard H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere. | |
| **H.E.3A. Conceptual Understanding:** Evidence indicates Earth's interior is divided into a solid inner core, a liquid outer core, a solid (but flowing) mantle and solid crust. Although the crust is solid, it is in constant motion and is recycled through time. Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a coherent account of its geological history. Weathering (physical and chemical) and soil formation are a result of the interactions of Earth's geosphere, hydrosphere, and atmosphere. All forms of resource extraction and land use have associated economic, social, environmental, and geopolitical costs, risks, and benefits. Natural hazards and other geological events have shaped the course of human history. | |
| **Performance Indicator** | **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). |
| **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.<br><br>Patterns<br>Cause and Effect<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students construct explanations concerning the following:

- Many crustal changes occur because of the forces interacting at and within plate boundaries.
    - At divergent boundaries, new crustal material forms as volcanic eruptions bring magma up to the surface and create undersea mountain ranges. Earthquakes often accompany a volcanic eruption.
    - At convergent boundaries, the force of plates being pushed together may form deep sea trenches at subduction zones and volcanic eruptions will form either volcanic island arcs or volcanoes within continental mountain ranges. Converging forces may slowly push two continental crusts together so the land crumples and folds to form a mountain range without volcanoes.

  - At transform boundaries, plates slide past each other and the buildup of pressure along the boundary may cause the fault to quickly move resulting in an earthquake.
- Hot spots are volcanoes far from plate boundaries where high-temperature mantle material rises toward the surface in plumes that melt crustal rock turning it to magma. The magma melts through the crust to form volcanoes. A trail of older volcanoes forms as a plate moves over a hot spot, such as the Hawaiian Islands.
- Seafloor spreading can be modeled to demonstrate the formation of the paleomagnetic signatures and rock ages that we see in the oceanic crust

**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.
- A knowledge of some of the major plates, their locations, and relative motion helps students to identify plate boundaries and the formations and activities that are evident along the plate boundary in that region of Earth. For example, the hot spot beneath the Yellowstone Basin in Wyoming.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**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.<br>**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).<br>**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. |

# Earth's Geosphere

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| **Standard H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere. | |
| **H.E.3A. Conceptual Understanding:** Evidence indicates Earth's interior is divided into a solid inner core, a liquid outer core, a solid (but flowing) mantle and solid crust. Although the crust is solid, it is in constant motion and is recycled through time. Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a coherent account of its geological history. Weathering (physical and chemical) and soil formation are a result of the interactions of Earth's geosphere, hydrosphere, and atmosphere. All forms of resource extraction and land use have associated economic, social, environmental, and geopolitical costs, risks, and benefits. Natural hazards and other geological events have shaped the course of human history. | |
| **Performance Indicator** | **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. |
| **Science and Engineering Practice** | **S.1A.5:** Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) 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.<br><br>Patterns<br>Scale, Proportion, and Quantity<br>Energy and Matter |

**Essential Learning Experiences:**
It is essential that students use mathematical and computational thinking concerning the following:

- The epicenter of an earthquake is the point directly above the focus (where the earthquake originated along the fault). The magnitude of an earthquake quantifies how much energy is released during the event. There are a number of scales used to define the magnitudes of earthquakes: the Richter Scale and the Moment Magnitude scale
- In order to determine the epicenter of an earthquake, seismologists use a process called triangulation. The steps are outlined below:
    1. Use the seismogram to determine the time difference between the arrival of the first P wave and the arrival of the first S wave.
    2. Find the place on the travel time graph where the difference between the P and S curves is equal to the P-S Interval determined in step 1.

3. From this point, draw a vertical line to the bottom of the graph to read the distance to the epicenter.
4. Repeat steps 1-3 for seismograms from two other stations.
5. Use a compass to draw a circle around each station where the radius for each is the distance to the epicenter found in step 3.
6. The point where the three circles overlap is the epicenter.

- The frequency and magnitude of an earthquake are inversely proportional. The frequency of an earthquake decreases as the magnitude increases.

**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.

- Use seismograms from more additional distant stations to triangulate calculations.
- Teachers may consider linking earthquakes to tsunamis from recent earthquakes in the Pacific Rim.
- Teachers may evaluate what hazards will occur based upon the geology of the area.

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

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|---|---|
| **Learning Connections** | **Previous Connections (6-8):**<br>**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). |

# Earth's Geosphere

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| **Standard H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere. | |
| **H.E.3A. Conceptual Understanding:** Evidence indicates Earth's interior is divided into a solid inner core, a liquid outer core, a solid (but flowing) mantle and solid crust. Although the crust is solid, it is in constant motion and is recycled through time. Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a coherent account of its geological history. Weathering (physical and chemical) and soil formation are a result of the interactions of Earth's geosphere, hydrosphere, and atmosphere. All forms of resource extraction and land use have associated economic, social, environmental, and geopolitical costs, risks, and benefits. Natural hazards and other geological events have shaped the course of human history. | |
| **Performance Indicator** | **H.E.3A.5:** Analyze and interpret data to describe the physical and chemical properties of minerals and rocks, and classify each based on the properties and environment in which they were formed. |
| **Science and Engineering Practice** | **S.1A.4:** Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions. |
| **Crosscutting Concepts** | The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6.<br><br>Patterns<br>Cause and Effect<br>Scale, Proportion, and Quantity<br>Structure and Function |

**Essential Learning Experiences:**

It is essential that students interpret and analyze data including the following:

- The rock cycle illustrates the continuous changing and remaking of rocks on Earth. There is more than one path in the rock cycle. Processes can change any rock into another rock. Internal processes include heat & pressure, melting, cooling and crystallization, and uplift. External processes include weathering, erosion, deposition, burial, and lithification. The three types of rock are igneous, sedimentary, and metamorphic and are grouped according to how they form.
- Mineral identification consists of the following:
    - Use classification charts to identify minerals
    - Use the results from a combination of tests to determine a mineral's classification and identity.

  - Comparing test results from the mineral sample with known properties of minerals from a mineral identification chart increases the accuracy of the identification.
  - Mineral identification properties and tests students should be able to perform include: Color, luster, texture, streak, hardness, cleavage, fracture, and density.
  - Some minerals have special properties that are useful in identification, such as reaction with acid, magnetic attraction, or light refraction in transparent or translucent minerals.
- Rock identification consists of the following:
  - Use classification charts to identify rocks
  - Rocks are made up of minerals and are formed very differently.
  - Geologists analyze mineral composition, evidence of type of formation, and size & arrangement of minerals to determine the classification of rocks. After basic information is gathered on a specific rock to determine its major rock type and classification, properties on a rock identification chart can be used to identify the specific rock sample.
  - Rock identification properties and tests students should be able to perform include:
    - (1) For igneous rocks – intrusive or extrusive based on texture (fine-grained, coarse grained, glassy crystal size); composition of minerals (using common minerals such as quartz, feldspar, mica, hornblende)
    - (2) For metamorphic rocks – foliated or nonfoliated based on texture (layers or bands of minerals, not banded); coarse-grained or fine-grained
    - (3) For sedimentary rocks – clastic, organic, or chemical based on evidence of sediment particles/grains (coarse-grained, medium-grained, fine-grained) cemented together; evidence of once-living material (shells, plants/carbon,); evidence that the material could have been precipitated or settled out of water or was evaporated from solution.
- The properties of the rocks also give clues to the environment in which they were formed.
  - Intrusive igneous rocks with their larger crystals were formed deep inside Earth where slow cooling could take place. Small grained or glassy texture of extrusive igneous rocks indicates rapid cooling at Earth's surface with little to no time for crystals to grow.
  - The grade of metamorphic rock is dependent upon a combination of factors including pressure on the rocks, temperature, and the depth below the surface.
  - Clastic sedimentary rocks with particles that are rounded are evidence of water-transported materials while angular fragments indicated little transport or possibly wind born.
  - Changes in river level or sea level may result in stratification of sedimentary rock layers.

**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.

- Classification of minerals into groups/families

- Identify specific mineral crystal systems
- Further classification of igneous, metamorphic, or sedimentary rocks beyond the main grouping.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**7.P.2B.1:** Analyze and interpret data to describe substances using physical properties (including state, boiling/melting point, density, conductivity, color, hardness, and magnetic properties) and chemical properties (the ability to burn or rust). |

# Earth's Geosphere

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| **Standard H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere. | |
| **H.E.3A. Conceptual Understanding:** Evidence indicates Earth's interior is divided into a solid inner core, a liquid outer core, a solid (but flowing) mantle and solid crust. Although the crust is solid, it is in constant motion and is recycled through time. Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a coherent account of its geological history. Weathering (physical and chemical) and soil formation are a result of the interactions of Earth's geosphere, hydrosphere, and atmosphere. All forms of resource extraction and land use have associated economic, social, environmental, and geopolitical costs, risks, and benefits. Natural hazards and other geological events have shaped the course of human history. | |
| **Performance Indicator** | **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). |
| **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.<br><br>Cause and Effect<br>Systems and System Models<br>Energy and Matter<br>Stability and Change |



**Essential Learning Experiences:**

It is essential that students develop and use models concerning the following:

- How to use illustrations, imagery, topographic maps, pictures, or descriptions of surface features to determine geologic processes responsible for those features.
- Weathering is the process of disintegration (physical/mechanical weathering) and decomposition (chemical weathering) of surface rock material.
- Erosion is the process of moving weathered material from one place to another through various erosional agents (gravity, wind, water, plants/animal/humans). Erosion is a destructive process that wears down Earth's surface, Gullies, rills, changes in coastal topography, sand dunes, and landslides are evidence of erosion by those various agents.
- Deposition is the process in which eroded material from one place will deposit it in another. It is a constructive process that builds up Earth's surface. Deltas and sandbars or barrier islands are a result of deposition.

- Glaciation is the process with the capacity to carry huge rocks and piles of debris over great distances. Glaciers scrape and gouge out large sections of Earth's landscape. Features left in the wake of glaciation include U-shaped valleys, waterfalls, glacial lakes, and various types of deposits such as moraines.

**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.

- Teachers may elect to delve further into the individual processes of weathering erosion or glaciation.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**8.E.5A.1:** Develop and use models to explain how the processes of weathering, erosion, and deposition change surface features in the environment. |

# Earth's Geosphere

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| **Standard H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere. | |
| **H.E.3A. Conceptual Understanding:** Evidence indicates Earth's interior is divided into a solid inner core, a liquid outer core, a solid (but flowing) mantle and solid crust. Although the crust is solid, it is in constant motion and is recycled through time. Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a coherent account of its geological history. Weathering (physical and chemical) and soil formation are a result of the interactions of Earth's geosphere, hydrosphere, and atmosphere. All forms of resource extraction and land use have associated economic, social, environmental, and geopolitical costs, risks, and benefits. Natural hazards and other geological events have shaped the course of human history. | |
| **Performance Indicator** | **H.E.3A.7:** Plan and conduct controlled scientific investigations to determine the factors that affect the rate of weathering. |
| **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 based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. 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.<br><br>Cause and Effect<br>Scale, Proportion, and Quantity<br>Energy and Matter<br>Stability and Change |



**Essential Learning Experiences:**

It is essential that students plan and conduct research including:

- The rate at which rocks weather is determined by a number of factors.
    - Climate: Temperature and moisture affect the rate of weathering. In warm, humid climates, chemical weathering takes place relatively quickly. Cycles of freezing and thawing also accelerate weathering. Hot and dry climates have the slowest rate of weathering. The rocks in very cold dry areas, there is little weathering as well. Be mindful that the presence or absence of significant wind abrasion will affect the rate also.
    - Rock Composition: Sedimentary rocks weather faster than igneous and metamorphic rocks. This is due to the chemical properties of the substances that

hold them together. Rocks consisting of materials that tend to undergo chemical reactions will weather faster than others. For example, rocks that are made of calcite, iron or feldspar will weather quickly, while those made of quartz will weather more slowly.
  - Surface Area: The amount of surface area can affect the rate of weathering. The greater the amount of a rock's surface that is exposed to the elements, the faster at which a rock will weather. Fractures and joints found within rocks increase the surface area, thereby increasing the rate of weathering as well.

