SUPPORT GUIDE 2.0
FOR EARTH SCIENCE
SOUTH CAROLINA ACADEMIC STANDARDS AND PERFORMANCE INDICATORS FOR SCIENCE



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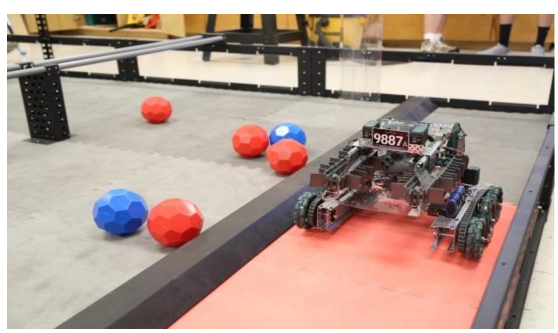
South Carolina Department of Education
Columbia, South Carolina

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INTRODUCTION TO EARTH SCIENCE STANDARDS

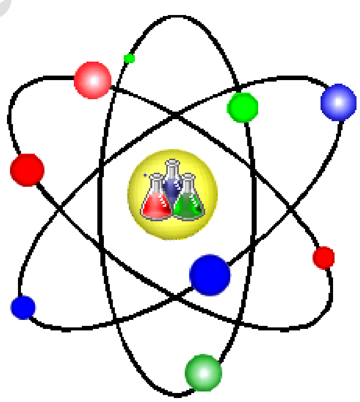
Science is a way of understanding the physical universe using observation and experimentation to explain natural phenomena. Science also refers to an organized body of knowledge that includes core ideas to the disciplines and common themes that bridge the disciplines. This document, *South Carolina Academic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

ACADEMIC STANDARDS

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

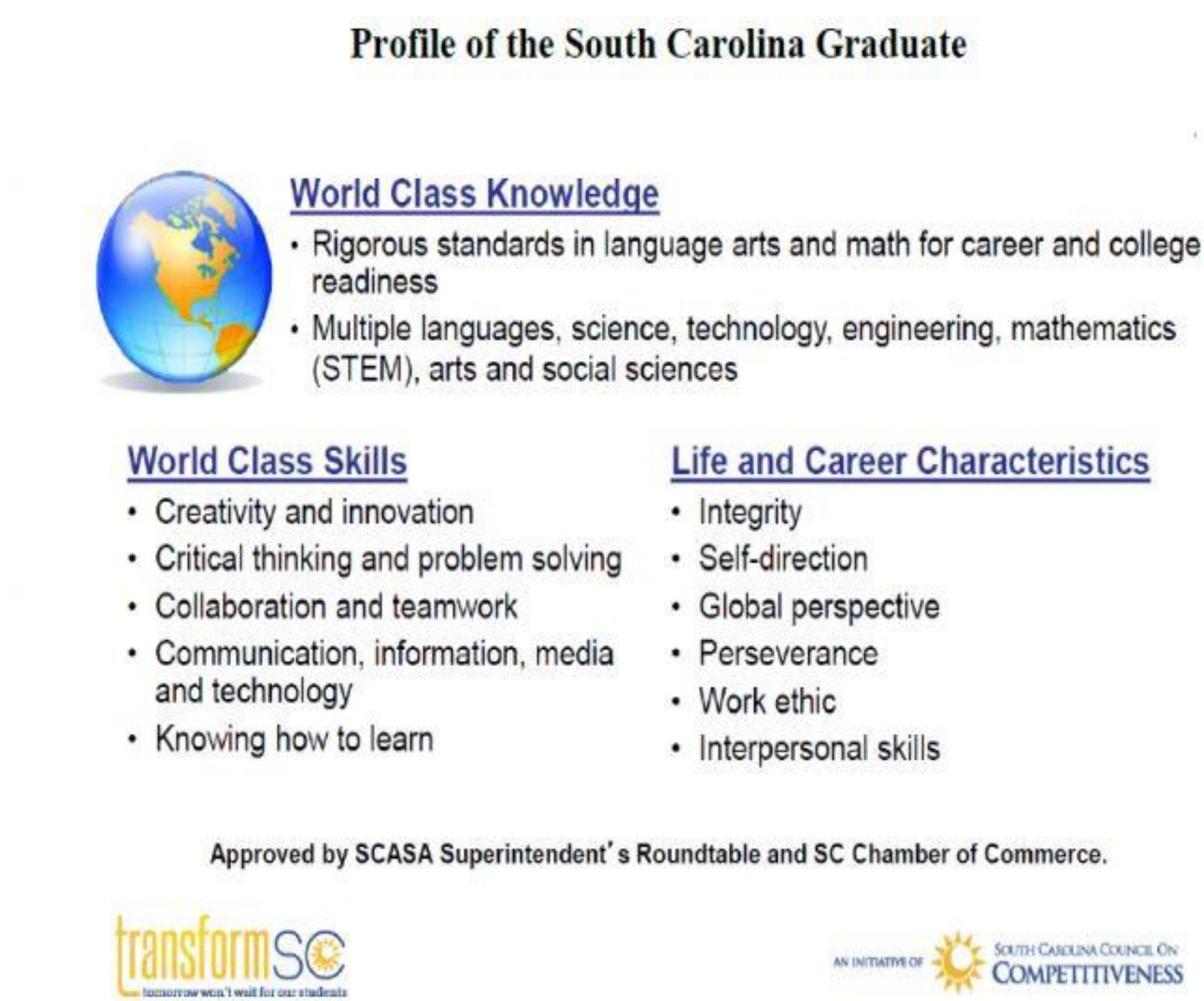
Operating procedures for the review and revision of all South Carolina academic standards were jointly developed by staff at the State Department of Education (SCDE) and the Education Oversight Committee (EOC). According to these procedures, a field review of the first draft of the revised South Carolina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

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



THE PROFILE OF THE SOUTH CAROLINA GRADUATE

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


Profile of the South Carolina Graduate

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

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

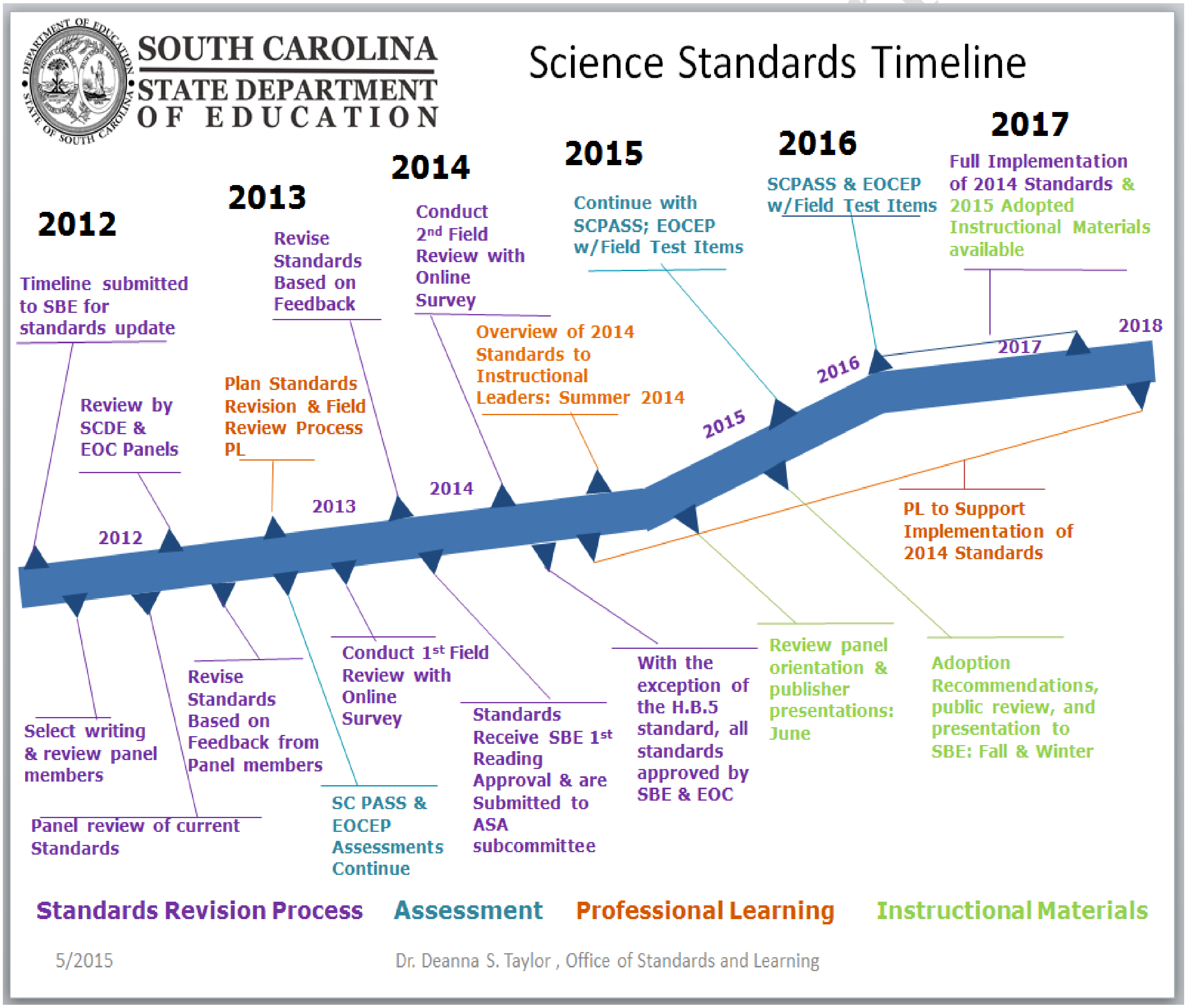
Life and Career Characteristics
- Integrity
- Self-direction
- Global perspective
- Perseverance
- Work ethic
- Interpersonal skills

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

SCIENCE STANDARDS TIMELINE

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

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



CROSSCUTTING CONCEPTS

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

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

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

SCIENCE AND ENGINEERING PRACTICES

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

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

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

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

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

DECIPHERING THE STANDARDS

KINDERGARTEN

LIFE SCIENCE: EXPLORING ORGANISMS AND THE ENVIRONMENT

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

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

Performance Indicators: Students who demonstrate this understanding can:

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

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

Figure 1: Example from the Kindergarten Standards

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

- **K: The first part of each indicator denotes the grade or subject.** The example indicator is from Kindergarten. The key for grade levels are as follows—
  - K: Kindergarten
  - 1: First Grade
  - 2: Second Grade
  - 3: Third Grade
  - 4: Fourth Grade
  - 5: Fifth Grade
  - 6: Sixth Grade
  - 7: Seventh Grade
  - 8: Eighth Grade
  - H.B: High School Biology 1
  - H.C: High School Chemistry 1
  - H.P: High School Physics 1
  - H.E: High School Earth Science

- **L: After the grade or subject, the content area is denoted by an uppercase letter.** The L in the example indicator means that the content covers Life Science. The key for content areas are as follows—

  E: Earth Science
  EC: Ecology
  L: Life Science
  P: Physical Science
  S: Science and Engineering Practices

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

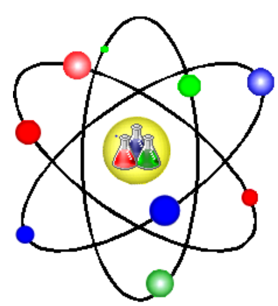
- **A: After the specific content standard, the conceptual understanding is denoted by an uppercase letter.** The conceptual understanding is a statement of the core idea for which students should demonstrate understanding. There may be more than one conceptual understanding per academic standard. The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

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

CORE AREAS OF EARTH SCIENCE

The five core areas of the Earth Science standards include:

- Astronomy
- Earth's Geosphere
- Earth's Paleobiosphere
- Earth's Atmosphere – Weather and Climate
- Earth's Hydrosphere



EARTH SCIENCE
SCIENCE AND ENGINEERING PRACTICES

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

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

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

Performance Indicators: Students who demonstrate this understanding can:

H.E.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.

H.E.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.

H.E.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.

H.E.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.

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

H.E.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.

H.E.1A.7 Construct and analyze scientific arguments to support claims, explanations, or designs using evidence and valid reasoning from observations, data, or informational texts.

Science and Engineering Practices *(continued)*

H.E.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.

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

Performance Indicators: Students who demonstrate this understanding can:

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

Astronomy

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 Indicators: Students who demonstrate this understanding can:

H.E.2A.1 Construct explanations for how gravity and motion affect the formation and shapes of galaxies (including the Milky Way Galaxy).

H.E.2A.2 Use the Hertzsprung-Russell diagram to classify stars and explain the life cycles of stars (including the Sun).

H.E.2A.3 Construct explanations for how elements are formed using evidence from nuclear fusion occurring within stars and/or supernova explosions.

H.E.2A.4 Construct and analyze scientific arguments to support claims about the origin of the universe (including the red shift of light from distant galaxies, the measured composition of stars and nonstellar gases, and the cosmic background radiation).

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.

