

A Correlation of

Miller & Levine Biology:



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to the

**Next Generation Science Standards
DCI Arrangement
High School**

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NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

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Citation Key:

SE = Student Edition;

TE = Teacher Edition;

Digital Resources: Program assents can be accessed at www.savvasrealize.com.

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Next Generation Science Standards High School	<i>Miller & Levine Biology</i> , ©2019
High School Life Sciences	
HS-LS1 From Molecules to Organisms: Structures and Processes	
Performance Expectation	
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.	SE/TE: The Nucleus, 249 Organelles That Build Proteins, 250-251 The Role of DNA, 416 The Components of DNA, 418-419 The Double-Helix Model, 422-423 Comparing RNA and DNA, 440-441 Reading Check: Summarize, 441 Transcription, 443 Lesson 14.1 Review, #3, 444 Translation, 447-449 Performance-Based Assessment: A New Kind of Drug: mRNA, #4, 466-467 Chapter 14 Assessment, #27, #32, #34, 469-470 Digital Resources: Chapter 14: RNA and Protein Synthesis >Lesson 1: RNA>Quick Lab: How Can You Model DNA and RNA?
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. (HS-LS1-1)	SE/TE: Lesson 14.1 Review, #3, 444
Disciplinary Core Ideas	
LS1.A: Structure and Function	
Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)	SE/TE: Cell Specialization, 267 The Role of DNA, 416 Three Main Types of RNA, 442
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. (HS-LS1-1)	SE/TE: The Nucleus, 249 Organelles That Build Proteins, 250 The Role of RNA, 440

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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. (HS-LS1-1)	SE/TE: Figure 14-1: Comparing RNA and DNA, 441 Performance-Based Assessment: A New Kind of Drug: mRNA, #3, #4, 466-467 Digital Resources: Chapter 14: RNA and Protein Synthesis >Lesson 1: RNA>Quick Lab: How Can You Model DNA and RNA?
Performance Expectation	
HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.	SE/TE: Multicellular Life, 267-268 Lesson 23.1 Review, #8, 775 Lesson 25.4 Review, #5, 857 Responding, 871 Muscles and Movements, 878-879 Lesson 26.2 Review, #5, 879 Interrelationship of Body Systems, 888-889 Performance-Based Assessment: Design a model of interacting systems, 896-897 Organization of the Body, 904-905 Figure 27-2: Human Body Systems, 906 Figure 27-5: The Digestive System, 911 Figure 27-8: Structure and Function of the Kidneys, 914 Figure 27-10: Circulation, 916 Figure 27-13: The Lymphatic System, 919 Figure 27-15: The Respiratory Systems, 921 Figure 27-20: The Skeleton, 926 Figure 27-25: The Endocrine System and Its Organs, 930 Chapter 27 Assessment, #38, 952 Digital Resources: Chapter 27: The Human Body >Lesson 1: Organization of the Human Body>Quick Lab: How Do You Respond to an External Stimulus?

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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. (HS-LS1-2)	SE/TE: Lesson 25.4 Review, #5, 857 Performance-Based Assessment: Design a model of interacting systems, 896-897 Digital Resources: Chapter 27: The Human Body >Lesson 1: Organization of the Human Body>Quick Lab: How Do You Respond to an External Stimulus?
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. (HS-LS1-2)	SE/TE: Multicellular Life, 267-268 Interrelationship of Body Systems, 888-889 Organization of the Body, 904-905 Digital Resources: Chapter 8: Cell Structure and Function >Lesson 4: Homeostasis and Cells>Interactivity: Multicellular Life
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. (HS-LS1-2)	SE/TE: Structure and Function of Roots, 766 Performance-Based Assessment: Design a model of interacting systems, 896-897 Figure 27-8: Structure and Function of the Kidneys, 914 Figure 27-21: Structure of a Bone, 927 Chapter 27 Assessment, #38, 952 Digital Resources: Chapter 23: Plant Structure and Function >Lesson 1: Roots, Stems, and Leaves>Interactivity: Plant Structure and Function

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Performance Expectation	
HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.	SE/TE: Passive Transport, 260 The Cell as an Organism, 266 Multicellular Life, 267 Tropisms and Rapid Movements, 780-781 Response to Seasons, 782-783 What Animals Do to Survive, 801-802 Interrelationship of Body Systems, 888-889 Body Temperature Control, 890-891 Lesson 26.4 Review, #1, #4, 891 Homeostasis, 907-909 Lesson 27.1 Review, #4, 909 The Endocrine System, 930-932 Reading Check: Summarize, 932 Digital Resources: Chapter 27: The Human Body >Lesson 2: Human Systems I>Exploration Lab: Exercise and Heart Rate
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. (HS-LS1-3)	Digital Resources: Chapter 27: The Human Body >Lesson 2: Human Systems I>Exploration Lab: Exercise and Heart Rate
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. (HS-LS1-3)	SE/TE: Scientific Attitudes, 16 Avoiding Bias, 20 Digital Resources: Chapter 27: The Human Body >Lesson 2: Human Systems I>Exploration Lab: Exercise and Heart Rate

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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. (HS-LS1-3)	SE/TE: Maintaining Homeostasis, 801 Feedback Inhibition, 907-908 Control of the Endocrine System, 932 Digital Resources: Chapter 27: The Human Body >Lesson 2: Human Systems I>Exploration Lab: Exercise and Heart Rate
Crosscutting Concepts	
Stability and Change	
Feedback (negative or positive) can stabilize or destabilize a system. (HS-LS1-3)	SE/TE: Maintaining Homeostasis, 801 Figure 27-3: Feedback Inhibition, 907 Feedback Inhibition, 907-908 Figure 27-4: Body Temperature Control, 908 Lesson 27.1 Review, #4, 909 Control of the Endocrine System, 932 Digital Resources: Chapter 27: The Human Body >Lesson 2: Human Systems I>Exploration Lab: Exercise and Heart Rat
Performance Expectation	
HS-LS1-4. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.	SE/TE: Cell Division, 340 The Cell Cycle, 345-346 Mitosis, 346-347 Cytokinesis, 348 Lesson 11.2 Review, #5, 348 Figure 11-10: Mitosis, 349 From One Cell to Many, 355-356 Figure 11-16: Differentiation in <i>C. elegans</i>, 356 Human Development, 357 Lesson 11.4, #4, 361 Digital Resources: Chapter 11: Cell Growth and Division >Lesson 2: The Process of Cell Division>Quick Lab: Make a Model of Mitosis >Lesson 4: Cell Differentiation>Exploration Lab: Regeneration in Planaria

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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. (HS-LS1-4)	SE/TE: Figure 11-10: Mitosis, 349 Figure 11-16: Differentiation in <i>C. elegans</i> , 356 Chapter 11 Assessment, #28, 369 Digital Resources: Chapter 11: Cell Growth and Division >Lesson 2: The Process of Cell Division>Quick Lab: Make a Model of Mitosis >Lesson 4: Cell Differentiation>Exploration Lab: Regeneration in Planaria
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. (HS-LS1-4)	SE/TE: Mitosis, 346-347 From One Cell to Many, 355-356 Lesson 11.4 Review, #4, 361 Digital Resources: Chapter 11: Cell Growth and Division >Lesson 2: The Process of Cell Division>Interactivity: Exploring Mitosis
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. (HS-LS1-4)	SE/TE: Chapter 11 Assessment, #28, #32, 369-370 Digital Resources: Chapter 11: Cell Growth and Division >Lesson 2: The Process of Cell Division>Quick Lab: Make a Model of Mitosis

