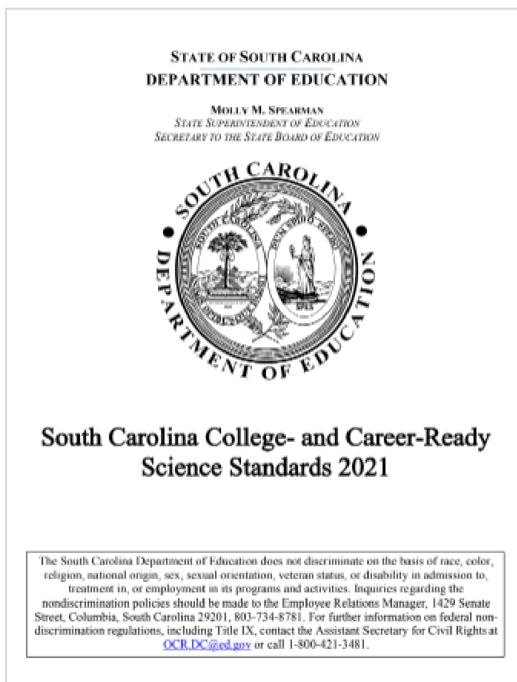
Earth Science


STATE OF SOUTH CAROLINA
DEPARTMENT OF EDUCATION

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SOUTH CAROLINA DEPARTMENT OF EDUCATION

South Carolina College- and Career-Ready
Science Standards 2021

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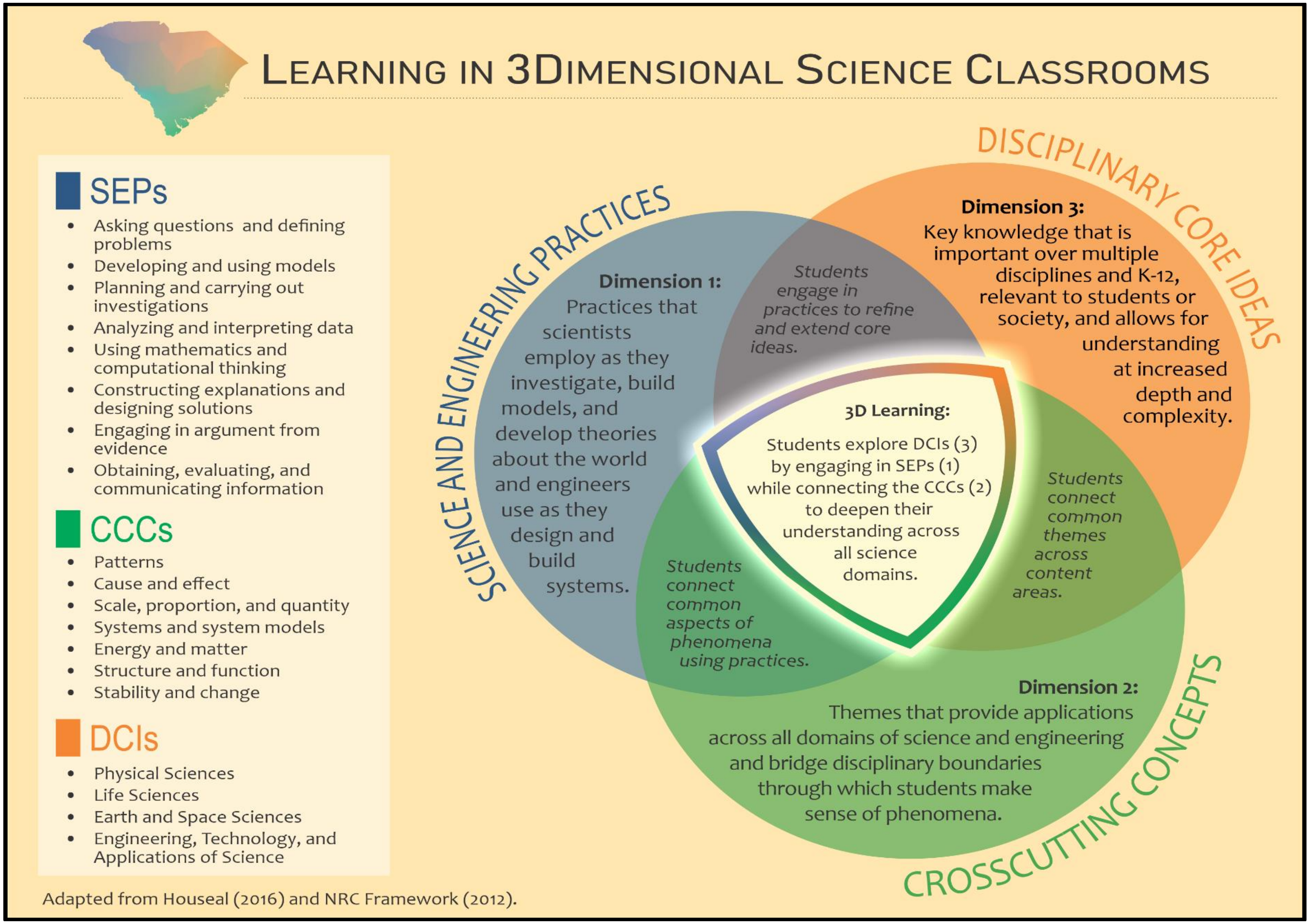
Learning in 3 Dimensional Science Classrooms