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 Indicators: Students who demonstrate this understanding can:

H.E.2B.1 Analyze and interpret data to compare the properties of Earth and other planets (including composition, density, surface expression of tectonics, climate, and conditions necessary for life).

H.E.2B.2 Obtain, evaluate, and communicate information about the properties and features of the moon to support claims that it is unique among other moons in the solar system in its effects on the planet it orbits.

H.E.2B.3 Use mathematical and computational thinking to explain the motion of an orbiting object in the solar system.

H.E.2B.4 Construct explanations for how the solar system was formed.

EARTH'S GEOSPHERE

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 Indicators: Students who demonstrate this understanding can:

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.

H.E.3A.2 Analyze and interpret data from ocean topography, correlation of rock assemblages, the fossil record, the role of convection current, and the action at plate boundaries to explain the theory of plate tectonics.

H.E.3A.3 Construct explanations of how forces cause crustal changes as evidenced in sea floor spreading, earthquake activity, volcanic eruptions, and mountain building using evidence of tectonic environments (such as mid-ocean ridges and subduction zones).

H.E.3A.4 Use mathematical and computational thinking to analyze seismic graphs to (1) triangulate the location of an earthquake's epicenter and magnitude, and (2) describe the correlation between frequency and magnitude of an earthquake.

H.E.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.

H.E.3A.6 Develop and use models to explain how various rock formations on the surface of Earth result from geologic processes (including weathering, erosion, deposition, and glaciation).

H.E.3A.7 Plan and conduct controlled scientific investigations to determine the factors that affect the rate of weathering.

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.

H.E.3B. Conceptual Understanding: 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 Indicators: Students who demonstrate this understanding can:

H.E.3B.1 Obtain and communicate information to explain how the formation, availability, and use of ores and fossil fuels impact the environment.

H.E.3B.2 Construct scientific arguments to support claims that responsible management of natural resources is necessary for the sustainability of human societies and the biodiversity that supports them.

H.E.3B.3 Analyze and interpret data to explain how natural hazards and other geologic events have shaped the course of human history.

H.E.3B.4 Obtain and evaluate available data on a current controversy regarding human activities which may affect the frequency, intensity, or consequences of natural hazards.

H.E.3B.5 Define problems caused by the impacts of locally significant natural hazards and design possible devices or solutions to reduce the impacts of such natural hazards on human activities.

EARTH'S PALEOBIOSPHERE

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 Indicators: Students who demonstrate this understanding can:

H.E.4A.1 Construct scientific arguments to support claims that the physical conditions of Earth enable the planet to support carbon-based life.

H.E.4A.2 Construct explanations for how various life forms have altered the geosphere, hydrosphere and atmosphere over geological time.

H.E.4A.3 Construct explanations of how changes to Earth's surface are related to changes in the complexity and diversity of life using evidence from the geologic time scale.

H.E.4A.4 Obtain and evaluate evidence from rock and fossil records and ice core samples to support claims that Earth's environmental conditions have changed over time.

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.

H.E.4A.6 Use mathematical and computational thinking to calculate the age of Earth materials using isotope ratios (actual or simulated).

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.

EARTH SCIENCE
EARTH'S ATMOSPHERE – WEATHER AND CLIMATE

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 Indicators: Students who demonstrate this understanding can:

H.E.5A.1 Develop and use models to describe the thermal structures (including the changes in air temperature due to changing altitude in the lower troposphere), the gaseous composition, and the location of the layers of Earth's atmosphere.

H.E.5A.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.

H.E.5A.3 Analyze and interpret data to predict local and national weather conditions on the basis of the relationship among the movement of air masses, pressure systems, and frontal boundaries.

H.E.5A.4 Analyze and interpret data of pressure differences, the direction of winds, and areas of uneven heating to explain how convection determines local wind patterns (including land/sea breezes, mountain/valley breezes, Chinook winds, and monsoons).

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.

H.E.5A.6 Develop and use models to exemplify how climate is driven by global circulation patterns.

H.E.5A.7 Construct scientific arguments to support claims of past changes in climate caused by various factors (such as changes in the atmosphere, variations in solar output, Earth's orbit, changes in the orientation of Earth's axis of rotation, or changes in the biosphere).

H.E.5A.8 Analyze scientific arguments regarding the nature of the relationship between human activities and climate change.

EARTH SCIENCE
EARTH'S HYDROSPHERE

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 Indicators: Students who demonstrate this understanding can:

H.E.6A.1 Analyze and interpret data to describe and compare the physical and chemical properties of saltwater and freshwater.

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).

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.

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.

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).

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.

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.

H.E.6A.8 Develop and use models to describe how waves and currents interact with the ocean shore.

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.

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

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ACKNOWLEDGEMENTS

SOUTH CAROLINA DEPARTMENT OF EDUCATION

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

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INTRODUCTION

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

How to Use the Crosswalks

This document may be used with the science academic standards, science and engineering support document, and grade/content support documents to assist local districts, schools and teachers as they construct standards-based science curriculum, allowing them to add or expand topics they feel are important and to organize content to fit their students' needs and match available instructional materials. 2005 and 2014 performance indicators that share similar content knowledge and skills that students should demonstrate to meet the grade level or high school course standards have been paired. These pairings have been organized into tables and are sequenced by the 2014 academic standards. The 2005 content indicators that do not match 2014 content have been placed at the end of each table. Additionally, since the conceptual understandings are novel to the *2014 South Carolina Academic Standards and Performance Indicators for Science* these portions of the crosswalk to not correlate to the *2005 South Carolina Science Academic Standards*. Conceptual understandings are statements of the core ideas for which students should demonstrate an understanding. Some grade level topics include more than one conceptual understanding with each building upon the intent of the standard.

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

EARTH SCIENCE CROSSWALK DOCUMENT

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

Standard H.E.1—Science and Engineering Practices		
2005	**2014**	**Comments**
ES-1: The student will demonstrate an understanding of how scientific inquiry and technological design, including mathematical analysis, can be used appropriately to pose questions, seek answers, and develop solutions.	**H.E.1:** The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	
Conceptual Understanding		
	H.E.1A.: The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers.	
Performance Indicators		
	H.E.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.	
	H.E.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.	This is a new expectation in these standards.

ES-1.2 Use appropriate laboratory apparatuses, technology, and techniques safely and accurately when conducting a scientific investigation. **ES-1.3** Use scientific instruments to record measurement data in appropriate metric units that reflect the precision and accuracy of each particular instrument. **ES-1.4** Design a scientific investigation with appropriate methods of control to test a hypothesis (including independent and dependent variables), and evaluate the designs of sample investigations. **ES-1.5** Organize and interpret the data from a controlled scientific investigation by using mathematics, graphs, models, and/or technology. **ES-1.10** Use appropriate safety procedures when conducting investigations.	**H.E.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.	

ES-1.5 Organize and interpret the data from a controlled scientific investigation by using mathematics, graphs, models, and/or technology. **ES-1.6** Evaluate the results of a controlled scientific investigation in terms of whether they refute or verify the hypothesis. **ES-1.7** Evaluate conclusions based on qualitative and quantitative data (including the impact of parallax, instrument malfunction, or human error) on experimental results.	**H.E.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.	Note that A.4 is a much richer set of expectations than **ES-1.6**, and could be done in many instructional contexts, not just for lab investigations.
ES-1.1 Apply established rules for significant digits, both in reading scientific instruments and in calculating derived quantities from measurement. **ES-1.5** Organize and interpret the data from a controlled scientific investigation by using mathematics, graphs, models, and/or technology. (see above)	**H.E.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.	
	H.E.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.	Students constructing their own explanations, like models in A.2. is one of the hallmarks of these new standards.

ES-1.4 Design a scientific investigation with appropriate methods of control to test a hypothesis (including independent and dependent variables), and evaluate the designs of sample investigations. **ES-1.9** Communicate and defend a scientific argument or conclusion.	**H.E.1A.7** Construct and analyze scientific arguments to support claims, explanations, or designs using evidence and valid reasoning from observations, data, or informational texts	Once again, compared to **ES-1.4**, A.7 is intended to be taught in many different contexts. One of the ideas here is that hands-on investigations and activities are great, but in the end, if students can't explain the concepts they are not instructionally appropriate.
	H.E.1A.8 Obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations.	
	Conceptual Understanding	
	H.E.1B. Conceptual Understanding: Technology is any modification to the natural world created to fulfill the wants and needs of humans. The engineering design process involves a series of iterative steps used to solve a problem and often leads to the development of a new or improved technology.	

Performance Indicators		
ES-1.8 Evaluate a technological design or product on the basis of designated criteria (including cost, time, and materials).	**H.E.1B.1** Construct devices or design solutions using scientific knowledge to solve specific problems or needs: (1) ask questions to identify problems or needs, (2) ask questions about the criteria and constraints of the device or solutions, (3) generate and communicate ideas for possible devices or solutions, (4) build and test devices or solutions, (5) determine if the devices or solutions solved the problem and refine the design if needed, and (6) communicate the results.	

Standard H.E.2-- Astronomy		
2005	**2014**	**Comments**
ES-2: Students will demonstrate an understanding of the structure and properties of the universe.	**H.E.2:** The student will demonstrate an understanding of the structure, properties, and history of the observable universe.	
Conceptual Understanding		
	H.E.2A: 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 Indicators	
ES-2.8 Explain how gravity and motion affect the formation and shapes of galaxies (including the Milky Way).	**H.E.2A.1** Construct explanations for how gravity and motion affect the formation and shapes of galaxies (including the Milky Way Galaxy).	
ES-2.5 Classify stars by using the Hertzsprung-Russell diagram **ES-2.7** Summarize the life cycles of stars.	**H.E.2A.2** Use the Hertzsprung-Russell diagram to classify stars and explain the life cycles of stars (including the Sun).	
ES-2.4 Explain the formation of elements that results from nuclear fusion occurring within stars or supernova explosions.	**H.E.2A.3** Construct explanations for how elements are formed using evidence from nuclear fusion occurring within stars and/or supernova explosions.	
ES-2.3 Summarize the evidence that supports the big bang theory and the expansion of the universe (including the red shift of light from distant galaxies and the cosmic background radiation).	**H.E.2A.4** Construct and analyze scientific arguments to support claims about the origin of the universe (including the red shift of light from distant galaxies, the measured composition of stars and nonstellar gases, and the cosmic background radiation).	
ES-2.6 Compare the information obtained through the use of x-ray, radio, and visual (reflecting and refracting) telescopes.	**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.	

Conceptual Understanding		
	H.E.2B: 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 Indicators		
	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).	
ES-2.2 Identify properties and features of the Moon that make it unique among other moons in the solar system.	**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.	
ES-2.9 Explain how technology and computer modeling have increased our understanding of the universe.	**H.E.2B.3** Use mathematical and computational thinking to explain the motion of an orbiting object in the solar system.	The 2005 Standard emphasizes understanding the use of technology whereas the 2014 standard asks for students to understand and apply the technology to explain phenomena

ES-2.1 Summarize the properties of the solar system that support the theory of its formation along with the planets.	**H.E.2B.4** Construct explanations for how the solar system was formed.	

Standard H.E.3—Earth's Geosphere		
2005	**2014**	**Comments**
ES-3: Students will demonstrate an understanding of the internal and external dynamics of solid Earth.	**H.E.3:** The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.	
Conceptual Understanding		
	H.E.3A: Evidence in 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 Indicators		
ES-3.2 Explain the differentiation of the structure of Earth's layers into a core, mantle, and crust based on the production of internal heat from the decay of isotopes and the role of gravitational energy.	**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.	
ES-3.3 Summarize theory of plate tectonics (including the role of convection currents, the action at plate boundaries, and the scientific evidence for the theory).	**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.	
ES-3.3 Summarize theory of plate tectonics (including the role of convection currents, the action at plate boundaries, and the scientific evidence for the theory). **ES-3.4** Explain how forces due to plate tectonics cause crustal changes as evidenced in earthquake activity, volcanic eruptions, and mountain building.	**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).	
	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.	

ES-3.6 Explain how the dynamic nature of the rock cycle accounts for the interrelationships among igneous, sedimentary, and metamorphic rocks. **ES-3.7** Classify minerals and rocks on the basis of their physical and chemical properties and the environment in which they were formed.	**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.	
ES-3.5 Analyze surface features of Earth in order to identify geologic processes (including weathering, erosion, deposition, and glaciation) that are likely to have been responsible for their formation.	**H.E.3A.6** Develop and use models to explain how various rock formations on the surface of Earth result from geologic processes (including weathering, erosion, deposition, and glaciation).	
	H.E.3A.7 Plan and conduct controlled scientific investigations to determine the factors that affect the rate of weathering.	
	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.	
	Conceptual Understanding	
	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 Indicators		
ES-3.8 Summarize the formation of ores and fossil fuels and the impact on the environment that the use of these fuels has had.	**H.E.3B.1** Obtain and communicate information to explain how the formation, availability, and use of ores and fossil fuels impact the environment.	
	H.E.3B.2 Construct scientific arguments to support claims that responsible management of natural resources is necessary for the sustainability of human societies and the biodiversity that supports them.	
	H.E.3B.3 Analyze and interpret data to explain how natural hazards and other geologic events have shaped the course of human history.	
	H.E.3B.4 Obtain and evaluate available data on a current controversy regarding human activities which may affect the frequency, intensity, or consequences of natural hazards.	
	H.E.3B.5 Define problems caused by the impacts of locally significant natural hazards and design possible devices or solutions to reduce the impacts of such natural hazards on human activities.	

