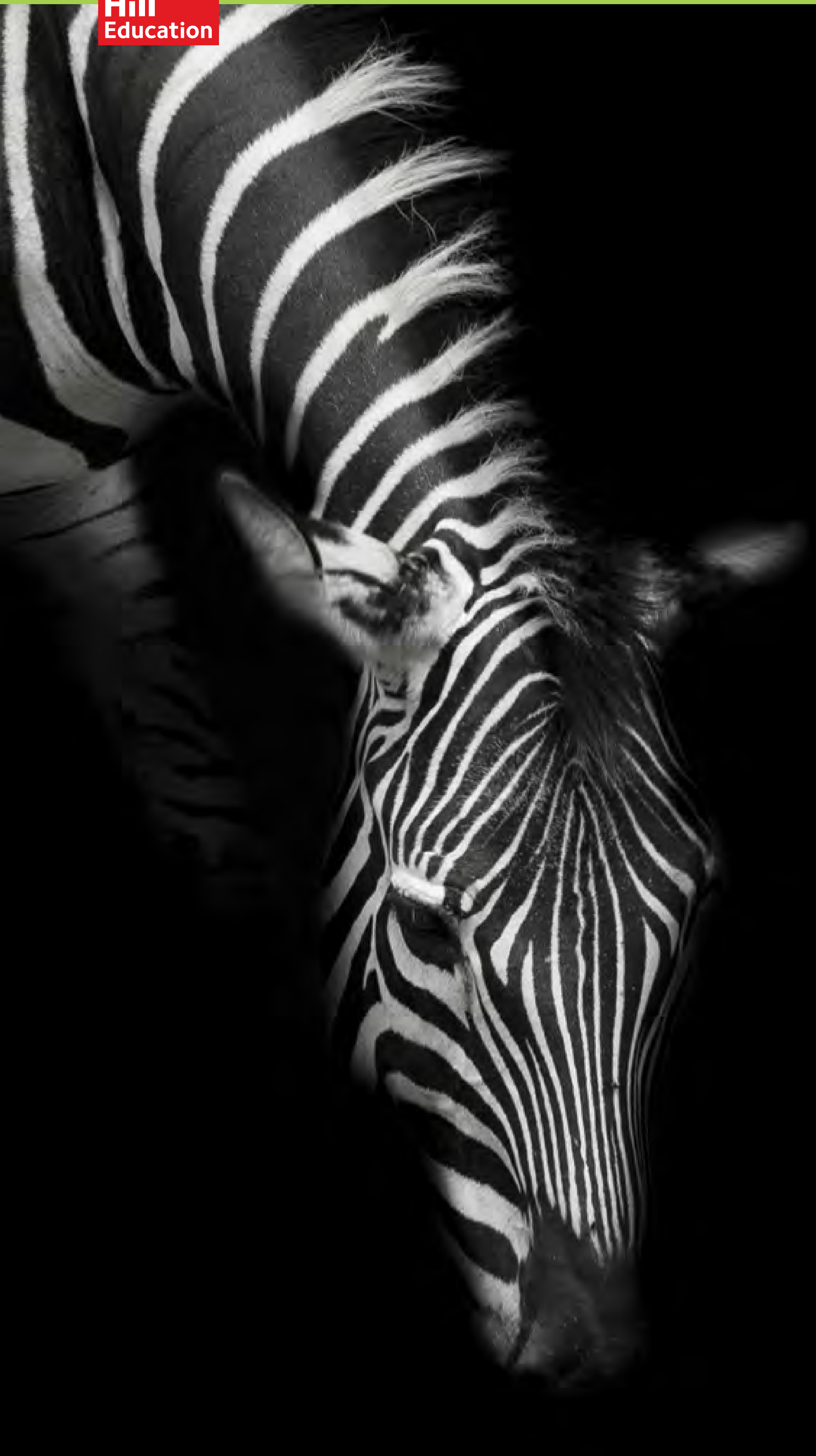
Alignment Guide



GLENCOE

BIOLOGY

Glencoe Biology—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 Biology

McGraw Hill Education

The Correlation Table lists a Performance Expectation that integrates a combination of Science and Engineering Practices, Disciplinary 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-LS1	**From Molecules to Organisms: Structures and Processes**	
HS-LS1-1	**Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.** **Assessment Boundary:** Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.	**Activity:** *Transcription and Translation,* Chapter 12 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, 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		
LS1.A	**Structure and Function**	
	• Systems of specialized cells within organisms help them perform the essential functions of life.	**Student Edition:** 256–257, 258, 632–638, 639–640, 694, 947–948, 962–963, 997–998, 1085–1089
	• All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. *(Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)*	**Student Edition:** 171, 186, 193, 247, 249, 270, 272, 336–341, 342–345
Crosscutting Concepts		
	Structure and Function	
	• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.	

Code	Title/Text	Location
HS-LS1	**From Molecules to Organisms: Structures and Processes** *continued*	
HS-LS1-2	**Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** **Clarification Statement:** Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system. **Assessment Boundary:** Assessment does not include interactions and functions at the molecular or chemical reaction level.	**Activity:** *Hierarchical Organization in Plants,* Chapter 22 Section 1, Chapter 22 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		
	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 worlds.	
	• Develop and use 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		
LS1.A	**Structure and Function**	
	• Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.	**Student Edition:** 632–638, 639–640, 642, 728, 739, 747, 768, 796, 865, 886, 947–948, 962–967, 968–972, 973–976, 992–998, 1000–1003, 1005–1007, 1020–1024, 1031–1037
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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Code	Title/Text	Location
HS-LS1	**From Molecules to Organisms: Structures and Processes** *continued*	
HS-LS1-3	**Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.** **Clarification Statement:** Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels. **Assessment Boundary:** Assessment does not include the cellular processes involved in the feedback mechanism.	**Activity:** *Investigate Osmosis,* Chapter 7 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		
	Planning and Carrying Out Investigations Planning and carrying out 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
	Connections to Nature of Science **Scientific Investigations Use a Variety of Methods**	
	• Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.	**Science and Engineering Practices Handbook:** Practice 3 **Student Edition:** 16–21
Disciplinary Core Ideas		
LS1.A	**Structure and Function**	
	• Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.	**Student Edition:** 10, 203–206, 547, 556, 636–638, 639–640, 642, 644–647, 727, 739, 747, 767, 795, 825, 854, 884, 938–939, 946, 969–970, 992, 1005–1007, 1032–1037
Crosscutting Concepts		
	Stability and Change	
	• Feedback (negative or positive) can stabilize or destabilize a system.	

Code	Title/Text	Location
HS-LS1	**From Molecules to Organisms: Structures and Processes** *continued*	
HS-LS1-4	**Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.** Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.	**Activity:** *Mitosis and Cellular Differentiation,* Chapter 9 Section 1, Chapter 9 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		
	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 worlds.	
	• Use 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		
LS1.B	**Growth and Development of Organisms**	
	• In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.	**Student Edition:** 246–247, 248–252, 270, 275, 696–697, 1055
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.	

Code	Title/Text	Location
HS-LS1	**From Molecules to Organisms: Structures and Processes** *continued*	
HS-LS1-5	**Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.** **Clarification Statement:** Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models. **Assessment Boundary:** Assessment does not include specific biochemical steps.	**Activity:** *Modeling Photosynthesis,* Chapter 8 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		
	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 worlds.	
	• Use 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		
LS1.C	**Organization for Matter and Energy Flow in Organisms**	
	• The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.	**Student Edition:** 41–44, 220, 222–227, 233, 235, 644–645
Crosscutting Concepts		
	Energy and Matter	
	• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.	

Code	Title/Text	Location
HS-LS1	**From Molecules to Organisms: Structures and Processes** *continued*	
HS-LS1-6	**Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.** **Clarification Statement:** Emphasis is on using evidence from models and simulations to support explanations. **Assessment Boundary:** Assessment does not include the details of the specific chemical reactions or identification of macromolecules.	**Activity:** *Exploring Macromolecules,* Chapter 6 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 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.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
LS1.C	**Organization for Matter and Energy Flow in Organisms**	
	• The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.	**Student Edition:** 166–171, 222, 226, 229–232
	• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.	**Student Edition:** 41–44, 45–49, 218–220, 222, 229–232, 1026–1029
Crosscutting Concepts		
	Energy and Matter	
	• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.	

Code	Title/Text	Location
HS-LS1	**From Molecules to Organisms: Structures and Processes** *continued*	
HS-LS1-7	**Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.** **Clarification Statement:** Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration. **Assessment Boundary:** Assessment should not include identification of the steps or specific processes involved in cellular respiration.	**Activity:** *Modeling Cellular Respiration,* Chapter 8 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 worlds.	
	• Use 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		
LS1.C	**Organization for Matter and Energy Flow in Organisms**	
	• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.	**Student Edition:** 220, 228–233
	• As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.	**Student Edition:** 220, 228–233
Crosscutting Concepts		
	Energy and Matter	
	• Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.	