Dimension 1: Science and Engineering Practices

The **Science and Engineering Practices (SEPs)** are the major practices that scientists apply as they investigate and build models and theories about the world, and that engineers use as they design and build systems. Students should not learn about these practices secondhand, in an isolated unit, or apart from the other two dimensions. While one **SEP** is identified to be assessable and represents the student performance goal for the end of instruction, other **SEPs** should be applied by students to support their progress leading up to the end of instruction. This is vital, as the fields of science and engineering are related and mutually supportive through the eight **SEPs** that students **DO** (NRC Framework, 2012, p. 50-53).

Asking Questions and Defining Problems

Scientists ask and refine questions about phenomena that lead to explanations of how the natural and designed world(s) works.
Engineers ask questions to define the problems, identify constraints, and determine criteria for an effective solution.

Use Mathematical and Computational Thinking

Scientists use mathematics and computation as tools for representing physical variables and their relationships.
Engineers use mathematical and computational representations of established relationships and principles as an integral part of design.

Developing and Using Models

Scientists construct and use models to help develop and understand explanations about natural phenomena.
Engineers use models as helpful tools to test proposed systems and to recognize strengths and limitations of new designs.

Constructing Explanations and Designing Solutions

Scientists construct logically coherent explanations of phenomena that are consistent with the available evidence.
Engineers' designs are based on scientific knowledge and models of the material world.

Planning and Carrying out Scientific Investigations

Scientists use observations and data collected to test existing theories and explanations or to revise and develop new ones.
Engineers use investigations to gain data to specify design criteria and to test their designs.

Engaging in Argument from Evidence

Scientists identify the strengths and weaknesses of a line of reasoning to engage in argument for finding the best explanation of a natural phenomenon.
Engineers engage in argument from evidence to find the best possible solution to a problem.

Analyzing and Interpreting Data

Scientists use a range of tools to identify the significant features and patterns in data.
Engineers use a range of tools and analyze data collected in the tests of their designs and investigations.

Obtaining, Evaluating, and Communicating Information

Scientists derive meaning from texts and evaluate the validity of information to then communicate ideas.
Engineers derive meaning from other's work and texts and evaluate the information, to apply it usefully to express their ideas.

Link to the grounding research for the **SEPs** from the [NRC Framework.](NRC Framework)

Dimension 2: Crosscutting Concepts

The **Crosscutting Concepts (CCCs)** represent seven themes that span across science domains (Physical, Life, Earth and Space, and Engineering, Technology, and Applications of Science) and have value to both scientists and engineers as they identify and connect universal properties and processes found in all domains. Students should not learn about these concepts secondhand, in an isolated unit, or apart from the other two dimensions. While one **CCC** is identified to be assessable and represents the student performance goal for the end of instruction, other **CCCs** could be applied by students to support their progress leading up to the end of instruction. The **CCCs** give students an organizational framework for connecting knowledge from the various disciplines into a coherent and scientific based view of the world (NRC Framework, 2012, 83-102).

Patterns
Students observe patterns of forms and events to guide organization and classification. Patterns prompt student questions about the factors that influence cause-and-effect relationships and are useful as evidence to support student explanations and arguments.

Systems and System Models
Students define the system(s) under study by specifying its boundaries and making explicit a model of the system(s). By doing so, the students are provided tools for understanding and testing ideas that are applicable throughout science and engineering.

Cause and Effect
Students investigate and explain causal relationships and the mechanisms by which they are mediated. Events have causes, some simple, some multifaceted and complex. Students can test such mechanisms across given contexts and the mechanisms can be used to predict and explain events in new contexts.

Energy and Matter
Students understand the system's possibilities and limitations by tracking fluxes of energy and matter into, out of, and within systems.

Scale, Proportion, Quantity
Students, while considering phenomena, come to recognize what is relevant at different measures of size, time, and energy, and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Structure and Function
Students observe an object or living thing's structure and shape to determine many of its properties and functions. The functioning of natural and built systems both depend on the shapes and relationships of certain key parts and on the properties of the materials from which they are made.

Stability and Change
Students recognize the conditions of stability and rates of change for natural and built systems to develop an understanding of how the system operates and causes for changes in systems.

Link to the grounding research for the **CCCs** from the NRC Framework.

Dimension 3: Disciplinary Core Ideas

Disciplinary Core Ideas (**DCIs**) are a set of four science and engineering domains for K–12 science that have broad importance across multiple science and engineering disciplines. The **DCIs** provide a tool for understanding or investigating more complex ideas and solving problems, relate to the interests and life experiences of students, and are learnable over multiple grades at increasing levels of depth and sophistication. Students should not memorize or learn isolated facts about the **DCIs** secondhand or apart from the other two dimensions (NRC Framework, 2012, p. 31).