***ES-3.1** Summarize theories and evidence of the origin and formation of Earth's systems by using the concepts of gravitational force and heat production.

Standard H.E4—Earth's Paleobiosphere		
2005	**2014**	**Comments**
ES-6: Students will demonstrate an understanding of the dynamic relationship between Earth's conditions over geologic time and the diversity of its organisms.	**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.	
Conceptual Understanding		
	H.E.4A. 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 Indicators		
ES-6.1 Summarize the conditions of Earth that enable the planet to support life.	**H.E.4A.1** Construct scientific arguments to support claims that the physical conditions of Earth enable the planet to support carbon-based life.	
	H.E.4A.2 Construct explanations for how various life forms have altered the geosphere, hydrosphere and atmosphere over geological time.	
ES-6.2 Recall the divisions of the geologic time scale and illustrate the changes (in complexity and/or diversity) of organisms that have existed across these time units.	**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.	

ES-6.3 Summarize how fossil evidence reflects the changes in environmental conditions on Earth over time.	**H.E.4A.4** Obtain and evaluate evidence from rock and fossil records and ice core samples to support claims that Earth's environmental conditions have changed over time.	
ES-6.4 Match dating methods (including index fossils, ordering of rock layers, and radiometric dating) with the most appropriate application for estimating geologic time.	**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.	
ES-6.5 Infer explanations concerning the age of the universe and the age of Earth on the basis of scientific evidence	**H.E.4A.6** Use mathematical and computational thinking to calculate the age of Earth materials using isotope ratios (actual or simulated).	
	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.	

Standard H.E.5—Earth's Atmosphere—Weather and Climate		
2005	**2014**	**Comments**
ES-4: The student will demonstrate an understanding of the dynamics of Earth's atmosphere.	**H.E.5:** The student will demonstrate an understanding of the dynamics of Earth's atmosphere.	
Conceptual Understanding		
	H.E.5A: 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 Indicators		
ES-4.1 Summarize the thermal structures, the gaseous composition, and the location of the layers of Earth's atmosphere.	**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.	
ES-4.5 Explain the relationship between the rotation of Earth and the pattern of wind belts.	**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.	
	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.	
ES-4.3 Summarize the cause and effects of convection within Earth's atmosphere.	**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).	
ES-4.8 Predict weather conditions and storms (including thunderstorms, hurricanes, and tornados) on the basis of the relationship among the movement of air masses, high and low pressure systems, and frontal boundaries.	**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.	

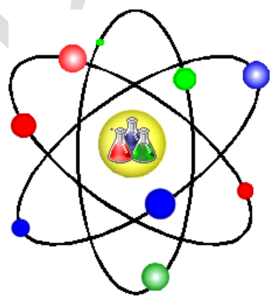
ES-4.4 Attribute global climate patterns to geographic influences (including latitude, topography, elevation, and proximity to water).	**H.E.5A.6** Develop and use models to exemplify how climate is driven by global circulation patterns.	
ES-4.6 Summarize possible causes of and evidence for past and present global climate changes.	**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).	
ES-4.7 Summarize the evidence for the likely impact of human activities on the atmosphere (including ozone holes, greenhouse gases, acid rain, and photochemical smog).	**H.E.5A.8** Analyze scientific arguments regarding the nature of the relationship between human activities and climate change.	

*__ES-4.2__ Summarize the changes in Earth's atmosphere over geologic time (including the importance of photosynthesizing organisms to the atmosphere).

Standard H.E.6—Earth's Hydrosphere		
2005	**2014**	**Comments**
ES-5: The student will demonstrate an understanding of Earth's freshwater and ocean systems	**H.E.6:** The student will demonstrate an understanding of Earth's freshwater and ocean systems.	
Conceptual Understanding		
	H.E.6A: 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 Indicators		
ES-5.4 Compare the physical and chemical properties of seawater and freshwater.	**H.E.6A.1** Analyze and interpret data to describe and compare the physical and chemical properties of saltwater and freshwater.	
ES-5.1 Summarize the location, movement, and energy transfers involved in the movement of water on Earth's surface (including lakes, surface-water drainage basins [watersheds], freshwater wetlands, and groundwater zones).	**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).	
ES-5.2 Illustrate the characteristics of the succession of river systems	**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.	
ES-5.8 Analyze environments to determine possible sources of water pollution (including industrial waste, agriculture, domestic waste, and transportation devices).	**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.	
ES-5.8 Analyze environments to determine possible sources of water pollution (including industrial waste, agriculture, domestic waste, and transportation devices).	**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).	

ES-5.3 Explain how karst topography develops as a result of groundwater processes.	**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.	
ES-5.7 Explain the effects of the transfer of solar energy and geothermal energy on the oceans of Earth (including the circulation of ocean currents and chemosynthesis).	**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.	
ES-5.5 Explain the results of the interaction of the shore with waves and currents.	**H.E.6A.8** Develop and use models to describe how waves and currents interact with the ocean shore.	
ES-5.6 Summarize the advantages and disadvantages of devices used to control and prevent coastal erosion and flooding.	**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	



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

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SOUTH CAROLINA DEPARTMENT OF EDUCATION

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INTRODUCTION

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

FORMAT OF THE CONTENT SUPPORT GUIDE

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

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

EARTH SCIENCE CONTENT SUPPORT GUIDE

Standard H.E.2: The student will demonstrate an understanding of the structure, properties, and history of the observable universe.

Conceptual Understanding
H.E.2A. 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).

Assessment Guidance
The objective of this indicator is to *construct explanations* for how gravity and motion affect the formation and shapes of galaxies (including the Milky Way Galaxy). Therefore, the primary focus of assessment should be to construct explanations using primary or secondary scientific evidence and models or data communicated in graphs, tables or diagrams to understand that motion and gravity determine the formation and shapes of galaxies (including the Milky Way Galaxy).
This could include but is not limited to having students using informational texts to research how motion and gravity determine the formation and shapes of galaxies. While viewing pictures and simulations of the motion of different galaxies, they could use this information to construct explanations about the distance between and motion of objects within a particular galaxy. In addition to *construct explanations,* students should be asked to *ask questions; develop and use models; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence;* and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge
8.P.2A.1 (Motion)
8.P.2A.5 (Gravity**)**
8.E.4A.1 (Shapes, composition, and location of galaxies)
8.E.4A.2 (Origin of the Universe)
H.P.2D. 2 (Law of Universal Gravitation)
H.P.2D.3 (Gravitational interactions and patterns of motion of galaxies)

Essential Knowledge
Students should 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.
Spiral Galaxies:

- Contain a flattened galactic disk in which the spiral arms are found, a central galactic bulge, and a halo of faint, old stars.
- The galaxy contains both young and old stars along with gas and dust that continue formation of new stars.
- The Milky Way galaxy that contains our solar system is a spiral galaxy; it looks milky or hazy because the stars are too close together for human eyes to see them individually.
- The gas and stars in the disk move in circular orbits around the galactic center.

Elliptical Galaxies:
- Have no galactic disk; stars are distributed throughout the nearly spherical to very flattened shape.
- There are no obvious structures other than a dense central nucleus.
- The galaxy contains only old stars along with little or no gas and dust for new star formation.
- The stars in the galaxy move in random orbits.

Irregular Galaxies:
- Have no obvious structure; some have an explosive appearance.
- The galaxy contains both young and old stars with ongoing star formation.
- The gas and stars in the disk move in very irregular orbits.

Extended Knowledge
Students may name specific galaxies other than the Milky Way or the further classifications within the main three. Students may also explore distances between galaxies, galaxy clusters, or properties of galaxies.

Science and Engineering Practices
S.1A.6

Standard H.E.2: The student will demonstrate an understanding of the structure, properties, and history of the observable universe.

Conceptual Understanding
H.E.2A: 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.2 Use the Hertzsprung-Russell diagram to classify stars and explain the life cycles of stars (including the Sun).
Assessment Guidance
The objective of this indicator is to *use a model* (the Hertzsprung-Russell diagram) to classify stars and explain the life cycles of stars (including the Sun). Therefore, the primary focus of assessment should be to use a Hertzsprung-Russell diagram (a model) to classify stars and explain their life cycles to understand that most stars, including our Sun, are main sequence stars and that stars are born, live, and die. This could include, but is not limited to, students using the properties of stars to place them on a Hertzsprung-Russell diagram (H-R diagram) and constructing an explanation of each star's placement.

In addition to *using a model*, students should be asked to *ask questions; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations;* and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge
8.E.4A.1 (Measurement units for star identification)

Essential Knowledge
Students should know the properties of mass, magnitude/brightness, temperature and diameter of stars are closely related. This relationship is shown on a chart known as the Hertzsprung-Russell diagram (H-R diagram).

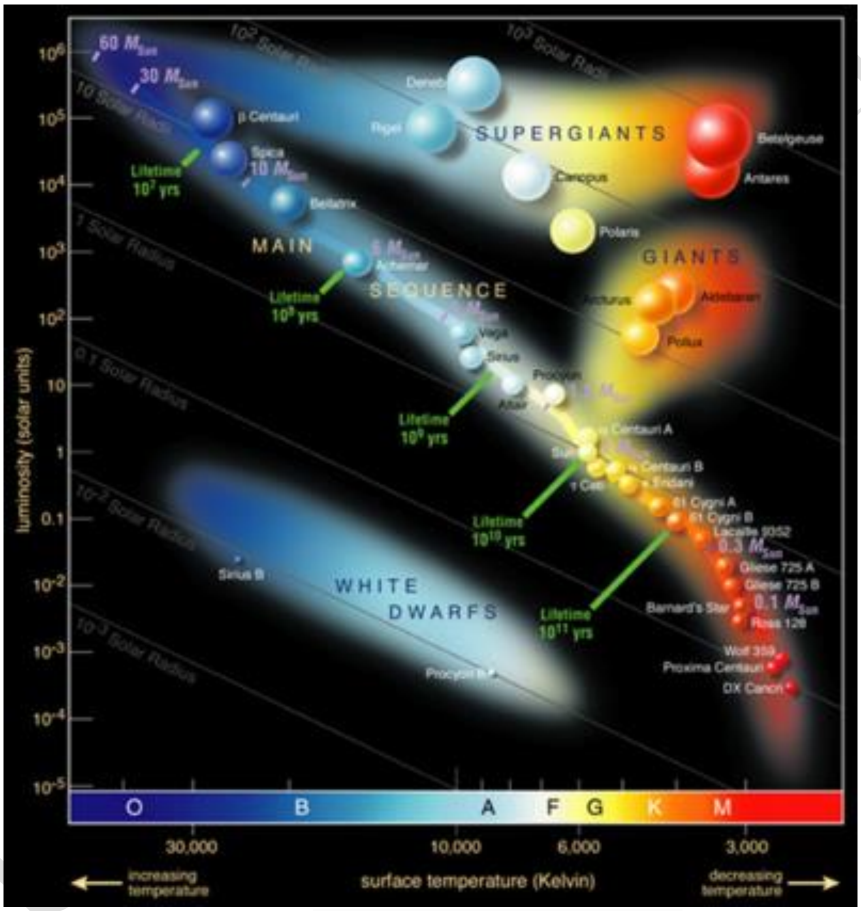

Image Source: ESO - http://www.eso.org/public/images/

Absolute magnitude This property of brightness is plotted on the vertical axis of the chart; also defined as *luminosity*.
Spectral type This property is found on the lower horizontal axis. Stars are given a letter and number based on the pattern of spectral lines produced by the star and temperature. O stars being the hottest and M stars being the coolest.
Surface temperature Measured in Kelvin is located along the top horizontal axis. Highest temperatures are on the left and coolest temperatures on the right.
Students will need to use these properties on the axes of the chart to classify stars.

Main sequence 90% of stars, including the Sun, are found along a diagonal that runs from the upper left where hot, bright stars are found to the lower right where cool, dim stars are found. All these stars have similar internal structures and functions.
Giants These stars are found in the upper right of the chart. They are cool stars with large surface areas that are bright, so they are called red giants.
Dwarfs Dim, hot stars are plotted in the lower left corner. They are small or they would be brighter. These are called white dwarfs.

The life cycle of a star depends on its mass.
Birth of a Star
- All stars begin their lives as parts of nebulas.
- A protostar is the earliest stage of a star's life.
- A star is born when the contracting gas and dust become so hot that nuclear fusion starts.

Life of a Star
Main-Sequence stars
- The second and longest stage in a main-sequence star's life cycle takes place while the star has an ample supply of hydrogen to fuse into helium.
- When the hydrogen has fused into helium, the core of the star contracts and the outer shell expands greatly; it has become a giant star.