Code	Title/Text	Location
HS-LS2	**Ecosystems: Interactions, Energy, and Dynamics**	
HS-LS2-1	**Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** **Clarification Statement:** Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets. **Assessment Boundary:** Assessment does not include deriving mathematical equations to make comparisons.	**Activity:** *Carrying Capacity of Nectar-Feeding Bats,* Chapter 4 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.	
	• Use mathematical and/or computational representations of phenomena or design solutions to support explanations.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
LS2.A	**Interdependent Relationships in Ecosystems**	
	• Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.	**Student Edition:** 94–99, 105
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-LS2	**Ecosystems: Interactions, Energy, and Dynamics** *continued*	
HS-LS2-2	**Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data. Assessment Boundary: Assessment is limited to provided data.	**Activity:** *Biodiversity in Leaf Litter,* Chapter 5 Section 1, Chapter 5 Section 2, Chapter 5 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 mathematical representations of phenomena or design solutions to support and revise explanations.	**Science and Engineering Practices Handbook:** Practice 5
	Connections to Nature of Science **Scientific Knowledge is Open to Revision in Light of New Evidence**	
	• Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.	**Science and Engineering Practices Handbook:** Practice 6, Practice 7 **Student Edition:** 11–14, 16–20
Disciplinary Core Ideas		
LS2.A	**Interdependent Relationships in Ecosystems**	
	• Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.	**Student Edition:** 94–99, 105
LS2.C	**Ecosystem Dynamics, Functioning, and Resilience**	
	• A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	**Student Edition:** 60–64, 94–99, 122–128, 134–135
Crosscutting Concepts		
	Scale, Proportion, and Quantity	
	• Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.	

Code	Title/Text	Location
HS-LS2	**Ecosystems: Interactions, Energy, and Dynamics** *continued*	
HS-LS2-3	**Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.** **Clarification Statement:** Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments. **Assessment Boundary:** Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.	**Activity:** *The Cycling of Matter and Flow of Energy in Aerobic and Anaerobic Conditions,* Chapter 2 Section 1, Chapter 2 Section 2, Chapter 2 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 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.	**Science and Engineering Practices Handbook:** Practice 6
	Connections to Nature of Science **Scientific Knowledge is Open to Revision in Light of New Evidence**	
	• Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.	**Science and Engineering Practices Handbook:** Practice 6, Practice 7 **Student Edition:** 11–14, 16–20
Disciplinary Core Ideas		
LS2.B	**Cycles of Matter and Energy Transfer in Ecosystems**	
	• Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.	**Student Edition:** 41–44, 47, 197, 219–220, 222–227, 228–233, 235
Crosscutting Concepts		
	Energy and Matter	
	• Energy drives the cycling of matter within and between systems.	

Code	Title/Text	Location
HS-LS2	**Ecosystems: Interactions, Energy, and Dynamics** *continued*	
HS-LS2-4	**Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.** **Clarification Statement:** Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem. **Assessment Boundary:** Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.	**Activity:** *Ecological Pyramids,* Chapter 2 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		
	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 representations of phenomena or design solutions to support claims.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
LS2.B	**Cycles of Matter and Energy Transfer in Ecosystems**	
	• Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.	**Student Edition:** 41–44, 45–49, 219–220
Crosscutting Concepts		
	Energy and Matter	
	• Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.	

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Code	Title/Text	Location
HS-LS2	**Ecosystems: Interactions, Energy, and Dynamics** *continued*	
HS-LS2-5	**Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.** **Clarification Statement:** Examples of models could include simulations and mathematical models. **Assessment Boundary:** Assessment does not include the specific chemical steps of photosynthesis and respiration.	**Activity:** *Modeling the Carbon Cycle,* Chapter 2 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 worlds.	
	• Develop a model based on evidence to illustrate the relationships between systems or components of a system.	**Science and Engineering Practices Handbook:** Practice 2
Disciplinary Core Ideas		
LS2.B	**Cycles of Matter and Energy Transfer in Ecosystems**	
	• Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.	**Student Edition:** 43, 45, 47, 219–220
PS3.D	**Energy in Chemical Processes**	
	• The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.	**Student Edition:** 41, 197, 222–227, 233
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.	

Code	Title/Text	Location
HS-LS2	**Ecosystems: Interactions, Energy, and Dynamics** *continued*	
HS-LS2-6	**Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.	**Activity:** *Local Ecosystem Dynamics,* Chapter 2 Section 1, Chapter 3 Section 1, Chapter 5 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		
	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 the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	**Science and Engineering Practices Handbook:** Practice 7
	Connections to Nature of Science **Scientific Knowledge is Open to Revision in Light of New Evidence**	
	• Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	**Science and Engineering Practices Handbook:** Practice 1, Practice 7, Practice 8 **Student Edition:** 14, 20, 1127
Disciplinary Core Ideas		
LS2.C	**Ecosystem Dynamics, Functioning, and Resilience**	
	• A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	**Student Edition:** 34–40, 62–64, 94–98, 123–128
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-LS2	**Ecosystems: Interactions, Energy, and Dynamics** *continued*	
HS-LS2-7	**Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.	**Activity:** *Microbeads, Mega-Problem,* Chapter 3 Section 3, Chapter 5 Section 2, Chapter 5 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.	
	• Design, evaluate, and 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		
LS2.C	**Ecosystem Dynamics, Functioning, and Resilience**	
	• Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.	**Student Edition:** 120, 122–128, 744, 801, 833, 841, 860, 869
LS4.D	**Biodiversity and Humans**	
	• Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary)*	**Student Edition:** 116–118, 122–123, 131–135
	• Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)*	**Student Edition:** 118–120, 123–128, 129–135
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 to HS-LS2-7)*	**Science and Engineering Practices Handbook:** Practice 1, Practice 6 **Student Edition:** 129–135
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-LS2	**Ecosystems: Interactions, Energy, and Dynamics** *continued*	
HS-LS2-8	**Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.** Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.	**Activity:** *Investigating Group Behavior,* Chapter 31 Section 1, Chapter 31 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		
	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 the evidence behind currently accepted explanations to determine the merits of arguments.	**Science and Engineering Practices Handbook:** Practice 7
	Connections to Nature of Science **Scientific Knowledge is Open to Revision in Light of New Evidence**	
	• Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	**Science and Engineering Practices Handbook:** Practice 1, Practice 7, Practice 8 **Student Edition:** 14, 20, 1127
Disciplinary Core Ideas		
LS2.D	**Social Interactions and Group Behavior**	
	• Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.	**Student Edition:** 909–915, 916–923
Crosscutting Concepts		
	Cause and Effect	
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

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Code	Title/Text	Location
HS-LS3	**Heredity: Inheritance and Variation of Traits**	
HS-LS3-1	**Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.** Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.	**Activity:** *Meiosis,* Chapter 10 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		
	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.	
	• Ask questions that arise from examining models or a theory to clarify relationships.	**Science and Engineering Practices Handbook:** Practice 1
Disciplinary Core Ideas		
LS1.A	**Structure and Function**	
	• All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. *(secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS1-1.)*	**Student Edition:** 193, 247, 249, 270, 272, 336–341, 342–344
LS1.A	**Structure and Function**	
	• Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.	**Student Edition:** 247, 270, 329–332, 336–341, 342–345, 373
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-LS3	**Heredity: Inheritance and Variation of Traits** *continued*	
HS-LS3-2	**Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.** Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs. Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.	**Activity:** *Investigating Genetic Variation,* Chapter 10 Section 1, Chapter 10 Section 2, Chapter 10 Section 3, Chapter 11 Section 3, Chapter 12 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		
	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.	
	• Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
LS3.B	**Variation of Traits**	
	• In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited.	**Student Edition:** 271–276, 283–285, 312–313, 342–349
	• Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.	**Student Edition:** 309–310
Crosscutting Concepts		
	Cause and Effect	
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

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Code	Title/Text	Location
HS-LS3	**Heredity: Inheritance and Variation of Traits** *continued*	
HS-LS3-3	**Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.** **Clarification Statement:** Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits. **Assessment Boundary:** Assessment does not include Hardy-Weinberg calculations.	**Activity:** *Punnett Squares,* Chapter 10 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		
	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.	
	• Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.	**Science and Engineering Practices Handbook:** Practice 4
Disciplinary Core Ideas		
LS3.B	**Variation of Traits**	
	• Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.	**Student Edition:** 309–310
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).	
	Science is a Human Endeavor	
	• Technological advances have influenced the progress of science and science has influenced advances in technology.	
	• Science and engineering are influenced by society and society is influenced by science and engineering.	

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-LS4	**Biological Evolution: Unity and Diversity** *continued*	
HS-LS4-2	**Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.** **Clarification Statement:** Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning. **Assessment Boundary:** Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.	**Activity:** *Pest Management and Natural Selection,* Chapter 15 Section 1, Chapter 15 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		
	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, 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		
LS4.B	**Natural Selection**	
	• Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals.	**Student Edition:** 420–422
LS4.C	**Adaptation**	
	• Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.	**Student Edition:** 420–422, 431–436
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-LS4	**Biological Evolution: Unity and Diversity** *continued*	
HS-LS4-3	**Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.** **Clarification Statement:** Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations. **Assessment Boundary:** Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.	**Activity:** *Could You Beat Natural Selection Using Camouflage?*, Chapter 15 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		
	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.	
	• Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.	**Science and Engineering Practices Handbook:** Practice 4
Disciplinary Core Ideas		
LS4.B	**Natural Selection**	
	• Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals.	**Student Edition:** 420–422
	• The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.	**Student Edition:** 420, 434–436
LS4.C	**Adaptation**	
	• Adaptation also means that the distribution of traits in a population can change when conditions change.	**Student Edition:** 428–430
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.	