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Performance Expectation	
HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.	SE/TE: An Overview of Photosynthesis, 289-290 Figure 9-6: Stages of Photosynthesis, 290 Lesson 9.2 Review, #4, #6, 290 Figure 9-8: The Light-Dependent Reactions, 293 Figure 9-9: The Light-Independent Reactions, 295 Lesson 9.3 Review, #4, 297 Chapter 9 Assessment, #23, #34, 305-306 Digital Resources: Chapter 9: Photosynthesis >Lesson 2: Photosynthesis: An Overview>Interactivity: A Model of Photosynthesis;>Develop a Solution Lab: Plant Pigments and Photosynthesis
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. (HS-LS1-5)	SE/TE: An Overview of Photosynthesis, 289-290 Lesson 9.2 Review, #3, #6, 290 The Light-Dependent Reactions: Generating ATP and NADPH, 291-294 The Light-Independent Reactions: Producing Sugars, 294-295 Digital Resources: Chapter 9: Photosynthesis >Lesson 2: Photosynthesis: An Overview>Interactivity: A Model of Photosynthesis >Lesson 3: The Process of Photosynthesis>Interactivity: The Details of Photosynthesis
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. (HS-LS1-5)	SE/TE: Lesson 9.2 Review, #4, #6, 290 Figure 9-9: The Light-Independent Reactions: Interpret Visuals, 295 Lesson 9.4 Review, #4, 297 Chapter 9 Assessment, #23, 305 Digital Resources: Chapter 9: Photosynthesis >Lesson 2: Photosynthesis: An Overview>Interactivity: A Model of Photosynthesis;>Develop a Solution Lab: Plant Pigments and Photosynthesis

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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-LS1-5)	SE/TE: Chapter 9 Assessment, #34, 306
Performance Expectation	
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.	SE/TE: The Chemistry of Carbon, 52 Carbohydrates, 53 Lipids, 54-55 Nucleic Acids, 55 Proteins, 55 Lesson 2.3 Review, #2, #3, 57 Chemical Reactions, 58 The Light-Independent Reactions: Producing Sugars, 294-295 Digital Resources: Chapter 2: The Chemistry of Life >Lesson 3: Carbon Compounds>Interactivity: Understanding Macromolecules
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. (HS-LS1-6)	Digital Resources: Chapter 2: The Chemistry of Life >Lesson 3: Carbon Compounds>Interactivity: Understanding Macromolecules
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. (HS-LS1-6)	SE/TE: Carbohydrates, 53-54 Lipids, 54-55 Nucleic Acids, 55 Proteins, 55-57 Lesson 2.3 Review, #2, #3, #5, 57 Digital Resources: Chapter 2: The Chemistry of Life >Lesson 3: Carbon Compounds>Interactivity: Understanding Macromolecules

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As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6)	SE/TE: Chemical Reactions, 58 Energy in Reactions, 58-59 The Light-Dependent Reactions: Generating ATP and NADPH, 291 The Light-Independent Reactions: Producing Sugars, 294 The End Results, 295
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-LS1-6)	SE/TE: Energy in Reactions, 58-59 Reading Check: Interpret Graphs, 59
Performance Expectation	
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.	SE/TE: Overview of Cellular Respiration, 311-312 Figure 10-3: Glycolysis, 315 Figure 10-4: The Krebs Cycle, 317 Figure 10-5: The Electron Transport Chain and ATP Synthesis, 319 Figure 10-6: Energy Totals, 320 Lesson 10.2 Review, #7, 320 Chapter 10 Assessment, #37, 334 Digital Resources: Chapter 10: Cellular Respiration >Lesson 2: The Process of Cellular Respiration>Interactivity: The Mechanics of Cellular Respiration;>Modeling Lab: Making a Model of Cellular Respiration
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. (HS-LS1-7)	SE/TE: Lesson 10.2 Review, #7, 320 Digital Resources: Chapter 10: Cellular Respiration >Lesson 2: The Process of Cellular Respiration>Interactivity: The Mechanics of Cellular Respiration;>Modeling Lab: Making a Model of Cellular Respiration

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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. (HS-LS1-7)	SE/TE: Chemical Energy and Food, 310-311 Overview of Cellular Respiration, 311 Comparing Photosynthesis and Cellular Respiration, 313 Glycolysis, 314 The Krebs Cycle, 316 Electron Transport and ATP Synthesis, 318 Digital Resources: Chapter 10: Cellular Respiration >Lesson 2: The Process of Cellular Respiration>Interactivity: The Mechanics of Cellular Respiration
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. (HS-LS1-7)	SE/TE: Overview of Cellular Respiration, 311-312 Comparing Photosynthesis and Cellular Respiration, 313 Glycolysis, 314-315 The Krebs Cycle, 316 Electron Transport and ATP Synthesis, 318 The Totals, 320
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. (HS-LS1-7)	SE/TE: Chapter 10 Assessment, #37, 334
HS-LS2 Ecosystems: Interactions, Energy, and Dynamics	
Performance Expectation	
HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.	SE/TE: Figure 5-5: Logistic Growth, 150 Carrying Capacity, 151 Limiting Factors, 152 Reading Check: Stability and Change, 152 Density-Dependent Limiting Factors, 153-155 Figure 5-9: Moose-Wolf Populations on Isle Royale: Interpret Graphs, 154 Density-Independent Limiting Factors, 156-157 Limiting Factors and Extinction, 157 Lesson 5.2 Review, #2, #5, 157 Historical Overview, 158 Digital Resources: Chapter 5: Populations >Lesson 1: How Populations Grow>Modeling Lab: Estimating Population Size >Lesson 2: Limits to Growth>Interactivity: Limiting Factors

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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. (HS-LS2-1)	SE/TE: Lesson 5.1 Review, #5, 151 Figure 5-9: Moose-Wolf Populations on Isle Royale: Interpret Graphs, 154 Chapter 5 Assessment, #26, 169 Digital Resources: Chapter 5: Populations >Lesson 1: How Populations Grow>Modeling Lab: Estimating Population Size
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. (HS-LS2-1)	SE/TE: Carrying Capacity, 151 Limiting Factors, 152 Reading Check: Stability and Change, 152 Density-Dependent Limiting Factors, 153-155 Density-Independent Limiting Factors, 156-157 Lesson 5.2 Review, #2, #5, 157 Historical Overview, 158 Digital Resources: Chapter 5: Populations >Lesson 1: How Populations Grow>Modeling Lab: Estimating Population Size >Lesson 2: Limits to Growth>Interactivity: Limiting Factors
Crosscutting Concepts	
Scale, Proportion, and Quantity	
The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1)	SE/TE: Population Growth, 147-148 Exponential Growth, 148 Logistic Growth, 150 Figure 5-9: Moose-Wolf Populations on Isle Royale, 154 Predator-Prey Relationships, 154-155 Exponential Human Population Growth, 158-159

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Performance Expectation	
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.	SE/TE: Limiting Factors, 152 Reading Check: Stability and Change, 152 Competition, 153 Figure 5-9: Moose-Wolf Populations on Isle Royale: Interpret Graphs, 154 Predation and Herbivory, 154-155 Reading Check: Describe, 155 Density-Independent Limiting Factors, 156 Lesson 5.2 Review, #3, 157 Patterns of Human Population Growth, 160-161 Lesson 5.3 Review, #2, #4, 161 Performance-Based Assessment: A Tale of Two Countries, China and India, #2, #3, 166-167 Chapter 5 Assessment, #35, 170 Predation and Herbivory, 179 Lesson 6.1 Review, #3, 181 Performance-Based Assessment: The Populations of Yellowstone, #2, #3, 194-195 Ecological Impacts, 220-221 Digital Resources: Chapter 5: Populations >Lesson 2: Limits to Growth>Analyzing Data: Monarchs in Decline >Lesson 3: Human Population Growth>Quick Lab: Modeling Population Changes Chapter 6: Communities and Ecosystem Dynamics >Lesson 1: Habitats, Niches, and Species Interactions>Analyzing Data: Predator-Prey Dynamics: Case Study;>Science Skills Worksheet: Life on the Reef