Massive stars
- Have many shells fusing different elements; as more shells are formed, the star expands to a larger size and becomes a supergiant star.
- The star is very luminous and uses up its fuel quickly.

Death of a Star
- When a star runs out of fuel, its core no longer releases energy, it becomes a white dwarf, a neutron star, or a black hole;
- Giants that have had their outer parts drift out into space, leave behind the blue-white hot core – a white dwarf.
- A dying supergiant star can suddenly explode; the explosion is called a supernova; material that is left behind forms a neutron star.
- The remains of the most massive stars collapse into black holes; not even light can escape from a black hole.

Extended Knowledge
This indicator can be extended through students classifying individually named stars.
Students can also explore the internal dynamics of what goes on within the star at the various stages of life. Temperature data and life cycle time should be relative terms. Some basic study of constellations may spark student's interest.

Science and Engineering Practices
S.1A.2

Standard H.E.2: The student will demonstrate an understanding of the structure, properties, and history of the observable universe.

Conceptual Understanding

H.E.2A. 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.

Assessment Guidance

The objective of this indicator is to *construct explanations* for how elements are formed using evidence from nuclear fusion occurring within stars and/or supernova explosions. *Therefore the focus of assessment should be for students to construct explanations using (1) primary or secondary scientific evidence and models, or data communicated in graphs, tables, or diagrams to describe* how elements are formed using scientific evidence and models to understand that elements are formed by nuclear fusion within stars and/or supernova explosions. This could include, but is not limited to students using simulations, online data and informational texts to gather information regarding how the fusion and supernovas occur. They could use this information and periodic tables to diagram how elements may be formed from these occurrences (for example, hydrogen atoms fusing into helium atoms).

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

Previous and Future Knowledge

7.P.2A.1 (Atomic Models)
8.E.4A.1 (Shapes, composition, and location of galaxies)
8.E.4A.2 (Origin of the Universe)
H.C.2B (Nuclear Fission and Fusion)
H.P.3G- (Atomic Structure; Fission and Fusion; Radioactive Decay; Applications of Radioactive Decay)

Essential Knowledge

Students should have a basic understanding of the process of nuclear fusion. The temperature inside a star governs that rate of nuclear fusion. Stars in the Main Sequence (see H.E.2A.2) all produce energy by fusing hydrogen into helium as the Sun does. Stars outside the main sequence may fuse different elements in their cores or may not undergo fusion at all. Once a star's core has been converted from hydrogen to helium, if the temperature is high enough, the helium may fuse to form carbon. This is the second nuclear fusion reaction phase of a star. At even higher temperatures other elements such as oxygen, neon, magnesium and silicon may form. Stars can produce few elements heavier than iron. When certain stars explode in a massive explosion, known as a supernova, elements heavier than iron are created and enrich the universe. The star's element composition is determined by how many fusion reaction phases it has gone through.

Science and Engineering Practices
S.1A.6

Standard H.E.2: The student will demonstrate an understanding of the structure, properties, and history of the observable universe

Conceptual Understanding
H.E.2A. 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.4 Construct and analyze scientific arguments to support claims about the origin of the universe (including the red shift of light from distant galaxies, the measured composition of stars and non-stellar gases, and the cosmic background radiation).

Assessment Guidance
The objective of this indicator is to *construct and analyze scientific arguments* to support claims about the origin of the universe (including the red shift of light from distant galaxies, the measured composition of stars and non-stellar gases, and the cosmic background radiation). Therefore, the primary focus of assessment should be to construct and analyze scientific arguments to support claims and explanations using evidence and valid reasoning from observations, data, or informational texts to understand that the universe began as a single concentrated point of matter and energy that was propelled outward and has been expanding ever since (the Big Bang Theory). This could include, but is not limited to, students using evidence from models, scientific text and media, and secondary sources of data to support claims about the origin of the universe. They can use data about red shifts, Hubble's law, and evidence from cosmic microwave background radiation to determine if the scientific evidence supports the claim about the origin of the universe.

In addition to *construct scientific arguments to support claims,* students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations;* and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge
H.C.2 (Emission spectrum and absorption)
H.P.3D (Doppler Effect)
H.P.3F (Electromagnetic spectrum)
8.E.4 (Measurement unit needed to identify star and galaxy location
8.E.4 (How the universe began based on composition of starts and gases)

Essential Knowledge
Students should know that 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. As gravity began to have an

effect, galaxies formed. Element analysis shows that spectral lines are shifted towards the red end, indicating these galaxies are moving away from ours. This evidence suggests that the universe is still expanding. There is another theory, the Steady-State Theory, but evidence weighs in favor of the Big Bang. Background radiation, in the form of microwaves, was discovered and is believed to be left over from the initial event.

Extended Knowledge
Students can compare the Big Bang Theory to other theories including an understanding of critical density and the ultimate fate of the universe based on this theory.

Science and Engineering Practices
S.1A.7

Standard H.E.2: The student will demonstrate an understanding of the structure, properties, and history of the observable universe.

Conceptual Understanding
H.E.2A. 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.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.

Assessment Guidance
The objective of this indicator is *to 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. Therefore, the primary focus of assessment should be to obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, or (3) describe models to understand that that x-ray, radio, and visual telescopes are each constructed in such a way as to allow information to be gathered regarding objects and events in the universe. This could include, but is not limited to, students evaluating scientific information about the use of x-ray, gamma-ray, radio, and visual telescopes and computer modeling from scientific texts, primary and secondary data, and models. They can evaluate different objects in space and how they emit radiation in all frequencies of the electromagnetic spectrum.

In addition to *obtain and evaluate scientific information,* students should be asked to *ask questions; develop and use models; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence;* and *construct explanations.*

Previous and Future Knowledge
8.E.4 (Telescopes, spectroscopes)
8.P.3A.3 (Reflections, refraction, transmission and absorption of waves)

H.P.3F (Electromagnetic spectrum, reflection, refraction)
H.C.2 Absorption and emission spectrum

Essential Knowledge
Students should know that x-ray, radio, and visual telescopes are each constructed in such a way as to allow information to be gathered regarding objects and events in the universe. Objects in space emit radiation in all frequencies of the electromagnetic spectrum. Some of the wavelengths the human eye cannot detect, therefore a variety of telescopes have been developed. The goal of all telescopes is to bring as much radiation as possible to a focus.

X-ray Telescopes
- Since x-rays cannot be easily reflected by any surface, a special design for detecting x-rays had to be developed.
- An arrangement of cylindrical mirrors allows X-rays to be guided to a precise focus to form an image.

Visual Telescopes
Reflecting
- Uses a concave mirror instead of an objective lens 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
- Uses 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
- Most 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 Knowledge
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.

Science and Engineering Practices
S.1A.8

Standard H.E.2: The student will demonstrate an understanding of the structure, properties, and history of the observable universe.

Conceptual Understanding:

H.E.2B 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).

Assessment Guidance

The objective of this indicator is *to 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). Therefore, the primary focus of assessment should be to analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to reveal patterns and construct meaning, support or refute explanations, or evaluate the strength of conclusions to understand that without Earth's hydrosphere, atmosphere, and environments of the biosphere, life could not exist on Earth.

This could include, but is not limited to, students determining if evidence supports the scientific claim that the atmospheric compositions of Earth, Venus and Mars are suitable for life. This evidence may include, but is not limited to the hydrosphere and biosphere as well.

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

Previous and Future Knowledge

8.E.4 (Earth's solar system)
7.P.2B.1 (Density)
6.E.2 (Climate)
8.E.5 (Plate tectonics)

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Essential Knowledge

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	No
Uranus	Gaseous	1.270	No	-216	No
Neptune	Gaseous	1.638	No	-214	No

Conditions necessary for life would include an exploration of the surface temperature and presence of water on the planets.

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

Science and Engineering Practices
S.1A.4

Standard H.E.2: The student will demonstrate an understanding of the structure, properties, and history of the observable universe.

Conceptual Understanding
H.E.2B 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.

Assessment Guidance
The objective of this indicator is to *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. Therefore, the primary focus of assessment should be to answer questions, describe phenomena, develop models, evaluate explanations, or identify and/or fill gaps in knowledge regarding how the Moon's pull of gravity creates bulges of ocean water on both the near and far sides of Earth because of its size

and its close proximity to Earth. This could include, but is not limited to, students using scientific information from scientific texts, primary or secondary data and observations, models and descriptions to determine the relative sizes, orbits and composition of the other moons (natural satellites) compared to the planets they orbit. They will use the scientific information collected and compare the information to Earth's moon.

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

Previous and Future Knowledge
8.E.4 (Gravity)
8.E.4 (Effects of motion within the Earth- Moon-Sun system)
8.E.4 (Tides)
H.P.2D (Universal Law of Gravitation)

Essential Knowledge
It is essential for students to know that the Moon as Earth's natural satellite is unique among the moons in the solar system.

Unique Properties:

- *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:

- *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 c*over most of the lunar surface, are mountainous, and are heavily covered with craters.

Other features of the Moon, due to its movement and relation to Earth, are its phases and its gravitational effect causing tidal pull on Earth.

- 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.

Extended Knowledge
Investigate the number of moons in our solar system and their properties.

Science and Engineering Practices
S.1A.8

Standard H.E.2: The student will demonstrate an understanding of the structure, properties, and history of the observable universe.

Conceptual Understanding
H.E.2B. 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.

Assessment Guidance
The objective of this indicator is to *use mathematical and computational thinking* to explain the motion of an orbiting object in the solar system. Therefore, the primary focus of assessment should be to use mathematical and computational thinking to (1) use and manipulate appropriate metric units and (2) express relationships between variables for models and investigations to understand that the motion of an orbiting object in the solar system can be explained and predicted using mathematics. This could include, but is not limited to, students recognizing and communicating Kepler's Law of Ellipses, Law of Equal Areas, and Law of Periods using appropriate methods and units. Students can compare the orbits of various moons around the planets they orbit.

In addition to using *mathematical and computational thinking*, students should be asked to *ask questions; develop and use models;; analyze and interpret data; engage in argument from evidence; obtain, evaluate, and communicate information; and construct explanations.*

Previous and Future Knowledge
8.E.4 (Gravity)
H.P.2D (Universal Law of Gravitation)
H.P.2D (Kepler's Laws)

Essential Knowledge

Kepler's Laws

Concept	Explanation

Law of Ellipses	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%.
Law of Equal Areas	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.

Planet	Eccentricity (0=circle)
Mercury	0.205
Venus	0.007
Earth	0.017
Mars	0.94
Jupiter	0.049
Saturn	0.057
Uranus	0.046
Neptune	0.011

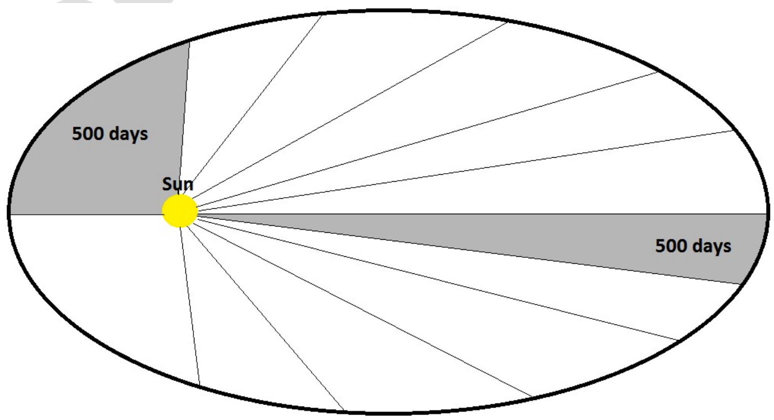

Image Source: 2005 Science Support Document

Law of Periods	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.

Extended Knowledge
Orbital period is calculated by $P(\text{years})^2 = a(\text{AU})^3$. Teachers may have students calculate and compare the orbital periods.
Ellipticity describes the shape of a galaxy. A galaxy with the shape of a sphere has an ellipticity of zero (0).

Science and Engineering Practices
S.1A.5

Standard H.E.2: The student will demonstrate an understanding of the structure, properties, and history of the observable universe.

Conceptual Understanding
H.E.2B. 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.

Assessment Guidance
The objective of this indicator is to *construct explanations* for how the solar system was formed. Therefore, the primary focus of assessment should be to construct explanations of phenomena using primary or secondary evidence and models or data communicated in graphs, tables or diagrams to understand that the solar system formed from a collapsing and rotating cloud of interstellar gases (the Nebular Theory).This could include, but is not limited to, students using evidence from appropriate sources to connect their supporting evidence to the Nebular Theory. Evidence can include the composition of planets, red/ blue shifts, and gravity.

In addition to *constructing explanations*, students should be asked to *ask questions; develop and use models; analyze and interpret data; engage in argument from evidence; obtain, evaluate, and communicate information; and use mathematics and computational thinking.*

Previous and Future Knowledge
8.E.4 (How the universe began based on composition of stars and gases, and motion of the universe)

8.E.4 (Gravity)
7.P2A.2 (Periodic table)
H.P.2D (Universal Law of Gravitation)

Essential Knowledge
Students should know properties that are evident 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 rotating motion is the beginning of the flattened rotating disk that became the Solar System.