Code	Title/Text	Location
HS-LS4	**Biological Evolution: Unity and Diversity** *continued*	
HS-LS4-4	**Construct an explanation based on evidence for how natural selection leads to adaptation of populations.** Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.	**Activity:** *Can Scientists Model Natural Selection?,* Chapter 15 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		
	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, 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		
LS4.C	**Adaptation**	
	• Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.	**Student Edition:** 428–430
Crosscutting Concepts		
	Cause and Effect	
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	
	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-LS4	**Biological Evolution: Unity and Diversity** *continued*	
HS-LS4-5	**Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.** Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.	**Activity:** *Evaluating Impacts of Environmental Change on Populations,* Chapter 5 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		
	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 or historical episodes in science.	
	• Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.	**Science and Engineering Practices Handbook:** Practice 7
Disciplinary Core Ideas		
LS4.C	**Adaptation**	
	• Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline-and sometimes the extinction-of some species.	**Student Edition:** 122–128, 438
	• Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.	**Student Edition:** 122–123
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-LS4	**Biological Evolution: Unity and Diversity** *continued*	
HS-LS4-6	**Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*** **Clarification Statement:** Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.	**Activity:** *Cleaning Up an Oil Spill,* Chapter 5 Section 2, Chapter 5 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.	
	• Create or revise a simulation of a phenomenon, designed device, process, or system.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
LS4.C	**Adaptation**	
	• Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline-and sometimes the extinction-of some species.	**Student Edition:** 122–123, 438
LS4.D	**Biodiversity and Humans**	
	• Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(Note: This Disciplinary Core Idea is also addressed by HS-LS2-7.)*	**Student Edition:** 118–121, 123–128
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:** 134–135
	• 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. *(secondary)*	**Science and Engineering Practices Handbook:** Practice 2, Practice 5
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-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.	

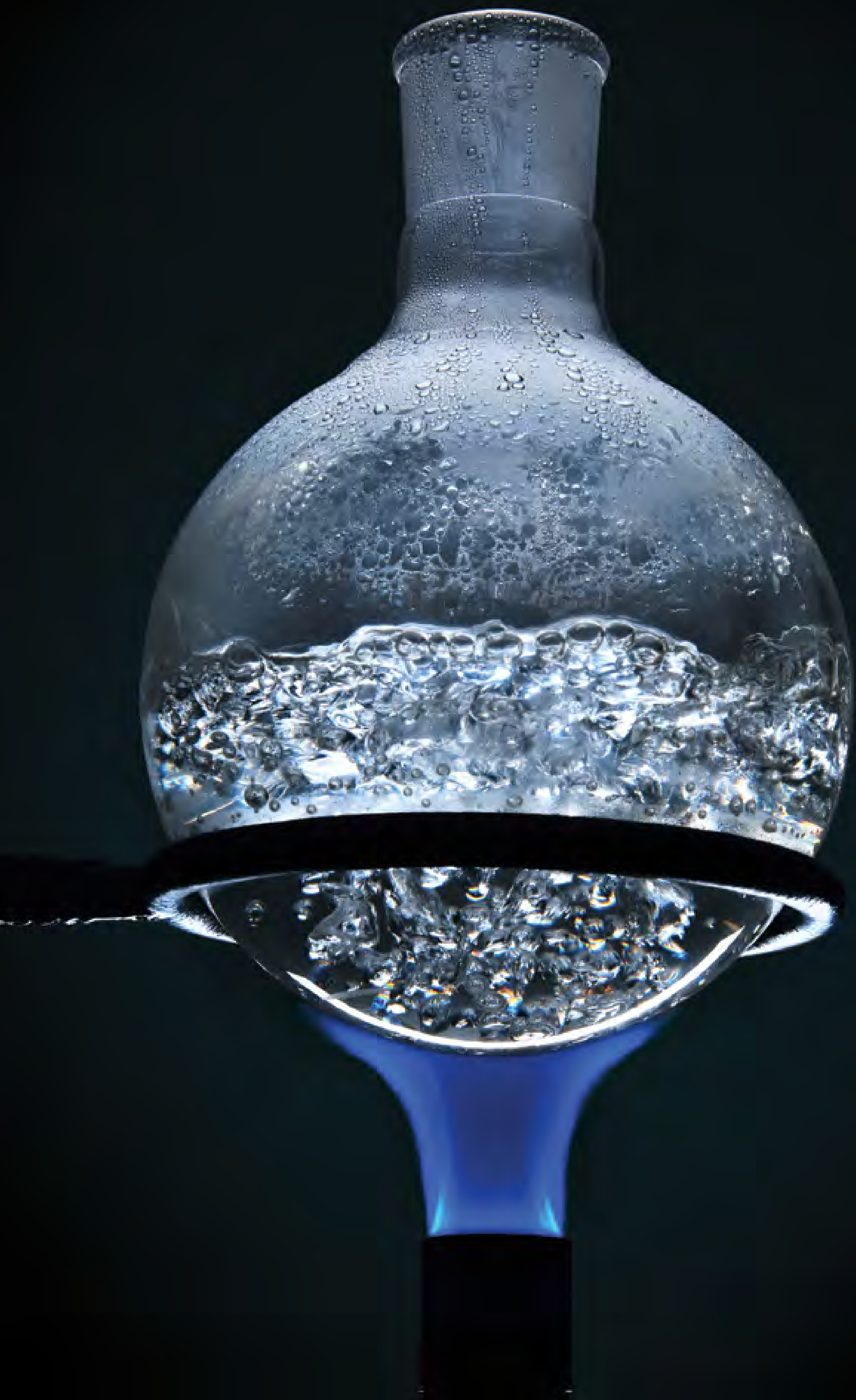
McGraw Hill Education

Alignment Guide

GLENCOE

CHEMISTRY

MATTER & CHANGE



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 Chemistry

The Correlation Table lists a Performance Expectation that integrates a combination of Science and Engineering Practices, Disciplinary 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-PS1	**Matter and Its Interactions**	
HS-PS1-1	**Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen. Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.	**Activity:** *Electron Patterns in Atoms,* Chapter 6 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 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 worlds.	
	• Use a model to predict the relationships between systems or between components of a system.	**Science and Engineering Practices Handbook:** Practice 2
Disciplinary Core Ideas		
PS1.A	**Structure and Properties of Matter**	
	• Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.	**Student Edition:** 106–114, 115–121, 128, 129, 130, 131, 146–155, 156–162, 167, 168, 169
	• The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.	**Student Edition:** 174–181, 182–186, 187–194, 196, 198, 199, 200, 201
PS2.B	**Types of Interactions**	
	• Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary)*	**Student Edition:** 206–209, 210–217, 225–228, 232, 233, 234, 235, 240–241, 242, 246–247, 265–270, 271, 274, 275, 276, 411–414, 417–419, 422–424, 432, 434, 435, 436, 477, 489–491, 497
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.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-2	**Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.** **Clarification Statement:** Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen. **Assessment Boundary:** Assessment is limited to chemical reactions involving main group elements and combustion reactions.	**Activity:** *Electron States and Simple Chemical Reactions,* Chapter 8 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.	
	• 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.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
PS1.A	**Structure and Properties of Matter**	
	• The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.	**Student Edition:** 174–181, 182–186, 187–194, 196, 198, 199, 200, 201
PS1.B	**Chemical Reactions**	
	• The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**Student Edition:** 77–79, 105, 128, 285–288, 289–298, 299–308, 310, 312, 313, 314, 315, 368–372, 373–378, 379–384, 385–388, 390, 392, 393, 394, 395, 396, 397
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.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-3	**Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.** **Clarification Statement:** Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension. **Assessment Boundary:** Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.	**Activity:** *Investigate Interparticle Forces,* Chapter 12 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		
	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		
PS1.A	**Structure and Properties of Matter**	
	• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.	**Student Edition:** 191–194, 199, 200, 201, 212–217, 226, 227, 228, 242, 246–247, 269–270, 411–414, 417, 418–419, 434, 435, 436, 437
PS2.B	**Types of Interactions**	
	• Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary)*	**Student Edition:** 206–209, 210–217, 225–228, 232, 233, 234, 235, 240–241, 242, 246–247, 265–270, 271, 274, 275, 276, 411–414, 417–419, 422–424, 432, 434, 435, 436, 477, 489–491, 497
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.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-4	**Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.** **Clarification Statement:** Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved. **Assessment Boundary:** Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.	**Activity:** *Modeling Energy in Chemical Reactions,* Chapter 15 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 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 worlds.	
	• 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		
PS1.A	**Structure and Properties of Matter**	
	• A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.	**Student Edition:** 159, 193, 216–217, 240–241, 246–247
PS1.B	**Chemical Reactions**	
	• Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	**Student Edition:** 516–522, 522–528, 529–533, 535–541, 550, 552, 553, 554, 555, 560–567, 568–573, 580–582, 584, 586, 587, 588
Crosscutting Concepts		
	Energy and Matter	
	• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-5	**Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.** **Clarification Statement:** Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules. **Assessment Boundary:** Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.	**Activity:** *Concentration, Temperature, and Reaction Rates,* Chapter 16, 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		
	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 principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
PS1.B	**Chemical Reactions**	
	• Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	**Student Edition:** 516–522, 522–528, 529–533, 535–541, 550, 552, 553, 554, 555, 560–567, 568–573, 580–582, 584, 586, 587, 588
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.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-6	**Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*** **Clarification Statement:** Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products. **Assessment Boundary:** Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.	**Activity:** *Food for Thought,* 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		
	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.	
	• 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		
PS1.B	**Chemical Reactions**	
	• In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.	**Student Edition:** 594–605, 606–611, 612–622, 623, 624, 626, 627, 628, 629
ET S1.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. (secondary)	**Science and Engineering Practices Handbook:** Practice 1, Practice 6
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-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-7	**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.** **Clarification Statement:** Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques. **Assessment Boundary:** Assessment does not include complex chemical reactions.	**Activity:** *Conservation of Mass,* Chapter 11 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 at the 9–12 level builds on K–8 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 representations of phenomena to support claims.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
PS1.B	**Chemical Reactions**	
	• The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**Student Edition:** 77–79, 105, 128, 285–288, 289–298, 299–308, 310, 312, 313, 314, 315, 368–372, 373–378, 379–384, 385–388, 390, 392, 393, 394, 395, 396, 397
Crosscutting Concepts		
	Energy and Matter	
	• The total amount of energy and matter in closed systems is conserved.	
	Connections to Nature of Science **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**	
	• Science assumes the universe is a vast single system in which basic laws are consistent.	