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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. (HS-LS2-2)	SE/TE: Figure 5-9: Moose-Wolf Populations on Isle Royale: Interpret Graphs, 154 Lesson 5.3 Review, #4, 161 Case Study Wrap-Up: What can we learn from China?, #2, 162-163 Performance-Based Assessment: A Tale of Two Countries, China and India, #1, #3, 166-167 Performance-Based Assessment: The Populations of Yellowstone, #1, #2, 194-195 Digital Resources: Chapter 5: Populations >Lesson 2: Limits to Growth>Analyzing Data: Monarchs in Decline >Lesson 3: Human Population Growth>Quick Lab: Modeling Population Changes Chapter 6: Communities and Ecosystem Dynamics >Lesson 1: Habitats, Niches, and Species Interactions>Analyzing Data: Predator-Prey Dynamics: Case Study;>Science Skills Worksheet: Life on the Reef
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. (HS-LS2-2)	SE/TE: Competition, 153 Parasitism and Disease, 153 Predation and Herbivory, 154-155 Historical Overview, 158 Predation and Herbivory, 179 Performance-Based Assessment: The Populations of Yellowstone, #2, #3, 194-195 Digital Resources: Chapter 6: Communities and Ecosystem Dynamics >Lesson 1: Habitats, Niches, and Species Interactions>Analyzing Data: Predator-Prey Dynamics: Case Study

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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. (HS-LS2-2)	SE/TE: Limiting Factors, 152 Figure 5-9: Moose-Wolf Populations on Isle Royale: Interpret Graphs, 154 Predator-Prey Relationships, 154 Predation and Herbivory, 179 Keystone Species, 180 Symbioses, 181 Succession After Natural Disturbances, 184 Performance-Based Assessment: The Populations of Yellowstone, #1, #2, 194-195 Ecological Impacts, 220-221 Digital Resources: Chapter 6: Communities and Ecosystem Dynamics >Lesson 1: Habitats, Niches, and Species Interactions>Analyzing Data: Predator-Prey Dynamics: Case Study
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. (HS-LS2-2)	SE/TE: Figure 5-15: Population Age Structure, 161 Performance-Based Assessment: A Tale of Two Countries, China and India, #3, 166-167 Lesson 6.1 Review, #6, 181 Figure 6-8: Primary and Secondary Succession, 183 Performance-Based Assessment: The Populations of Yellowstone, #1, #2, 194-195 Chapter 6 Assessment, #32, 198 Figure 7-5: Understanding Global Change, 207 Figure 7-16: Biological Magnification, 216 Lesson 7.2 Review, #5, 217 Digital Resources: Chapter 5: Populations >Lesson 2: Limits to Growth>Analyzing Data: Monarchs in Decline >Lesson 3: Human Population Growth>Interactivity: Human Population Growth

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Performance Expectation	
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.	SE/TE: Consumers, 116 Lesson 4.1 Review, #3, #4, 117 Biological Processes, 124 Nutrient Cycles, 126 Biological Processes, 126 Lesson 4.3 Review, #7, 131 Comparing Photosynthesis and Cellular Respiration, 313 Lesson 10.1 Review, #5, 313 Fermentation, 321-322 Lesson 10.3 Review, #4, 325 Chapter 10 Assessment, #21, 333 Digital Resources: Chapter 10: Cellular Respiration >Lesson 3: Fermentation>Interactivity: Comparing Cellular Respiration and Fermentation
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. (HS-LS2-3)	SE/TE: Lesson 4.1 Review, #4, 117 Lesson 10.1 Review, #5, 313 Lesson 10.3 Review, #4, 325 Chapter 10 Assessment, #21, 333 Digital Resources: Chapter 10: Cellular Respiration >Lesson 3: Fermentation>Interactivity: Comparing Cellular Respiration and Fermentation
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. (HS-LS2-3)	SE/TE: Energy From the Sun, 114 Lesson 4.1 Review, #1, 117 Biological Processes, 124 Biological Processes, 126 Comparing Photosynthesis and Cellular Respiration, 313 Fermentation, 321-322 Digital Resources: Chapter 10: Cellular Respiration >Lesson 3: Fermentation>Interactivity: Comparing Cellular Respiration and Fermentation

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Crosscutting Concepts	
Energy and Matter	
Energy drives the cycling of matter within and between systems. (HS-LS2-3)	SE/TE: Energy From the Sun, 114 Lesson 4.1 Review, #3, 117 Biological Processes, 126 Chapter 4 Assessment, #32, 140 Digital Resources: Chapter 10: Cellular Respiration >Lesson 3: Fermentation>Interactivity: Comparing Cellular Respiration and Fermentation
Performance Expectation	
HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.	SE/TE: Food Chains and Food Webs, 118 Decomposers and Detritivores in Food Webs, 120 Ecological Pyramids, 121-122 Lesson 4.2 Review, #4, 122 Nutrient Cycles, 126-130 Lesson 4.3 Review, #5, 131 Performance-Based Assessment: Data From the Corn Field, #2, 302-303 Digital Resources: Chapter 4: Ecosystems >Lesson 2: Energy Flow in Ecosystems>Quick Lab: How Can You Model Energy Flow in Ecosystems?
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. (HS-LS2-4)	SE/TE: Lesson 4.2 Review, #4, 122 Lesson 4.3 Review, #5, 131 Performance-Based Assessment: Data From the Corn Field, #2, 302-303 Digital Resources: Chapter 4: Ecosystems >Lesson 2: Energy Flow in Ecosystems>Quick Lab: How Can You Model Energy Flow in Ecosystems?

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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. (HS-LS2-4)	SE/TE: Figure 4-3: Food Web, 119 Pyramids of Energy, 121 Pyramids of Biomass and Numbers, 122 Recycling in Nature, 123-124 Nutrient Cycles, 126-130 Lesson 4.3 Review, #1, 131 Performance-Based Assessment: Data From the Corn Field, #1, 302-303 Digital Resources: Chapter 4: Ecosystems >Lesson 2: Energy Flow in Ecosystems>Quick Lab: How Can You Model Energy Flow in Ecosystems? >Lesson 3: Cycles of Matter>Exploration Lab: The Effect of Fertilizer on Algae
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. (HS-LS2-4)	SE/TE: Food Chains and Food Webs, 118 Pyramids of Energy, 121 Lesson 4.2 Review, #1, 122 Chapter 4 Assessment, #32, 140 Digital Resources: Chapter 4: Ecosystems >Lesson 2: Energy Flow in Ecosystems>Quick Lab: How Can You Model Energy Flow in Ecosystems?
Performance Expectation	
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.	SE/TE: Figure 4-11: The Carbon Cycle, 127 Lesson 4.3 Review, #7, 131 Performance-Based Assessment: Can Algal Blooms Be Useful?, #1, 136-137 An Overview of Photosynthesis, 289 Lesson 9.2 Review, #4, 290 Carbon Dioxide Enters the Cycle, 294 Summary of the Calvin Cycle, 295 Figure 9-9: The Light-Independent Reactions, 295 Lesson 9.3 Review, #7, 297 Comparing Photosynthesis and Cellular Respiration, 313 Lesson 10.1 Review, #5, 313 Digital Resources: Chapter 4: Ecosystems >Lesson 3: Cycles of Matter>Interactivity: Biogeochemical Cycles