Physical Science (PS)

PS1: Matter and its interactions
PS2: Motion and stability: Forces and interactions
PS3: Energy
PS4: Waves and their applications in technologies for information transfer

Students gain awareness of the structure of matter, interactions occurring in terms of the forces between objects, related energy transfers, and their consequences to understand the physical and chemical basis of a system. Chemistry and physics underlie all natural and human-created phenomena and helps students see the mechanisms of cause and effect in all systems and processes that are understood through a common set of physical and chemical principles.

Life Science (LS)

LS1: From molecules to organisms: Structures and processes
LS2: Ecosystems: Interactions, energy, and dynamics
LS3: Heredity: Inheritance and variation of traits
LS4: Biological evolution: Unity and diversity

Students focus on patterns, processes, and relationships of living organisms. The study of life ranges over scales from single molecules, organisms, and ecosystems, to the biosphere. A core principle of the life sciences is that organisms are related through common ancestry and that processes of natural selection have led to the tremendous diversity on Earth. Students in life science courses explore all aspects of living things and the environments they live in.

Earth and Space Science (ESS)

ESS1: Earth's place in the universe
ESS2: Earth's systems
ESS3: Earth and human activity

Students investigate processes that operate on Earth and address Earth's place in the universe. Earth and space science involve phenomena that range in scale from unimaginably large to invisibly small. Earth and space sciences also provide students opportunities to understand how the atmosphere, geosphere, and biosphere are interconnected.

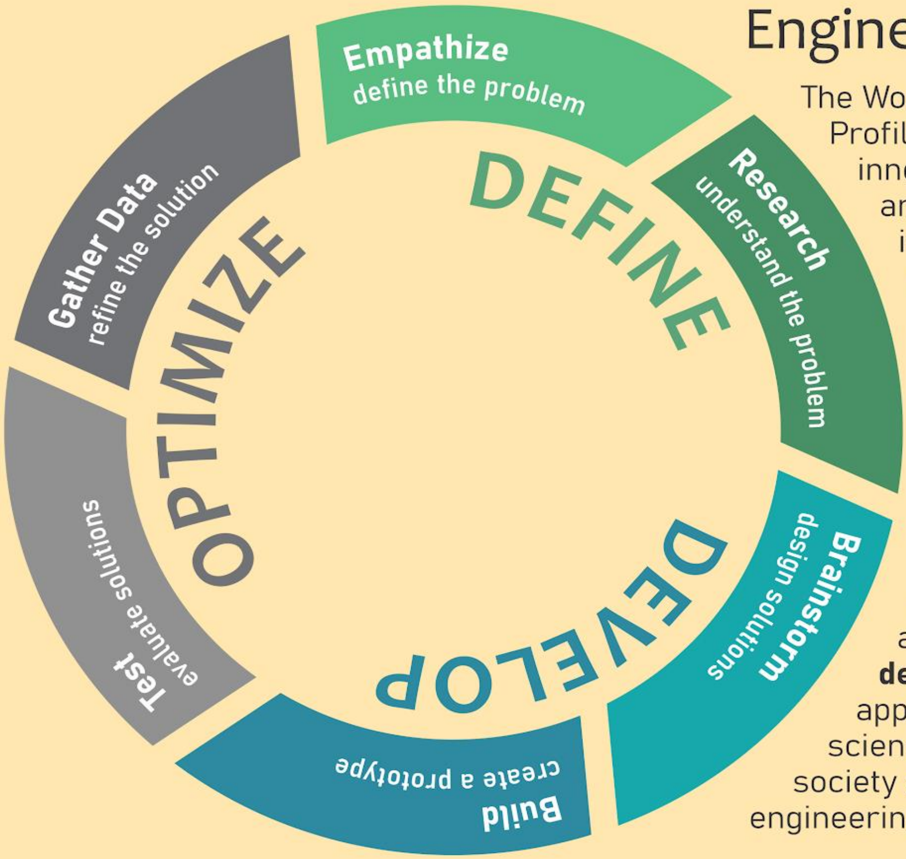
Engineering, Technology, and Applications of Science (ETS)

ETS1: Engineering design
ETS2: Links among engineering, technology, science, and society

Students learn how science is utilized, through the engineering design process, and have the opportunity to appreciate the distinctions and relationships between engineering, technology, and applications of science alongside the physical, life, and Earth and space sciences of other science domains. Science-based designs of technologies and systems affect the ways in which people interact with each other and with the environment, indicating how these designs deeply influence society.

Link to the grounding research for the **DCIs** from the NRC Framework: PS, LS, ESS, and ETS.