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Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-8	**Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.** **Clarification Statement:** Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations. **Assessment Boundary:** Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.	**Activity:** *Modeling Fission, Fusion, and Radioactive Decay,* 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 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 worlds.	
	• 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		
PS1.C	**Nuclear Processes**	
	• Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.	**Student Edition:** 122–124, 129, 130, 860–864, 865–869, 875–884, 894, 895, 896, 897
Crosscutting Concepts		
	Energy and Matter	
	• In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	

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Code	Title/Text	Location
HS-PS2	**Motion and Stability: Forces and Interactions**	
HS-PS2-6	**Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*** **Clarification Statement:** Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors. **Assessment Boundary:** Assessment is limited to provided molecular structures of specific designed materials.	**Activity:** *Touching the Future,* Chapter 12 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 and progresses to evaluating the validity and reliability of the claims, methods, and designs.	
	• Communicate scientific and technical information (e.g. about 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		
PS1.A	**Structure and Properties of Matter**	
	• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. *(secondary)*	**Student Edition:** 191–194, 199, 200, 201, 212–217, 226, 227, 228, 242, 246–247, 269–270, 411–414, 417, 418–419, 434, 435, 436, 437
PS2.B	**Types of Interactions**	
	• Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	**Student Edition:** 206–209, 210–217, 225–228, 232, 233, 234, 235, 240–241, 242, 246–247, 265–270, 271, 274, 275, 276, 411–414, 417–419, 422–424, 432, 434, 435, 436, 477, 489–491, 497
Crosscutting Concepts		
	Structure and Function	
	• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.	

Code	Title/Text	Location
HS-PS3	**Energy**	
HS-PS3-4	**Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).** Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water. Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.	**Activity:** *Coffee Cup Calorimetry,* Chapter 15 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		
	Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems 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		
PS3.B	**Conservation of Energy and Energy Transfer**	
	• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**Student Edition:** 516–517, 525–528, 552, 554
	• Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).	**Student Edition:** 240–241, 542–548, 554, 865–866, 874, 894
PS3.D	**Energy in Chemical Processes**	
	• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.	**Student Edition:** 516–517
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-PS4	**Waves and Their Applications in Technologies for Information Transfer**	
HS-PS4-1	**Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** **Clarification Statement:** Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth. **Assessment Boundary:** Assessment is limited to algebraic relationships and describing those relationships qualitatively.	**Activity:** *Wave Characteristics,* Chapter 5 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 at the 9–12 level builds on K–8 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 representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
PS4.A	**Wave Properties**	
	• The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	**Student Edition:** 137–138, 140, 145, 166, 168
Crosscutting Concepts		
	Cause and Effect	
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

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Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
HS-PS4-3	**Evaluate the claims, evidence, and reasoning behind behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.** **Clarification Statement:** Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect. **Assessment Boundary:** Assessment does not include using quantum theory.	**Activity:** *Is light a wave or a particle?,* Chapter 5 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		
	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 worlds. 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.	**Science and Engineering Practices Handbook:** Practice 7
	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:** 16
Disciplinary Core Ideas		
PS4.A	**Wave Properties**	
	• [From the 3-5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.)	
PS4.B	**Electromagnetic Radiation**	
	• Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.	**Student Edition:** 136–145, 146–155, 166, 167
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.	

Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
HS-PS4-4	**Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.** **Clarification Statement:** Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias. **Assessment Boundary:** Assessment is limited to qualitative descriptions.	**Activity:** *Human Health and Radiation Frequency,* Chapter 24 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		
	Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.	
	• Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible.	**Science and Engineering Practices Handbook:** Practice 8
Disciplinary Core Ideas		
PS4.B	**Electromagnetic Radiation**	
	• When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.	**Student Edition:** 888–890, 892, 895, 896
Crosscutting Concepts		
	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.	

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.	

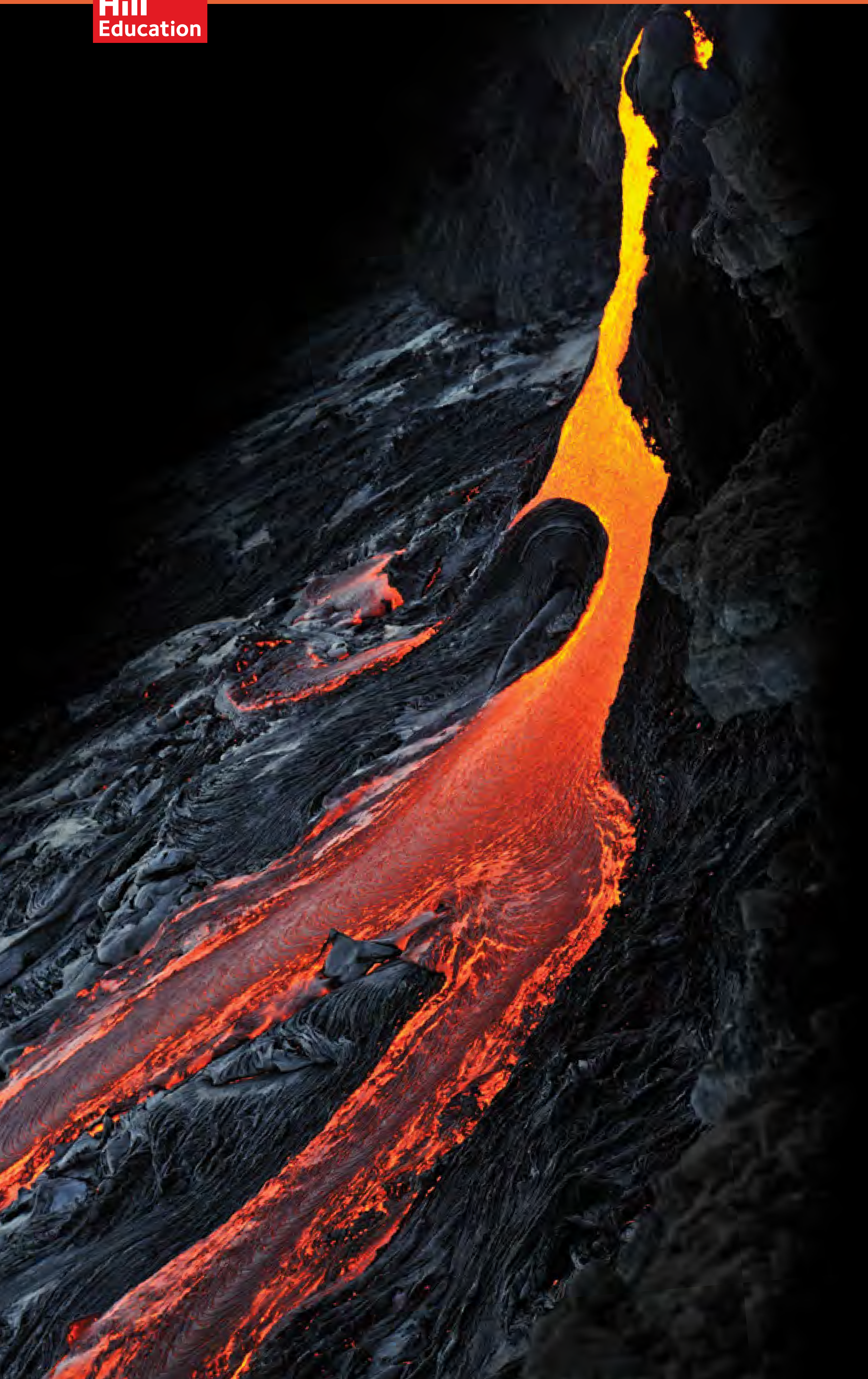
McGraw Hill Education

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.	