**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 benefit from exploring the binding chemicals in sedimentary rocks. Additional factors for investigation could include environmental factors or the effects of humans, plants, and animals.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**8.E.5A.1:** Develop and use models to explain how the processes of weathering, erosion, and deposition change surface features in the environment. |

# Earth's Geosphere

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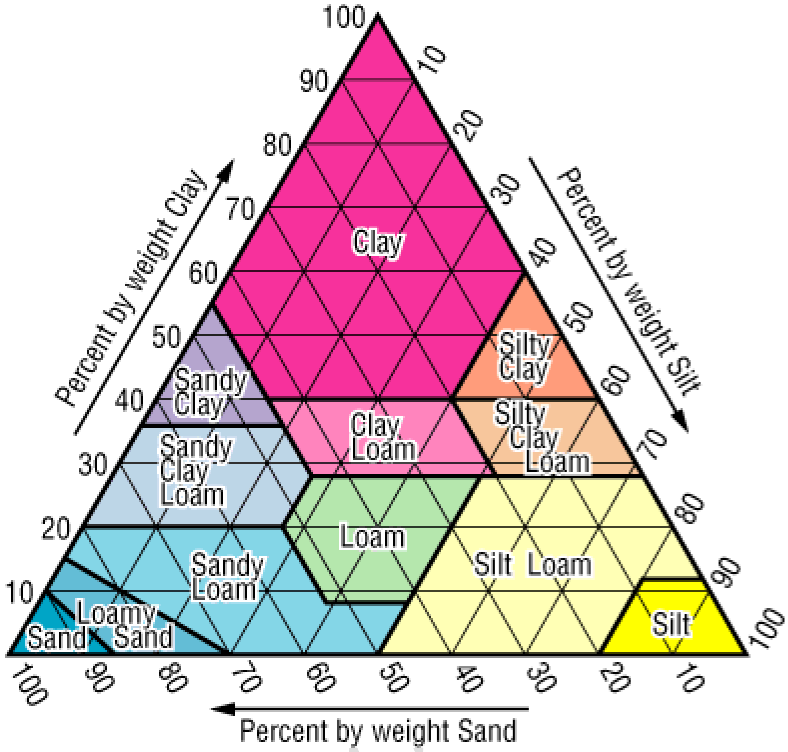
| **Standard H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere. | |
| **H.E.3A. Conceptual Understanding:** Evidence indicates Earth's interior is divided into a solid inner core, a liquid outer core, a solid (but flowing) mantle and solid crust. Although the crust is solid, it is in constant motion and is recycled through time. Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a coherent account of its geological history. Weathering (physical and chemical) and soil formation are a result of the interactions of Earth's geosphere, hydrosphere, and atmosphere. All forms of resource extraction and land use have associated economic, social, environmental, and geopolitical costs, risks, and benefits. Natural hazards and other geological events have shaped the course of human history. | |
| **Performance Indicator** | **H.E.3A.8:** Analyze and interpret data of soil from different locations to compare the major physical components of soil (such as the amounts of sand, silt, clay, and humus) as evidence of Earth processes in that region producing each type of soil. |
| **Science and Engineering Practice** | **S.1A.4:** Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions |
| **Crosscutting Concepts** | The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6.<br><br>Patterns<br>Scale, Proportion, and Quantity<br>Structure and Function |

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

- The characteristics of soil are dependent upon the characteristics of the parent rock.
- Soil is a mixture a number of particles.
  - The clay particles are the smallest in size with a smooth texture and feels sticky and pasty when wet. Due to the properties of clay, water does not drain well from soil with a large amount of clay.
  - The silt particles are larger in size than the clay and feel like flour and is often carried by water, and then deposited as sediment. Though the particles are too small to see with the naked eye, silt gives soil a gritty feel.
  - Sand is the largest of the soil particles, does not hold water well, and has a very gritty texture.

- The texture of soil is dependent upon the proportions of sand, silt and clay contained in the sample. Students should be able to determine the percentages of sand, silt and clay based on the triangle below.




NASA (2016). Soil Triangle. Retrieved from https://earthobservatory.nasa.gov/blogs/earthmatters/files/2016/01/blog_soil-triangle.gif

- Hummus is a layer of decaying organic matter. It provides air space in the soil and helps with water retention.

**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 should evaluate how the abiotic and biotic conditions of soil will influence the ability of the soil to grow plants, ease of farming, transmit water to the groundwater table, etc.

**Assessment Guidelines:**

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| Learning Connections | **Previous Connections (6-8):**<br>**8.E.5A.1:** Develop and use models to explain how the processes of weathering, erosion, and deposition change surface features in the environment. |
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# Earth's Geosphere

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| **Standard H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere. | |
| **H.E.3B:** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. Human transformation of the natural environment can contribute to the frequency and intensity of some natural hazards. | |
| **Performance Indicator** | **H.E.3B.1:** Obtain and communicate information to explain how the formation, availability, and use of ores and fossil fuels impact the environment. |
| **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.<br><br>Cause and Effect<br>Energy and Matter<br>Structure and Function<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students obtain, evaluate and communicate the following information:

- Ore formation:
  - A metal element or mineral is an ore if it contains a useful substance that can be mined at a profit. Ores form within Earth's crust as magma cools. Dense metallic minerals sink to the bottom of a body of magma. Layers of minerals accumulate and form ore deposits within the hardened magma.
  - Hot mineral solutions may also spread through small cracks in rock and harden in fingerlike bands called veins or lodes.
- Fossil fuel Formation (Coal, petroleum, and natural gas are examples):
  - Coal is a dark-colored organic rock formed from the remains of plants that flourished millions of years ago. Usually dead plants decompose, but if oxygen in a swamp area is limited and decay rate is slow, the compressed organic matter becomes coal.
  - Petroleum and natural gas originated with once living organisms that died and their remains accumulated on the ocean floor and lake bottoms, buried by

sediments. As with coal, limited oxygen prevented the remains from decomposing completely.
    - As more and more sediments accumulated, heat and pressure increased becoming great enough to convert the remains into petroleum and natural gas.
- Fossil fuels, like minerals, are nonrenewable resources that are needed in our world today, but the obtaining and use of these fuels can have an impact on the environment:
    - Coal is the most abundant fossil fuel in the world with present reserves that may last about 200 more years. Anthracite coal is the most efficient, cleanest burning coal, but it has the smallest reserves. Most coal burned is bituminous coal which releases carbon, sulfur, and nitrogen oxides into the air causing air pollution and acid precipitation. Safeguards are important to keep the abundance of these oxides from building up in the air. Strip mining of coal leaves deep ditches where the coal is removed, so mining companies work to ensure that the land around the mine is reclaimed as close to its natural state as possible.
    - Petroleum production involves looking for oil traps in folds of the rock layers or in fracture or fault zones. Oil shale may also contain petroleum between its layers, but it is very expensive to extract it. Transporting of oil must also be done with care so that oil spills from tankers and pipelines do not pollute ocean waters or harm wildlife.

It is essential that students use the above information how fossil fuels and ores impact the environment through formation, availability and use.

**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.

- Investigate the historical use of fossil fuels and their societal and environmental impacts over time.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**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.<br><br>**Biology Connections:**<br>**H.B.6B.1:** Develop and use models of the carbon cycle, which include the interactions between photosynthesis, cellular respiration and other processes that release carbon dioxide, to evaluate the effects of increasing atmospheric carbon dioxide on natural and agricultural ecosystems.<br>**H.B.6B.2:** Analyze and interpret quantitative data to construct an explanation for the effects of greenhouse gases (such as carbon dioxide and methane) on the carbon cycle and global climate. |

# Earth's Geosphere

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| **Standard H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere. | |
| **H.E.3B:** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. Human transformation of the natural environment can contribute to the frequency and intensity of some natural hazards. | |
| **Performance Indicator** | **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. |
| **Science and Engineering Practice** | **S.1A.7:** Construct and analyze scientific arguments to support claims, explanations, or designs using evidence and valid reasoning 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.<br><br>Cause and Effect<br>Energy and Matter<br>Structure and Function<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students construct scientific arguments including the following:

- The sustainability of human societies, as well as the biodiversity that supports them, is reliant upon the responsible management of the society's natural resources.
- Some factors that affect the management of natural resources include the extraction of resources, the management of waste, the development of new technologies and the per capita consumption.
- Often there is a relationship between the cost of extraction and the level of sustainability of that method.
- The factors that directly affect the human sustainability include urban planning, agricultural efficiency and level conservation of the available natural resources. Loss of biodiversity is often the result of habitat destruction.

It is essential that students use the above information to construct scientific arguments that responsible natural resource management is necessary to support human societies.

**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 should analyze various claims that support or reject the definition of responsible use of natural resources.

**Assessment Guidelines:**
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| **Learning Connections** | **Previous Learning Connections (6-8):**<br>**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.<br><br>**Biology Connections:**<br>**H.B.6B.1:** Develop and use models of the carbon cycle, which include the interactions between photosynthesis, cellular respiration and other processes that release carbon dioxide, to evaluate the effects of increasing atmospheric carbon dioxide on natural and agricultural ecosystems.<br>**H.B.6B.2:** Analyze and interpret quantitative data to construct an explanation for the effects of greenhouse gases (such as carbon dioxide and methane) on the carbon cycle and global climate. |

## Earth's Geosphere

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| **Standard H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere. | |
| **H.E.3B:** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. Human transformation of the natural environment can contribute to the frequency and intensity of some natural hazards. | |
| **Performance Indicator** | **H.E.3B.3:** Analyze and interpret data to explain how natural hazards and other geologic events have shaped the course of human history. |
| **Science and Engineering Practice** | **S.1A.4:** Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions. |
| **Crosscutting Concepts** | The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6.<br><br>Patterns<br>Cause and Effect<br>System and System Models<br>Energy and Matter<br>Structure and Function<br>Stability and Change |

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

- Natural hazards include earthquakes, tsunamis, volcanic eruptions, severe weather, floods, and coastal erosion. These natural processes have shaped the course of human history through driving human migrations and sometimes significantly changing the size of human populations in the affected areas.
- Natural hazards can destroy buildings and cities, erode land, change the course of rivers, and reduce the amount of arable land. Natural hazards may have local, regional, or global origins and impacts.

