McGraw Hill Education

Alignment Guide

GLENCOE

EARTH SCIENCE

GEOLOGY, THE ENVIRONMENT, & THE UNIVERSE

Glencoe Science—Your Partner in Understanding and Implementing NGSS*

Ease the Transition to Next Generation Science Standards

Meeting NGSS

Glencoe Science helps ease the transition to Next Generation Science Standards (NGSS). Our high school science programs ensure you are fully aligned to:

- Performance Expectations
- Science and Engineering Practices
- Disciplinary Core Ideas
- Crosscutting Concepts

We are committed to ensuring that you have the tools and resources necessary to meet the expectations for the next generation of science standards.

What is NGSS?

The purpose of the NGSS Framework is to act as the foundation for science education standards while describing a vision of what it means to be proficient in science. It emphasizes the importance of the practices of science where the content becomes a vehicle for teaching the processes of science.

Why NGSS?

The NGSS were developed in an effort to create unified standards in science education that consider content, practices, pedagogy, curriculum, and professional development. The standards provide all students with an internationally benchmarked education in science.

Correlation of NGSS Performance Expectations to Earth Science

The Correlation Table lists a Performance Expectation that integrates a combination of Science and Engineering Practices, Discliplinary Core Ideas, and Crosscutting Concepts.

Performance Expectations

are tasks to evaluate student's knowledge. Each Performance Expectation is correlated to an Applying Practices activity written specifically for the purpose. These activities can be found in the resources for the section listed.

Science and Engineering Practices

are skills that scientists and engineers use in their work. Each Practice is correlated to a part of the Science and Engineering Practices Handbook, which can be found in the program resources.

Disciplinary Core Ideas

are the content knowledge students will need to learn. These are correlated to the main student text.

Crosscutting Concepts

are themes that appear throughout all branches of science and engineering. These are not directly correlated but are found implicitly in the other correlations listed on the page.

Find it here!

Code	Title/Text	Location
HS-LS4	**Biological Evolution: Unity and Diversity**	
HS-LS4-1	**Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.	**Activity:** *Evidence for Evolution,* Chapter 15 Section 2, Chapter 17 Section 2
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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 information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**Science and Engineering Practices Handbook:** Practice 8
	Connections to Nature of Science **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**	
	• A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 11, 13
Disciplinary Core Ideas		
LS4.A	**Evidence of Common Ancestry and Diversity**	
	• Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.	**Student Edition:** 423–427, 491, 493–495
Crosscutting Concepts		
	Patterns	
	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.	
	Scientific Knowledge Assumes an Order and Consistency in Natural Systems	
	• Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.	

Code	Title/Text	Location
HS-ESS1	**Earth's Place in the Universe**	
HS-ESS1-1	**Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation.** Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries. Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.	**Activity:** *The Sun's Formation and Radiation,* Chapter 29 Section 1
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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 the relationships between systems or between components of a system.	**Science and Engineering Practices Handbook:** Practice 2
Disciplinary Core Ideas		
ESS1.A	**The Universe and Its Stars**	
	• The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.	**Student Edition:** 834, 836, 848–849
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)*	**Student Edition:** 287, 288, 834, 847–849, 852, 856–866
Crosscutting Concepts		
	Scale, Proportion, and Quantity	
	• The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.	

Code	Title/Text	Location
HS-ESS1	**Earth's Place in the Universe** *continued*	
HS-ESS1-2	**Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.** Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).	**Activity:** *The Big Bang Theory,* Chapter 30 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 6
	Connections to Nature of Science **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**	
	• A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 19
Disciplinary Core Ideas		
ESS1.A	**The Universe and Its Stars**	
	• The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.	**Student Edition:** 835, 843, 845, 853
	• 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.	**Student Edition:** 873–881, 885–887
	• 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. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.	**Student Edition:** 836, 845–847, 849–851
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)*	**Student Edition:** 835, 836, 843, 853
Crosscutting Concepts		
	Energy and Matter	
	• Energy cannot be created or destroyed-only moved between one place and another place, between objects and/or fields, or between systems.	
	Connections to Engineering, Technology, and Applications of Science **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.	
	Connections to Nature of Science **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**	
	• Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.	
	• Science assumes the universe is a vast single system in which basic laws are consistent.	