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.	

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.	

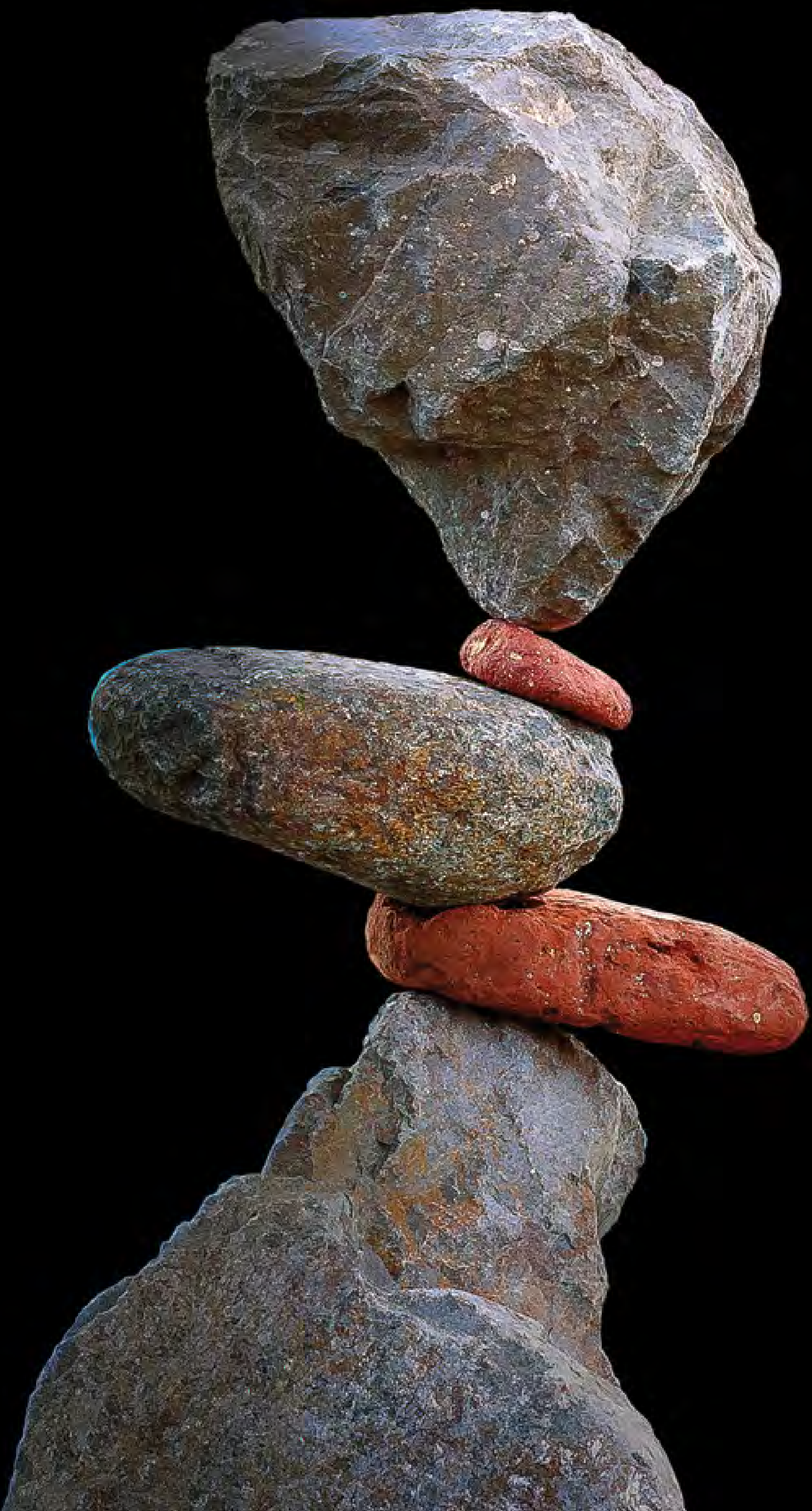
Code	Title/Text	Location
HS-ETS1	**Engineering Design** *continued*	
HS-ETS1-4	**Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.**	**Activity:** *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.	

Alignment Guide

GLENCOE

PHYSICS

PRINCIPLES & PROBLEMS



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 Science

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The Correlation Table lists a Performance Expectation that integrates a combination of Science and Engineering Practices, Disciplinary 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-PS1	**Matter and Its Interactions**	
HS-PS1-8	**Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.** **Clarification Statement:** Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations. **Assessment Boundary:** Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.	**Activity:** *Modeling Fission, Fusion, and Radioactive Decay,* Chapter 30 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		
	Developing and Using Models Modeling in 9–12 builds on K–8 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 worlds.	
	• 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		
PS1.C	**Nuclear Processes**	
	• Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.	**Student Edition:** 808–817, 828, 830–833
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-PS2	**Motion and Stability: Forces and Interactions**	
HS-PS2-1	**Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.** Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.	**Activity:** *Newton's Second Law,* Chapter 4 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		
	Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 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
	Connections to Nature of Science **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**	
	• Theories and laws provide explanations in science.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 8–9
	• Laws are statements or descriptions of the relationships among observable phenomena.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 8–9
Disciplinary Core Ideas		
PS2.A	**Forces and Motion**	
	• Newton's second law accurately predicts changes in the motion of macroscopic objects.	**Student Edition:** 94–97, 99, 114, 116–119
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-PS2	**Motion and Stability: Forces and Interactions** *continued*	
HS-PS2-2	**Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.** **Clarification Statement:** Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle. **Assessment Boundary:** Assessment is limited to systems of two macroscopic bodies moving in one dimension.	**Activity:** *Conservation of Momentum,* Chapter 9 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		
	Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 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 representations of phenomena to describe explanations.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
PS2.A	**Forces and Motion**	
	• Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.	**Student Edition:** 236–239, 243
	• If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.	**Student Edition:** 236–239, 243, 244–254, 256–261
Crosscutting Concepts		
	Systems and System Models	
	• When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.	

Code	Title/Text	Location
HS-PS2	**Motion and Stability: Forces and Interactions** *continued*	
HS-PS2-3	**Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*** **Clarification Statement:** Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute. **Assessment Boundary:** Assessment is limited to qualitative evaluations and/or algebraic manipulations.	**Activity:** *Egg Heads,* Chapter 9 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 ideas to solve a design problem, taking into account possible unanticipated effects.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
PS2.A	**Forces and Motion**	
	• If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.	**Student Edition:** 236–239, 243, 244–254, 256–261, 306–309
ETS1.A	**Defining and Delimiting an Engineering Problem**	
	• 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. *(secondary)*	**Science and Engineering Practices Handbook:** Practice 1, Practice 6
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. *(secondary)*	**Science and Engineering Practices Handbook:** Practice 1, Practice 6
Crosscutting Concepts		
	Cause and Effect	
	• Systems can be designed to cause a desired effect.	

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Code	Title/Text	Location
HS-PS2	**Motion and Stability: Forces and Interactions** *continued*	
HS-PS2-4	**Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.** Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields. Assessment Boundary: Assessment is limited to systems with two objects.	**Activity:** *Gravitational and Electrostatic Forces,* Chapter 20 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		
	Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 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 representations of phenomena to describe explanations.	**Science and Engineering Practices Handbook:** Practice 5
	Connections to Nature of Science **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**	
	• Theories and laws provide explanations in science.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 8–9
	• Laws are statements or descriptions of the relationships among observable phenomena.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 8–9
Disciplinary Core Ideas		
PS2.B	**Types of Interactions**	
	• Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.	**Student Edition:** 182–185, 190, 196–201, 557–561, 564–567, 570–576, 582–587, 590–595
	• Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	**Student Edition:** 190, 193, 197–201, 570–587, 590–595,653–657, 668–673, 676–679, 683, 694–698, 710–711
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.	