It is essential that students use the above information to analyze how natural hazards have shaped human history.

**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.

- Conduct research and develop models regarding how the different natural hazards affect different regions in the world.

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

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| **Learning Connections** | **Previous Learning Connections (6-8):**<br>**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. |

## Earth's Geosphere

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| **Standard H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere. | |
| **H.E.3B:** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. Human transformation of the natural environment can contribute to the frequency and intensity of some natural hazards. | |
| **Performance Indicator** | **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. |
| **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.<br><br>Patterns<br>Cause and Effect<br>Energy and Matter<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students obtain, evaluate and communicate information including:
- Human activities in agriculture, industry and everyday life can affect the frequency, intensity, or consequences of some natural hazards (for example flooding, erosion, forest fires, air and water pollution, and species endangerment/extinction).
- Human activities that impact the land, rivers, ocean, air, and biodiversity; include but are not limited to mining, burning of fossil fuels, use of certain chemicals in industrial and everyday processes, expansions of communities and roads, and increased per-capita consumption.

It is essential that students obtain and evaluate data to examine the effect of human activities on frequency, intensity, or other consequences of natural hazards.

**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.

- Investigate and compare the effects of different types of invasive species to the impact of humans in their respective environments.

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

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| **Learning Connections** | **Previous Learning Connections (6-8):**<br>**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. |

# Earth's Geosphere

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| **Standard H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere. | |
| **H.E.3B:** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. Human transformation of the natural environment can contribute to the frequency and intensity of some natural hazards. | |
| **Performance Indicator** | **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. |
| **Science and Engineering Practice** | **S.1.B1:** 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.<br><br>Cause and Effect<br>Energy and Matter<br>Structure and Function<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students define problems and design possible solutions concerning:
- The negative impact of human activities and how they can be reduced (and in some cases reversed) with responsible management, which can include regulations for the reduction, reuse, recycling or prohibition of materials and practices.
- Problems caused from natural hazards and design solutions to reduce the problems for daily human activity caused by these natural hazards.

**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.
- Define problems and design possible devices or solutions to lessen the negative impact of invasive species.

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

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| **Learning Connections** | **Previous Learning Connections (6-8):**<br>**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. |

## Earth's Paleobiosphere

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| **Standard H.E.4:** The student will demonstrate an understanding of the dynamic relationship between Earth's conditions over geologic time and the diversity of organisms. |
| **H.E.4A. Conceptual Understanding:** Living things have changed the makeup of Earth's geosphere, hydrosphere, and atmosphere over geological time. Organisms ranging from bacteria to human beings may contribute to the global carbon cycle. They may influence the global climate by modifying the chemical makeup of the atmosphere. As Earth changes, life on Earth adapts and evolves to those changes. Just as life influences components of the Earth System, changes in the Earth System influences life. |

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| **Performance Indicator** | **H.E.4A.1:** Construct scientific arguments to support claims that the physical conditions of Earth enable the planet to support carbon-based life. |
| **Science and Engineering Practice** | **S.1A.7:** Construct and analyze scientific arguments to support claims, explanations, or designs using evidence and valid reasoning 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.<br><br>Cause and Effect<br>Systems and System Models<br>Stability and Change |



**Essential Learning Experiences:**
It is essential that students should construct scientific arguments concerning:
- The Earth is suitable for life because of its unique orbital position, water exists in all three phases on the surface (making Earth unique), and the hydrosphere (Earth's mass of liquid water) is constantly on the move and vital to life.
- The Earth is surrounded by a life-giving gaseous envelope called the atmosphere which provides the air that organisms need to breathe. The atmosphere also protects organisms from the Sun's intense heat and harmful radiation.
- The biosphere includes all life on Earth and the abiotic factors necessary for organisms to breathe, obtain/make food, find shelter, and reproduce. Organisms not only respond to the environmental conditions on Earth, but also help maintain and alter the environment.
- Scientists examine evidence from the rock and fossil record to develop theories about life and the changes in Earth's conditions. Evidence supports that life forms went through many changes in order to exist. Geologic changes, changes in the amount of Earth's surface water, changes in the atmosphere resulting in climatic changes, and temperature changes have affected the existing life forms throughout Earth's history.

NOTE TO TEACHER: This indicator is directly related to several other standards (H.E.2B, H.E.6A, H.E.5A). It should be covered as the "big idea" after teaching the geosphere, hydrosphere, and atmosphere.

**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 other planets and moons in our solar system, or exoplanets in the universe to identify some of the characteristics necessary to life and compare them to Earth's past.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**6.E.2A.1:** Develop and use models to exemplify the properties of the atmosphere (including the gases, temperature and pressure differences, and altitude changes) and the relative scale in relation to the size of Earth.<br>**6.E.2A.2:** Critically analyze scientific arguments based on evidence for and against how different phenomena (natural and human induced) may contribute to the composition of Earth's atmosphere.<br>**6.E.2A.3:** Construct explanations of the processes involved in the cycling of water through Earth's systems (including transpiration, evaporation, condensation and crystallization, precipitation, and downhill flow of water on land).<br>**8.E.4 B.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.<br>**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.<br>**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.<br>**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.<br>**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 |

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| | of its life forms.<br>**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.<br>**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.<br>**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.<br>**8.E.6B.2:** Obtain and communicate information to support claims that natural and human-made factors can contribute to the extinction of species. |

# Earth's Paleobiosphere

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| **Standard H.E.4:** The student will demonstrate an understanding of the dynamic relationship between Earth's conditions over geologic time and the diversity of organisms. | |
| **H.E.4A. Conceptual Understanding:** Living things have changed the makeup of Earth's geosphere, hydrosphere, and atmosphere over geological time. Organisms ranging from bacteria to human beings may contribute to the global carbon cycle. They may influence the global climate by modifying the chemical makeup of the atmosphere. As Earth changes, life on Earth adapts and evolves to those changes. Just as life influences components of the Earth System, changes in the Earth System influences life. | |
| **Performance Indicator** | **H.E.4A.2:** Construct explanations for how various life forms have altered the geosphere, hydrosphere and atmosphere over geological 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.<br><br>Cause and Effect<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students construct explanations concerning the following:

- Humans and other life forms have the capacity to alter Earth's geosphere, hydrosphere, and atmosphere.
- The Earth's geologic, hydrologic, and atmospheric processes have contributed to the extinction of species, the emergence of new species, and other changes in animal, plant, and microbial populations. Likewise, the extinction, emergence, and change in living things affect the Earth, including its water and atmosphere.
- Through the process of photosynthesis, plants, algae, and microorganisms have contributed most of the oxygen in the atmosphere. These organisms also contributed greatly to the conversion of ancient plant matter into fossil fuels, and the formation of certain types of sedimentary rock.
- Microorganisms constantly contribute to the recycling of nitrogen and other nutrients.
- The human impact has contributed to an increase in greenhouse gases and thinning of layers of the atmosphere. For example, a greater range of electromagnetic radiation can penetrate the atmosphere and reach the Earth's surface.

**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.

- Research correlations between the events covered in the indicator and the events of the corresponding eras of geologic time.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**6.E.2A.2:** Critically analyze scientific arguments based on evidence for and against how different phenomena (natural and human induced) may contribute to the composition of Earth's atmosphere.<br>**6.L.5A.1:** Analyze and interpret data from observations to compare how the structures of protists (including euglena, paramecium, and amoeba) and fungi allow them to obtain energy and explore their environment.<br>**6.L.5B.4:** Plan and conduct controlled scientific investigations to determine how changes in environmental factors (such as air, water, light, minerals, or space) affect the growth and development of a flowering plant.<br>**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.<br>**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.<br><br>**Biology Connections:**<br>**H.B.3A.2:** Develop and revise models to describe how photosynthesis transforms light energy into stored chemical energy. |

# Earth's Paleobiosphere

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| **Standard H.E.4:** The student will demonstrate an understanding of the dynamic relationship between Earth's conditions over geologic time and the diversity of organisms. | |
| **H.E.4A. Conceptual Understanding:** Living things have changed the makeup of Earth's geosphere, hydrosphere, and atmosphere over geological time. Organisms ranging from bacteria to human beings may contribute to the global carbon cycle. They may influence the global climate by modifying the chemical makeup of the atmosphere. As Earth changes, life on Earth adapts and evolves to those changes. Just as life influences components of the Earth System, changes in the Earth System influences life. | |
| **Performance Indicator** | **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. |
| **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.<br><br>Patterns<br>Cause and Effect<br>Systems and System Models<br>Energy and Matter<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students construct explanations concerning the following:

- Scientists have developed a geologic history of Earth from evidence found in the rock layers. The type of rock that makes up the layer and the fossils that are found in each layer help to reveal information about the conditions that existed when the layer formed. Fossils also indicate the kinds of organisms that lived during that geologic time.
- Major divisions, eons and eras, and the fact that periods within the eras were further divided based on the life-forms that were abundant or became extinct during the time those rocks were deposited. A further division during the Cenozoic Era is epochs. Since the rock record during this last era is relatively complete with less time for change due to weathering and erosion, different groups of organisms can be used to distinguish the various epochs.
- Various illustrations of the geologic time scale noting major geologic events taking place on Earth. They should use the information on the illustrations to note changes in life

forms both in the complexity of the organisms and the diversity of those life-forms through time.

**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.

- Identify life forms in existence during various periods or epochs and justify their existence based on environmental conditions of the time period.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**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.<br>**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.<br>**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.<br>**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.<br><br>**Biology Connections:**<br>**H.B.4C.2:** Analyze data on the variation of traits among individual organisms within a population to explain patterns in the data in the context of transmission of genetic information. |

# Earth's Paleobiosphere

<table>
<tr><td colspan="2">Standard H.E.4: The student will demonstrate an understanding of the dynamic relationship between Earth's conditions over geologic time and the diversity of organisms.</td></tr>
<tr><td colspan="2">H.E.4A. Conceptual Understanding: Living things have changed the makeup of Earth's geosphere, hydrosphere, and atmosphere over geological time. Organisms ranging from bacteria to human beings may contribute to the global carbon cycle. They may influence the global climate by modifying the chemical makeup of the atmosphere. As Earth changes, life on Earth adapts and evolves to those changes. Just as life influences components of the Earth System, changes in the Earth System influences life.</td></tr>
<tr><td>Performance Indicator</td><td>H.E.4A.4: <u>Obtain and evaluate evidence</u> from rock and fossil records and ice core samples to support claims that Earth's environmental conditions have changed over time.</td></tr>
<tr><td>Science and Engineering Practice</td><td>S.1A.8: <u>Obtain and evaluate</u> 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.</td></tr>
<tr><td>Crosscutting Concepts</td><td>The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6.<br><br>Cause and Effect<br>Scale, Proportion, and Quantity<br>Energy and Matter<br>Stability and Change</td></tr>
</table>

**Essential Learning Experiences:**
<u>It is essential</u> that students obtain and evaluate evidence concerning the following:

- There are various types of fossils. Some may be direct evidence of the organism such as shells, bones, or plant fragments; others may be indirect evidence, such as tracks, trails, or footprints. Students may review the various types of fossils from their previous learning.
- A fossil is considered to be originally preserved when the organism remains as it was when it died; it is considered to be an altered fossil when all of the organic material has decomposed and been replaced by minerals deposits.
- Fossils of all types furnish scientists with clues to changes that have occurred in Earth's past, such as changes in climate and environment. If a fossil of a warm climate reptile is found in a northern colder region today, the fossil indicates that that area once had a tropical climate. Tropical plants have been found in Antarctica; fossils of marine animals

have been found far from any ocean. Students should be researching examples of fossil organisms that give scientists these clues.