Code	Title/Text	Location
HS-ESS1	**Earth's Place in the Universe** *continued*	
HS-ESS1-3	**Communicate scientific ideas about the way stars, over their life cycle, produce elements.** **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. **Assessment Boundary:** Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.	**Activity:** *Element Production in Stars*, Chapter 29 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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 ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**Science and Engineering Practices Handbook:** Practice 8
Disciplinary Core Ideas		
ESS1.A	**The Universe and Its Stars**	
	• The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.	**Student Edition:** 835, 843, 845, 853
	• 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. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.	**Student Edition:** 836, 845–847, 849–851
Crosscutting Concepts		
	Energy and Matter	
	• In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	

Code	Title/Text	Location
HS-ESS1	**Earth's Place in the Universe** *continued*	
HS-ESS1-4	**Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.** **Clarification Statement:** Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons. **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.	**Activity:** *Planetary Orbits,* Chapter 28 Section 1
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	Using Mathematical 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 or computational representations of phenomena to describe explanations.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
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.	**Student Edition:** 799–803, 807, 823
Crosscutting Concepts		
	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).	
	Connections to Engineering, Technology, and Applications of Science **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.	

Code	Title/Text	Location
HS-ESS1	**Earth's Place in the Universe** *continued*	
HS-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 oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).	**Activity:** *How Old are Crustal Rocks?,* Chapter 17 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 7
Disciplinary Core Ideas		
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.	**Student Edition:** 8, 477–478
ESS2.B	**Plate Tectonics and Large-Scale System Interactions**	
	• Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. *(ESS2.B Grade 8 GBE) (secondary)*	**Student Edition:** 469–472, 480–485, 490–491, 493–495
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. *(secondary)*	**Student Edition:** 601–605, 615
Crosscutting Concepts		
	Patterns	
	• Empirical evidence is needed to identify patterns.	

Code	Title/Text	Location
HS-ESS1	**Earth's Place in the Universe** *continued*	
HS-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 along with the rest of the solar system 4.6 billion years ago. 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.	**Activity:** *Earth's Formation and Early History*, Chapter 22 Section 1
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 6
	Connections to Nature of Science **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**	
	• A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 19
	• Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.	**Science and Engineering Practices Handbook:** Practice 2, Practice 3, Practice 4, Practice 5, Practice 6 **Student Edition:** 17–19
Disciplinary Core Ideas		
ESS1.C	**The History of Planet Earth**	
	• 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. Studying these objects can provide information about Earth's formation and early history.	**Student Edition:** 468–469, 472, 480–485, 512–513, 567–573, 590–597, 601–605, 620–632, 638, 770–774, 786–787
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. *(secondary)*	**Student Edition:** 601–605, 615
Crosscutting Concepts		
	Stability and Change	
	• Much of science deals with constructing explanations of how things change and how they remain stable.	

Code	Title/Text	Location
HS-ESS2	**Earth's Systems**	
HS-ESS2-1	**Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.** **Clarification Statement:** Emphasis is on how the appearance of land features (such as mountains, valleys, 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). **Assessment Boundary:** Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.	**Activity:** *Modeling Earth's Internal and Surface Processes*, Chapter 20 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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 the relationships between systems or between components of a system.	**Science and Engineering Practices Handbook:** Practice 2
Disciplinary Core Ideas		
ESS2.A	**Earth Materials and Systems**	
	• Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	**Student Edition:** 8–9, 134–136, 139, 149, 151, 164–184, 194–199, 201–215, 224–230, 232–237, 252–262, 282–288, 303, 438–443, 447–455, 456–457
ESS2.B	**Plate Tectonics and Large-Scale System Interactions**	
	• Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)*	**Student Edition:** 468–489, 490–491, 500–507, 511, 514–517, 528–531, 553, 562–576
Crosscutting Concepts		
	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.	

Code	Title/Text	Location
HS-ESS2	**Earth's Systems** *continued*	
HS-ESS2-2	**Analyze geoscience 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 feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts 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; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.	**Activity:** *Mammoths... in Ohio?*, Chapter 23 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 4
Disciplinary Core Ideas		
ESS2.A	**Earth Materials and Systems**	
	• Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	**Student Edition:** 8–9, 134–136, 166–170, 172–175, 194–219, 224–226, 228–229, 230, 231, 232–237, 239, 241, 245–247, 253, 261, 273–275, 282–283, 286–288, 296, 304, 309, 392–396, 400, 401, 410, 412, 445, 512, 743–746, 751
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.	**Student Edition:** 282–283, 286–288, 314–315, 393–396
Crosscutting Concepts		
	Stability and Change	
	• Feedback (negative or positive) can stabilize or destabilize a system.	
	Connections to Engineering, Technology, and Applications of Science **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.	