Engineering, Technology, and Applications of Science: Engineering Design Process



Engineering Design Process:

The World Class Skills as articulated in the Profile of the SC Graduate: creativity and innovation, critical thinking, collaboration and teamwork, and communication are infused in the **engineering design process** to support student development of both individual and cooperative engineering practices. During the iterative process, students **define** problems to **develop** and **optimize** solutions to local, national, and global issues. The fields of science and engineering are related and mutually supportive and by engaging students in the knowledge and practices related to the **engineering design process**, students establish an appreciation for the interdependence of science, engineering, and technology within society and the natural world and view engineering as a possible career path.

ETS1 — This icon found within the PE aligns to ETS1 and notes where students engage directly in the engineering design process.

ETS2 — This icon found within the DCI box shows learning connections to ETS2 - Links Among Engineering, Technology, and Society.

Link to the grounding research for the **ETS** from the NRC Framework.

Earth and Space Science

South Carolina Earth and space science students engage in thinking and solving problems the way scientists and engineers do to help them better see how science is relevant to their lives. To capitalize on the natural curiosity all students have about the world around them, learning experiences are built around the three dimensions of science: **Science and Engineering Practices (SEPs)**, **Crosscutting Concepts (CCCs)**, and **Disciplinary Core Ideas (DCIs)**. This three-dimensional approach to teaching and learning helps educators provide meaningful learning experiences that offer varied entry points for students from diverse backgrounds.

The **performance expectations** in Earth and space science help students engage in inquiry questions such as, **but not limited to:**

What is the universe and what goes on in stars? What are the predictable patterns caused by Earth's movement in the solar system?
Students use evidence to explain the processes governing the formation, evolution, and workings of the solar system and universe in order to understand how matter in the universe formed and how changes in the behavior of the sun directly affect humans.

How do people reconstruct and date events in Earth's planetary history?
Students construct explanations based on data and evidence for the scales of time over which Earth's processes operate. An important aspect of the Earth and space sciences involves making inferences about events in Earth's history.

How do chemical cycles impact Earth's systems?
Students investigate and describe how water and carbon cycles impact Earth's systems. Students also communicate information on how Earth's systems and life change and influence each other.

What affects climate change and what are the effects?
Students forecast climate changes by analyzing data from models and evaluating the implications on Earth's systems. Students also describe how variations in energy flow in Earth's systems result in climate change and use evidence to create an argument that climate change affects human activity.

How do Earth's systems and humans influence each other?
Students construct explanations of the complex and significant interdependencies between humans and Earth's systems, and evaluate solutions for natural hazards, natural resources, and environmental factors.

***The PEs should be bundled to design classroom experiences. There are multiple ways to bundle the PEs to help students lead inquiry and see connections between ideas, and help teachers facilitate phenomenon-driven learning with efficient use of instructional time.**

Earth and Space Science

Through the Earth and space science performance expectations, students demonstrate grade-appropriate proficiency in each of three dimensions. When students explore **Disciplinary Core Ideas** (Dimension 3), they will do so by engaging in **Science and Engineering Practices** (Dimension 1) and should be supported in making connections to the **Crosscutting Concepts** (Dimension 2) to link their understanding across the four disciplinary core domains.

Each performance expectation contains one **SEP** and one **CCC** to be assessable and represents the student performance goal for the end of instruction; however, other **SEPs** and **CCCs** should be applied by students to support their progress leading up to the end of instruction. In Earth and space science, these **end-of-instruction** **SEPs**, **DCIs**, and **CCCs** include:

SEPs	DCIs	CCCs
• Developing and Using Models • Planning and Carrying Out Investigations • Analyzing and Interpreting Data • Using Mathematics and Computational Thinking • Constructing Explanations and Designing Solutions • Engaging in Argument from Evidence • Obtaining, Evaluating, and Communicating Information	• Physical Science (PS1, PS3, PS4) • Earth and Space Science (ESS1, ESS2, ESS3) • Engineering, Technology, and Applications of Science (ETS1, ETS2)	• Patterns • Cause and Effect • Scale, Proportion, and Quantity • Systems and System Models • Energy and Matter • Stability and Change

Hyperlinks within the Standards Document

SC Conceptual Vertical Articulation links: Hover over the above underlined and hyperlinked titles to view links for all SEPs, DCIs, and CCCs.

A Framework for K-12 Science Education links: Hover over titles found within the foundation boxes under each PE to link the guiding research for all SEPs, DCIs, and CCCs.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations. Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. NRC Framework Link	**LS1.C: Organization for Matter and Energy Flow in Organisms** All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow. NRC Framework Link	**Patterns** Patterns in the natural and human designed world can be observed and used as evidence. NRC Framework Link

*Equity in science education requires that all students are provided with equitable opportunities to learn science and become engaged in science and engineering practices; with access to quality space, equipment, and teachers to support and motivate that learning and engagement; and adequate time spent on science. In addition, the issue of connecting to students' interests and experiences is particularly important for broadening participation in science (NRC Framework, p. 28).

Earth's Place in the Universe (ESS1)

E-ESS1-1. Develop a model based on evidence to illustrate that energy generated by nuclear fusion within the sun (and other stars) radiates to and influences orbiting planets.