- The study of fossils allows scientists to:
    - describe how organisms have changed through time
    - have evidence of ancient environmental conditions
    - find patterns and cycles that can be used to predict future phenomena, such as climatic changes
    - Locate energy resources based on the environmental conditions needed for fossil fuels to have formed.
- The use of ice core data to analyze atmospheric conditions throughout Earth's history.

**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.

- Explore how fossils are formed in different ways

**Assessment Guidelines:**
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| **Learning Connections** | **Previous Connections (6-8):**<br>**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<br>**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.<br>**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.<br><br>**Biology Connections:**<br>**H.B.4C.2:** Analyze data on the variation of traits among individual organisms within a population to explain patterns in the data in the context of transmission of genetic information. |

# Earth's Paleobiosphere

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| **Standard H.E.4:** The student will demonstrate an understanding of the dynamic relationship between Earth's conditions over geologic time and the diversity of organisms. | |
| **H.E.4A. Conceptual Understanding:** Living things have changed the makeup of Earth's geosphere, hydrosphere, and atmosphere over geological time. Organisms ranging from bacteria to human beings may contribute to the global carbon cycle. They may influence the global climate by modifying the chemical makeup of the atmosphere. As Earth changes, life on Earth adapts and evolves to those changes. Just as life influences components of the Earth System, changes in the Earth System influences life. | |
| **Performance Indicator** | **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. |
| **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.<br><br>Patterns<br>Scale, Proportion, and Quantity<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students develop and use models concerning the following:

- Rocks contain clues to Earth's past, including life forms and evidence of geologic change. Several ways to learn about and date Earth's past come from the type of rock found, the rock layers, and fossils found within some of the rocks. Methods of dating the Earth are determined by whether the need is for which came first and sequencing to later dates, or whether the need is for an actual age.
- Relative Age Dating is used for ordering oldest to youngest in geologic time
  - Ordering Rock Layers: the geologic principles of uniformitarianism, superposition, and cross-cutting relationships help to determine the ordering of rock layers and changes that occur to those rock layers over time. Weathering and erosion can disturb the rock layering, and an intrusion or a fault can indicate younger or more recent changes to the rock layer(s) in which the fossil is found.
  - Index Fossils: Used to aid in the ordering of rock layers or to age the rock layer. Geologists use index fossils to correlate rock layers over large geographic areas and to date a particular rock layer. An index fossil must be easily recognized, have been abundant and widely distributed geographically. It also must have lived during a short period of time. With this information, a scientist can use index

fossils to date the age of the rock layer based upon when that organism was known to have lived in geologic time. An index fossil found in rock layers in different areas of the world indicates that the rock layers were probably formed during the same period.

- Radiometric/Absolute Age Dating is used to determine the actual age of a rock or fossil. Scientists use radioactive isotopes of elements found in rocks or fossils. Radioactive isotopes give off energy and particles at a regular rate, not influenced by environment, temperature, or any other changes, and eventually change to other isotopes of that element or into an isotope of a different element. They function as a natural clock. This process is called radioactive decay. By knowing how long a radioactive element takes to decay into its “daughter” elements, and by determining the ratio of the original radioactive element still present compared to the amount of “daughter” element, the age of the rock being analyzed can be determined. Since this process takes a long period of time for most radioactive elements, geologist use the length of time it takes for one-half of the original amount to decay, called the half-life, to determine age.
- Uranium-238 may be used for one dating compared to carbon-14 in another instance.

**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 know the details of the particles given off or the various daughter elements that occur in the radioactive decay process.

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| **Learning Connections** | **Previous Connections (6-8):**<br>**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.<br>**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.<br><br>**Chemistry Connections:**<br>**H.C.2B.2:** Develop models to exemplify radioactive decay and use the models to explain the concept of half-life and its use in determining the age of materials (such as radiocarbon dating or the use of radioisotopes to date rocks) |

## Earth's Paleobiosphere

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| **Standard H.E.4:** The student will demonstrate an understanding of the dynamic relationship between Earth's conditions over geologic time and the diversity of organisms. | |
| **H.E.4A. Conceptual Understanding:** Living things have changed the makeup of Earth's geosphere, hydrosphere, and atmosphere over geological time. Organisms ranging from bacteria to human beings may contribute to the global carbon cycle. They may influence the global climate by modifying the chemical makeup of the atmosphere. As Earth changes, life on Earth adapts and evolves to those changes. Just as life influences components of the Earth System, changes in the Earth System influences life. | |
| **Performance Indicator** | **H.E.4A.6:** Use mathematical and computational thinking to calculate the age of Earth materials using isotope ratios (actual or simulated). |
| **Science and Engineering Practice** | **S.1A.5:** Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) 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.<br><br>Patterns<br>Scale, Proportion, and Quantity<br>Energy and Matter<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students use mathematical and computational thinking with the following:

- Scientists are collecting and analyzing data to develop theories about the age of Earth. Radiometric dating has determined the age of the oldest rocks on Earth at present time but the rocks that formed Earth's crust have been eroded over time. Radiometric dating has occurred because radioactive atoms are trapped in the molten rock that cools, forming igneous rock. The radioactive elements decay at predictable rates. If the isotopes of the radioactive atoms are measured, the quantities of unstable atoms left in a rock are compared to the stable atoms in the rock to estimate the amount of time that has passed since the rock formed. Meteorites and moon rocks have also been studied for evidence of age.

**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.

- Research data analyzed by scientist in order to come up with a determination of the age of the universe and Earth.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**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.<br><br>**Chemistry Connections:**<br>**H.C.2B.2:** Develop models to exemplify radioactive decay and use the models to explain the concept of half-life and its use in determining the age of materials (such as radiocarbon dating or the use of radioisotopes to date rocks) |

# Earth's Paleobiosphere

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| **Standard H.E.4:** The student will demonstrate an understanding of the dynamic relationship between Earth's conditions over geologic time and the diversity of organisms. | |
| **H.E.4A. Conceptual Understanding:** Living things have changed the makeup of Earth's geosphere, hydrosphere, and atmosphere over geological time. Organisms ranging from bacteria to human beings may contribute to the global carbon cycle. They may influence the global climate by modifying the chemical makeup of the atmosphere. As Earth changes, life on Earth adapts and evolves to those changes. Just as life influences components of the Earth System, changes in the Earth System influences life. | |
| **Performance Indicator** | **H.E.4A.7:** Develop and use models to predict the effects of an environmental change (such as the changing life forms, tectonic change, or human activity) on global carbon cycling. |
| **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.<br><br>Patterns<br>Cause and Effect<br>Systems and System Models<br>Energy and Matter<br>Structure and Function<br>Stability and Change |



**Essential Learning Experiences:**
It is essential that students develop and use models to predict the effects of environmental change including:

- The carbon cycle is a process by which carbon is cycled through the atmosphere, land, water, and organisms.
    - Carbon dioxide is used by plants when carbon enters the cycle when producers convert carbon dioxide from the air into carbohydrates through the process of photosynthesis.
    - Animals (consumers) convert the carbohydrates, from the producers, into carbon through the process of cellular respiration. This releases carbon dioxide back into the air.
    - In the oceans, carbon dioxide is being dissolved in water through diffusion. The carbon dioxide is used by marine plants during photosynthesis. Some carbon

dioxide remains in the water and is converted into carbonates and bicarbonates. Some of the carbonates are used by marine mammals for habitat, such as shells.
  - When organisms die, their bodies decay and decompose and release carbon dioxide. Sometimes, those organisms are buried under the ground. After millions of years, high pressure and other physical and chemical changes, cause a change into fossil fuels. Fossil fuels stored deep in the ground are mined and used for industrial purposes, like car fuel. Fossil fuels are burned and release waste, often in the form of gas, into the air. These gases contain a large amount of carbon dioxide.

- The carbon cycle can be altered by many factors including changing life forms, plate tectonics, and human activity.
  - Changing life forms: Biodiversity of plants decreases as human impact on the land continues to grow. Overproduction in farming and deforestation decreases the amount of plants. As a result, less carbon dioxide is absorbed by plants. Thus causing an increase in carbon dioxide remaining in the air. An increase of carbon dioxide in the air increases the temperatures and humidity in the air.
  - Plate tectonics: Subduction of plate boundaries and volcanoes causes changes in the amount of carbon in the carbon cycle. When plate boundaries subduct, continental crust slides under another plate. The subducting crust melts and becomes magma. Carbon from the crust is recycled and the magma then becomes fuel for a volcanic eruption. During the eruption, carbon dioxide is recycled, increasing the amount of carbon dioxide in the atmosphere.
  - Human activity: Human activity increases the amount of carbon dioxide in the atmosphere. Deforestation, land-use concerns, burning of fossil fuels, over population, and carbon emissions are examples of human impacts on the carbon cycle. The increase of carbon dioxide has been linked to climate changes and increase in greenhouse gases.

**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.
- Explore how the environmental factors change the carbon cycle, but also result in changes to other biological cycles (phosphorus, oxygen, nitrogen).

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

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| **Future Learning Experiences** | **Previous Connections (6-8):**<br>**6.E.2A.2:** Critically analyze scientific arguments based on evidence for and against how different phenomena (natural and human induced) may contribute to the composition of Earth's atmosphere<br>**6.L.5B.2:** Analyze and interpret data to explain how the processes of photosynthesis, respiration, and transpiration work together to meet the needs of plants.<br><br>**Biology Connections:**<br>**H.B.6B.1:** Develop and use models of the carbon cycle, which include the interactions between photosynthesis, cellular respiration and other processes that release carbon dioxide, to evaluate the effects of increasing atmospheric carbon dioxide on natural and agricultural ecosystems.<br>**H.B.6B.2:** Analyze and interpret quantitative data to construct an explanation for the effects of greenhouse gases (such as carbon dioxide and methane) on the carbon cycle and global climate. |

# Earth's Atmosphere

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| **Standard H.E.5**: The student will demonstrate an understanding of the dynamics of Earth's atmosphere. | |
| **H.E.5A Conceptual Understanding:** Weather is the condition of the atmosphere at a particular location at a particular time. Weather is primarily determined by the angle and amount (time) of sunlight. Climate is the general weather conditions over a long period of time and is influenced by many factors. | |
| **Performance Indicator** | **H.E.5A.1:** Develop and use models to describe the thermal structures (including the changes in air temperature due to changing altitude in the lower troposphere), the gaseous composition, and the location of the layers of Earth's atmosphere. |
| **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.<br><br>Cause and Effect<br>Energy and Matter<br>Structure and Function |

**Essential Learning Experiences:**
It is essential that students develop and use models concerning the following:

- The Earth's atmosphere is the layer of gases that surrounds the planet and makes conditions on Earth suitable for living things.
- The atmosphere is a mixture of chemical elements and compounds differentiated by distinct differences in temperature with increasing altitude. This thermal structure differentiates the layers:
    - Troposphere is where all the weather occurs. Temperature decreases until the upper boundary (tropopause).
    - Stratosphere is where the ozone layer is contained. Temperature is increasing until the upper boundary (stratopause).
    - Mesosphere is the coldest layer. Temperature decreases as altitude increases until the upper boundary (mesopause).
    - Thermosphere is a very thin layer and extremely hot, with temperature increasing as altitude increases.
    - Exosphere is the boundary between our atmosphere and outer space.
- There are multiple gases in the atmosphere including:
    - Nitrogen ($N_2$) and Oxygen ($O_2$) are the most common gases, found in all layers.