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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 how 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. (HS-LS2-5)	SE/TE: Lesson 4.3 Review, #7, 131 Performance-Based Assessment: Can Algal Blooms Be Useful?, #1, 136-137 Chapter 4 Assessment, #21, 139 Lesson 9.1 Review, #4, 285 Lesson 9.2 Review, #4, 290 Lesson 9.3 Review, #4, #7, 297 Chapter 9 Assessment, #22, 305 Chapter 10 Assessment, #29, #30, 333
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. (HS-LS2-5)	SE/TE: The Carbon Cycle, 126-128 Performance-Based Assessment: Can Algal Blooms Be Useful?, #1, 136-137 Light-Independent Reactions, 290 Lesson 9.2 Review, #4, 290 The Light-Independent Reactions: Producing Sugars, 294-295 Lesson 9.3 Review, #7, 297 Performance-Based Assessment: Data from the Corn Field, #1, 302-303 Comparing Photosynthesis and Cellular Respiration, 313 Digital Resources: Chapter 4: Ecosystems >Lesson 3: Cycles of Matter>Interactivity: Biogeochemical Cycles
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. (<i>secondary to HS-LS2-5</i>)	SE/TE: Heterotrophs and Autotrophs, 285

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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. (HS-LS2-5)	SE/TE: Figure 4-11: The Carbon Cycle, 127 Performance-Based Assessment: Can Algal Blooms Be Useful?, #1, 136-137 Chapter 4 Assessment, #33, 140 Figure 9-6: Stages of Photosynthesis, 290 Figure 9-9: The Light-Independent Reactions, 295 Chapter 9 Assessment, #33, 306 Figure 10-2: A Global Balance, 313 Chapter 10 Assessment, #38, 334 Digital Resources: Chapter 4: Ecosystems >Lesson 3: Cycles of Matter>Interactivity: Biogeochemical Cycles
Performance Expectation	
HS-LS2-6. Evaluate 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.	SE/TE: Primary and Secondary Succession, 182-184 Succession After Natural Disturbances, 184 Succession After Human-Caused Disturbances, 185 Lesson 6.2 Review, #4, #5, 185 Biodiversity and Ecosystem Resilience, 187 Lesson 6.3 Review, #4, 189 Digital Resources: Chapter 6: Communities and Ecosystem Dynamics >Lesson 2: Succession>Quick Lab: How Does Succession Occur? >Lesson 3: Biodiversity, Ecosystems, and Resilience>In Your Neighborhood Lab: Biodiversity on the Forest Floor
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. (HS-LS2-6)	SE/TE: Lesson 6.2 Review, #3, #4, 185 Lesson 6.3 Review, #5, 189 Digital Resources: Chapter 6: Communities and Ecosystem Dynamics >Lesson 2: Succession>Quick Lab: How Does Succession Occur? >Lesson 3: Biodiversity, Ecosystems, and Resilience>In Your Neighborhood Lab: Biodiversity on the Forest Floor

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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. (HS-LS2-6)	SE/TE: Secondary Succession, 183 Succession After Natural Disturbances, 184 Succession After Human-Caused Disturbances, 185 Biodiversity and Ecosystem Resilience, 187 Digital Resources: Chapter 6: Communities and Ecosystem Dynamics >Lesson 3: Biodiversity, Ecosystems, and Resilience>In Your Neighborhood Lab: Biodiversity on the Forest Floor
Crosscutting Concepts	
Stability and Change	
Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-6)	SE/TE: Lesson 6.2 Review, #3, #5, 185 Chapter 6 Assessment, #33, 198 Digital Resources: Chapter 6: Communities and Ecosystem Dynamics >Lesson 3: Biodiversity, Ecosystems, and Resilience>In Your Neighborhood Lab: Biodiversity on the Forest Floor

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Performance Expectation	
HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*	SE/TE: Lesson 6.3 Review, #5, 189 Lesson 7.1 Review, #5, 205 Reforestation, 211 Habitat Restoration, 213 Lesson 7.2 Review, #6, 217 Designing Solutions, 222 Sustainable Development, 223-225 Case Study Wrap-Up: How can a rising tide be stopped?, #2, 226-227 Performance-Based Assessment: Biodiversity in the Everglades, #3, #4, #5, 230-231 Case Study Wrap-Up: How do animal processes and human activity affect the environment?, #2, 858-859 Performance-Based Assessment: Design a Zoo Exhibit, #5, #6, 862-863 Digital Resources: Chapter 7: Humans and Global Change >Lesson 1: Ecological Footprints>Argument-Based Inquiry: Calculating Ecological Footprint >Lesson 3: Measuring and Responding to Change>Science Skills Worksheet: Plan an Urban Tree Planting >Lesson 4: Sustainability>Science Skills Worksheet: Biogas Farming

* The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

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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. (HS-LS2-7)	SE/TE: Lesson 6.3 Review, #5, 189 Lesson 7.1 Review, #5, 205 Lesson 7.2 Review, #6, 217 Designing Solutions, 222 Case Study Wrap-Up: How can a rising tide be stopped?, #2, 226-227 Performance-Based Assessment: Biodiversity in the Everglades, #3, #4, #5, 230-231 Chapter 7 Assessment, #33, #39, 233-234 Performance-Based Assessment: Design a Rooftop Garden, #3, 792-793 Case Study Wrap-Up: How do animal processes and human activity affect the environment?, #2, 858-859 Performance-Based Assessment: Design a Zoo Exhibit, #5, #6, 862-863 Digital Resources: Chapter 7: Humans and Global Change >Lesson 1: Ecological Footprints>Argument-Based Inquiry: Calculating Ecological Footprint >Lesson 3: Measuring and Responding to Change>Science Skills Worksheet: Plan an Urban Tree Planting >Lesson 4: Sustainability>Science Skills Worksheet: Biogas Farming
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. (HS-LS2-7)	SE/TE: Succession After Human-Caused Disturbances, 185 Lesson 6.2 Review, #5, 185 Lesson 6.3 Review, #5, 189 Human Causes of Global Change, 206 Fossil Fuels and the Atmosphere, 208-209 Habitat Fragmentation, 213 Invasive Species, 214 Industrial and Agricultural Pollution, 216 Ecological Impacts, 220-221 Lesson 7.3 Review, #2, 222 Performance-Based Assessment: Biodiversity in the Everglades, #2, 230-231 Digital Resources: Chapter 7: Humans and Global Change >Lesson 2: Causes and Effects of Global Change>Interactivity: Human Impact on Ecosystems

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LS4.D: Biodiversity and Humans	
Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (<i>secondary to HS-LS2-7</i>)	SE/TE: Climate Change, 208 Habitat Fragmentation, 213 Invasive Species, 214 Ecological Impacts, 220-221
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. (<i>secondary to HS-LS2-7</i>)	SE/TE: The Anthropocene, 204-205 Human Causes of Global Change, 206 Climate Change, 208 Habitat Loss, Fragmentation, and Restoration, 213 Invasive Species, 214 Pollution, 214 Ecological Impacts, 220-221 Impacts on Human Systems, 221 Sustainable Development, 223 Performance-Based Assessment: Biodiversity in the Everglades, #2, 230-231 Digital Resources: Chapter 7: Humans and Global Change >Lesson 2: Causes and Effects of Global Change>Interactivity: Human Impact on Ecosystems
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. (<i>secondary to HS-LS2-7</i>)	SE/TE: Designing Solutions, 222 Case Study Wrap-Up: How can a rising tide be stopped?, #2, 226-227 Performance-Based Assessment: Biodiversity in the Everglades, #4, 230-231 Performance-Based Assessment: Design a Rooftop Garden, #3, #4, 792-793 Case Study Wrap-Up: How do animal processes and human activity affect the environment?, #2, 858-859 Digital Resources: Chapter 7: Humans and Global Change >Lesson 3: Measuring and Responding to Change>Science Skills Worksheet: Plan an Urban Tree Planting