Code	Title/Text	Location
HS-PS2	**Motion and Stability: Forces and Interactions** *continued*	
HS-PS2-5	**Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.** Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.	**Activity:** *Investigate Electromagnetism,* Chapter 25 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		
	Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems 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		
PS2.B	**Types of Interactions**	
	• Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)	**Student Edition:** 182–185, 190, 196–201, 557–561, 564–567, 570–576, 582–587, 590–595
	• Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	**Student Edition:** 190, 193, 197–201, 570–587, 590–595,653–657, 668–673, 676–679, 683, 694–698, 710–711
PS3.A	**Definitions of Energy**	
	• "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. *(secondary)*	**Student Edition:** 577–587, 591–595, 598–613, 616–621
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-PS3	**Energy**	
HS-PS3-1	**Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.** **Clarification Statement:** Emphasis is on explaining the meaning of mathematical expressions used in the model. **Assessment Boundary:** Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.	**Activity:** *Modeling Changes in Energy,* Chapter 11 Section 2, Chapter 12 Section 2, Chapter 22, 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		
	Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 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		
PS3.A	**Definitions of Energy**	
	• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**Student Edition:** 270, 293–309, 312–317, 322–328, 330–336, 343–345
PS3.B	**Conservation of Energy and Energy Transfer**	
	• Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.	**Student Edition:** 292–293, 301–309, 313–317, 334–336, 577, 634, 684
	• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**Student Edition:** 292–317, 322–329, 334–339, 341–345, 633–634
	• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.	**Student Edition:** 270, 292–309, 312–317, 383–385
	• The availability of energy limits what can occur in any system.	**Student Edition:** 270
Crosscutting Concepts		
	Systems and System Models	
	• Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.	
	Connections to Nature of Science **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**	
	• Science assumes the universe is a vast single system in which basic laws are consistent.	

Code	Title/Text	Location
HS-PS3	**Energy** *continued*	
HS-PS3-2	**Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).** Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.	**Activity:** *Modeling Energy at Different Scales,* Chapter 12 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		
	Developing and Using Models Modeling in 9–12 builds on K–8 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 worlds.	
	• Develop and use 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		
PS3.A	**Definitions of Energy**	
	• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**Student Edition:** 270, 293–309, 312–317, 322–328, 330–336, 343–345
	• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	**Student Edition:** 292–300, 310, 312–317, 383, 389
	• These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.	**Student Edition:** 190, 292–300, 320–345, 570–595, 598–601, 650–657, 710–719
Crosscutting Concepts		
	Energy and Matter	
	• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.	
	• Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.	

Code	Title/Text	Location
HS-PS3	**Energy** *continued*	
HS-PS3-3	**Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*** **Clarification Statement:** Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency. **Assessment Boundary:** Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.	**Activity:** *Earth Power,* Chapter 11 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		
	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, evaluate, and/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		
PS3.A	**Definitions of Energy**	
	• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	**Student Edition:** 292–300, 310, 312–317, 383, 389
PS3.D	**Energy in Chemical Processes**	
	• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.	**Student Edition:** 301–309, 312–317, 339, 343–345
ETS1.A	**Defining and Delimiting an Engineering Problem**	
	• 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. *(secondary)*	**Science and Engineering Practices Handbook:** Practice 1, Practice 6
Crosscutting Concepts		
	Energy and Matter	
	• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.	
	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. 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-PS2	**Motion and Stability: Forces and Interactions** *continued*	
HS-PS2-3	**Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*** **Clarification Statement:** Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute. **Assessment Boundary:** Assessment is limited to qualitative evaluations and/or algebraic manipulations.	**Activity:** *Egg Heads,* Chapter 9 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 ideas to solve a design problem, taking into account possible unanticipated effects.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
PS2.A	**Forces and Motion**	
	• If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.	**Student Edition:** 236–239, 243, 244–254, 256–261, 306–309
ETS1.A	**Defining and Delimiting an Engineering Problem**	
	• 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. *(secondary)*	**Science and Engineering Practices Handbook:** Practice 1, Practice 6
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. *(secondary)*	**Science and Engineering Practices Handbook:** Practice 1, Practice 6
Crosscutting Concepts		
	Cause and Effect	
	• Systems can be designed to cause a desired effect.	

Code	Title/Text	Location
HS-PS3	**Energy** *continued*	
HS-PS3-5	**Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.** **Clarification Statement:** Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other. **Assessment Boundary:** Assessment is limited to systems containing two objects.	**Activity:** *Modeling Magnetic Fields,* Chapter 24 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 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 worlds.	
	• Develop and use 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		
PS3.C	**Relationship Between Energy and Forces**	
	• When two objects interacting through a field change relative position, the energy stored in the field is changed.	**Student Edition:** 190, 570–595, 598–621, 650–699
Crosscutting Concepts		
	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.	

Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer**	
HS-PS4-1	**Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** **Clarification Statement:** Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth. **Assessment Boundary:** Assessment is limited to algebraic relationships and describing those relationships qualitatively.	**Activity:** *Wave Characteristics,* Chapter 14 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		
	Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 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 representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
PS4.A	**Wave Properties**	
	• The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	**Student Edition:** 391–393, 503–407, 410–412, 419–423, 453–455, 493–499, 711–713
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-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
HS-PS4-2	**Evaluate questions about the advantages of using a digital transmission and storage of information.** Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.	**Activity:** *Digital Transmission and Storage of Information,* Chapter 26 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		
	Asking Questions and Defining Problems Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.	
	• Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.	**Science and Engineering Practices Handbook:** Practice 1
Disciplinary Core Ideas		
PS4.A	**Wave Properties**	
	• Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.	**Student Edition:** 714–720, 722–725, 735
Crosscutting Concepts		
	Stability and Change	
	• Systems can be designed for greater or lesser stability.	
	Connections to Engineering, Technology, and Applications of Science **Influence of Engineering, Technology, and Science on Society and the Natural World**	
	• Modern civilization depends on major technological systems.	
	• Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	

Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
HS-PS4-3	**Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.** **Clarification Statement:** Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect. **Assessment Boundary:** Assessment does not include using quantum theory.	**Activity:** *Is light a wave or a particle?,* Chapter 27 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		
	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 worlds. 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.	**Science and Engineering Practices Handbook:** Practice 7
	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:** 13
Disciplinary Core Ideas		
PS4.A	**Wave Properties**	
	• [From the 3-5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.)	**Student Edition:** 395–397, 403–407, 419–426
PS4.B	**Electromagnetic Radiation**	
	• Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.	**Student Edition:** 447, 453–455, 458–461, 710–713, 728–740, 746–749
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.	

Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
HS-PS4-4	**Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.** **Clarification Statement:** Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias. **Assessment Boundary:** Assessment is limited to qualitative descriptions.	**Activity:** *Human Health and Radiation Frequency,* Chapter 26 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 and progresses to evaluating the validity and reliability of the claims, methods, and designs.	
	• Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible.	**Science and Engineering Practices Handbook:** Practice 8
Disciplinary Core Ideas		
PS4.B	**Electromagnetic Radiation**	
	• When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.	**Student Edition:** 710–713
Crosscutting Concepts		
	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.	

Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
HS-PS4-5	**Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*** **Clarification Statement:** Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology. **Assessment Boundary:** Assessments are limited to qualitative information. Assessments do not include band theory.	**Activity:** *Catching Waves,* Chapter 26 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 and progresses to evaluating the validity and reliability of the claims, methods, and designs.	
	• Communicate technical information or 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		
PS3.D	**Energy in Chemical Processes**	
	• Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. *(secondary)*	**Student Edition:** 310, 731–732
PS4.A	**Wave Properties**	
	• Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.	**Student Edition:** 714–720, 722–725, 735
PS4.B	**Electromagnetic Radiation**	
	• Photoelectric materials emit electrons when they absorb light of a high-enough frequency.	**Student Edition:** 731–738, 746–749
PS4.C	**Information Technologies and Instrumentation**	
	• Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	**Student Edition:** 712–720, 722–725
Crosscutting Concepts		
	Cause and Effect	
	• Systems can be designed to cause a desired effect.	
	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).	
	Influence of Engineering, Technology, and Science on Society and the Natural World	
	• Modern civilization depends on major technological systems.	

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Code	Title/Text	Location
HS-ESS1	**Earth's Place in the Universe**	
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 7 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		
	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:** 178–181
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-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.	