Code	Title/Text	Location
HS-ESS2	**Earth's Systems** *continued*	
HS-ESS2-3	**Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.** 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), and identification of the composition of Earth's layers from high-pressure laboratory experiments.	**Activity:** *The Cycling of Matter through Thermal Convection*, Chapter 17 Section 4
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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 the relationships between systems or between components of a system.	**Science and Engineering Practices Handbook:** Practice 2
	Connections to Nature of Science **Scientific Knowledge is Based on Empirical Evidence**	
	• Science knowledge is based on empirical evidence.	**Science and Engineering Practices Handbook:** Practice 1, Practice 6 **Student Edition:** 10–13
	• Science disciplines share common rules of evidence used to evaluate explanations about natural systems.	**Science and Engineering Practices Handbook:** Practice 6, Practice 7 **Student Edition:** 10–13
	• Science includes the process of coordinating patterns of evidence with current theory.	**Science and Engineering Practices Handbook:** Practice 6, Practice 7 **Student Edition:** 10–13, 17–19
Disciplinary Core Ideas		
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. 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 gravitational movement of denser materials toward the interior.	**Student Edition:** 486–488, 536–538, 557
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.	**Student Edition:** 486–488, 621
Crosscutting Concepts		
	Energy and Matter	
	• Energy drives the cycling of matter within and between systems.	
	Connections to Engineering, Technology, and Applications of Science **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.	

Code	Title/Text	Location
HS-ESS2	**Earth's Systems** *continued*	
HS-ESS2-4	**Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** **Clarification Statement:** Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition. **Assessment Boundary:** Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.	**Activity:** *Variations in Albedo*, Chapter 11 Section 1
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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 to provide mechanistic accounts of phenomena.	**Science and Engineering Practices Handbook:** Practice 2
	Connections to Nature of Science **Scientific Knowledge is Based on Empirical Evidence**	
	• Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**Science and Engineering Practices Handbook:** Practice 6, Practice 7 **Student Edition:** 10–13, 17–19
Disciplinary Core Ideas		
ESS1.B	**Earth and the Solar System**	
	• Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. *(secondary)*	**Student Edition:** 314–315, 388–391, 776–777
ESS2.A	**Earth Materials and Systems**	
	• The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	**Student Edition:** 282–283, 286–288, 314–315, 388–391, 393–396, 400–401, 412, 500, 502–504, 512, 636, 651–665, 743–744, 776–777, 834–835
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.	**Student Edition:** 286–288, 314–315, 393–396
	• Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	**Student Edition:** 282–283, 393–396, 743–744
Crosscutting Concepts		
	Cause and Effect	
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

Code	Title/Text	Location
HS-ESS2	**Earth's Systems** *continued*	
HS-ESS2-5	**Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.** Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).	**Activity:** *Investigating Stream Erosion*, Chapter 7 Section 2 (Erosion by Water), Chapter 9 Section 1 (Stream Load)
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**Science and Engineering Practices Handbook:** Practice 3
Disciplinary Core Ideas		
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, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.	**Student Edition:** 67, 113, 134–136, 166–169, 171–174, 177, 192, 196, 198, 207–212, 218,219, 222, 224–231, 232–240, 247, 250, 252–262, 282, 286–288, 294–295, 302–303, 308, 309, 315, 378–380, 400, 404, 409–420, 432, 433, 439–442, 693–694
Crosscutting Concepts		
	Structure and Function	
	• The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.	

Code	Title/Text	Location
HS-ESS2	**Earth's Systems** *continued*	
HS-ESS2-6	**Develop a quantitative model to describe the cycling of carbon among 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 (including humans), providing the foundation for living organisms.	**Activity:** *Carbon Cycling through the Earth's Spheres*, Chapter 24 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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 the relationships between systems or between components of a system.	**Science and Engineering Practices Handbook:** Practice 2
Disciplinary Core Ideas		
ESS2.D	**Weather and Climate**	
	• Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.	**Student Edition:** 167, 282–283, 412, 687–689
	• Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	**Student Edition:** 282–283, 393–396, 688–689, 743–744
Crosscutting Concepts		
	Energy and Matter	
	• The total amount of energy and matter in closed systems is conserved.	