The Nebular Theory continues to explain the formation of the Sun and then planetesimals, many of which formed the planets. 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. The outer gas planets formed farther from the Sun where it is cooler. Other remnants from the Solar System formation are asteroids and comets.

Extended Knowledge
Describe the formation process of the individual bodies within the Solar System.

Science and Engineering Practices
S.1A.6

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

Conceptual Understanding
H.E.3A. 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.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to explain the differentiation of Earth's internal structure. Therefore, the primary focus of assessment should be for students to analyze data, to look for patterns, to evaluate the validity of conclusions that can be inferred from a data set, and to determine if relationships demonstrated by the data are correlative or casual with respect to radioactive decay, gravitational energy, seismic wave data and Earth's magnetic field. This could include, but is not limited to, students analyzing relevant data from informational text, organizing the data into tables or charts to use for

argumentation/justification of the existence of Earth's layers and sub-layers, as well as the consistency and composition of each.

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

Previous and Future Knowledge
8.E.5 (Earth's Layers)
H.C.2/ H.P.2D (Radioactive decay)
8.P.3A.1 (Seismic waves)
6.P.3A.4/ H.P.2D (Magnetic field)
Essential Knowledge
Students should know that 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 were pulled to the core. Heat from the core and radioactivity within the mantle keep the mantle hot. The gradual increase in temperature and pressure within Earth affects the physical properties and the mechanical behavior of Earth materials. Therefore, depending upon the temperature and pressure, a particular Earth material may behave like a solid, or like a puttylike material, or even melt and become a liquid in various Earth layers.

Core: The heavier (more dense) material sank to become the core. At the extreme pressures found in the core, the iron- rich material becomes very dense. The solid inner core and the liquid outer core make up nearly one third of Earth's mass. The convective flow of metallic iron in the outer core generates Earth's magnetic field. Despite its high temperature, the material in the inner core under immense pressure behaves like a solid.

Mantle: 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. 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.

Crust: Earth's outermost layer is the crust, a relatively cool, rigid shell. It makes up only about one percent of Earth's mass. There are two types of crustal material – oceanic crust and continental crust.

The behavior of seismic waves has allowed scientists to learn much about Earth's interior structure.

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

Science and Engineering Practices
S.1A.4

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

Conceptual Understanding
H.E.3A. 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.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to explain the theory of plate tectonics. Therefore, the primary focus of assessment should be for students to analyze data to look for patterns, to evaluate the validity of conclusions that can be inferred from a data set, and to determine if relationships demonstrated by the data are correlative or casual regarding ocean topography, correlation of rock assemblages, the fossil record, the role of convection current, and the action at plate boundaries. This could include, but is not limited to, students analyzing oceanic topographic maps, Ring of Fire maps, to support the idea that the convection currents cause tectonic plates to move forming the divergent, convergent and transform boundaries. These same maps may be used to support the shapes of the tectonic plates.

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

Previous and Future Knowledge
8.E.5 (Plate Tectonics)
8.E.5 (Fossil and rock layers)
6.P.3A.5 (Convection)

Essential Knowledge
Students should know the Theory of Plate Tectonics states that Earth's crust and rigid upper mantle 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.

What causes Earth's plates to move is explained in a hypothesis that proposes convection currents within the mantle.

Role of Convection Currents: The movement of the plates is driven by the unequal distribution of heat within Earth that set up convection currents within the upper mantle. 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. There are still many unanswered questions about mantle convection currents.

When tectonic plates move, they interact at places called plate boundaries. Each type of boundary has certain geologic characteristics and processes associated with it.

Action at Plate Boundaries

Divergent Boundaries:
Places where two plates are moving apart (separating) are called divergent boundaries. Most are found on the sea floor and form ocean ridges. The formation of new crust occurs at most divergent boundaries 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:
Places where two plates are moving toward each other are called convergent boundaries. 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 becomes denser due to cooling and descends beneath the other in a process called subduction, Subduction creates a deep trench and a volcanic arc of islands. The subducted plate descends into the mantle and melts, thus recycling the crustal material. (2) Oceanic crust converging with less dense continental crust – subduction also occurs but the subduction causes a trench and a mountain range with many volcanoes along the continent's edge. (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:
Places where two plates slide horizontally past each other are called transform boundaries. At these boundaries crust is only deformed or fractured. Most transform boundaries are not found on continents; a famous exception is the San Andreas Fault in southwest California.

Early evidence for the Theory of Plate Tectonics began with early observations made about the shape of the continents. A Hypothesis of Continental Drift was developed from this early evidence. Evidence for this hypothesis included similar rock types and formations on continents now separated, as well as similar fossils of several different animals and plants that once lived on land now found on widely separated continents. That hypothesis was originally rejected because the force great enough to move continents could not be shown. As more evidence was gathered it was revisited and led to the Theory of Plate Tectonics. In the 1960s evidence was found on the seafloor that could explain how continents move.

Extended Knowledge
Cover the work of Alfred Wegener, the developer of the Hypothesis of Continental Drift. Research Harry Hess and his development of the Sea-Floor Spreading Hypothesis.

Science and Engineering Practices
S.1A.4

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

Conceptual Understanding
H.E.3A. 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).

Assessment Guidance
The objective of this indicator is to *construct explanations* of how forces cause crustal changes. Therefore, the primary focus of assessment should be for students to construct explanations using scientific evidence and models, predictions based on observations and measurements, or data communicated in graphs, tables or diagrams regarding sea floor spreading, earthquake activity, volcanic eruptions, and mountain building. This could include, but is not limited to, using seafloor spreading models, magnetic striping models/maps, and age of seafloor in relation to ocean ridges and trenches, mountain-building, and hot spot formation as they derive a claim and provide evidence to support their ideas.

In addition to *construct scientific arguments to support claims*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; construct explanations; obtain, evaluate and communicate information;* and *develop and use models.*

Previous and Future Knowledge
8.E.5 (Plate Tectonics)
8.P.2A.1 (Forces)
8.E.5 (Earthquakes/volcanoes)
Essential Knowledge
Students should know that many crustal changes occur because of the forces interacting at and within plate boundaries.

- Where forces on the plates are pulling them apart, new crustal material forms as volcanic eruptions bring magma up to the surface. Earthquakes often accompany a volcanic eruption. Undersea mountain ridges are built from this activity as magma cools and hardens.
- At converging boundaries, the force of plates being pushed together may form deep undersea trenches. Volcanic eruptions occur as some magma is forced back to the surface to form either volcanic island arcs or volcanoes within mountain ranges. Converging forces may slowly push continental crust against continental crust so that the land crumples and folds to form a mountain range.
- As plates slide past each other along transform fault boundaries, the buildup of pressure along the boundary may cause the fault to quickly move resulting in an earthquake.
- Some volcanoes are located far from plate boundaries in regions known as hot spots. These are formed 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. Chains of volcanoes that form over hot spots

provide important information about plate motions, such as rate and direction.

Scientific evidence for the theory:

Seafloor spreading

This theory states that new ocean crust is formed at ocean ridges where magma rises to the surface and hardens. A new section of crust forms which slowly moves away from the ridge. Crust is destroyed, re-melted, at deep-sea trenches.

Magnetic striping

As scientists collected data about the areas parallel to the ocean ridges, magnetic patterns emerged. The magnetic pattern on one side of the ridge matched the pattern on the other. Scientists were able to determine the age of the ocean floor from the magnetic recording. Relatively young ocean floor crust is found near ocean ridges and older ocean crust is found along deep-sea trenches.

Extended Knowledge

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.

Science and Engineering Practices

S.1.A.6

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

Conceptual Understanding

H.E.3A. 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.

Assessment Guidance

The objective of this indicator is to *use mathematical and computational thinking* to analyze seismic graphs. Therefore the focus of assessment should be for students to construct use and manipulate appropriate metric units, express relationships between variables for models and investigations, and use grade-level appropriate statistics to analyze data to (1) triangulate the location of an earthquake's epicenter and magnitude, and (2) describe correlation between frequency and magnitude of an earthquake. This could include, but is not limited to, students analyzing frequency and magnitude data from recent earthquakes and writing a mathematical formula to describe the trend in the model.

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

Previous and Future Knowledge
8.E.5 (Plate tectonics)
8.E.5 (Earthquakes and volcanoes)

Essential Knowledge
The epicenter of an earthquake is the point directly above the focus, or point where the earthquake originated. 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 most common of which is the Richter 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 vertical separation 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. The radius for each will represent the distance to the epicenter and should be drawn to scale.

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 Knowledge
Use seismograms from more additional distant stations to triangulate calculations.
Teachers may consider linking earthquakes to tsunamis from recent earthquakes in the Pacific Rim.
Science and Engineering Practices
S.1A.5

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

Conceptual Understanding

H.E.3A. 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.

Assessment Guidance

The objective of this indicator is to *analyze and interpret data*. Therefore, the primary focus of assessment should be for students to analyze and interpret data from informational texts to reveal patterns and support claims that the Earth's rocks are formed through dynamic processes and may be classified according to chemical and physical properties. This could include, but is not limited to, analysis of data related to hardness, cleavage, luster, and density; as well as classification of rocks and minerals using dichotomous keys. This could also include a comparison of the processes that could form or change each type of rock.

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

Previous and Future Knowledge

3.E.4 (Rocks and minerals)
7.P.2B.1 (Physical and chemical properties)
8.E.5 (Rock Cycle)

Essential Knowledge

The rock cycle illustrates the continuous changing and remaking of rocks on Earth. The rocks of Earth, whether they are at the surface or below the crust, are always positioned somewhere on the rock cycle. The three types of rock – igneous, sedimentary, and metamorphic – are grouped according to how they form. These rock types form the divisions of the rock cycle. Processes can change any rock into another rock. Internal processes include heat & pressure, melting, cooling & crystallization; and uplift. External processes include weathering, erosion, deposition, burial, and lithification. There is more than one path in the rock cycle; that's its dynamics. It is essential for students to know the processes and properties that allow for mineral identification and rock identification. They should be able to use mineral and rock identification keys/charts.

Mineral Identification:

Geologists rely on several relatively simple tests to identify minerals. These tests are based upon a mineral's physical and chemical properties. By using the results from a combination of tests rather than just one, the mineral's classification and identity is more accurate. 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, and cleavage & fracture.
- Density tests may also be performed if the right equipment is available. Heft (heaviness compared to sample size) is sometimes used as a simple relative density comparison.
- 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:

Rocks are made up of minerals and are formed very differently, therefore their identification and classification is fairly complicated. Geologists must 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:

- For igneous rocks – determine if the igneous rock is 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).
- For metamorphic rocks – determine if the metamorphic rock is foliated or non-foliated based on texture (layers or bands of minerals, not banded); coarse-grained or fine-grained
- For sedimentary rocks – determine if the sedimentary rock is 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 Knowledge

Teachers may elect to have students extend the classification of minerals into groups/families or to identify specific mineral crystal systems. Further classification of igneous, metamorphic, or sedimentary rocks beyond the main grouping is elective.

Science and Engineering Practices

S.1A4

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

Conceptual Understanding

H.E.3A. 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).

Assessment Guidance

The objective of this indicator is to *develop and use models* to explain how geologic processes result in various rock formations. Therefore, the primary focus of assessment should be for students to develop and use diagrams, constructs, mathematical formulae and simulations of actions to represent and communicate ideas about weathering, erosion, deposition, and glaciation. This could include, but is not limited to, students, using evidence and scientific information through research or investigation, construct a functional model that represents erosion, weather, deposition, and/or glaciation. A historical approach to beach weathering in Myrtle Beach before and after a hurricane or the formation of local barrier islands can provide relevance to the students.

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

Previous and Future Knowledge

8.E.5 (Rock cycle)
8.E.5 (weathering, erosion, and deposition)

Essential Knowledge

Students should use illustrations, imagery, topographic maps, pictures, or descriptions of surface features to determine geologic processes responsible for those features.

Weathering:

This process includes both the disintegration and decomposition of surface rock material. ***Disintegration*** is the physical or mechanical breakdown of Earth materials; the original material has not changed, just its size or shape. Rocks may be cracked, broken, or peeled off through mechanical weathering. ***Decomposition*** is the chemical altering of the composition of the material. Acids, water, carbon dioxide, or oxygen may react with the rock material causing the change.

Erosion:

This process moves weathered material from one place to another. Various erosional agents (gravity, wind, water, plants/animal/humans) pick up Earth materials and carry them to other locations. 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:
This process is closely related with erosion because they are dependent on one another. The agent that eroded the material in 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:
This process has 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 Knowledge
Teachers may elect to delve further into the individual processes of weathering erosion or glaciation.

Science and Engineering Practices
S.1.A.2

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

Conceptual Understanding
H.E.3A. 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.

Assessment Guidance
The objective of this indicator is to *plan and conduct controlled scientific investigations* to determine the factors that affect the rate of weathering. Therefore, the primary focus of assessment should be for students to plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations by (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 while using appropriate safety procedures to determine the factors that affect the rate of weathering. This could include, but is not limited to, students developing a testable hypothesis about climate, surface area, or rock composition and the affects these variables can have on the rate of weathering.