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Crosscutting Concepts	
Stability and Change	
▪ Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-7)	SE/TE: Performance-Based Assessment: A Tale of Two Countries, China and India, #4, #5, 166-167 Lesson 6.2 Review, #5, 185 Lesson 6.3 Review, #4, 189 Lesson 7.1 Review, #3, 205 Lesson 7.2 Review, #5, 217 Lesson 7.3 Review, #6, 222 Performance-Based Assessment: Biodiversity in the Everglades, #5, 230-231 Chapter 7 Assessment, #36, 234 Digital Resources: Chapter 7: Humans and Global Change >Lesson 1: Ecological Footprints>Argument-Based Inquiry: Calculating Ecological Footprint
Performance Expectation	
HS-LS2-8. Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.	SE/TE: Behavior and Evolution, 822 Social Behavior, 825-826 Communication, 827 Lesson 2.4 Review, #4, #6, 827 Digital Resources: Chapter 24: Animal Evolution, Diversity, and Behavior >Lesson 4: Social Interactions and Group Behavior>Modeling Lab: The Role of Group Behavior
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. (HS-LS2-8)	SE/TE: Lesson 2.4 Review, #6, 827 Digital Resources: Chapter 24: Animal Evolution, Diversity, and Behavior >Lesson 4: Social Interactions and Group Behavior>Modeling Lab: The Role of Group Behavior

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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. (HS-LS2-8)	SE/TE: Social Behavior, 825-826 Lesson 2.4 Review, #4, #6, 827 Digital Resources: Chapter 24: Animal Evolution, Diversity, and Behavior >Lesson 4: Social Interactions and Group Behavior>Modeling Lab: The Role of Group Behavior
Crosscutting Concepts	
Cause and Effect	
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS2-8)	SE/TE: Lesson 2.4 Review, #1, #6, 827 Digital Resources: Chapter 24: Animal Evolution, Diversity, and Behavior >Lesson 4: Social Interactions and Group Behavior>Modeling Lab: The Role of Group Behavior
HS-LS3 Heredity: Inheritance and Variation of Traits	
Performance Expectation	
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.	SE/TE: Eukaryotic Chromosomes, 344 Chromosome Number, 393-394 Phases of Meiosis, 394-395 Comparing Meiosis and Mitosis, 396 Gene Linkage, 398 The Role of DNA, 416 Comparing RNA and DNA, 440-441 Molecular Genetics, 450 Lesson 14.2 Review, #6, 450 Eukaryotic Gene Regulation, 453 Chromosomal Mutations, 459 Transmission of Human Traits, 476-477 From Molecule to Phenotype, 481 Case Study Wrap-Up: DNA – to test or not to test?, #1, 494-495 Performance-Based Assessment: Tracking Royal Blood, #4, 498-499 Lesson 16.3 Review, #5, 523 Digital Resources: Chapter 12: Introduction to Genetics >Lesson 4: Meiosis>Modeling Lab: Make a Model of Meiosis Chapter 13: DNA >Lesson 1: Identifying the Substance of Genes>Forensics Lab: Using DNA to Identify Species

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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. (HS-LS3-1)	SE/TE: Chapter 13 Assessment, #28, 435 Case Study Wrap-Up: DNA – to test or not to test?, #1, 494-495 Chapter 15 Assessment, #30, 501 Digital Resources: Chapter 12: Introduction to Genetics >Lesson 4: Meiosis>Modeling Lab: Make a Model of Meiosis Chapter 13: DNA >Lesson 1: Identifying the Substance of Genes>Forensics Lab: Using DNA to Identify Species
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 to HS-LS3-1)	SE/TE: The Role of DNA, 416 The Role of RNA, 440 Comparing RNA and DNA, 440-441 The Genetic Code, 445 Translation, 447 Chapter 14 Assessment, #34, 470
LS3.A: Inheritance of Traits	
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. (HS-LS3-1)	SE/TE: Chromosomes, 343-344 The Role of RNA, 440 The Genetic Code, 445 Translation, 447 Prokaryotic Gene Regulation, 451 Eukaryotic Gene Regulation, 453 Homeotic Genes, 454-455 Figure 15-16: Functions of Human Genes, 489 The Large and Small of It, 491
Crosscutting Concepts	
Cause and Effect	
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS3-1)	SE/TE: Chapter 15 Assessment, #36, 502

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Performance Expectation	
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.	SE/TE: Replication and Separation of Genetic Material, 396 Lesson 12.4 Review, #7, 399 Eukaryotic DNA Replication, 427 Types of Mutations, 457-459 Effects of Mutations, 459-461 Sources of Genetic Variation, 582-583 Hox Genes and Evolution, 597 Digital Resources: Chapter 12: Introduction to Genetics >Lesson 4: Meiosis>Modeling Lab: A Model of Meiosis Chapter 13: DNA >Lesson 3: DNA Replication>Quick Lab: Modeling DNA Replication Chapter 14: RNA and Protein Synthesis >Lesson 4: Mutations>Modeling Lab: The Effect of Mutations
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. (HS-LS3-2)	SE/TE: Lesson 14.4 Review, #4, 461 Digital Resources: Chapter 13: DNA >Lesson 3: DNA Replication>Quick Lab: Modeling DNA Replication Chapter 14: RNA and Protein Synthesis >Lesson 4: Mutations>Modeling Lab: The Effect of Mutations
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. (HS-LS3-2)	SE/TE: Phases of Meiosis, 394-395 Replication and Separation of Genetic Material, 396 Eukaryotic DNA Replication, 427 Types of Mutations, 457-459 Digital Resources: Chapter 12: Introduction to Genetics >Lesson 4: Meiosis>Modeling Lab: A Model of Meiosis

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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. (HS-LS3-2)	SE/TE: Types of Mutations, 457-459 Mutagens, 460
Crosscutting Concepts	
Cause and Effect	
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS3-2)	SE/TE: Reading Tool, 458 Lesson 14.4 Review, #1, 461 Digital Resources: Chapter 12: Introduction to Genetics >Lesson 4: Meiosis>Modeling Lab: A Model of Meiosis Chapter 13: DNA >Lesson 3: DNA Replication>Quick Lab: Modeling DNA Replication Chapter 14: RNA and Protein Synthesis >Lesson 4: Mutations>Modeling Lab: The Effect of Mutations
Performance Expectation	
HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.	SE/TE: Genes and Alleles, 380 Dominant and Recessive Alleles, 380 Segregation, 381-382 Probability and Heredity, 383-385 Independent Assortment, 387 Lesson 12.2 Review, #4, 388 Beyond Dominant and Recessive Alleles, 389-391 Case Study Wrap-Up: Genetic disorders: understanding the odds, #1, #2, 400-401 Performance-Based Assessment: Growing More and Better Corn, #2, #3, #6, 404-405 Populations and Gene Pools, 581 Single-Gene and Polygenic Traits, 583-584 Figure 18-5: Selection on a Single-Gene Trait, 586 The Hardy-Weinberg Principle, 590 Performance-Based Assessment: When Weeds Fight Back!, #2, 604-605 Digital Resources: Chapter 12: Introduction to Genetics >Lesson 2: Applying Mendel's Principles>Interactivity: Using Punnett Squares Chapter 18: Evolution of Populations >Lesson 2: Evolution as Genetic Change>Quick Lab: Modeling Genetic Drift >Lesson 4: Molecular Evolution>Analyzing Data: Variation of Expressed Traits