- Ozone ($O_3$) is found mostly in the stratosphere and protects Earth from harmful UV rays from the Sun.
- Water vapor ($H_2O$) and carbon dioxide ($CO_2$) are the most important compounds in the atmosphere and important for weather conditions in the troposphere.
- Trace gases such as argon, etc. play an insignificant role in the atmosphere.

It is essential that students use the above information to develop their own model of the atmosphere how temperature, gases, and layers change from the Earth to 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.

- Explore the maintenance of stable amounts of gases in the atmospheres using the oxygen, carbon dioxide, and nitrogen cycle.
- Compare the properties of pure air with air containing particulate matter.

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

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| **Learning Connections** | **Previous Learning Connections (6-8):**<br>**6.E.2A.1:** Develop and use models to exemplify the properties of the atmosphere (including the gases, temperature and pressure differences, and altitude changes) and the relative scale in relation to the size of Earth. |

# Earth's Atmosphere

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| **Standard H.E.5**: The student will demonstrate an understanding of the dynamics of Earth's atmosphere. | |
| **H.E.5A. Conceptual Understanding:** Weather is the condition of the atmosphere at a particular location at a particular time. Weather is primarily determined by the angle and amount (time) of sunlight. Climate is the general weather conditions over a long period of time and is influenced by many factors. | |
| **Performance Indicator** | **H.E.5A.2:** Develop and use models to predict and explain how the angle of solar incidence and Earth's axial tilt impact (1) the length of daylight, (2) the atmospheric filtration, (3) the distribution of sunlight in any location, and (4) seasonal changes. |
| **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.<br><br>Patterns<br>Cause and Effect |

**Essential Learning Experiences:**
It is essential that students develop and use models concerning the following:
- The angle of solar incidence and the Earth's axial tilt impact the length of day, atmospheric filtration, the distribution of sunlight and seasonal changes.
- The tilt of the Earth alters the length of daylight throughout the year because as Earth revolves around the Sun, the tilt of its axis (23½ degrees) determines the amount of time that the Sun is penetrating on a portion of Earth. The tilt remains at the same angle and points at the same direction as Earth revolves around the Sun. When the southern hemisphere is tilted towards the sun the northern hemisphere is tilted away from the sun and vice versa.
    - If the tilt of Earth is toward the Sun, there is a longer length of day, the season is summer.
    - If it is neither tilted toward or away from the Sun, the length of day and night is equal, the season is fall and spring.
    - If the tilt of Earth is away from the Sun, there is a shorter length of day, the season is winter. Earth has seasons because its axis is tilted in the same direction as it moves around the Sun not because of any distance difference between the Sun and Earth.

  - 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.

- Explore the cause and effect of the jet streams and details of shifts in wind belts due to changes in seasons.

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

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| **Learning Connections** | **Previous Learning Connections (6-8):**<br>**6.E.2B.4:** Construct explanations for how climate is determined in an area (including latitude, elevation, shape of the land, distance from water, global winds, and ocean currents).<br>**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. |

# Earth's Atmosphere

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| **Standard H.E.5**: The student will demonstrate an understanding of the dynamics of Earth's atmosphere. | |
| **H.E.5A. Conceptual Understanding:** Weather is the condition of the atmosphere at a particular location at a particular time. Weather is primarily determined by the angle and amount (time) of sunlight. Climate is the general weather conditions over a long period of time and is influenced by many factors. | |
| **Performance Indicator** | **H.E.5A.3:** Analyze and interpret data to predict local and national weather conditions on the basis of the relationship among the movement of air masses, pressure systems, and frontal boundaries. |
| **Science and Engineering Practice** | **S.1A.4:** Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions. |
| **Crosscutting Concepts** | The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6.<br><br>Patterns<br>Systems and System Models<br>Energy and Matter<br>Structure and Function<br>Stability and Change |



**Essential Learning Experiences:**
It is essential that students analyze and interpret data to predict conditions including:

- Air masses, pressure systems, and frontal boundaries are the major causes of weather variations and storms. Many meteorological processes involve atmospheric movement, such as convection, on different scales. Weather is the current, day-to-day, conditions of the atmosphere. Predicting weather conditions and storms comes from knowing that they are part of and the result of relationships among the following factors in the atmosphere.
    - Air masses: A large body of air with similar temperature and moisture characteristics. There are several types of air masses that usually affect North America. As air masses move their characteristics modify according to the surface(s) over which they travel.
    - High pressure system: Sinking air is associated with high pressure systems, also called anticyclones. With the Coriolis effect, sinking air circulates downward and to the right in the northern hemisphere spreading away from the center when it reaches Earth's surface. High pressure systems rotate clockwise. High pressure

systems are usually associated with fair weather and generally pleasant conditions.
  - Low pressure: In surface low pressure systems, also called cyclones, system air rises. Rising air must be replaced, so the flow of air is inward toward the center and then upward. A low pressure system in the northern hemisphere moves in a counterclockwise direction. Low pressure systems are usually associated with clouds and precipitation.
  - Fronts: Air masses influence the formation of the four main types of fronts: cold front, warm front, occluded front, and stationary front. The direction of airflow within the frontal region influences the direction of frontal movement which determines the characteristic cloud formations and weather patterns that result from each frontal boundary.
- The Coriolis Effect is caused when the circulation of the atmosphere is affected by the rotation of Earth on its axis. The rotation causes the surface winds in the Northern Hemisphere to be deflected to the right and those in the Southern Hemisphere to be deflected to the left. Deflects winds that would otherwise blow directly from a high-pressure area toward a lower-pressure area from that path.
- Global winds which are caused by convection cells in the atmosphere while Earth is spinning on its axis, global winds are found in each convection region. The global wind belt regions, the prevailing direction of the wind, and how air movement in these large regions affects weather patterns.
  - Trade winds: The trade winds blow from east to west in the tropical region moving warm tropical air in that climate zone. Like all winds they are names according to the direction from which they flow, the northeast trade winds or the southeast trade winds.
  - Westerly winds: The prevailing westerly winds blow from west to east in the temperate region. The temperate zone temperatures are affected most by the changing seasons, but since the westerly wind belt is in that region, the weather systems during any season move generally from west to east. Since the United States is in the westerly wind belt, the weather systems move across this country from west to east. (Tropical weather systems, for example, hurricanes, are moved in the prevailing easterly direction of the trade winds. If they enter the westerly wind belt, they are often turned, and move in the direction of that prevailing system.)
  - Polar winds: The polar winds blow northeast to west in the polar region, often called the polar easterlies, moving cold polar air in that climate zone from the poles toward the west. Where the polar easterlies meet warm air from the westerlies, a stormy region known as a polar front forms.
- The information about the factors that influence weather conditions is also important to understand storms. The major storms – thunderstorm, hurricanes, and tornadoes, are associated with low pressure cyclonic movement of air and/or frontal boundaries. The conditions under which these storms form, how they are related to the factors that influence weather conditions (air masses, pressure systems, and fronts), and also factors concerning their duration and severity. Plotting the course of a hurricane and predicting it possible path based on atmospheric conditions is also essential in the study of this storm.

- Use weather map data that includes air masses, pressure systems and isobar lines, and fronts (as well as station model data) to predict weather conditions in regions across the United States.

It is essential that students use local and national weather data to predict weather patterns.

**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.

- In addition to weather data, students can read radar images or infrared satellites images in addition to weather maps.

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

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| **Learning Connections** | **Previous Learning Connections (6-8):**<br>**6.E.2B.2:** Develop and use models to explain how relationships between the movement and interactions of air masses, high and low pressure systems, and frontal boundaries result in weather conditions and storms (including thunderstorms, hurricanes and tornadoes).<br>**6.E.2B.3:** Develop and use models to represent how solar energy and convection impact Earth's weather patterns and climate conditions (including global winds, the jet stream, and ocean currents). |

## Earth's Atmosphere

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| **Standard H.E.5**: The student will demonstrate an understanding of the dynamics of Earth's atmosphere. | |
| **H.E.5A. Conceptual Understanding**: Weather is the condition of the atmosphere at a particular location at a particular time. Weather is primarily determined by the angle and amount (time) of sunlight. Climate is the general weather conditions over a long period of time and is influenced by many factors. | |
| **Performance Indicator** | **H.E.5A.4:** Analyze and interpret data of pressure differences, the direction of winds, and areas of uneven heating to explain how convection determines local wind patterns (including land/sea breezes, mountain/valley breezes, Chinook winds, and monsoons). |
| **Science and Engineering Practice** | **S.1A.4:** Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions. |
| **Crosscutting Concepts** | The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6.<br><br>Patterns<br>Cause and Effect<br>Systems and System Models<br>Energy and Matter<br>Structure and Function |

**Essential Learning Experiences:**
It is essential that students analyze and interpret data concerning the following:

- Convection is the transfer of heat energy in fluids, liquids or gases, by the movement of the heated particles.
    - In convection, particles with higher energy move from one location to another carrying their energy with them. Particles with the higher energy move from warmer to cooler parts of the fluid. Because of Earth's spherical shape, the Sun's rays strike Earth more directly at the tropics than they do at the poles.
    - At the poles, the same amount of solar radiation is spread over a larger area than at the equator. This unequal heating sets up the warmer-cooler regions necessary for global convection to take place in the atmosphere.
- The air flowing from the equator completes three looping patterns of flow called convection cells. There are three atmospheric convection cells in the northern hemisphere and three in the southern hemisphere.

- The tropical convection region begins at the equator and extends to the about 30 degrees north or south latitude – warm air rises at the equator then cools enough to descend at about 30 degrees latitude from which air flows both north and south;
- The temperate convection region extends from there to about 60 degrees north or south latitude – descending air moves either back toward the equator or toward the poles where the air at about 60 degrees and warmed enough to create a low pressure area and again rise;
- The polar convection region extends from there to the poles, 90 degrees north or south latitude – air at the poles is descending cold air that moves toward the equator; at about 60 degrees it has warmed enough to begin rising.