Clarification Statement: *Emphasis should be on the energy from nuclear fusion in a star's core (relative to the star's mass and age) radiating to nearby planets as seen in the Earth-Sun system. This energy varies in cyclic and non-cyclic ways over the lifespan of the star. Examples of evidence could include observations of other solar systems, surface fluctuations, electromagnetic radiation emissions, atmospheric interactions, solar incidence, and albedo.*
State Assessment Boundary: *Assessment does not include details of the mechanism of nuclear fusion. Assessment does not include details of the atomic and subatomic processes involved with the sun's nuclear fusion.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Use a Model Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). Develop a model (including mathematical and computational) to generate data to support explanations, predict phenomena, and analyze systems. NRC Framework Link	**ESS1.A: The Universe and Its Stars** Nuclear fusion within stars releases electromagnetic energy (seen as starlight). Stars go through a sequence of developmental stages over their lifespans--they are formed; evolve in size, mass, and brightness; and eventually burn out. The Sun is a medium sized star that is about halfway through its predicted life span of approximately 10 billion years. The Sun is just one of more than 200 billion stars in the Milky Way galaxy, and the Milky Way is just one of hundreds of billions of galaxies in the universe. NRC Framework Link **PS3.D: Energy in Chemical Processes and Everyday Life** Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. *(secondary)* NRC Framework Link	**Energy and Matter** Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. NRC Framework Link

Earth’s Place in the Universe (ESS1)

E-ESS1-2. Construct an explanation of the Big Bang Theory based on evidence to show that the universe is changing over time.

Clarification Statement: *Emphasis is on astronomical evidence that shows the expansion, cooling, and observed composition of the universe. Examples of supporting data include red shift of light from receding galaxies, cosmic microwave background radiation, and spectra of electromagnetic radiation from stars and interstellar gases that match predictions from models of the Big Bang theory.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. NRC Framework Link	**ESS1.A: The Universe and Its Stars** The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Stars’ radiation of visible light and other forms of energy can be measured and studied to develop explanations about the formation, age, and composition of the universe. The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. NRC Framework Link (continued on next page)	**Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable. NRC Framework Link

	PS4.B: Electromagnetic Radiation Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. *(secondary)* NRC Framework Link **ETS2.A: Interdependence of Science, Engineering, and Technology** Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. *(secondary)* NRC Framework Link	

Earth's Place in the Universe (ESS1)		
E-ESS1-3. **Construct an explanation using evidence to explain the ways elements are produced over the life cycle of a star.** ***Clarification Statement:*** *Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime. Emphasis is on the concept that the matter found in our solar system originated from the deaths of other stars. Examples of evidence include data from stars such as composition, temperature, size, mass, and luminosity.* ***State Assessment Boundary:*** *Assessment does not include details of the atomic and subatomic processes involved with nucleosynthesis.*		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. NRC Framework Link	**ESS1.A: The Universe and Its Stars** The study of stars' light spectra and brightness is used to identify compositional elements of stars. Stars go through a sequence of developmental stages--they are formed; evolve in size, mass, and brightness; and eventually burn out. Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. Material from earlier stars that explode as supernovas is recycled to form younger stars and their planetary systems. NRC Framework Link	**Energy and Matter** Energy and matter cannot be created nor destroyed - only moved between one place and another place between objects and/or fields, or between systems. NRC Framework Link

Earth's Place in the Universe (ESS1)		
E-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the universe due to gravity. ***Clarification Statement:*** *Emphasis is on predicting orbital motion of naturally occurring or human-made objects using Kepler's laws and Newton's law of gravity.* ***State Assessment Boundary:*** *Mathematical representations for the gravitational attraction of bodies and Kepler's laws of orbital motions should not deal with more than two bodies, nor involve calculus.*		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical, computational, and/or algorithmic representations of phenomena to describe and/or support claims and/or explanations. NRC Framework Link	**ESS1.B: Earth and the Solar System** Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. NRC Framework Link ETS2 **ETS2.A: Interdependence of Science, Engineering, and Technology** Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. *(secondary)* NRC Framework Link	**Scale, Proportion, and Quantity** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). NRC Framework Link

Earth's Place in the Universe (ESS1)

E-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

Clarification Statement: *Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages of oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust decreasing with distance away from a central ancient core of the continental plate (a result of past plate interactions).*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. NRC Framework Link	**ESS1.C: The History of Planet Earth** Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. Tectonic processes continually generate new ocean seafloor at ridges and destroy old seafloor at trenches. NRC Framework Link **ESS2.B: Plate Tectonics and Large-Scale System Interactions** The theory of plate tectonics is supported by evidence of ocean floor spreading over time given by tracking magnetic patterns in undersea rocks and coordinating them with changes to Earth's magnetic axis data. Earth's history is still being written. Continents are continually being shaped and reshaped by competing constructive and destructive geological processes. North America, for example, has gradually grown in size over the past 4 billion years through a complex set of interactions with other continents, including the addition of many new crustal segments. NRC Framework Link	**Patterns** Empirical evidence is needed to identify patterns. NRC Framework Link

Earth's Place in the Universe (ESS1)