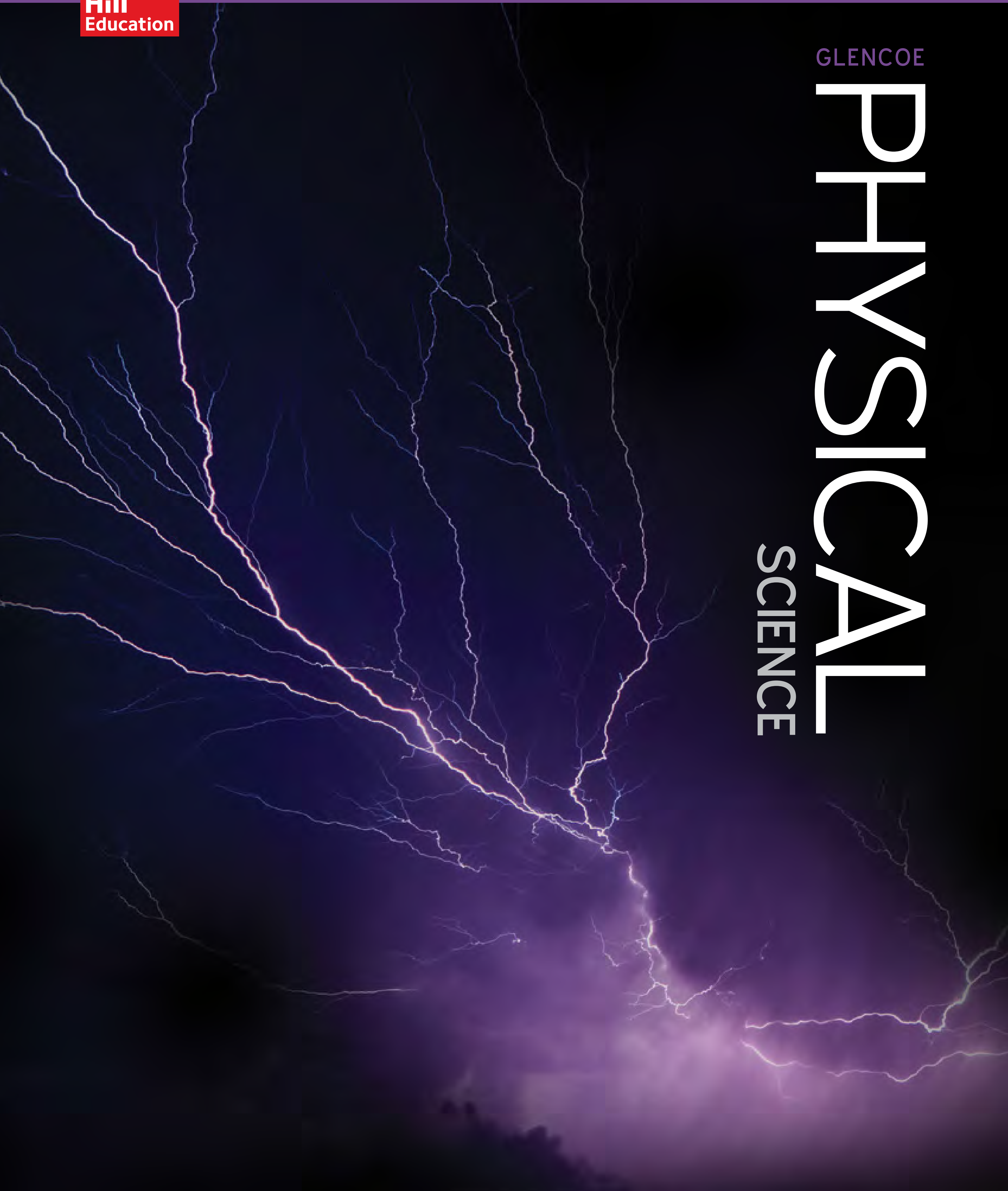
Code	Title/Text	Location
HS-ETS1	**Engineering Design** *continued*	
HS-ETS1-4	**Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.**	**Activity:** *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.	

McGraw Hill Education

Alignment Guide

GLENCOE

PHYSICAL SCIENCE



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 Physical Science

The Correlation Table lists a Performance Expectation that integrates a combination of Science and Engineering Practices, Disciplinary 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-PS1	**Matter and Its Interactions**	
HS-PS1-1	**Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** **Clarification Statement:** Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen. **Assessment Boundary:** Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.	**Activity:** *Electron Patterns in Atoms,* Chapter 16 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 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 worlds.	
	• Use a model to predict the relationships between systems or between components of a system.	**Science and Engineering Practices Handbook:** Practice 2
Disciplinary Core Ideas		
PS1.A	**Structure and Properties of Matter**	
	• Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.	**Student Edition:** 488–493, 494–497, 503, 512, 513, 618–620, 633–639
	• The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.	**Student Edition:** 498–506, 507, 508–509, 512, 513, 518–525, 526–530, 531, 532–539, 544, 545
PS2.B	**Types of Interactions**	
	• Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary)*	**Student Edition:** 519, 558–560, 562–564, 572–573, 577, 618–620, 638, 639
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.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-2	**Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.** **Clarification Statement:** Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen. **Assessment Boundary:** Assessment is limited to chemical reactions involving main group elements and combustion reactions.	**Activity:** *Electron States and Simple Chemical Reactions,* Chapter 19 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.	
	• 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.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
PS1.A	**Structure and Properties of Matter**	
	• The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.	**Student Edition:** 498–506, 507, 508–509, 512, 513, 518–525, 526–530, 531, 532–539, 544, 545
PS1.B	**Chemical Reactions**	
	• The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**Student Edition:** 475–476, 478–479, 483, 518–525, 526–530, 532–539, 544, 545, 558–564, 576, 577, 582–589, 590–593, 610, 611
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.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-3	**Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.** **Clarification Statement:** Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension. **Assessment Boundary:** Assessment does not include Raoult's law calculations of vapor pressure.	**Activity:** *Investigate Interparticle Forces,* Chapter 18 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		
	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		
PS1.A	**Structure and Properties of Matter**	
	• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.	**Student Edition:** 432–436, 438, 439, 440, 456, 558–564, 572–573, 649, 658–659, 663–667
PS2.B	**Types of Interactions**	
	• Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary)*	**Student Edition:** 519, 558–560, 562–564, 572–573, 577, 618–620, 638, 639
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.	

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Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-4	**Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.** Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved. Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.	**Activity:** *Modeling Energy in Chemical Reactions,* Chapter 19 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 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 worlds.	
	• 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		
PS1.A	**Structure and Properties of Matter**	
	• A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.	**Student Edition:** 554–556, 557, 577, 594–597
PS1.B	**Chemical Reactions**	
	• Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	**Student Edition:** 594–597, 598–601, 604, 605, 606–607, 611
Crosscutting Concepts		
	Energy and Matter	
	• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-5	**Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.** **Clarification Statement:** Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules. **Assessment Boundary:** Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.	**Activity:** *Concentration and Reaction Rates,* Chapter 19 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 ideas, principles, and theories.	
	• Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
PS1.B	**Chemical Reactions**	
	• Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	**Student Edition:** 594–597, 598–601, 604, 605, 606–607, 611
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.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-6	**Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*** **Clarification Statement:** Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products. **Assessment Boundary:** Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.	**Activity:** *Food For Thought,* Chapter 19 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 ideas, principles, and theories.	
	• 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		
PS1.B	**Chemical Reactions**	
	• In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.	**Student Edition:** 601–604, 611
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. *(secondary)*	**Science and Engineering Practices Handbook:** Practice 1, Practiced 6
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-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-7	**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.** **Clarification Statement:** Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques. **Assessment Boundary:** Assessment does not include complex chemical reactions.	**Activity:** *Conservation of Mass,* Chapter 15 Section 2, Chapter 19 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 at the 9–12 level builds on K–8 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 representations of phenomena to support claims.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
PS1.B	**Chemical Reactions**	
	• The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**Student Edition:** 475–476, 478–479, 483, 518–525, 526–530, 532–539, 544, 545, 558–564, 576, 577, 582–589, 590–593, 610, 611
Crosscutting Concepts		
	Energy and Matter	
	• The total amount of energy and matter in closed systems is conserved.	
	Connections to Nature of Science **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**	
	• Science assumes the universe is a vast single system in which basic laws are consistent.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
HS-PS1-8	**Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.** **Clarification Statement:** Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations. **Assessment Boundary:** Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.	**Activity:** *Modeling Fission, Fusion, and Radioactive Decay,* 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 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 worlds.	
	• 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		
PS1.C	**Nuclear Processes**	
	• Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.	**Student Edition:** 616–620, 621–627, 628, 634–635, 638, 639
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-PS2	**Motion and Stability: Forces and Interactions**	
HS-PS2-1	**Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.** **Clarification Statement:** Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. **Assessment Boundary:** Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.	**Activity:** *Newton's Second Law*, Chapter 3 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		
	Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 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
	Connections to Nature of Science **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**	
	• Theories and laws provide explanations in science.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 13
	• Laws are statements or descriptions of the relationships among observable phenomena.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 13
Disciplinary Core Ideas		
PS2.A	**Forces and Motion**	
	• Newton's second law accurately predicts changes in the motion of macroscopic objects.	**Student Edition:** 72–73, 80–90, 92–95, 98–101
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-PS2	**Motion and Stability: Forces and Interactions** *continued*	
HS-PS2-2	**Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.** **Clarification Statement:** Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle. **Assessment Boundary:** Assessment is limited to systems of two macroscopic bodies moving in one dimension.	**Activity:** *Conservation of Momentum,* Chapter 3 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 at the 9–12 level builds on K–8 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 representations of phenomena to describe explanations.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
PS2.A	**Forces and Motion**	
	• Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.	**Student Edition:** 54–55, 62–63, 66–67
	• If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.	**Student Edition:** 54–55, 62–63, 91–92, 96, 99–101
Crosscutting Concepts		
	Systems and System Models	
	• When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.	

Code	Title/Text	Location
HS-PS2	**Motion and Stability: Forces and Interactions** *continued*	
HS-PS2-3	**Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*** Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute. Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.	**Activity:** *Egg Heads,* Chapter 3 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.	
	• Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
PS2.A	**Forces and Motion**	
	• If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.	**Student Edition:** 54–55, 62–63, 91–92, 96, 99–101
ETS1.A	**Defining and Delimiting an Engineering Problem**	
	• 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. *(secondary)*	**Science and Engineering Practices Handbook:** Practice 1, Practiced 6
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. *(secondary)*	**Science and Engineering Practices Handbook:** Practice 1, Practiced 6
Crosscutting Concepts		
	Cause and Effect	
	• Systems can be designed to cause a desired effect.	