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

Previous and Future Knowledge
8.E.5 (Rock cycle)
8.E.5 (weathering, erosion, and deposition)

Essential Knowledge
It is essential that the students comprehend that 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 Knowledge
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.

Science and Engineering Practices
S.1A.3

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

Conceptual Understanding
H.E.3A. 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.

Assessment Guidance

The objective of this indicator is to *analyze and interpret data* of soil from different locations to compare the major physical components of soil as evidence of Earth processes in that region producing each type of soil. Therefore, the primary focus of assessment should be for students to analyze data, to look for patterns, to evaluate the validity of conclusions that can be inferred from a data set, and to determine if relationships demonstrated by the data are correlative or casual with respect to the amount of sand, silt, clay, and humus as evidence of Earth's processes in a particular region producing each type of soil. This could include, but is not limited, students conducting a comparative analysis of soil for various regions in South Carolina to determine if the physical components of the sand are related to the process that occur in that region.

In addition to *analyzing and interpreting data* students should be asked to *ask questions; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models;* and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge

8.E.5 (Rock cycle)

8.E.5 (weathering, erosion, and deposition)

Essential Knowledge

It is essential that students know that the characteristics of soil are dependent upon the characteristics of the parent rock.

Soil is a mixture a number of particles. Of the components of soil, the clay particles are the smallest in size. Clay has 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. Silt feels 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. It 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.

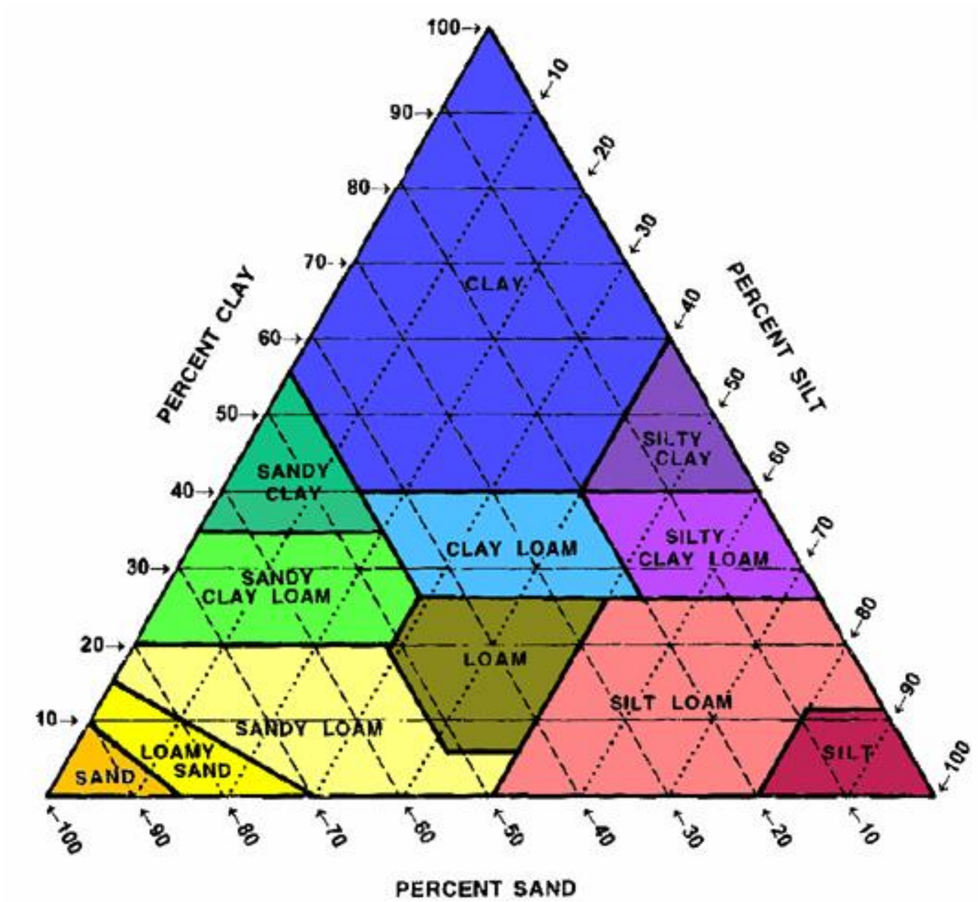

Image Source: www.nrcs.usgs.gov

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

Science and Engineering Practices
S.1A.4

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

Conceptual Understanding
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.

Assessment Guidance
The objective of this indicator is to *obtain and communicate information* to explain how the formation, availability, and use of ores and fossil fuels impact the environment. Therefore, the primary focus of assessment should be for students to obtain and evaluate informational texts, observations, data collected or

discussions to (1) generate and answer questions, (2) understand, (3) develop models, or (4) support explanations about the formation of ores and fossil fuels and environmental impact issues regarding the use of fossil fuels. This could include, but is not limited to, students writing and presenting position statements regarding the continued use of fossil fuels based on research from secondary data sources.

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

Previous and Future Knowledge
8.E.6A (Earth's History)
H.B.6B (Photosynthesis, Cellular Respiration, Carbon Cycle, Global Climate)

Essential Understanding
It is essential for students to know how ores and fossil fuels form.

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
Because of their organic origin, coal, petroleum, and natural gas are called fossil fuels. 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
Coal is the most abundant fossil fuel in the world. The present reserves of coal should last about 200 years. Anthracite coal is the most efficient, cleanest burning coal, but it has the smallest reserves. Most coal burned is bituminous that releases carbon, sulfur, and nitrogen oxides into the air causing air pollution and acid precipitation, so safeguards are important to keep the abundance of these oxides from 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
This involves looking for oil traps in folds of the rock layers or in fracture or fault zones. Oil shale also contains petroleum between its layers, but the cost is great to mine 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.

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

Science and Engineering Practices
S.1A.8

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

Conceptual Understanding
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.

Assessment Guidance
The objective of this indicator is to *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. Therefore, the primary focus of assessment should be for students to construct scientific arguments to support claims or explanations using evidence from observations, data, or informational texts regarding the factors that affect management of natural resources and the factors that affect human sustainability. This could include but is not limited to students exploring case studies of regional biodiversity crisis and use evidence from the studies to make and challenge claims regarding how particular factors may affect the crisis.

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

Previous and Future Knowledge
8.E.6A (Earth's History)
H.B.6B (Photosynthesis, Cellular Respiration, Carbon Cycle, Global Climate)

Essential Understanding
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.

Science and Engineering Practices
S.1A.7

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

Conceptual Understanding
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.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to explain how natural hazards and other geologic events have shaped the course of human history. Therefore, the primary focus of assessment should be for students to analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions regarding how natural processes have shaped the course of human history. This could include but is not limited to students making claims about the long-term effects of an eminent hurricane based on data obtained from studying the effects of previous hazardous events (for example 1989 Hurricane Hugo, 2005 Hurricane Katrina).

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

Previous and Future Knowledge
8.E.6A (Earth's History)

Essential Understanding
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.

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

Science and Engineering Practices
S.1A.4

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

Conceptual Understanding
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.

Assessment Guidance
The objective of this indicator is to *obtain and evaluate* available data on a current controversy regarding human activities, which may affect the frequency, intensity, or consequences of natural hazards. Therefore, the primary focus of assessment should be for students to 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 regarding human activities which may affect the frequency, intensity, or consequences of natural hazards. This could include but is not limited to students researching how use of certain industrial chemicals and practices influence the ozone and evaluating the effectiveness of local and global regulations in reducing the growth of holes in the ozone layer.

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

Previous and Future Knowledge
8.E.6A (Earth's History)

Essential Understanding
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). Examples of 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.

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

Science and Engineering Practices
S.1A.8

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

Conceptual Understanding
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.

Assessment Guidance
The objective of this indicator is to 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. Therefore, the primary focus of assessment should be for students to construct devices or design solutions using scientific knowledge to solve specific problems or needs with the responsible management of the negative impact of human activities. This will include having the students to: (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.

In addition to *define problems* and *design possible solutions*, students should be asked to *develop and use models; plan and carry out tests; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence*; and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge
8.E.6A (Earth's History)
Essential Understanding
The negative impact of human activities 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.

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

Science and Engineering Practices
S.1B.1

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.

Conceptual Understanding
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.1
Construct scientific arguments to support claims that the physical conditions of Earth enable the planet to support carbon-based life.

Assessment Guidance
The objective of this indicator is to *construct scientific arguments to support claims* that the conditions on Earth are necessary for the support of life. Therefore, the primary focus of assessment should be to construct and analyze scientific arguments to support claims and explanations using evidence and valid reasoning from informational texts to understand that without Earth's hydrosphere, atmosphere, and environments of the biosphere, life could not exist on Earth.

This could include, but is not limited to, students determining if evidence supports the scientific claim that the atmospheric compositions of Earth, Venus and Mars are suitable for life. This evidence may include, but is not limited to, the study of Earth's hydrosphere and biosphere..

In addition to *construct scientific arguments to support claims*, students should *ask questions; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; and construct explanations; obtain, evaluate, and communicate information.*

Previous and Future Knowledge
6.E.2/ Atmospheric layers
8.E.4 Earth's solar system
8.E.6 Biological adaptation and genetic variation
8.E.5 Rock layers and fossil

Essential Knowledge
Without Earth's hydrosphere, atmosphere, and environments of the biosphere, life could not exist on Earth.

- Earth is suitable for life because of its unique orbital position that allows for water to exist in all three phases on the surface. Water makes Earth unique. The hydrosphere, Earth's mass of liquid water that is constantly on the move, is vital to life within it and also to life on the land.
- Earth is surrounded by a life-giving gaseous envelope called the atmosphere. Earth's atmosphere provides the air that organisms need to breathe and also acts to protect organisms from the Sun's intense heat and radiation.
- The biosphere includes all life on Earth – life found from the depths of the ocean floor to life existing in the lower atmosphere. The biosphere contains biotic and 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 through their interactions, 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 . During the formation of Earth's spheres, scientists have found evidence 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.

Teacher Note: 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.

Science and Engineering Practices
S.1.A.7

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.

Conceptual Understanding
H.E.4A. 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.

Assessment Guidance
The objective of this indicator is to *construct explanations* for how various life forms have altered the geosphere, hydrosphere and atmosphere over geological time; therefore the focus of assessment should be for students to construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams to describe how the extinction, emergence, and evolution of plants, animals and microorganisms have altered the geosphere, hydrosphere, and atmosphere. This could include, but is not limited to, describing the impact various biogeochemical cycles have on the availability of nutrients in the environment, and the current conditions on Earth.

In addition to *construct explanations*, students should ask questions; engage in argument from evidence, obtain, evaluate and communicate information; and develop and use models.
Previous and Future Knowledge:
8.E.6 (Impact of events on the conditions of Earth)
8.E.6 (Geological time periods)
6.E.2 (Atmospheric layers)
6.L.5/ H.B.3 (Photosynthesis)
8.E.6 (Fossil Fuels and rock layers)

Essential Knowledge
Humans and other life forms have the capacity to alter Earth's geosphere, hydrosphere, and atmosphere.
- 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.
- Additionally, 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 Knowledge
Research correlations between the events covered in the indicator and the events of the corresponding eras of geologic time.

Science and Engineering Practices:
S.1.A.6

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.

Conceptual Understanding
H.E.4A. 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.

Assessment Guidance
The objective of this indicator is to *construct explanations* how changes to Earth's surface are related to changes in the complexity and diversity of life using evidence from the geologic time scale; therefore the focus of assessment should be for students to construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams to describe changes in complexity or organisms. This could include but is not limited to students explaining the changes to a group of organisms through the use of fossil data during an era. Students could construct an explanation of the role the changing environment played in the observed changes.

In addition to *construct explanations*, students should be asked to ask questions; engage in argument from evidence; obtain, evaluate, and communicate information; and develop and use models.

Previous and Future Knowledge:
8.E.6 (Geologic time scales)
8.E.6 (Fossils and rocks layers)
8.E.5 (Weathering and erosion)
8.E.5/ H.B.4 Biological adaptation and genetic variation

Essential Knowledge
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.

Students need to know the 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.

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

Science and Engineering Practices
S.1.A.6

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.

Conceptual Understanding
H.E.4A. 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.4 Obtain and evaluate evidence from rock and fossil records and ice core samples to support claims that Earth's environmental conditions have changed over time.
Assessment Guidance
The objective of this indicator is to *obtain and evaluate evidence* from rock and fossil records and ice core samples to support claims that Earth's environmental conditions have changed over time.   Therefore the focus

of assessment should be for students to obtain and evaluate scientific information to explain or describe phenomena, evaluate hypotheses and claims, or to identify and fill in gaps in knowledge regarding changes in Earth's environmental conditions over time   This could include but is not limited to students obtaining and evaluating scientific information such as CO_2 data from ice core samples to support claims regarding fluctuations in the average global temperature over time.