- Convection occurs on a global scale in the atmosphere, which causes global winds, and therefore is the mover of weather systems in particular directions. Due to the spinning of Earth, the weather systems in these convection cells move in certain directions because the global wind belts are set up. On a smaller scale, convection currents near bodies of water or near mountains can cause local winds known as land and sea breezes or mountain and valley breezes.
- Because of the unequal heating of Earth, climate zones (tropical, temperate, and polar) also occur.
- Since temperature is a major factor in climate zones, students should relate climate to the convection regions at various latitudes, to temperature differences between the equator and the poles, and also to warm and cold surface ocean currents.

**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.
- Explore seasonal patterns, strengths, and the environmental impact of Santa Ana and Desert winds.

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

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| **Learning Connections** | **Previous Learning Experiences (6-8):**<br>**6.E.2B.3:** Develop and use models to represent how solar energy and convection impact Earth's weather patterns and climate conditions (including global winds, the jet stream, and ocean currents).<br>**6.E.2B.4**: Construct explanations for how climate is determined in an area (including latitude, elevation, shape of the land, distance from water, global winds, and ocean currents). |

# Earth's Atmosphere

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| **Standard H.E.5**: The student will demonstrate an understanding of the dynamics of Earth's atmosphere. | |
| **H.E.5A. Conceptual Understanding:** Weather is the condition of the atmosphere at a particular location at a particular time. Weather is primarily determined by the angle and amount (time) of sunlight. Climate is the general weather conditions over a long period of time and is influenced by many factors. | |
| **Performance Indicator** | **H.E.5A.5:** Construct explanations for the formation of severe weather conditions (including tornadoes, hurricanes, thunderstorms, and blizzards) using evidence from temperature, pressure and moisture conditions. |
| **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.<br><br>Cause and Effect<br>Systems and System Models<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students construct explanations concerning the following:
- The major storms – thunderstorm, hurricanes, and tornadoes, are associated with low-pressure cyclonic movement of air and/or frontal boundaries. The conditions under which these storms form, how they are related to the factors that influence weather conditions (air masses, pressure systems, and fronts), and also factors concerning their duration and severity depend on the frontal boundary.
  - Hurricane landfalls can be predicted by plotting the course of a hurricane.
- By looking at raw data, students should explain what severe weather is likely to occur.

**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.
- Evaluate how air masses, fronts, and severe weather impact your area of South Carolina.

**Assessment Guidelines:**
In addition, students should engage in multiple science and engineering practices when interacting with the content outlined in this performance indicator. (See SEP Support document.)

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| **Learning Connections** | **Previous Connections (6-8):**<br>**6.E.2B.1:** Analyze and interpret data from weather conditions (including wind speed and direction, air temperature, humidity, cloud types, and air pressure), weather maps, satellites, and radar to predict local weather patterns and conditions.<br>**6.E.2B.2:** Develop and use models to explain how relationships between the movement and interactions of air masses, high and low pressure systems, and frontal boundaries result in weather conditions and storms (including thunderstorms, hurricanes and tornadoes). |

## Earth's Atmosphere

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| **Standard H.E.5**: The student will demonstrate an understanding of the dynamics of Earth's atmosphere. | |
| **H.E.5A. Conceptual Understanding**: Weather is the condition of the atmosphere at a particular location at a particular time. Weather is primarily determined by the angle and amount (time) of sunlight. Climate is the general weather conditions over a long period of time and is influenced by many factors. | |
| **Performance Indicator** | **H.E.5A.6:** Develop and use models to exemplify how climate is driven by global circulation patterns. |
| **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.<br><br>Patterns<br>Cause and Effect<br>Energy and Matter<br>Stability and Change |



**Essential Learning Experiences:**
It is essential that students develop and use models concerning the following:

- Climate is referred to as the average weather conditions of a region.
    - Latitude: A major influence on the climate of a region is its distance from the equator – latitude. Latitude determines the amount of solar energy received by, and the prevailing wind belts of, the region. Climate zones based on latitude include tropical climates, middle-latitude climates, and polar climates.
    - Topography & Elevation: The shape of the land, topography, also influences climate. Mountains influence the temperature and moisture content of air masses. Ascending air or descending air on mountain slopes causes differences in temperature and precipitation on the windward and leeward sides of the mountain. Since temperatures usually decrease with altitude, higher elevation climates are usually cooler that sea level climates.
    - Proximity to Water: Water heats up and cools down more slowly than land. Thus, large bodies of water affect the climates of coastal areas. Many coastal regions are warmer in the winter and cooler in the summer than inland areas of similar latitude.

**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.

- Classify each particular climate region based on latitude or on the Koppen classification system based on distribution of vegetation.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**6.E.2B.3:** Develop and use models to represent how solar energy and convection impact Earth's weather patterns and climate conditions (including global winds, the jet stream, and ocean currents).<br>**6.E.2B.4:** Construct explanations for how climate is determined in an area (including latitude, elevation, shape of the land, distance from water, global winds, and ocean currents). |

# Earth's Atmosphere

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| **Standard H.E.5**: The student will demonstrate an understanding of the dynamics of Earth's atmosphere. | |
| **H.E.5A. Conceptual Understanding:** Weather is the condition of the atmosphere at a particular location at a particular time. Weather is primarily determined by the angle and amount (time) of sunlight. Climate is the general weather conditions over a long period of time and is influenced by many factors. | |
| **Performance Indicator** | **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). |
| **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.<br><br>Patterns<br>Cause and Effect<br>Systems and System Models<br>Energy and Matter<br>Stability and Change |



**Essential Learning Experiences:**

It is essential that students construct scientific arguments concerning the following:

- Some years Earth may be warmer, cooler, wetter, or drier than others, but on the average during a person's lifetime, climate does not change significantly. However, in Earth history, evidence shows that Earth's climate has changed and is in a constant state of change. Major climate changes take long time periods.
  - Ice ages: A long period of climatic cooling during which continental ice sheets, glaciers, cover large areas of Earth's surface is known as an ice age, or glacial period. Scientists have discovered several major glacial periods during Earth history. Features such as U-shaped valleys and moraine deposits are evidence of how far ice sheets advanced during an ice age.
  - Interglacial Period Times: Periods of warmer temperatures between the colder glacial periods are known as interglacial periods. Earth is currently experiencing such an interval.

- Natural causes of climate change include small changes in Earth's orbit or in the tilt of Earth's axis. This may show a change in the amount of solar energy reaching Earth's surface. Perhaps, ice ages were caused by tectonic plate motion changing the position of the continents. Perhaps volcanic dust blocked the Sun's rays.
- Evidence gathered from tree rings, ice-core samples, fossils, and radiocarbon sample provide evidence of past climatic changes. Evidence has also come from the ocean floor in the shells of dead marine animals.
- Present short-term climate changes also occur.

**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.

- Explore details of glaciers and ice movement. Explore why Antarctica's subsurface lakes are studied for insight regarding Earth's history.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**6.E.2B.3:** Develop and use models to represent how solar energy and convection impact Earth's weather patterns and climate conditions (including global winds, the jet stream, and ocean currents).<br>**6.E.2B.4:** Construct explanations for how climate is determined in an area (including latitude, elevation, shape of the land, distance from water, global winds, and ocean currents).<br>**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. |

# Earth's Atmosphere

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| **Standard H.E.5**: The student will demonstrate an understanding of the dynamics of Earth's atmosphere. | |
| **H.E.5A. Conceptual Understanding:** Weather is the condition of the atmosphere at a particular location at a particular time. Weather is primarily determined by the angle and amount (time) of sunlight. Climate is the general weather conditions over a long period of time and is influenced by many factors. | |
| **Performance Indicator** | **H.E.5A.8:** Analyze scientific arguments regarding the nature of the relationship between human activities and climate change. |
| **Science and Engineering Practice** | **S.1.A.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.<br><br>Cause and Effect<br>Systems and System Models<br>Energy and Matter<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students analyze scientific arguments regarding the following:

- Human activities have an impact on Earth's atmosphere. Global atmospheric effects include ozone depletion, global warming, acid precipitation, and air pollution, such as photochemical smog, ozone, and particulate matter.
    - Ozone depletion: Ozone depletion results from human activity through the use of chlorofluorocarbons (CFCs). CFCs are stable and harmless near Earth's surface but when they move into the upper atmosphere, they destroy ozone molecules that protect Earth from harmful ultraviolet radiation. Since the mid-1980s studies of the atmosphere have detected a thinning of Earth's protective ozone layer, most dramatically over Antarctica, called the "ozone hole". Because all CFCs released into the atmosphere are from man-made products, ozone depletion is entirely the result of human activity. Students should understand that Earth's atmosphere has natural ozone holes that are seasonal, and not all are caused by CFCs.
    - Global warming: It is natural for Earth's atmosphere to trap heat in the troposphere; this is known as the greenhouse effect. Global warming is the increase in Earth's average surface temperature. This is partly caused by human activities especially the burning of fossil fuels that significantly increases amounts of carbon dioxide, a main greenhouse gas, into the atmosphere. Carbon dioxide

absorbs heat very readily. Increases in amount of carbon dioxide will intensify the greenhouse effect and may cause Earth to become warmer. Increases in global temperatures can have dramatic effects, such as changes in agricultural belts, glacier-ice cap melting resulting in rise in sea level, and difficulty of certain plants and animals to adapt resulting in extinction.

- Acid precipitation: Acid precipitation, or acid rain, is defined as precipitation with a pH of less than 5.0. Natural precipitation has a pH of about 5.0 to 5.6, which is slightly acidic. Sulfuric and nitric acid results when precipitation combines with sulfur dioxide and nitrogen oxides in the atmosphere as a result of emissions from coal-burning power plants for example. These acids can be carried by winds, long distances, thereby affecting areas far from their source. When acid precipitation makes its way into water bodies, it causes damage to the aquatic ecosystems and vegetation. It can affect plants and soil. Acid rain also damages stone buildings, statues, and even metal structures accelerating the processes of weathering and corrosion.
- Air pollution: The air near Earth's surface can become polluted several ways. (1) Photochemical smog, a yellow-brown haze in the air, is caused by the action of solar radiation on an atmosphere polluted with hydrocarbons and nitrogen oxides, mostly from automobile exhaust systems. The air becomes harmful to breathe. (2) A major chemical in smog is ozone – in the upper atmosphere it is beneficial, but near the surface it is a pollutant. Ozone irritates the eyes, nose, and lungs of humans and is also harmful to plants. (3) Air pollution also occurs when particulate matter, such as carbon ash, dust, pollen, or asbestos fibers accumulate in the atmosphere. These particles are breathed in and lodge in the nose and lungs disrupting normal functions.

**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.

- Explain the chemistry behind the formation of these types of pollution by completing acid/base/neutralization reactions. Use evidence from water and soil pH readings to strengthen their arguments.