Code	Title/Text	Location
HS-ESS2	**Earth's Systems** *continued*	
HS-ESS2-7	**Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.** **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 of 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 that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms. **Assessment Boundary:** Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.	**Activity:** *The Coevolution of Living Things & the Atmosphere*, Chapter 22 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 7
Disciplinary Core Ideas		
ESS2.D	**Weather and Climate**	
	• Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.	**Student Edition:** 628–632, 633–637, 642–643
ESS2.E	**Biogeology**	
	• 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.	**Student Edition:** 8–9, 628–631, 633–637, 688–689
Crosscutting Concepts		
	Stability and Change	
	• Much of science deals with constructing explanations of how things change and how they remain stable.	

Code	Title/Text	Location
HS-ESS3	**Earth and Human Activity**	
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** Clarification Statement: Examples of key natural resources 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). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.	**Activity:** *Human Activity, Natural Resources, Hazards, and Climate Change*, Chapter 19 Section 4 (Earthquake Forecasting), Chapter 26 Section 4
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	
	• Construct 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.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
ESS3.A	**Natural Resources**	
	• Resource availability has guided the development of human society.	**Student Edition:** 98–100, 121–123, 150, 152, 236, 241–242, 263–268, 275, 678–686, 693–698, 708–713, 719, 728, 729, 734–741, 748–750
ESS3.B	**Natural Hazards**	
	• Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.	**Student Edition:** 171–175, 194–200, 202–203, 214–215, 219, 230–231, 270–271, 352–365, 376, 385–386, 393–396, 397, 401, 443, 445, 502–503, 519, 530–531, 545–552, 665, 683, 702, 703, 734–736, 739
Crosscutting Concepts		
	Cause and Effect	
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	
	Connections to Engineering, Technology, and Applications of Science **Influence of Science, Engineering, and Technology on Society and the Natural World**	
	• Modern civilization depends on major technological systems.	

Code	Title/Text	Location
HS-ESS3	**Earth and Human Activity** *continued*	
HS-ESS3-2	**Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*** 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 (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.	**Activity:** *Environmental Consulting: Finding Solutions*, Chapter 24 Section 2, Chapter 25 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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 competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).	**Science and Engineering Practices Handbook:** Practice 7
Disciplinary Core Ideas		
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.	**Student Edition:** 98–101, 150, 176–184, 678–686, 702, 703, 708–723, 728, 729, 737–742, 756, 757
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. *(secondary)*	**Science and Engineering Practices Handbook:** Practice 1, Practice 6 **Student Edition:** 722, 725, 729, 757
Crosscutting Concepts		
	Connections to Engineering, Technology, and Applications of Science **Influence of Science, Engineering, and Technology 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.	
	Connections to Nature of Science **Science Addresses Questions About the Natural and Material World**	
	• Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions.	
	• Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge.	
	• Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.	

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Code	Title/Text	Location
HS-ESS3	**Earth and Human Activity** *continued*	
HS-ESS3-3	**Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.** **Clarification Statement:** Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning. **Assessment Boundary:** Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.	**Activity:** *Modeling Relationships: Resource Management, Human Sustainability and Biodiversity*, Chapter 26 Section 1
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	
	• Create a computational model or simulation of a phenomenon, designed device, process, or system.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
ESS3.C	**Human Impacts on Earth Systems**	
	• The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.	**Student Edition:** 176–184, 238–242, 249, 263–269, 270–271, 275, 676, 678–698, 699, 702–703, 708–724, 725, 728–729, 734–750
Crosscutting Concepts		
	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.	
	Connections to Engineering, Technology, and Applications of Science **Influence of Science, Engineering, and Technology on Society and the Natural World**	
	• Modern civilization depends on major technological systems.	
	• New technologies can have deep impacts on society and the environment, including some that were not anticipated.	
	Connections to Nature of Science **Science is a Human Endeavor**	
	• Science is a result of human endeavors, imagination, and creativity.	

Code	Title/Text	Location
HS-ESS3	**Earth and Human Activity** *continued*	
HS-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).	**Activity:** *Locking Up Carbon*, Chapter 26 Section 2, Chapter 26 Section 3, Chapter 26 Section 4
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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 tradeoff considerations.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
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.	**Student Edition:** 167, 265–269, 392–396, 678–681, 690–691, 714–724, 734–750
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. *(secondary)*	**Science and Engineering Practices Handbook:** Practice 1, Practice 3 **Student Edition:** 722, 723, 724, 725, 729, 756, 757
Crosscutting Concepts		
	Stability and Change	
	• Feedback (negative or positive) can stabilize or destabilize a system.	
	Connections to Engineering, Technology, and Applications of Science **Influence of Science, Engineering, and Technology 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.	