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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. (HS-LS3-3)	SE/TE: Figure 12-5: Segregation and Probability: Reason Quantitatively, 384 Lesson 12.2 Review, #4, 388 Case Study Wrap-Up: Genetic disorders: understanding the odds, #1, #2, 400-401 Performance-Based Assessment: Growing More and Better Corn, #3, 404-405 The Hardy-Weinberg Principle, 590 Performance-Based Assessment: When Weeds Fight Back!, #2, 604-605 Digital Resources: Chapter 12: Introduction to Genetics >Lesson 2: Applying Mendel's Principles>Interactivity: Using Punnett Squares Chapter 18: Evolution of Populations >Lesson 2: Evolution as Genetic Change>Quick Lab: Modeling Genetic Drift >Lesson 4: Molecular Evolution>Analyzing Data: Variation of Expressed Traits
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. (HS-LS3-3)	SE/TE: Genes and Alleles, 380 A Summary of Mendel's Principles, 388 Genes and the Environment, 392 Case Study Wrap-Up: Genetic disorders: understanding the odds, #1, #2, 400-401 Performance-Based Assessment: Growing More and Better Corn, #1, 404-405 Digital Resources: Chapter 18: Evolution of Populations >Lesson 4: Molecular Evolution>Analyzing Data: Variation of Expressed Traits

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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). (HS-LS3-3)	SE/TE: Using Segregation to Predict Outcomes, 384 Probabilities Predict Averages, 385 Case Study Wrap-Up: Genetic disorders: understanding the odds, #1, #2, 400-401 Performance-Based Assessment: Growing More and Better Corn, #3, 404-405 Chapter 12 Assessment, #32, 408 The Hardy-Weinberg Principle, 590 Performance-Based Assessment: When Weeds Fight Back!, #2, 604-605 Digital Resources: Chapter 18: Evolution of Populations >Lesson 4: Molecular Evolution>Analyzing Data: Variation of Expressed Traits
HS-LS4 Biological Evolution: Unity and Diversity	
Performance Expectation	
HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.	SE/TE: Observations from the Voyage, 546-548 Biogeography, 560-561 The Age of Earth and Fossils, 561 Comparing Anatomy and Development, 562-564 Reading Check: Summarize, 564 Genetics and Molecular Biology, 564-565 Lesson 17.4 Review, #3, #6, 567 Evolutionary Classification, 619 Cladograms, 620 DNA in Classification, 624-625 Figure 19-12: Tree of Life, 626-627 Case Study Wrap-Up: It's a duck! No, it's a beaver! No, it's a platypus!, #2, 630-631 Performance-Based Assessment: Build a Cladogram, #5, 634-635 Case Study Wrap-Up: How did fossil hunters find Tiktaalik?, #2, 666-667 Digital Resources: Chapter 17: Darwin's Theory of Evolution >Lesson 1: The Voyage of Discovery>Analyzing Data: Darwin's Voyage >Lesson 4: Evidence of Evolution>Exploration Lab: Evidence of Evolution Chapter 19: Biodiversity and Classification >Lesson 2: Modern Evolutionary Classification>Argument-Based Inquiry Lab: Construct a Cladogram

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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). (HS-LS4-1)	SE/TE: Reading Check: Summarize, 564 Chapter 17 Assessment, #40, 576 Digital Resources: Chapter 17: Darwin’s Theory of Evolution >Lesson 4: Evidence of Evolution>Exploration Lab: Evidence of Evolution Chapter 19: Biodiversity and Classification >Lesson 2: Modern Evolutionary Classification>Argument-Based Inquiry Lab: Construct a Cladogram
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. (HS-LS4-1)	SE/TE: Darwin’s Epic Journey, 544-545 Lesson 17.1 Review, #1, 548 Testing Natural Selection, 565-567 New Techniques Suggest New Trees, 625 The Tree of All Life, 626 Digital Resources: Chapter 17: Darwin’s Theory of Evolution >Lesson 4: Evidence of Evolution>Exploration Lab: Evidence of Evolution
Disciplinary Core Ideas	
LS4.A: Evidence of Common Ancestry and Diversity	
Genetic information 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. (HS-LS4-1)	SE/TE: Species Vary Over Time, 547 Comparing Anatomy and Development, 562-564 Genetics and Molecular Biology, 564-565 Genes as Derived Characters, 624 Performance-Based Assessment: Build a Cladogram, #5, 634-635 Case Study Wrap-Up: How did fossil hunters find Tiktaalik?, #2, 666-667 Digital Resources: Chapter 17: Darwin’s Theory of Evolution >Lesson 4: Evidence of Evolution>Exploration Lab: Evidence of Evolution

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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. (HS-LS4-1)	SE/TE: Observations from the Voyage, 546-547 Lesson 17.1 Review, #3, 548 Chapter 17 Assessment, #33, 576 Figure 19-8: Interpreting a Cladogram, 622 Digital Resources: Chapter 17: Darwin’s Theory of Evolution >Lesson 1: The Voyage of Discovery>Analyzing Data: Darwin’s Voyage Chapter 19: Biodiversity and Classification >Lesson 2: Modern Evolutionary Classification>Science Skills Worksheet: Shark Classification;>Argument-Based Inquiry Lab: Construct a Cladogram
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. (HS-LS4-1)	SE/TE: An Ancient, Changing Earth, 549-550
Performance Expectation	
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.	SE/TE: Evolution by Natural Selection, 555-557 Lesson 17.3 Review, #3, 559 Natural Selection, 567 Performance-Based Assessment: Evolution in Action: Beak Size Among Darwin’s Finches, #3, 572-573
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. (HS-LS4-2)	SE/TE: Performance-Based Assessment: Evolution in Action: Beak Size Among Darwin’s Finches, #3, 572-573

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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. (HS-LS4-2)	SE/TE: Variation and Adaptation, 556 Survival of the Fittest, 556 Natural Selection, 557 Lesson 17.3 Review, #1, 559 Digital Resources: Chapter 17: Darwin’s Theory of Evolution >Lesson 3: Darwin’s Theory: Natural Selection>Interactivity: Discovering Natural Selection
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. (HS-LS4-2)	SE/TE: Evolution by Natural Selection, 555-557 Performance-Based Assessment: Evolution in Action: Beak Size Among Darwin’s Finches, #3, 572-573
Crosscutting Concepts	
Cause and Effect	
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-2)	SE/TE: Case Study Wrap-Up: Lizards, Legs, and the Diversity of Life, #1, 568-569 Performance-Based Assessment: Evolution in Action: Beak Size Among Darwin’s Finches, #3, 572-573 Chapter 17 Assessment, #34, 576
Performance Expectation	
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.	SE/TE: Natural Selection, 557 How Natural Selection Works, 585-587 Case Study Wrap-Up: How can antibiotics keep up with drug-resistant bacteria?, #2, 600-601 Performance-Based Assessment, #2, 604-605 Chapter 18 Assessment, #33, 607 Digital Resources: Chapter 18: Evolution of Populations >Lesson 2: Evolution as Genetic Change>Interactivity: Genetic Change