Code	Title/Text	Location
HS-PS2	**Motion and Stability: Forces and Interactions** *continued*	
HS-PS2-5	**Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.** **Assessment Boundary:** Assessment is limited to designing and conducting investigations with provided materials and tools.	**Activity:** *Investigate Electromagnetism,* Chapter 7 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		
	Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems 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		
PS2.B	**Types of Interactions**	
	• Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)	**Student Edition:** 76–79, 98–101, 170–172, 177, 196–197
	• Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	**Student Edition:** 77–79, 172, 202–204, 209–225, 228–229
PS3.A	**Definitions of Energy**	
	• "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. *(secondary)*	**Student Edition:** 178–181, 188–191, 196–199
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-PS2	**Motion and Stability: Forces and Interactions** *continued*	
HS-PS2-6	**Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*** **Clarification Statement:** Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors. **Assessment Boundary:** Assessment is limited to provided molecular structures of specific designed materials.	**Activity:** *Touching the Future,* 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		
	Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.	
	• Communicate scientific and technical information (e.g. about 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		
PS1.A	**Structure and Properties of Matter**	
	• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. *(secondary)*	**Student Edition:** 432–436, 438, 439, 440, 456, 558–564, 572–573, 649, 658–659, 663–667
PS2.B	**Types of Interactions**	
	• Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	**Student Edition:** 519, 558–560, 562–564, 572–573, 577, 618–620, 638, 639
Crosscutting Concepts		
	Structure and Function	
	• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.	

Code	Title/Text	Location
HS-PS3	**Energy**	
HS-PS3-1	**Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.** **Clarification Statement:** Emphasis is on explaining the meaning of mathematical expressions used in the model. **Assessment Boundary:** Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.	**Activity:** *Modeling Changes in Energy,* Chapter 4 Section 3, Chapter 5 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 at the 9–12 level builds on K–8 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		
PS3.A	**Definitions of Energy**	
	• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**Student Edition:** 114–129, 132–135, 138–161, 164–167
PS3.B	**Conservation of Energy and Energy Transfer**	
	• Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.	**Student Edition:** 120–129, 132–135, 138–161, 164–167, 597
	• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**Student Edition:** 120–129, 132–135, 138–161, 164–167
	• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.	**Student Edition:** 114–124
	• The availability of energy limits what can occur in any system.	**Student Edition:** 114
Crosscutting Concepts		
	Systems and System Models	
	• Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.	
	Connections to Nature of Science **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**	
	• Science assumes the universe is a vast single system in which basic laws are consistent.	

Code	Title/Text	Location
HS-PS3	**Energy** *continued*	
HS-PS3-2	**Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).** Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.	**Activity:** *Modeling Energy on Different Scales,* Chapter 5 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 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 worlds.	
	• Develop and use 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		
PS3.A	**Definitions of Energy**	
	• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**Student Edition:** 114–129, 132–135, 138–161, 164–167
	• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	**Student Edition:** 114–119, 132–135, 138–140, 187–191, 196–199, 212–222, 228–229, 248–252, 254, 338–343, 432–439, 594–597
	• These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.	**Student Edition:** 138–147, 432–439, 660–661
Crosscutting Concepts		
	Energy and Matter	
	• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS3-3)	
	• Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.	

Code	Title/Text	Location
HS-PS3	**Energy** *continued*	
HS-PS3-3	**Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*** **Clarification Statement:** Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency. **Assessment Boundary:** Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.	**Activity:** *Earth Power,* Chapter 4 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.	
	• 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 tradeoff considerations.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
PS3.A	**Definitions of Energy**	
	• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	**Student Edition:** 114–119, 132–135, 138–140, 187–191, 196–199, 212–222, 228–229, 248–252, 254, 338–343, 432–439, 594–597
PS3.D	**Energy in Chemical Processes**	
	• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.	**Student Edition:** 120–129, 154–157
ETS1.A	**Defining and Delimiting an Engineering Problem**	
	• 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. *(secondary)*	**Science and Engineering Practices Handbook:** Practice 1, Practiced 6
Crosscutting Concepts		
	Energy and Matter	
	• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.	
	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. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	

Code	Title/Text	Location
HS-PS3	**Energy** *continued*	
HS-PS3-4	**Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).** Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water. Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.	**Activity:** *Coffee Cup Calorimetry,* Chapter 5 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		
	Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems 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		
PS3.B	**Conservation of Energy and Energy Transfer**	
	• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**Student Edition:** 120–129, 132–135, 138–161, 164–167
	• Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).	**Student Edition:** 155
PS3.D	**Energy in Chemical Processes**	
	• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.	**Student Edition:** 120–129, 154–157
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.	
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Code	Title/Text	Location
HS-PS3	**Energy** *continued*	
HS-PS3-5	**Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.** Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other. Assessment Boundary: Assessment is limited to systems containing two objects.	**Activity:** *Modeling Magnetic Fields,* Chapter 7 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 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 worlds.	
	• Develop and use 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		
PS3.C	**Relationship Between Energy and Forces**	
	• When two objects interacting through a field change relative position, the energy stored in the field is changed.	*For related information, see* **Student Edition:** 118–119, 172
Crosscutting Concepts		
	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.	

Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer**	
HS-PS4-1	**Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** **Clarification Statement:** Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth. **Assessment Boundary:** Assessment is limited to algebraic relationships and describing those relationships qualitatively.	**Activity:** *Wave Characteristics,* Chapter 9 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		
	Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 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 representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
PS4.A	**Wave Properties**	
	• The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	**Student Edition:** 280–282, 296, 300–303, 307–308, 338–342, 344
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-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
HS-PS4-2	**Evaluate questions about the advantages of using a digital transmission and storage of information.** Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.	**Activity:** *Digital Transmission and Storage of Information,* Chapter 11 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		
	Asking Questions and Defining Problems Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.	
	• Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.	**Science and Engineering Practices Handbook:** Practice 1
Disciplinary Core Ideas		
PS4.A	**Wave Properties**	
	• Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.	**Student Edition:** 354
Crosscutting Concepts		
	Stability and Change	
	• Systems can be designed for greater or lesser stability.	
	Connections to Engineering, Technology, and Applications of Science **Influence of Engineering, Technology, and Science on Society and the Natural World**	
	• Modern civilization depends on major technological systems.	
	• 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-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
HS-PS4-3	**Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.** **Clarification Statement:** Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect. **Assessment Boundary:** Assessment does not include using quantum theory.	**Activity:** *Is Light a Wave or a Particle?*, 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		
	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 worlds. 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.	**Science and Engineering Practices Handbook:** Practice 7
	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:** 13
Disciplinary Core Ideas		
PS4.A	**Wave Properties**	
	• [From the 3-5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.)	**Student Edition:** 292–295, 322
PS4.B	**Electromagnetic Radiation**	
	• Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.	**Student Edition:** 338–343
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.	

Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
HS-PS4-4	**Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.** **Clarification Statement:** Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias. **Assessment Boundary:** Assessment is limited to qualitative descriptions.	**Activity:** *Human Health and Radiation Frequency,* Chapter 11 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 and progresses to evaluating the validity and reliability of the claims, methods, and designs.	
	• Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible.	**Science and Engineering Practices Handbook:** Practice 8
Disciplinary Core Ideas		
PS4.B	**Electromagnetic Radiation**	
	• When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.	**Student Edition:** 338–343, 345–351, 360, 362–365
Crosscutting Concepts		
	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.	

Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
HS-PS4-5	**Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*** **Clarification Statement:** Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology. **Assessment Boundary:** Assessments are limited to qualitative information. Assessments do not include band theory.	**Activity:** *Catching Waves,* Chapter 11 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 and progresses to evaluating the validity and reliability of the claims, methods, and designs.	
	• Communicate technical information or 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		
PS3.D	**Energy in Chemical Processes**	
	• Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. *(secondary)*	**Student Edition:** 153
PS4.A	**Wave Properties**	
	• Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.	**Student Edition:** 354
PS4.B	**Electromagnetic Radiation**	
	• Photoelectric materials emit electrons when they absorb light of a high-enough frequency.	**Student Edition:** 342
PS4.C	**Information Technologies and Instrumentation**	
	• Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	**Student Edition:** 316, 319–320, 324–329, 332–335, 344–360, 360–365, 378–388, 392, 394–397, 415–422, 424–427
Crosscutting Concepts		
	Cause and Effect	
	• Systems can be designed to cause a desired effect.	
	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).	
	Influence of Engineering, Technology, and Science on Society and the Natural World	
	• Modern civilization depends on major technological systems.	

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Code	Title/Text	Location
HS-ESS3	**Earth and Human Activity**	
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 8 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		
	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:** 232–269, 698, 838, 876
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)*	**Student Edition:** 26–32, 33, 64, 162, 226, 360, 480, 574, 760
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.	

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 8 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:** 244–247, 248–253, 255–261, 698, 902–905
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)*	**Student Edition:** 26–32, 33, 64, 162, 226, 360, 480, 574, 760
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.	

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, Practiced 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

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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: 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.	
	• 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 1, 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.	