In addition to *obtain and evaluate evidence* students should be asked to *ask questions; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; and develop and use models;*.

Previous and Future Knowledge:
8.E.6 (Rock and fossil layers)
8.E.6/ H.B.4 (Biological adaptation and genetic variation)

Essential Knowledge
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.

Students should also know that 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 climactic changes; and
- locate energy resources based on the environmental conditions needed for fossil fuels to have formed.

Extended Knowledge
Study how each fossil type was formed.

Science and Engineering Practices
S.1.A.8

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.

Conceptual Understanding
H.E.4A. 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.

Assessment Guidance
The objective of this indicator is to *develop and use models of* various dating methods to estimate geologic time. Therefore the focus of assessment should be for students to (1) develop and use models to understand or represent phenomena and relationships and (2) communicate ideas to others, regarding indexing fossils, ordering of rock layers, and radiometric dating. This could include but is not limited to students critically examining evidence in a provided model to determine relative age or absolute age of fossils or rock layers.

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

Previous and Future Knowledge
8.E.5 (Fossil and rock layers)
8.E.4 (Geological time periods)
H.C.2 (Radioactive dating)

Essential Knowledge
It is essential for students to know that 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: (used if the need is 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: (used if the need is for knowing the actual age of a rock or fossil) To determine the actual age, or absolute age, of a rock layer, scientist 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. Students should know why uranium-238 may be used for one dating compared to carbon-14 in another instance.

Extended Knowledge
Students can know the details of the particles given off or the various daughter elements that occur in the radioactive decay process.

Science and Engineering Practices
S.1.A.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.

Conceptual Understanding
H.E.4A. 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).

Assessment Guidance
The objective of this indicator is to use mathematical and computational thinking to calculate the age of Earth materials using isotope ratios (actual or simulated). Therefore, the primary focus of assessment should be to use mathematical and computational thinking to (1) use and manipulate appropriate metric units and (2) express relationships between variables for models and investigations to understand that since radioactive elements decay at predictable scientists can estimate the amount of time that has passed since a rock formed. This could include but is not limited to having students calculate the age of an Earth material (rock) given the half-life of a radioactive element and the ratio of the remaining parent: daughter.

In addition to *using mathematical and computational thinking*, students should be asked to *ask questions and define problems; analyze and interpret data; engage in argument from evidence; construct explanations; engage in scientific argument from evidence;* and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge

8.E.4 (Telescopes)
8.E.4 (How the universe began based on composition of stars and gases and motion of the universe)
8.E.6 (Fossil and rock layers)
H.C.2 (Radioactive dating)
8.E.6 Geologic time scales

Essential Knowledge

Scientists collect data, using various types of telescopes and instruments, to detect changes that are going on in the universe. This study, called cosmology, not only studies the universe as it is, but also forms models and theories concerning its origin and age.

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 Knowledge

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

Science and Engineering Practices

S.1A.5

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.

Conceptual Understanding

H.E.4A. 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.

Assessment Guidance
The objective of this indicator is to 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. Therefore, the primary focus of the assessment should be for students to develop and use models to understand or represent phenomena, processes, relationships, and communicate ideas to others about carbon cycling. This could include but is not limited to students developing a model to represent carbon cycling through the environment. Additionally, a terrarium could be constructed, observed, and used to support content throughout the course.

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

Previous and Future Knowledge
H.B.6 (Carbon cycle)
6.E.2 (Water cycle)
6.L.5B.2 (Photosynthesis)
H.B.6B (Photosynthesis, cellular respiration, global climate)

Essential Knowledge
The carbon cycle is a process by which carbon is cycled through the atmosphere, land, water, and organisms.

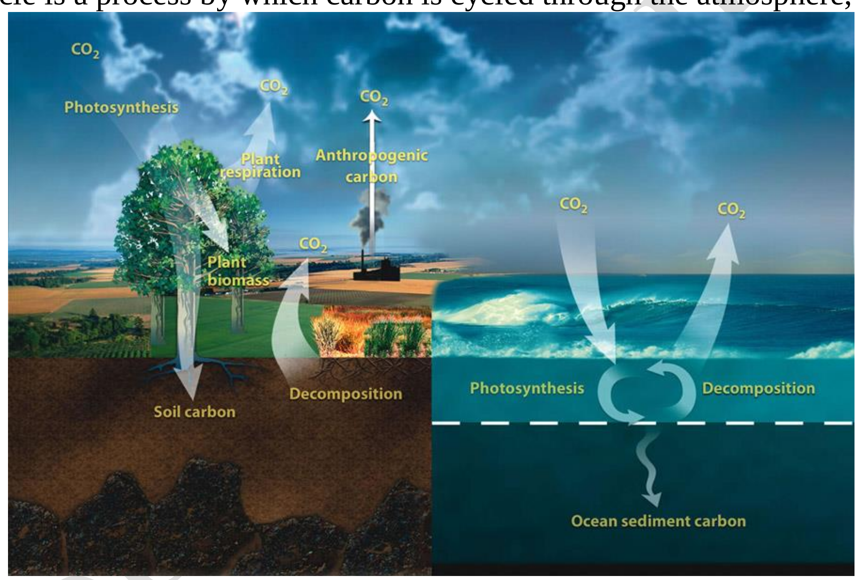

Image Source: http://spark.ucar.edu/carbon-cycle-diagram-doe.

Because Earth is dynamic, the amount of carbon is constantly changing.

Carbon Dioxide is used by plants: Carbon enters the cycle when producers convert carbon dioxide from the air into carbohydrates through the process of photosynthesis.

Consumption by animals: Consumers convert the carbohydrates, from the producers, into carbon through the process of cellular respiration. This releases carbon dioxide back into the air.

Ocean Intake: 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.

Decay and decomposition: When organisms die, their bodies decay and decompose and release carbon dioxide.

Formation of fossil fuels: As organisms die, they are buried under the ground. After millions of years, high pressure and other physical and chemical changes, cause a change into fossil fuels.

Use of fuels: Fossil fuels stored deep in the ground are mined and used for industrial purposes, like car fuel.

Carbon emissions: 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.

Respiration by plants and animals: Carbon dioxide is being returned to the air through the process of respiration.

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. Over production 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 Knowledge
Explore how the environmental factors change the carbon cycle, but also result in changes to other biological cycles.

Science and Engineering Practices
S.1.A.2

Standard H.E.5: The student will demonstrate an understanding of the dynamics of Earth’s atmosphere.

Conceptual Understanding
H.E.5A 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.

Assessment Guidance
The objective of this indicator is to *develop and use models* to describe the thermal structure, composition, and location of the layers of Earth's atmosphere. Therefore, the primary focus of the assessment should be for students to *develop and use models to understand or represent phenomena, processes, relationships, and communicate ideas to others* about the relationship of the layers of Earth's atmosphere in terms of temperature, composition, and location. This could include but is not limited to students developing a visual or computer model of Earth's atmospheric layers identifying the name of each layer and the temperature changes an astronaut would experience during a space shuttle launch.

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

Previous and Future Knowledge:
6.E.2 (Atmospheric layers)

Essential Knowledge
Earth's atmosphere is the layer of gases that surrounds the planet and makes conditions on Earth suitable for living things. It is a mixture of chemical elements and compounds differentiated by distinct differences in temperature with increasing altitude. This thermal structure differentiates the layers:

Atmospheric Layers **Earth's Surface** ↓ **Space**	Earth's atmosphere is divided into several different atmospheric layers extending from Earth's surface outward: • the troposphere, where all weather occurs • the stratosphere, where the ozone layer is contained • the mesosphere • the thermosphere the exosphere
Atmospheric Temperatures	Differences in temperature separate layers. • As altitude increases, temperature decreases in the troposphere; at the upper boundary, the tropopause, temperatures stop decreasing • The stratosphere is cold except in its upper region where ozone is located; high temperature zone, called the stratopause, marks the upper boundary • The mesosphere is the coldest layer;

	temperature decreases as altitude increases • Even though the air is thin in the thermosphere, it is very hot; temperature increases as altitude increases • The cold regions of outer space extend from the exosphere
Atmospheric Gases	Nitrogen (N_2) and Oxygen (O_2) • the two most common gases; found throughout all the layers Ozone (O_3) • a form of oxygen found in the stratosphere; in the upper atmosphere it protects Earth's inhabitants from harmful ultraviolet rays of the Sun Water vapor (H_2O) and carbon dioxide (CO_2) • the most important compounds in the atmosphere; important gases for weather conditions; found in the troposphere Trace gases, for example argon • play an insignificant role

Extended Knowledge
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.

Science and Engineering Practices
S.1.A.2

Standard H.E.5: The student will demonstrate an understanding of the dynamics of Earth's atmosphere.

Conceptual Understanding
H.E.5A 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.

Assessment Guidance
The objective of this indicator is to *develop and use models* to predict and explain the impacts of the angle of solar incidence and Earth's axial tilt. Therefore, the primary focus of the assessment should be for students to *develop and use models to understand or represent phenomena, processes, relationships, and communicate ideas to others* about the length of day, atmospheric filtration, distribution of sunlight in various locations and

seasonal changes due to axial tilt and the angle of solar incidence. This could include but is not limited to students developing a model to target the effects of the axial tilt and angle of solar incidence at various locations in the world, including the equator, northern hemisphere and southern hemisphere. Students should include models to demonstrate how daylight and sun distribution changes during different months of the year.

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

Previous and Future Knowledge
8.E.4 (Tilt of Earth's axis, seasons)
8.E.4 (Length of day)
6.E.2 (global winds)

Essential Knowledge
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 angle of the Sun's rays due to the position of Earth in its orbit, the tilt of Earth's axis, and the number of daylight hours causes the differences in the seasonal weather pattern.

The length of daylight changes 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.

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. This motion is called the Coriolis effect. The Coriolis effect deflects winds that would otherwise blow directly from a high-pressure area toward a lower-pressure area from that path.

Because convection cells are in place in the atmosphere and 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.

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

Science and Engineering Practices
S.1.A.2

Standard H.E.5: The student will demonstrate an understanding of the dynamics of Earth's atmosphere.

Conceptual Understanding
H.E.5A 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.
Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to predict local and national weather conditions. Therefore the focus of assessment should be for students to analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions to predict local and national weather conditions. This could include but is not limited to students identifying trends and patterns on weather maps to determine the predicted outcomes, such as hurricanes, tornados, and thunderstorms.

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

Previous and Future Knowledge
6.E.2 (Air masses, high and low pressure systems, frontal boundaries)
6.E.2 (Solar energy and convection)

Essential Knowledge
Air masses, high and low 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: 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 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.

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

Science and Engineering Practices:
S.1.A.4

Standard H.E.5: The student will demonstrate an understanding of the dynamics of Earth's atmosphere.

Conceptual Understanding
H.E.5A 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).

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to explain how convection determines local wind patterns. Therefore the focus of assessment should be for students to analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to reveal patterns and construct meaning to determine local wind patterns including land and sea breezes, mountain/valley breezes, Chinook winds and monsoons. This could include but is not limited to students choosing locations throughout the world to become a "survivor" for a short period of time. Students would need to use informational data to explain their survival techniques based on changes of weather due to differences in cooling because of local wind patterns throughout the day.

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

Previous and Future Knowledge
6.E.2 (Solar energy and convection (global winds)
6.E.2 (Climate)

Essential Knowledge:
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 Knowledge
Explore seasonal patterns, strengths, and the environmental impact of Santa Ana and Desert winds.

Science and Engineering Practices
S.1.A.4

Standard H.E.5: The student will demonstrate an understanding of the dynamics of Earth's atmosphere.

Conceptual Understanding
H.E.5A 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.

Assessment Guidance
The objective of this indicator is to *construct explanations* for the formation of severe weather conditions; therefore the focus of assessment should be for students to construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams to describe the formation of tornadoes, hurricanes, thunderstorms, and blizzards using evidence from temperature, pressure, and moisture conditions. This could include but is not limited to students comparing temperature, pressure, and moisture data to predict the formation of tornadoes, hurricanes, thunderstorms, and blizzards through various parts of the world. Students can use weather maps to predict the changes in weather based on the temperature, pressure, and moisture conditions especially during the fall and spring in the Midwest portion of the United States.

In addition to *construct explanations*, students should be asked to *ask questions; engage in argument from evidence; obtain, evaluate and communicate information; and develop and use models.*

Previous and Future Knowledge
6.E.2 (Weather (wind speed, air temperature, humidity, cloud type, and air pressure)
6.E.2 (air masses, high and low pressure systems, and frontal boundaries)
Essential Knowledge
Air masses, high and low 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: How an air mass forms, the type of air mass that forms, and the movement of the air mass all depend on , the, source regions for these air masses and 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, cloud formations, and weather patterns that result from each frontal boundary.

The information about the factors that influence weather conditions is also important for students to understanding 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 depend on the frontal boundary.

Hurricane landfalls can be predicted by plotting the course of a hurricane.

Extended Knowledge:
Use instruments to collect weather data and make predictions about upcoming weather patterns.