E-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

Clarification Statement: *Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed simultaneously along with the rest of the solar system. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. NRC Framework Link	**ESS1.B: The Earth and the Solar System** The solar system consists of the Sun and a collection of objects of varying sizes and conditions. This system appears to have formed from a disk of dust and gas, drawn together by gravity approximately 4.6 billion years ago. NRC Framework Link **ESS1.C: The History of Planet Earth** Radioactive decay lifetimes and isotopic content in rocks provide a way of dating rock formations and thereby fixing the scale of geological time. Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. (continued on next page)	**Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable. NRC Framework Link

	ESS1.C: The History of Planet Earth (Cont.) Studying these objects can provide information about Earth's formation and early history. Study of other planets and their moons, many of which exhibit features such as volcanism and meteor impacts similar to those found on Earth, also help illuminate aspects of Earth's history and changes. NRC Framework Link **PS1.C: Nuclear Processes** Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials thereby fixing the scale of geological time. *(secondary)* NRC Framework Link	

Earth's Systems (ESS2)

E-ESS2-1. Use evidence to argue how Earth's internal and external processes operate to form and modify continental and ocean-floor features throughout Earth's history.

Clarification Statement: *Emphasis is on the core idea that convection leads to the creation and destruction of surface features. Plate movements and many crustal features and events are a result of this phenomenon, but there are other surface processes, which shape Earth's surface as well. The appearance of land features (such as mountains, valleys, coastlines, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion). Examples include seafloor spreading at ridges (evidenced by paleomagnetic data and radiometric dating of rocks), subduction at trenches (evidenced by seismic data and volcanoes), and weathering and erosion among mountains (evidenced by weathering, erosion, and deposition patterns of streams).*
State Assessment Boundary: *Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. Construct an oral and written argument or counter- arguments based on data and evidence. NRC Framework Link	**ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. A deep knowledge of how feedback works within and among Earth's systems is still lacking, thus limiting scientists' ability to predict some changes and their impacts. The top part of the mantle, along with the crust, forms structures known as tectonic plates. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to long-term tectonic cycles. NRC Framework Link (continued on next page)	**Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable. NRC Framework Link

	ESS2.B: Plate Tectonics and Large-Scale System Interactions The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. The plates move across Earth's surface, carrying the continents, creating and destroying ocean basins, producing earthquakes and volcanoes, and forming mountain ranges and plateaus. Most continental and ocean floor features are the result of geological activity and earthquakes along plate boundaries. The exact patterns depend on whether the plates are being pushed together to create mountains or deep ocean trenches, being pulled apart to form new ocean floor at mid-ocean ridges, or sliding past each other along surface faults. NRC Framework Link	

Earth's Systems (ESS2)

E-ESS2-2. Analyze data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

Clarification Statement: *Examples should include climate feedback, such as how an increase in greenhouse gases causes a rise in global temperatures that melt glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures, and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion, how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. NRC Framework Link	**ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. Transfers of energy and the movements of matter can cause chemical and physical changes among Earth's materials and living organisms. NRC Framework Link **ESS2.D: Weather and Climate** The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. NRC Framework Link (continued on next page)	**Stability and Change** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. NRC Framework Link

	ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. *(secondary)* NRC Framework Link	

Earth's Systems (ESS2)

E-ESS2-3. Develop a model based on evidence of Earth's interior that describes cycling of matter through convection processes.

Clarification Statement: *Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), volcanoes, and identification of the composition of Earth's layers from high-pressure laboratory experiments.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). Develop a model based on evidence to illustrate and/or predict the relationships between systems or between components. NRC Framework Link	**ESS2.A: Earth Materials and Systems** Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle, and crust. All of Earth's processes are the result of energy flowing and matter cycling within and among Earth systems. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and the gravitational movement of denser materials toward the interior. NRC Framework Link **ESS2.B: Plate Tectonics and Large-Scale System Interactions** The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle providing the (continued on next page)	**Energy and Matter** Energy and matter cannot be created nor destroyed - only moved between one place and another place between objects and/or fields, or between systems. The total amount of energy and matter in closed systems is conserved. NRC Framework Link

	primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. The top part of the mantle, along with the crust, make up the moving tectonic plates of the lithosphere. Tectonic plates ride above giant convection cells that bring matter from the hot inner mantle up to the cool surface. The plates move across Earth's surface, carrying the continents, creating and destroying ocean basins, producing earthquakes and volcanoes, and forming mountain ranges and plateaus. NRC Framework Link **PS4.A: Wave Properties** Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. *(secondary)* NRC Framework Link ETS2 **ETS2.A: Interdependence of Science, Engineering, and Technology** Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. *(secondary)* NRC Framework Link	

Earth's Systems (ESS2)

E-ESS2-4. Use a model to describe how causes of short and long-term variations in the flow of energy into and out of Earth's systems result in changes to climate.