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| **Learning Connections** | **Previous Connections (6-8):**<br>**6.E.2B.4:** Construct explanations for how climate is determined in an area (including latitude, elevation, shape of the land, distance from water, global winds, and ocean currents). |

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| | **7P.2B.3:** Analyze and interpret data to compare the physical properties, chemical properties (neutralization to form a salt, reaction with metals), and pH of various solutions and classify solutions as acids or bases.<br><br>**Biology Connections:**<br>**H.B.6B.1:** Develop and use models of the carbon cycle, which include the interactions between photosynthesis, cellular respiration and other processes that release carbon dioxide, to evaluate the effects of increasing atmospheric carbon dioxide on natural and agricultural ecosystems.<br>**H.B.6B.2:** Analyze and interpret quantitative data to construct an explanation for the effects of greenhouse gases (such as carbon dioxide and methane) on the carbon cycle and global climate.<br><br>**Chemistry Connections:**<br>**H.C.5A.4:** Analyze and interpret data to describe the properties of acids, bases, and salts. |

# Earth's Hydrosphere

| **Standard H.E.6:** The student will demonstrate an understanding of Earth's freshwater and ocean systems. | |
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| **H.E.6A. Conceptual Understanding:** Water is an essential resource on Earth. Organisms (including humans) on Earth depend on water for life. Its unique physical and chemical properties are important to the dynamics of Earth systems. Multiple factors affect the quality, availability, and distribution of Earth's water. | |
| **Performance Indicator** | **H.E.6A.1:** Analyze and interpret data to describe and compare the physical and chemical properties of saltwater and freshwater. |
| **Science and Engineering Practice** | **S.1A.4:** Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions. |
| **Crosscutting Concepts** | The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6.<br><br>Energy and Matter |

**Essential Learning Experiences:**
It is essential that students analyze and interpret data concerning fresh and salt water.

- Unique properties of freshwater and seawater are important to processes on Earth. Pure water is a chemical compound whose molecule consists of hydrogen and oxygen (formula = $H_2O$). Water is not chemically reactive. As the universal solvent, water can dissolve many materials into solution.
- Freshwater
  - Freshwater is one of Earth's more abundant and important renewable resources.
  - Freshwater can be found within the temperature conditions on Earth in all three states of matter. As a liquid, it flows over Earth's surface and into the ground. It takes the shape of various containers on Earth – lakes, ponds, aquifers, and rivers. As a solid, freshwater is found in glaciers, snowfields, and the ice caps of Earth. Water vapor in the atmosphere is the great mover of water from one location to another on Earth.
  - Freshwater is a mixture that contains more substances than just pure water. As water dissolves minerals in rock and soil or pollutants in the air, it can form acid solutions that change the atmosphere, precipitation, and land formations of Earth.
  - Freshwater has a density of about 1.0 $g/cm^3$ and freezes at $0^{\circ}C$.
- Seawater

- Seawater is also a mixture, but it contains more dissolved substances than freshwater. It is a solution of about 96.5% water and 3.5% dissolved salts. The most abundant salt in seawater is sodium chloride (NaCl). Other chloride and sulfate salt compounds are also present. Dissolved gases, such as oxygen, nitrogen, and carbon dioxide, are also present along with dissolved nutrients.
- The salinity of ocean water varies from place to place. High salinities are found in areas where evaporation is high or seawater is freezing; low salinities occur where freshwater empties into oceans.
- Other physical properties of seawater include a density of about 1.02 – 1.03 $g/cm^3$.
- The freezing point of seawater is lower than freshwater at $-2^{\circ}C$.

**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.

- Explain the atomic structure of a water molecule or how its VSEPR shape (bent) and the electronegativity differences in the bonds make it a polar molecule.

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| **Learning Connections** | **Previous Connections (6-8):**<br>**7.P.2B.1:** Analyze and interpret data to describe substances using physical properties (including state, boiling/melting point, density, conductivity, color, hardness, and magnetic properties) and chemical properties (the ability to burn or rust). |

# Earth's Hydrosphere

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|---|---|
| **Standard H.E.6:** The student will demonstrate an understanding of Earth's freshwater and ocean systems. | |
| **H.E.6A. Conceptual Understanding:** Water is an essential resource on Earth. Organisms (including humans) on Earth depend on water for life. Its unique physical and chemical properties are important to the dynamics of Earth systems. Multiple factors affect the quality, availability, and distribution of Earth's water. | |
| **Performance Indicator** | **H.E.6A.2:** Obtain and communicate information to explain how location, movement, and energy transfers are involved in making water available for use on Earth's surface (including lakes, surface-water drainage basins, freshwater wetlands, and groundwater zones). |
| **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.<br><br>Systems and System Models<br>Energy and Matter<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students obtain, communicate, and evaluate information concerning the following:

- The Earth's water supply is continually being recycled across Earth's surface in a process known as the water cycle. The mechanics of the water cycle helps to explain the variations in the amount of water available throughout the world. Energy from the Sun is the driving force of this cycle.
- As water returns to Earth as precipitation, it may flow downslope along Earth's surface as runoff. Runoff may reach a stream, river, lake or wetlands area in its eventual surface flow toward the ocean.
- Lakes
    - Certain conditions are needed for lakes to form. Lakes are continually supplied with water, which is continuously moving in a cycle.
- Streams and Rivers
    - Stream systems form as water flows and collects in surface channels.

   - Tributaries form as streams flow into each other. A large stream is called a river, and all tributaries make up a river system.
   - Factors that affect the speed of water flow may also cause rejuvenation of river flow.
- Drainage basin
   - Water in a drainage basin is also called a watershed, and is determined by the land area that drains into a particular stream or river system. A divide is the highland area that separates one watershed from another.
- Freshwater wetlands
   - A wetland area is land that is covered with water for a large part of the year. There are various types of wetlands, depending on the source of water for wetlands, and the change in amount of water within a wetland area.
- Groundwater
   - Water that seeps into Earth's surface becomes groundwater. Conditions on the surface allow water to move downward into the ground, such as vegetation, rate of precipitation, rock or soil composition, as well as slope of the land area. Once water moves into the ground, zones of groundwater form. Zones include the zone of saturation, the water table, and the zone of aeration. The formation of stored underground water in an aquifer.

**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.
- Explore the human impact on the availability of water on Earth's surface.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**6.E.2A.3:** Construct explanations of the processes involved in the cycling of water through Earth's systems (including transpiration, evaporation, condensation and crystallization, precipitation, and downhill flow of water on land). |

# Earth's Hydrosphere

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| **Standard H.E.6:** The student will demonstrate an understanding of Earth's freshwater and ocean systems. | |
| **H.E.6A. Conceptual Understanding:** Water is an essential resource on Earth. Organisms (including humans) on Earth depend on water for life. Its unique physical and chemical properties are important to the dynamics of Earth systems. Multiple factors affect the quality, availability, and distribution of Earth's water. | |
| **Performance Indicator** | **H.E.6A.3:** Plan and conduct controlled scientific investigations to determine how a change in stream flow might affect areas of erosion and deposition of a meandering alluvial stream. |
| **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 based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. 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.<br><br>Patterns<br>System and System Models<br>Energy and Matter<br>Structure and Function<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students should plan and conduct scientific investigations concerning:

- The number of ways to classify streams, one of which is according to the stream bed (those that are formed in a bedrock basin and those that are formed in an alluvial basin).
  - Bedrock streams are cut into the actual bedrock itself.
  - Alluvial streams flow through beds of sediments such as gravel, sand, silt and clay, carrying these particles with them as they move.
- Erosion and deposition are key to the development of the meandering pattern seen in many alluvial streams. Erosion occurs when rock and soil particles are removed from a cutbank by the movement of water. Deposition takes place on a point bar when eroded rock and particles are left in a new location. This process may also be referred to as sedimentation.
- As gravity causes the water to flow from higher elevations (such as the mountains) to lower elevations (those at sea level), many particles are eroded and deposited along the

way. When particles are eroded along the outer banks of a stream, and are then deposited on the inner banks, the shape of the stream bed starts to curve. This curvature, or meandering, causes the stream to follow a snake-like pattern of curves and bends as it flows downstream.

- Due to steeper slopes (gradients), in higher elevations the water moves faster and much erosion takes place. In areas where the gradient is not as steep, more deposition takes place.
- The processes of erosion and deposition are impacted by changes in streamflow. Though there are many characteristics of stream flow that would affect erosion and deposition, four main factors are velocity, gradient, discharge, and size and shape of the stream bed.
    - Velocity: The faster the water moves, the greater the rates at which particles are eroded. Deposition takes place at a greater rate in areas where the water is not moving as swiftly. Stream velocity is heavily reliant upon the gradient.
    - Gradient: The gradient of the stream is essentially the slope, or steepness, of the stream in any given area. The greater the gradient, the faster the waters flow, the greater the erosion. The gentler, the gradient, the slower the waters flow, the greater the rate of deposition.
    - Discharge: Discharge is a quantity that defines the volume of water that passes a specified point of the stream in a unit of time. The equation for discharge is $D = A \times V$, D is the discharge, measured in $m^3/sec$. A is the area of the cross-section of the stream at that specific point, measured in $m^3$. V is velocity of the stream, measured in m/sec.
        - As the discharge of a stream increases, its competence (ability to carry large particles) and its capacity (the number of particles a stream can carry) increase as well.
    - Size and Shape of Stream Bed: Stream beds that are V-shaped and have channels that are narrow tend to experience greater rates of erosion. Those that have U-shaped channels tend to be wider and experience greater rates of deposition.

**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.

- Teachers could include a study of the methods of controlling water along and within river systems and floodplains, focusing on their use as safety measures and how effective these methods are. Teachers could also have students investigate how changes in stream flow affect the formation of other types of streams (non-alluvial.)

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| Learning Connections | **Previous Connections (6-8):**<br>**8.E.5A.1:** Develop and use models to explain how the processes of weathering, erosion, and deposition change surface features in the environment. |
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# Earth's Hydrosphere

| **Standard H.E.6:** The student will demonstrate an understanding of Earth's freshwater and ocean systems. | |
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| **H.E.6A. Conceptual Understanding:** Water is an essential resource on Earth. Organisms (including humans) on Earth depend on water for life. Its unique physical and chemical properties are important to the dynamics of Earth systems. Multiple factors affect the quality, availability, and distribution of Earth's water. | |
| **Performance Indicator** | **H.E.6A.4:** Analyze and interpret data of a local drainage basin to predict how changes caused by human activity and other factors influence the hydrology of the basin and amount of water available for use in the ecosystem. |
| **Science and Engineering Practice** | **S.1A.4:** Plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. 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.<br><br>Cause and Effect<br>Systems and System Models<br>Structure and Function |

**Essential Learning Experiences:**
It is essential that students analyze and interpret data concerning the following:

- Water is an essential resource on earth. A local water drainage basin is also called a watershed. A watershed is an area of land that drains into a body of water, like a river, ocean, or lake.
- The local water drainage basin is affected by human impact and other factors that influence the hydrology of the basin. Some of these impacts include land use, domestic and industrial waste, weather/climate conditions, topography of the river channel, pollution, and/or flooding.
- Land use by people, whether it is farms, houses or shopping centers, has a direct impact on the water quality of the watershed. By changing the contour of the land and adding storm-water systems, people change how and where the water goes. Water flows over parking lots and through catch basins. The water picks up pollution (oil, trash, and chemicals) along the way. Agricultural areas impact the water because fertilizers and pesticides are introduced and flow into the groundwater. Instead of water flowing to the

lowest point, a body of water, water is flowing through storm drains, which eventually flow to a river or lake.