Science and Engineering Practices:
S.1.A.6

Standard H.E.5: The student will demonstrate an understanding of the dynamics of Earth's atmosphere.

Conceptual Understanding
H.E.5A 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.

Assessment Guidance
The objective of this indicator is to *develop and use models* to exemplify how climate is driven; therefore the focus of assessment should be for students to develop and use models to understand or represent phenomena, processes, and relationships, test devices or solutions, and communicate ideas to others to use a model to explain how latitude, topography and elevation, and proximity to water affect local climates. This could include but is not limited to students using a model of the state of South Carolina, such as a topographical map, to predict and explain the weather conditions in each of the three regions of SC, the upstate, the Piedmont, and the low-country.

In addition to develop and use models, students should be asked to *ask questions;; engage in argument from evidence; construct explanations; and obtain, evaluate and communicate information.*

Previous and Future Knowledge
6.E.2 (Climate (latitude, elevation, distance from water)

Essential Knowledge
Climate is referred to as the average weather conditions of a region, the weather patterns that occur over many years. Scientists usually describe it in terms of the average monthly and yearly temperatures, or temperature range, and the average amount of precipitation. Other factors also influence the temperature and precipitation of a climate 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 Knowledge:
Classify each particular climate region based on latitude or on the Koppen classification system based on distribution of vegetation.

Science and Engineering Practices
S.1.A.2

Standard H.E.5: The student will demonstrate an understanding of the dynamics of Earth’s atmosphere.

Conceptual Understanding

H.E.5A 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).

Assessment Guidance

The objective of this indicator is to *construct and analyze scientific arguments*; therefore the focus of assessment should be for students construct and analyze scientific arguments to support claims, explanations, or designs, using evidence and valid reasoning from observations, data, or informational texts to support or refute global climate change. This could include but is not limited to students debating global warming and support their claims using historical weather data.

In addition to *constructing and analyzing scientific arguments*, students should be asked to ask questions; develop and use models; engage in argument from evidence; construct explanations; and obtain, evaluate and communicate information.

Previous and Future Knowledge

6.E.2 (Climate)
8.E.4 (Tilt of axis, seasons)
8.E.4 (Length of day, solar output)

Essential Knowledge

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.

Cause: One theory states that possibly a small change in Earth's orbit or in the tilt of Earth's axis occurs – basically a change in the amount of solar energy reaching Earth's surface. Another theory proposes that ice ages were caused by tectonic plate motion changing the position of the continents; others propose that volcanic dust blocked the Sun's rays.

Evidence: Evidence gathered from tree rings, ice-core samples, fossils, and radiocarbon sample provide evident 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 Knowledge
Explore details of glaciers and ice movement. Explore why Antarctica's subsurface lakes are studied for insight regarding Earth's history

Science and Engineering Practices:
S.1.A.6

Standard H.E.5: The student will demonstrate an understanding of the dynamics of Earth's atmosphere.

Conceptual Understanding
H.E.5A 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.

Assessment Guidance
The objective of this indicator is to *analyze scientific argument* regarding the relationship between human activities and climate change; therefore the focus of assessment should be for students to construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams to describe the role of human activities and environmental issues. This could include but is not limited to students composing letters to the Climate Change Task Force or the EPA supporting or refuting human activities' role in environmental issues such as ozone depletion, global warming, acid precipitation, and air pollution, such as photochemical smog, ozone, and particulate matter.

In addition to *construct explanations*, students should be asked to *ask questions; engage in argument from evidence; obtain, evaluate and communicate information;* and *develop and use models.*

Previous and Future Knowledge
6.E.2 (Climate)
7P.2B.3/ H.C.5 (Acids)
H.B.6B (Global climate)

Essential Knowledge
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.

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 Knowledge

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.

Science and Engineering Practices

S.1.A.6

Standard H.E.6: The student will demonstrate an understanding of Earth's freshwater and ocean systems.

Conceptual Understanding

H.E.6A 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.

Assessment Guidance

The objective of this indicator is to *analyze and interpret data* to describe and compare the physical and chemical properties of saltwater and freshwater. Therefore the focus of assessment should be for students to analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions to compare the physical and chemical properties of saltwater and freshwater that make water uniquely important to Earth's processes. This could include but is not limited to students identifying density, salinity, and freezing point of fresh and saltwater from graphs, tables, or other informational texts. In addition, having students construct tables or charts to display their comparison is suggested.

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

Previous and Future Knowledge

3.E.4 (Water)
5.E.3 (Oceans)
7.P.2B.1 (Physical and chemical properties)

Essential Knowledge

The 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.
- It 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 materials 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 0^0C.

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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^{0}C.

Extended Knowledge
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.

Science and Engineering Practices
S.1A.4

Standard H.E.6: The student will demonstrate an understanding of Earth's freshwater and ocean systems.

Conceptual Understanding
H.E.6A 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).

Assessment Guidance
The objective of this indicator is to *obtain and evaluate scientific information* to explain how location, movement, and energy transfers are involved in making water available for use on Earth's surface. Therefore the focus of assessment should be for students to obtain and evaluate scientific information to answer questions, explain or describe phenomena, and develop models regarding the recycling and differential availability of Earth's water This could include but is not limited to students modeling or narrating the flow of an individual water molecule as it moves through the water cycle or a watershed.

In addition to *obtain and evaluate evidence* students should be asked to *ask questions; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; and develop and use models.*

Previous and Future Knowledge
6.E.2 (water cycle)

Essential Knowledge
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 down slope 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 & Rivers	Stream systems form as water flows and collects in surface channels. Tributaries forms 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 high land 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.

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

Science and Engineering Practices
S.1A.8

Standard H.E.6: The student will demonstrate an understanding of Earth's freshwater and ocean systems.

Conceptual Understanding
H.E.6A 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.

Assessment Guidance
The objective of this indicator is to *plan and conduct controlled scientific investigations*. Therefore, the primary focus of assessment should be for students to plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses 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 regarding the relationship between stream flow and erosion and deposition. This could include but is not limited to students using a stream table to conduct investigations on characteristics such as slope, gradient, velocity, discharge, quantity and volume of water, and size and shape of the stream bed.

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

Previous and Future Knowledge
8.E.5 (weathering, erosion, and deposition)
5.E.3 (watershed, basin)

Essential Knowledge
There are a number of ways to classify streams, one of which is according to the stream bed. Stream beds may be classified into one of two broad categories: 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, in this case, by the movement of water. Deposition takes place when these 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, or gradients, in higher elevations the water moves faster and much erosion takes place. In areas where the gradient is not as steep

The processes of erosion and deposition are impacted by changes in stream flow. 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 x 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^2. 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 Knowledge
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.)

Science and Engineering Practices
S.1A.3

Standard H.E.6: The student will demonstrate an understanding of Earth's freshwater and ocean systems.

Conceptual Understanding
H.E.6A 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.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* of local drainage basins to predict the water available for use in the ecosystem. Therefore the focus of assessment should be for students to analyze and interpret data from informational texts to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions to show how changes

caused by human activity and other factors influence the hydrology of the basin and the quantity of water available for use. This could include but is not limited to providing data (available through USGS) on human impacts including land use, domestic and industrial waste, weather and climate, topography, and for students to predict water availability. In addition, if the data is available, a case study could be built around an impact assessment for a nearby land development project.

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

Previous and Future Knowledge
5.E.3 (watershed, basin)
8.E.5 (weathering, erosion, and deposition)
8.E.6 (Impact of catastrophic events- flooding)

Essential Knowledge
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, waterborne 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 Knowledge
Expand the study of drainage basins to include areas where water conservation and flooding is common.

Science and Engineering Practices
S.1A.4

Standard H.E.6: The student will demonstrate an understanding of Earth's freshwater and ocean systems.

Conceptual Understanding
H.E.6A 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).

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* of local drainage basins to predict how the quality of water is influenced by human and other factors. Therefore the focus of assessment should be for students to analyze and interpret data from informational texts to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions to show how changes caused by human activity and other factors influence the hydrology of the basin and water quality. This could include but is not limited to conduct a case study on a local water basin to determine the major pollutants and their sources. Students may use this data to assess the quality of this water according to local water quality standards or the Water Quality Index (WQI). Additionally, a fish kill could form the foundation for an investigation of pollution sources and water quality.

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

Previous and Future Knowledge
5.E.3 (pollution)

Essential Knowledge
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 sources	Point source pollution is 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, or toxic wastes that enter streams can send this pollution downstream into the environments.
Nonpoint sources	Nonpoint sources of pollution generate pollution 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. Nonpoint sources are not as easily identified nor as easily cleaned up as point sources.

Not only is surface runoff water a carrier of pollutants, 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 Knowledge
Collect water samples and test for pollutants.

Science and Engineering Practices
S.1A.4

Standard H.E.6: The student will demonstrate an understanding of Earth's freshwater and ocean systems.

Conceptual Understanding
H.E.6A 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.

Assessment Guidance
The objective of this indicator is to *develop and use models* to explain how groundwater processes affect limestone formations. Therefore, the primary focus of assessment should be for students to use their models to understand and represent natural phenomena such as caves and karst topography. This could include but is not limited to students modeling the chemical weathering that occurs when neutral, basic, and acidic water creates sinkholes, caverns, and caves.

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

Previous and Future Knowledge
8.E.5 (weathering, erosion, and deposition)

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

Science and Engineering Practices
S.1A.2

Standard H.E.6: The student will demonstrate an understanding of Earth's freshwater and ocean systems.

Conceptual Understanding
H.E.6A 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.

Assessment Guidance
The objective of this indicator is to *obtain and evaluate scientific information* to explain how the convection of ocean water influences the circulation of oceans. Therefore the focus of assessment should be for students to obtain and evaluate scientific information to answer questions, explain or describe phenomena, support a hypothesis, and communicate the results of an experiment regarding the role of water temperature and density on oceanic circulation. This could include but is not limited to students reviewing data from HE6.A.1 regarding saltwater and freshwater density and temperature differences, and the role each in creating currents by convection. Investigate and evaluate why there are temperature differences between waters off the coast of South Carolina, Virginia, and California.

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

Previous and Future Knowledge
6.E.2 (Solar energy and convection)
5.E.3 (Current)

Essential Knowledge
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 both absorbs and reflects light.
- Most sunlight that reaches Earth falls on the oceans; this sunlight penetrates the surface and is absorbed by water.
- Most wavelengths of visible light are absorbed, but blue light tends to be reflected.
- All wavelengths of light are absorbed by about 100m depth, so deep lakes and the oceans are dark except for surface region.

Infrared Rays

- Water also has the ability to absorb infrared wavelengths of sunlight.
- 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 in areas near the equator, surface water in that region is warmer. The surface ocean water is set into motion by energy from the wind. The wind belts determine the direction of the flow, but the Coriolis effect and interaction with continents also help determine surface ocean current direction of movement. Warm equatorial surface currents flow and bring warm water to cooler regions. Currents coming from areas near the poles where solar energy is less direct are cold currents. As cold currents move toward the equator, they cool the region around them.
Deep currents	Water warmed by solar energy near the equator expands and is less dense that cold water. Cold water from the poles is denser, therefore it 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. The most abundant marine life exists where there are ample nutrients and good sunlight. In deep ocean areas where sunlight does not reach, chemosynthesis (chemical reactions) supports life near hydrothermal vents, mainly along the oceanic ridge. Microscopic bacteria living in and near the vents perform chemosynthesis and become the bottom of the food web. Through chemosynthesis, the bacteria produce sugars and other foods that enable them and many other organisms to live in this very dark, very unusual environment.

Extended Knowledge
Research types of marine life that exists in marine zones.

Science and Engineering Practices
S.1A.8

Standard H.E.6: The student will demonstrate an understanding of Earth's freshwater and ocean systems.

Conceptual Understanding
H.E.6A 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.

Assessment Guidance
The objective of this indicator is to *develop and use models* to explain how waves and currents interact with the ocean shore. Therefore, the primary focus of assessment should be for students to use their models to understand and represent natural phenomena such as waves and currents interacting with the ocean shore. This could include but is not limited to students using a wave box to model shoreline changes by forming sandbars and barrier islands.

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

Previous and Future Knowledge
8.E.5 (weathering, erosion, and deposition)
5.E.3 (Currents)

Essential Knowledge
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.

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

Science and Engineering Practices
S.1A.2

Standard H.E.6: The student will demonstrate an understanding of Earth's freshwater and ocean systems.

Conceptual Understanding
H.E.6A 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.

Assessment Guidance
The objective of this indicator is to *ask questions* regarding devices designed for flood control and erosion. Therefore, the primary focus of assessment should be for students to ask questions to challenge or support the effectiveness of designs used to prevent and control coastal erosion and flooding. This could include but is not limited to students asking questions and evaluating the value of devices and practices such as sea walls, groins, jetties, sea walls, and beach nourishment. Students may engage in a debate or a Socratic seminar regarding what should be done along our coast.

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

Previous and Future Knowledge
8.E.5 (weathering, erosion, and deposition)

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

Science and Engineering Practices
S.1A.1