Clarification Statement: *Emphasis is on the relationships between components that affect the input, output, storage, and redistribution of energy on Earth. Emphasis is on specific cause-and-effect relationships between the factors that affect energy flow (into and out of Earth's systems) and their effects on climate over different timescales.*
State Assessment Boundary: *Assessment is limited to one example of a climate change and its associated impacts. Assessment of the results of changes in climate is limited to direct changes in climate such as surface temperatures and precipitation patterns.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). Use a model based on evidence to illustrate and/or predict the relationships between systems or between components. NRC Framework Link	**ESS1.B: Earth and the Solar System** Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the orientation of the planet's axis of rotation, both occurring over tens to hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on Earth. These phenomena cause cycles of ice ages and other gradual climate changes. *(secondary)* NRC Framework Link **ESS2.D: Weather and Climate** The foundation for Earth's global climate systems is the electromagnetic radiation from the Sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (continued on next page)	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlations and make claims about specific causes and effects. NRC Framework Link

	ESS2.D: Weather and Climate (Cont.) Climate changes, which are defined as significant and persistent changes in an area's average or extreme weather conditions can occur if any of Earth's systems change. Scientists can infer these changes from geological evidence. Some climate changes in Earth's history were rapid shifts (caused by natural events, such as volcanic eruptions and meteoric impacts, which suddenly put a large amount of particulate matter into the atmosphere or by abrupt changes in ocean currents, or variations in solar output). Other climate changes were gradual and longer term--due, for example, to solar output variations, or atmospheric changes due to the rise of plants and other life forms that modified the atmosphere via photosynthesis. The timescale of these changes varies from a few to millions of years. Cumulative increases in the atmospheric concentrations of carbon dioxide and other greenhouse gases, whether arising from natural sources or human industrial activity, increase the capacity of Earth to retain energy. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. NRC Framework Link	

Earth’s Systems (ESS2)

E-ESS2-5. Investigate the ways that water (given its unique physical and chemical properties) impacts various Earth systems.

Clarification Statement: *Emphasis should be on water’s ability to absorb/store and release energy, transmit sunlight, expand when freezing, and dissolve/transport materials. Examples of system interactions could include the hydrogeologic system (weathering, erosion, deposition, soil formation, groundwater formation, and the rock cycle), energy transfer system (weather and climate), and ecosystems (coral reefs and hydrothermal vents).*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying out Investigations Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence. NRC Framework Link	**ESS2.C: The Roles of Water in Earth’s Surface Processes** The abundance of liquid water on Earth’s surface and its unique combination of physical and chemical properties are central to the planet’s dynamics. These properties include water’s exceptional capacity to absorb, store, and release large amounts of energy as it changes state; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting points of the material when mixed with fluid rocks within the mantle. Each of these properties plays a role in how water affects other Earth systems (e.g., ice expansion contributes to rock erosion, or ocean thermal capacity contributes to moderating temperature variations). NRC Framework Link	**Cause and Effect** Cause-and-effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. Systems can be designed to cause a desired effect. NRC Framework Link

Earth's Systems (ESS2)

E-ESS2-6. Develop a quantitative model to describe the cycling of carbon through the hydrosphere, atmosphere, geosphere, and biosphere.

Clarification Statement: *Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (photosynthesis, chemosynthesis, cellular respiration), providing the foundation for living organisms.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). Develop a model based on evidence to illustrate and/or predict the relationships between systems or between components. NRC Framework Link	**ESS2.D: Weather and Climate** Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. NRC Framework Link	**Energy and Matter** The total amount of energy and matter in closed systems is conserved. NRC Framework Link

Earth's Systems (ESS2)

E-ESS2-7. Communicate scientific information that illustrates how Earth's systems and life on Earth change and influence each other over time.

Clarification Statement: *Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples could include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.*
State Assessment Boundary: *Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. Communicate scientific and/or technical information or ideas (e.g. about phenomena) in multiple formats (i.e., orally, graphically, textually, mathematically). Use words, tables, diagrams, and graphs, as well as mathematical expressions to communicate their understanding or to ask questions about a system under study. NRC Framework Link	**ESS2.D: Weather and Climate** Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. The time scales of these changes varied from a few to millions of years. NRC Framework Link **ESS2.E: Biogeology** As Earth changes, life on Earth adapts and evolves to those changes, so just as life influences other Earth systems, other Earth systems influence life. Life and the planet's nonliving systems can be said to co-evolve. The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. NRC Framework Link	**Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable. NRC Framework Link

Earth and Human Activity (ESS3)

E-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources and occurrence of natural hazards have influenced human activity.

Clarification Statement: *Examples of key natural resources could include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting, and soil erosion), and severe weather (such as hurricanes, floods, and droughts).*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories. Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. NRC Framework Link	**ESS3.A: Natural Resources** Resource availability has guided the development of human society. NRC Framework Link **ESS3.B: Natural Hazards** Natural hazards and other geologic events have shaped the course of human history by destroying buildings and cities, eroding land, changing the course of rivers, and reducing the amount of arable land. These have significantly altered the sizes of human populations and have driven human migrations. Natural hazards can be local, regional, or global in origin, and their risks increase as populations grow. NRC Framework Link **ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** Modern civilization depends on major technological systems. *(secondary)* NRC Framework Link	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlations and make claims about specific causes and effects. NRC Framework Link

Earth and Human Activity (ESS3)

E-ESS3-2. Evaluate competing design solutions that address the impacts of developing, managing, and using Earth's energy and mineral resources.