- Weather and climate can also affect water drainage. Flooding increases the amount of water flowing through drainage basins including the rivers and lakes. An increase in water can cause negative impacts including an increase in sewage overflows, water borne diseases, and increase pollution in the drinking water. In times of extreme drought, the watershed is limited in water. Water conservations plans must be developed to conserve the water that is available.

**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.

- Expand the study of drainage basins to include areas where water conservation and flooding is common.

**Assessment Guidelines:**
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| **Learning Connections** | **Previous Connections (6-8):**<br>**8.E.5A.1:** Develop and use models to explain how the processes of weathering, erosion, and deposition change surface features in the environment. |

# Earth's Hydrosphere

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|---|---|
| **Standard H.E.6:** The student will demonstrate an understanding of Earth's freshwater and ocean systems. | |
| **H.E.6A. Conceptual Understanding:** Water is an essential resource on Earth. Organisms (including humans) on Earth depend on water for life. Its unique physical and chemical properties are important to the dynamics of Earth systems. Multiple factors affect the quality, availability, and distribution of Earth's water. | |
| **Performance Indicator** | **H.E.6A.5:** Analyze and interpret data to describe how the quality of the water in drainage basins is influenced by natural and human factors (such as land use, domestic and industrial waste, weather/climate conditions, topography of the river channel, pollution, or flooding). |
| **Science and Engineering Practice** | **S.1A.4:** Plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. 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.<br><br>Cause and Effect<br>Systems and System Models<br>Energy and Matter<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students analyze and interpret data concerning the following:

- Water is an essential resource on Earth. Organisms on Earth depend on water for life. Humans depend on water in many ways. Water pollution is an area where humans have an impact on water supplies. Surface water pollution can be grouped into two main types: point sources and nonpoint sources.
  - Point source pollution: generated from a single point of origin. When analyzing an environment for water pollution sources, students may find the source to be a sewage treatment plant for domestic waste, or an industrial site. Improper bacteria and viruses that result from disposal of sewage, toxic wastes that enter streams can send this pollution downstream into the environments.
  - Nonpoint source pollution: generated from widely spread areas. Rainwater absorbs air pollutants and may become acidic, bringing down precipitation far from its origin. Rainwater may also drain fertilizers and pesticides from

agricultural sites, or wash oil, gasoline, and other chemicals from roads and parking lots. These are not as easily identified nor as easily cleaned up as point source.

- Surface runoff water is a carrier of pollutants and pollution can find its way into groundwater and into the ocean.
    - Groundwater: water filled with chemicals, road salt, fertilizer, pollution sewage or other pollutants may find its way into groundwater and aquifers in a region. Once groundwater is contaminated, the pollutants can be very difficult to remove.
    - Ocean pollution: pollution of ocean water is also a concern. Near-shore regions and estuaries are often the first regions of the ocean to become polluted. Sewage water is the most common source.
- In analyzing the sources of water pollution, students need to realize the importance of cleanup efforts and the importance of reducing water pollution. When there is not enough water to go around, water conservation is most important.

**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.

- Collect water samples and test for pollutants.
- Collect water samples and view under a microscope to see the impurities.

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

# Earth's Hydrosphere

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| **Standard H.E.6:** The student will demonstrate an understanding of Earth's freshwater and ocean systems. | |
| **H.E.6A. Conceptual Understanding:** Water is an essential resource on Earth. Organisms (including humans) on Earth depend on water for life. Its unique physical and chemical properties are important to the dynamics of Earth systems. Multiple factors affect the quality, availability, and distribution of Earth's water. | |
| **Performance Indicator** | **H.E.6A.6:** Develop and use models to explain how groundwater processes affect limestone formations leading to the formation of caves and karst topography. |
| **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.<br><br>Cause and Effect<br>Systems and System Models<br>Structure and Function<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students develop and use models to explain groundwater to Earth interactions.

- Water is a powerful agent of erosion at work underground as well as on Earth's surface. Groundwater that passes through permeable rock dissolves minerals in the rock. Water that moves through organic materials and soil may become acidic, chemically weathering the rock as it passes through. Rocks that contain calcite, such as limestone, are susceptible to chemical weathering. Students should know that regions where the chemical weathering effects are visible are said to have karst topography. These features include sinkholes, caverns, and streams that disappear into cracks in the rock emerging in caves or out cracks long distances away. The study of wells, springs, hot springs, and geysers is not part of karst topography.
- Sinkholes and caverns form depending on the rock present, the way water is moving, and the minerals in the water. Stalactites and stalagmites may also form in caverns.

**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.

- Explain the chemistry of the processes that take place when rock undergoes chemical weathering. Research how wells, springs, hot springs, and geysers are formed.

**Assessment Guidelines:**
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| **Learning Connections** | **Previous Connections (6-8):**<br>**6.E.2A.3:** Construct explanations of the processes involved in the cycling of water through Earth's systems (including transpiration, evaporation, condensation and crystallization, precipitation, and downhill flow of water on land).<br>**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). |

# Earth's Hydrosphere

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| **Standard H.E.6:** The student will demonstrate an understanding of Earth's freshwater and ocean systems. | |
| **H.E.6A. Conceptual Understanding:** Water is an essential resource on Earth. Organisms (including humans) on Earth depend on water for life. Its unique physical and chemical properties are important to the dynamics of Earth systems. Multiple factors affect the quality, availability, and distribution of Earth's water. | |
| **Performance Indicator** | **H.E.6A.7:** Obtain and communicate information to explain how the convection of ocean water due to temperature and density influence the circulation of oceans. |
| **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.<br><br>Patterns<br>Cause and Effect<br>System and System Models<br>Energy and Matter<br>Structure and Function |

**Essential Learning Experiences:**
It is essential that students should obtain, evaluate and communicate the following:

- The warming of the surface waters is a result of solar radiation. Both freshwater and seawater respond to solar radiation that strikes the Earth's water surfaces.
  - Visible light: water will absorb and reflect light. Most of the lights are absorbed but blue light tends to be reflected most. All wavelengths of light are absorbed by about 100m depth, so deep lakes and the oceans are dark except for surface region.
  - Infrared light: Infrared rays play an important role in determining the temperature of water. Rapidly moving water in fast-moving streams and rivers does not have time to absorb infrared waves. Lakes and ponds, especially shallow ones, become warm as the infrared rays are absorbed. Infrared rays are completely absorbed within the upper zone of ocean water; thus it heats the water only near the surface of the ocean. Surface temperature does vary with latitude – polar seawater is cold

or even frozen depending upon the season. Tropical seawater is generally warm all year. Seawater deep in the ocean is very cold.

- Solar energy penetrating the surface water region of the ocean and geothermal energy from thermal vents deep within the ocean have effects on the movement and chemical reactions that take place in ocean waters.
- Ocean currents:
    - Surface currents: As solar energy reaches Earth's oceans most directly near the equator, surface water in that region is warmer. The surface ocean water is set into motion by energy from the wind, directions are determined by the Coriolis effect and interaction with continents. Warm equatorial surface currents bring warm water to cooler regions. Currents coming from areas near the poles where solar energy is less direct are cold currents. These move toward the equator and cool those regions.
    - Deep currents: Water warmed by solar energy near the equator expands and is less dense than cold water. Cold water at poles is more dense, and sinks, and moves very slowly beneath warmer ocean water toward the equator.
- Chemosynthesis: Some regions of the ocean are teeming with life due to organisms using solar energy for photosynthesis. In deep areas, sunlight does not reach and chemosynthesis supports life near hydrothermal vents (mostly along oceanic ridges). Chemosynthesis provides the basis for the food web in these regions.

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

- Research types of marine life that exists in marine zones and evaluate the unique properties of those lifeforms that are an effect of the zone they live in.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**6.E.2A.3:** Construct explanations of the processes involved in the cycling of water through Earth's systems (including transpiration, evaporation, condensation and crystallization, precipitation, and downhill flow of water on land).<br>**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). |

# Earth's Hydrosphere

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| **Standard H.E.6:** The student will demonstrate an understanding of Earth's freshwater and ocean systems. | |
| **H.E.6A. Conceptual Understanding:** Water is an essential resource on Earth. Organisms (including humans) on Earth depend on water for life. Its unique physical and chemical properties are important to the dynamics of Earth systems. Multiple factors affect the quality, availability, and distribution of Earth's water. | |
| **Performance Indicator** | **H.E.6A.8:** Develop and use models to describe how waves and currents interact with the ocean shore. |
| **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.<br><br>Energy and Matter<br>Stability and Change |



**Essential Learning Experiences:**
It is essential that students develop and use models concerning wave interactions with the ocean floor.

- Students should describe the characteristic motion of water waves, including the factors that affect the height of a wave. They should know the cause of breaking waves and their effects on the shoreline. Surface ocean currents usually only affect the temperature of the shore area waters. Longshore currents transport sediment. Since most beaches consist of loose sediments, Longshore currents can spread them out in the direction of the current flow along the shore. Large waves are associated with fast moving longshore currents and lots of sediment transport.
- A result of wave erosion, longshore current transport, and sediment deposition, the shoreline is in a constant state of change. Sediments eroded in one area are moved and deposited in another building various coastal landforms, such as sandbars, spits and barrier islands. These features form and change due to wave action and current transport.

**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.

- Describe the cause and effects of tides on the shore zone. Research density ocean currents, turbidity currents, or upwellings.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**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). |

# Earth's Hydrosphere

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| **Standard H.E.6:** The student will demonstrate an understanding of Earth's freshwater and ocean systems. | |
| **H.E.6A. Conceptual Understanding:** Water is an essential resource on Earth. Organisms (including humans) on Earth depend on water for life. Its unique physical and chemical properties are important to the dynamics of Earth systems. Multiple factors affect the quality, availability, and distribution of Earth's water. | |
| **Performance Indicator** | **H.E.6A.9:** Ask questions about the designs of devices used to control and prevent coastal erosion and flooding and evaluate the designs in terms of the advantages and disadvantages required for solving the problems. |
| **Science and Engineering Practice** | **S.1A.1:** Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge scientific arguments or claims. |
| **Crosscutting Concepts** | The following Crosscutting Concepts may be applied to the content of this indicator. For more information see page 6.<br><br>Cause and Effect<br>Energy and Matter<br>Structure and Function<br>Stability and Change |

**Essential Learning Experiences:**
It is essential that students ask questions concerning the following:

- In coastal areas, structures such as seawalls, groins, jetties, and breakwaters are built in an attempt to prevent beach erosion and destruction of oceanfront properties. Each of these structures has advantages and disadvantages. Where structures are not built, beach nourishment, which involves adding large quantities of sand to the beach system, is sometimes used. Beach nourishment also has advantages and disadvantages. If the shoreline is not stable; shorelines continually undergo change. Erosion and deposition are natural processes of the interaction of ocean water with coastal features.

**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.

- Write persuasive letters to local politicians or newspaper editors regarding the advantages and disadvantages of these designs.

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

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| **Learning Connections** | **Previous Connections (6-8):**<br>**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). |

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