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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. (HS-LS4-3)	SE/TE: Performance-Based Assessment, #2, 604-605
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.(HS-LS4-3)	SE/TE: Variation and Adaptation, 556 Survival of the Fittest, 556 Natural Selection, 557 Lesson 17.3 Review, #1, 559 How Natural Selection Works, 585-587 Lesson 18.2 Review, #6, 591
▪ The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-3)	SE/TE: Natural Selection, 557 How Natural Selection Works, 585 Case Study Wrap-Up: How can antibiotics keep up with drug-resistant bacteria?, #2, 600-601 Chapter 18 Assessment, #33, 607 Digital Resources: Chapter 18: Evolution of Populations >Lesson 2: Evolution as Genetic Change>Interactivity: Genetic Change
Performance Expectation	
HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.	SE/TE: Evolution by Natural Selection, 555-557 Common Ancestry, 558 Lesson 17.3 Review, #4, 559 Speciation in Darwin’s Finches, 594-595 Lesson 18.3 Review, #3, 595 Case Study Wrap-Up: How can antibiotics keep up with drug-resistant bacteria?, #2, 600-601 Digital Resources: Chapter 18: Evolution of Populations >Lesson 3: The Process of Speciation>Modeling Lab: Competing for Resources

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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. (HS-LS4-4)	SE/TE: Case Study Wrap-Up: How can antibiotics keep up with drug-resistant bacteria?, #2, 600-601 Digital Resources: Chapter 18: Evolution of Populations >Lesson 3: The Process of Speciation>Modeling Lab: Competing for Resources
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. (HS-LS4-4)	SE/TE: Variation and Adaptation, 556 Survival of the Fittest, 556 Natural Selection, 557 Common Ancestry, 558 Geographic Isolation, 594 Changes in Gene Pools, 594 Digital Resources: Chapter 17: Darwin's Theory of Evolution >Lesson 3: Darwin's Theory: Natural Selection>Simulation: Bird Beaks Chapter 18: Evolution of Populations >Lesson 3: The Process of Speciation>Modeling Lab: Competing for Resources
Crosscutting Concepts	
Cause and Effect	
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-4)	SE/TE: Lesson 18.3 Review, #3, 595 Digital Resources: Chapter 18: Evolution of Populations >Lesson 3: The Process of Speciation>Modeling Lab: Competing for Resources
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. (HS-LS4-4)	SE/TE: Darwin's Epic Journey, 544-545 Common Ancestry, 558 Competition and Continued Evolution, 595

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Performance Expectation	
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.	SE/TE: Speciation and Extinction, 652-654 Macroevolutionary Patterns, 657 Lesson 20.2 Review, #5, 658 Performance-Based Assessment: Evaluating Evidence from the K-T Boundary, #3, 670-671 Digital Resources: Chapter 20: History of Life >Lesson 2: Evolutionary Patterns and Processes>Analyzing Data: Extinctions Through Time
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. (HS-LS4-5)	SE/TE: Performance-Based Assessment: Evaluating Evidence from the K-T Boundary, #3, 670-671
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. (HS-LS4-5)	SE/TE: Adaptation and Extinction, 653 Patterns of Extinction, 654 Adaptive Radiation, 657 Lesson 20.2 Review, #5, 658 Digital Resources: Chapter 20: History of Life >Lesson 2: Evolutionary Patterns and Processes>Analyzing Data: Extinctions Through Time
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. (HS-LS4-5)	SE/TE: Adaptation and Extinction, 653 Patterns of Extinction, 654
Crosscutting Concepts	
Cause and Effect	
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-5)	SE/TE: Performance-Based Assessment: Evaluating Evidence from the K-T Boundary, #4, 670-671 Chapter 20 Assessment, #32, 674 Digital Resources: Chapter 20: History of Life >Lesson 2: Evolutionary Patterns and Processes>Analyzing Data: Extinctions Through Time

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Performance Expectation	
HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*	SE/TE: Types of Biodiversity, 186 Biodiversity Benefits, 187 Figure 6-11, 187 Ecosystem Services and Biodiversity, 188 Figure 6-12, 189 Lesson 6.3 Review #5, 189 Human Causes of Global Change, 206-207 Changes in Land Use, 210-214 Pollution, 214-216 Lesson 7.2 Review, 217 Digital Resources: Chapter 7: Humans and Global Change >Lesson 2: Causes and Effects of Global Change> Interactivity: Human Impacts on Ecosystems; Quick Lab: Does Acid Affect Shells? >EJ-PBL Science Skills Activity & Worksheet: Controlling Invasives
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. (HS-LS4-6)	Digital Resources: Chapter 7: Humans and Global Change >Lesson 2: Causes and Effects of Global Change> Interactivity: Human Impacts on Ecosystems; Quick Lab: Does Acid Affect Shells? >EJ-PBL Science Skills Activity & Worksheet: Controlling Invasives
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. (HS-LS4-6)	SE/TE: Human Causes of Global Change, 206-207 Changes in Land Use, 210-214 Pollution, 214-216 Lesson 7.2 Review, 217 Digital Resources: Chapter 7: Humans and Global Change >Lesson 2: Causes and Effects of Global Change> Interactivity: Human Impacts on Ecosystems; Quick Lab: Does Acid Affect Shells? >EJ-PBL Science Skills Activity & Worksheet: Controlling Invasives

* The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

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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. (HS-LS4-6)	
Crosscutting Concepts Cause and Effect Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-6)	
High School Earth and Space Sciences	
HS-ESS1 Earth's Place in the Universe	
Performance Expectation	
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.	SE/TE: The Age of Earth and Fossils, 561 Dating Earth's History, 644-646 Divisions of the Geologic Time Scale, 646 Geologic Forces, 649 Lesson 20.1 Review, #5, 651 Digital Resources: Chapter 20: History of Life >Lesson 1: The Fossil Record>EJ-PBL Science Skills Worksheet: Radiometric Dating

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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. (HS-ESS1-5)	SE/TE: Lesson 20.1 Review, #5, 651
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. (HS-ESS1-5)	SE/TE: The Age of Earth, 561 Divisions of the Geologic Time Scale, 646
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. (<i>secondary to HS-ESS1-5</i>)	SE/TE: Geologic Forces, 649 Effects on Life, 650 Lesson 20.1 Review, #6, 651
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. (<i>secondary to HS-ESS1-5</i>)	SE/TE: Radiometric Dating, 644-645 Digital Resources: Chapter 20: History of Life >Lesson 1: The Fossil Record>Quick Lab: How Can You Model Half-Life?;>EJ-PBL Science Skills Worksheet: Radiometric Dating
Crosscutting Concepts	
Patterns	
Empirical evidence is needed to identify patterns. (HS-ESS1-5)	SE/TE: Relative Dating, 644
Performance Expectation	
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.	SE/TE: Evaluating Evidence in the Fossil Record, 643 Biological Forces, 651 Mysteries of Life's Origins, 659-662 Origin of the Eukaryotic Cell, 662-665 Lesson 20.3 Review, #5, 665 Chapter 20 Assessment, #24, #25, 673 Digital Resources: Chapter 20: History of Life >Lesson 3: Earth's Early History>Argument-Based Inquiry: Modeling Coacervates

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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. (HS-ESS1-6)	SE/TE: Lesson 20.3 Review, #5, 665 Digital Resources: Chapter 20: History of Life >Lesson 3: Earth's Early History>Argument-Based Inquiry: Modeling Coacervates
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. (HS-ESS1-6)	SE/TE: The Earliest Eukaryotes, 662-663 Lesson 20.3 Review, #3, 665
▪ Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6)	SE/TE: The Earliest Eukaryotes, 662-663 Lesson 20.3 Review, #6, 665
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. (HS-ESS1-6)	SE/TE: Evaluating Evidence in the Fossil Record, 643 Mysteries of Life's Origins, 659 Organic Molecules in Space, 659 The Miller-Urey Experiment, 660
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. (<i>secondary to HS-ESS1-6</i>)	SE/TE: Radiometric Dating, 644-645
Crosscutting Concepts	
Stability and Change	
▪ Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6)	SE/TE: Reading Check: Summarize, 662 Lesson 20.3 Review, #4, 665 Chapter 20 Assessment, #25, 673 Digital Resources: Chapter 20: History of Life >Lesson 3: Earth's Early History>Argument-Based Inquiry: Modeling Coacervates