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Code	Title/Text	Location
HS-ESS3	**Earth and Human Activity** *continued*	
HS-ESS3-5	**Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth 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). **Assessment Boundary:** Assessment is limited to one example of a climate change and its associated impacts.	**Activity:** *Forecasting Climate Change*, Chapter 14 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 4
	Connections to Nature of Science **Scientific Investigations Use a Variety of Methods**	
	• Science investigations use diverse methods and do not always use the same set of procedures to obtain data.	**Science and Engineering Practices Handbook:** Practice 1, Practice 3 **Student Edition:** 10–13
	• New technologies advance scientific knowledge.	**Science and Engineering Practices Handbook:** Introduction **Student Edition:** 9, 41–46, 47, 324-328, 331, 333, 455, 518, 534–535, 610, 764–769
	Scientific Knowledge is Based on Empirical Evidence	
	• Science knowledge is based on empirical evidence.	**Science and Engineering Practices Handbook:** Practice 1, Practice 6 **Student Edition:** 10–13
	• Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**Science and Engineering Practices Handbook:** Practice 6, Practice 7 **Student Edition:** 17–19
Disciplinary Core Ideas		
ESS3.D	**Global Climate Change**	
	• 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.	**Student Edition:** 41–47, 53, 207, 208, 263–269, 376–396, 400–401, 410, 445, 743–746, 751
Crosscutting Concepts		
	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.	

Code	Title/Text	Location
HS-ESS3	**Earth and Human Activity** *continued*	
HS-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. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations. Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.	**Activity:** *Exploring Relationships: Climate Change and Human Activities*, Chapter 14 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
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. *(secondary)*	**Student Edition:** 286–287, 393–396, 401, 445, 743–747, 751
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.	**Student Edition:** 8–9, 224, 247, 303, 393–396, 688–689, 702, 734–751
Crosscutting Concepts		
	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.	

Code	Title/Text	Location
HS-ETS1	**Engineering Design**	
HS-ETS1-1	**Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.**	**Activity:** *Engineer a Better World: Analyze a Major Global Challenge*, for use as long-term project (see Program Resources)
	The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*	
Science and Engineering Practices		
	Asking Questions and Defining Problems Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.	
	• Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	**Science and Engineering Practices Handbook:** Practice 1
Disciplinary Core Ideas		
ETS1.A	**Defining and Delimiting Engineering Problems**	
	• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.	**Science and Engineering Practices Handbook:** Practice 1, Practice 6
	• 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.	**Science and Engineering Practices Handbook:** Introduction, All Practices
Crosscutting Concepts		
	Connections to Engineering, Technology, and Applications of Science **Influence of Science, Engineering, and Technology 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.	

Code	Title/Text	Location
HS-ETS1	**Engineering Design** *continued*	
HS-ETS1-2	**Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.**	**Activity:** *Engineer a Better World: Design a Solution*, for use as long-term project (see Program Resources)
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	
	• Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
ETS1.C	**Optimizing the Design Solution**	
	• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	**Science and Engineering Practices Handbook:** Practice 1, Practice 6

Code	Title/Text	Location
HS-ETS1	**Engineering Design** *continued*	
HS-ETS1-3	**Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.**	**Activity:** *Engineer a Better World: Evaluate a Solution*, for use as long-term project (see Program Resources)
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	
	• Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
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.	**Science and Engineering Practices Handbook:** Practice 1, Practice 6
Crosscutting Concepts		
	Connections to Engineering, Technology, and Applications of Science **Influence of Science, Engineering, and Technology 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.	

Code	Title/Text	Location
HS-ETS1	**Engineering Design** *continued*	
HS-ETS1-4	**Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.**	**Activity:** *Engineer a Better World: Use a Computer Simulation*, for use as long-term project (see Program resources)
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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 models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
ETS1.B	**Developing Possible Solutions**	
	• Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.	**Science and Engineering Practices Handbook:** Practice 2, Practice 5, Practice 6
Crosscutting Concepts		
	Systems and System Models	
	• Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.	

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