Clarification Statement: *Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining, forestry, and risk/benefit analysis of the production of conventional, unconventional, or renewable energy resources.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories. Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and trade off considerations. NRC Framework Link	**ESS3.A: Natural Resources** All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks, as well as benefits. New technologies and social regulations can change the balance of these factors. NRC Framework Link **ETS1.A: Defining and Delimiting an Engineering Problem** Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. NRC Framework Link (continued on next page)	**Cause and Effect** Cause-and-effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. NRC Framework Link

	ETS1.B: Developing Possible Solutions When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. Testing should lead to improvements in the design through an iterative procedure. *(secondary)* NRC Framework Link **ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. Analysis of costs and benefits is a critical aspect of decisions about technology. *(secondary)* NRC Framework Link	

Earth and Human Activity (ESS3)

E-ESS3-3. Use computational representation to illustrate the relationships among the management of Earth's resources, the sustainability of human populations, and biodiversity.

Clarification Statement: *Examples of factors that affect the management of natural resources could include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability could include agricultural efficiency, levels of conservation, urban planning, as well as local and international policies.*
State Assessment Boundary: *Assessment for computational thinking is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. NRC Framework Link	**ESS3.C: Human Impacts on Earth Systems** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. When the source of an environmental problem is understood and international agreement can be reached, human activities can be regulated to mitigate global impacts (e.g., acid rain and the ozone hole near Antarctica). NRC Framework Link **ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** Modern civilization depends on major technological systems. *(secondary)* New technologies can have deep impacts on society and the environment, including some that were not anticipated. *(secondary)* NRC Framework Link	**Stability and Change** Feedback (negative or positive) can stabilize or destabilize a system. NRC Framework Link

Earth and Human Activity (ESS3)

E-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Clarification Statement: *Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories. Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. NRC Framework Link	**ESS3.C: Human Impacts on Earth Systems** Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. NRC Framework Link **ETS1.B: Developing Possible Solutions** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. Testing should lead to improvements in the design through an iterative procedure. NRC Framework Link **EST2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. NRC Framework Link	**Stability and Change** Feedback (negative or positive) can stabilize or destabilize a system. NRC Framework Link

Earth and Human Activity (ESS3)

E-ESS3-5. Analyze data and the results from global climate models to make an evidence-based forecast of the current rate of regional or global climate change and associated future impacts to Earth's systems.

Clarification Statement: *Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).*
State Assessment Boundary: *Assessment is limited to one example of a climate change and its associated impacts.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. Analyze data using computational models in order to make valid and reliable scientific claims. NRC Framework Link	**ESS3.D: Global Climate Change** Global climate models are often used to understand the process of climate change because these changes are complex and can occur slowly over Earth's history. Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. NRC Framework Link	**Stability and Change** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. NRC Framework Link

Earth and Human Activity (ESS3)

E-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Clarification Statement: *Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. One example of this relationship is how human activities can create changes in the atmosphere including an increase in carbon dioxide that has many far-reaching effects, including changes in photosynthetic biomass on land, ocean acidification, and storm intensity.*
State Assessment Boundary: *Assessment does not include running computational representations and is limited to using the published results of scientific computational models.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. NRC Framework Link	**ESS2.D: Weather and Climate** Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. Hence the outcomes depend on human behaviors as well as on natural factors that involve complex feedback among Earth's systems. *(secondary)* NRC Framework Link **ESS3.D: Global Climate Change** Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. NRC Framework Link (continued on next page)	**Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. NRC Framework Link

	ESS3.B: Natural Hazards Human activities can contribute to the frequency and intensity of some natural hazards. NRC Framework Link	

Earth and Human Activity (ESS3)

E-ESS3-7. Create an argument, based on evidence that describes how changes in climate on Earth have affected human activity.

Clarification Statement: *Emphasis is on changes in climate that influence past, modern, or future human activities. Examples of key changes in climate that can affect populations or drive mass migrations could include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. Construct a scientific argument based on data and evidence. NRC Framework Link	**ESS3.D: Global Climate Change** Impacts of climate change--for example, increased frequency of severe storms due to ocean warming-- have begun to influence human activities. Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities, as well as to changes in human activities. Thus, science and engineering will be essential both to understanding the possible impacts of global climate change and to informing decisions about how to slow its rate and consequences for humanity as well as for the rest of the planet. (continued on next page)	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. NRC Framework Link

	ESS3.D: Global Climate Change (Cont.) The impacts of climate change are uneven and may affect some regions, species, of human populations more severely than others. By using science-based predictive models, humans can anticipate long-term change more effectively than ever and plan accordingly. NRC Framework Link **ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** Modern civilization depends on major technological systems. *(secondary)* NRC Framework Link	