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HS-ESS2 Earth's Systems	
Performance Expectation	
HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.	SE/TE: Special Properties of Water, 48 Acids, Bases, and pH, 50-51 Case Study: How can a rising tide be stopped?, 201 Case Study Wrap-Up: How can a rising tide be stopped?, 226 Digital Resources: Chapter 2: The Chemistry of Life >Lesson 2: Properties of Water >Interactivity: Unique Properties of Water
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. (HS-ESS2-5)	For supporting content, please see: Digital Resources: Chapter 2: The Chemistry of Life >Lesson 2: Properties of Water >Interactivity: Unique Properties of Water
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. (HS-ESS2-5)	For supporting content, please see: SE/TE: The Water Molecule, 47 Special Properties of Water, 48 Acids, Bases, and pH, 50-51 Digital Resources: Chapter 2: The Chemistry of Life >Lesson 2: Properties of Water >Interactivity: Unique Properties of Water
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. (HS-ESS2-5)	SE/TE: The Water Molecule, 47 Special Properties of Water, 48 Acids, Bases, and pH, 50-51

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Performance Expectation	
HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.	SE/TE: Recycling in Nature, 123 The Carbon Cycle, 126-128 Figure 4-11: The Carbon Cycle, 127 Lesson 4.3 Review: Questions #5 & #7, 131 Performance-Based Assessment: Can Algal Blooms Be Useful? 136-136
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. (HS-ESS2-6)	SE/TE: Figure 4-11: The Carbon Cycle, 127 Figure 4-12: Atmospheric Carbon Dioxide Concentrations, 128 Lesson 4.3 Review: Questions #5 & #7, 131 Performance-Based Assessment: Can Algal Blooms Be Useful? 136-136 End-of Course Practice, 141
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. (HS-ESS2-6)	SE/TE: Biological Processes, 126 Figure 4-12: Atmospheric Carbon Dioxide Concentrations, 128
Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6)	SE/TE: Human Activity, 128 Figure 4-12: Atmospheric Carbon Dioxide Concentrations, 128
Crosscutting Concepts	
Energy and Matter	
The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6)	SE/TE: Recycling in Nature, 123 The Carbon Cycle, 126-128 Figure 4-11: The Carbon Cycle, 127 Assessment, #33, 141
Performance Expectation	
HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.	SE/TE: Effects on Life, 650 Biological Forces, 651 Lesson 20.1 Review, #4, 651 Chapter 20 Assessment, #25, 673

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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 counterarguments based on data and evidence. (HS-ESS2-7)	SE/TE: Lesson 20.1 Review, #4, 651
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. (HS-ESS2-7)	SE/TE: Biological Forces, 651 Chapter 20 Assessment, #25, 673
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. (HS-ESS2-7)	SE/TE: Effects on Life, 650 Biological Forces, 651
Crosscutting Concepts	
Stability and Change	
Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7)	SE/TE: Lesson 20.1 Review, #4, 651 Chapter 20 Assessment, #25, 673
HS-ESS3 Earth and Human Activity	
Performance Expectation	
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.	SE/TE: Case Study: What can we learn from China?, 143 Limiting Factors, 152 Human Population Growth: Historical Overview, 158-159 Patterns of Human Population Growth, 160-161 Case-Study Wrap-Up: What can we learn from China?, 162 Performance-Based Assessment: A Tale of Two Countries: China and India, 166-167 The Age of Humans, 204-205 Digital Resources: Chapter 5: Populations >Lesson 3: Human Population Growth >Quick Lab: Modeling Population Changes

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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. (HS-ESS3-1)	SE/TE: Performance-Based Assessment: A Tale of Two Countries: China and India, 166-167 Digital Resources: Chapter 5: Populations >Lesson 3: Human Population Growth >Quick Lab: Modeling Population Changes; >Interactivity: Human Population Growth; >Simulation: Investigate Population Growth Rates
Disciplinary Core Ideas	
ESS3.A: Natural Resources	
Resource availability has guided the development of human society. (HS-ESS3-1)	For supporting content, please see: SE/TE: Limiting Factors, 152 Human Population Growth: Historical Overview, 158-159 Patterns of Human Population Growth, 160-161 Case-Study Wrap-Up: What can we learn from China?, 162
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. (HS-ESS3-1)	For related content, please see: SE/TE: Limiting Factors, 152 Case Study: How can a rising tide be stopped?, 201, 226
Crosscutting Concepts	
Cause and Effect	
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1)	SE/TE: Performance-Based Assessment: A Tale of Two Countries: China and India, 166-167 Digital Resources: Chapter 5: Populations >Lesson 3: Human Population Growth >Quick Lab: Modeling Population Changes
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. (HS-ESS3-1)	SE/TE: Performance-Based Assessment: A Tale of Two Countries: China and India, 166-167 Case-Study Wrap-Up: What can we learn from China, 162

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Performance Expectation	
HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*	SE/TE: Case Study Wrap-Up: What can we learn from China?, #2, 162-163 Chapter 6 Assessment, #23, 197 Lesson 7.2 Review, #6, 217 Case Study Wrap-Up: How can a rising tide be stopped?, #2, 226-227 Performance-Based Assessment: Biodiversity in the Everglades, #3, #4, #5, 230-231 Chapter 7 Assessment, #38, #39, #43, 234
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. (HS-ESS3-4)	SE/TE: Chapter 6 Assessment, #23, 197 Lesson 7.2 Review, #6, 217 Designing Solutions, 222 Case Study Wrap-Up: How can a rising tide be stopped?, #2, 226-227 Performance-Based Assessment: Biodiversity in the Everglades, #3, #5, 230-231 Chapter 7 Assessment, #39, 234
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. (HS-ESS3-4)	SE/TE: Environmental Successes, 222 Chapter 7 Assessment, #43, 234
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. (<i>secondary HS-ESS3-4</i>)	SE/TE: Case Study Wrap-Up: What can we learn from China?, #2, 162-163 Case Study Wrap-Up: How can a rising tide be stopped?, #2, 226-227 Performance-Based Assessment: Biodiversity in the Everglades, #4, 230-231
Crosscutting Concepts	
Stability and Change	
Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)	SE/TE: Human Causes of Global Change, 206 Fossil Fuels and the Atmosphere, 208-209 Deforestation, 210 Habitat Fragmentation, 213

* The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

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Connections to Engineering, Technology, and Applications of Science	
Influence of Engineering, Technology, and Science on Society and the Natural World	
Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-ESS3-4)	SE/TE: Case Study Wrap-Up: How can a rising tide be stopped?, #2, 226-227 Performance-Based Assessment: Biodiversity in the Everglades, #5, 230-231
Performance Expectation	
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's systems.	SE/TE: Climate Change: The Data, 218-219 Figure 7-18: IPCC Data, 219 Climate Change Impacts, 220-221 Figure 7-19: Increasing Temperatures, 220 Case Study: Analyzing Data Evidence in Ice, 221 Designing Solutions, 222 Digital Resources: Chapter 7: Humans and Global Change >Lesson 3: Measuring and Responding to Change >Discussion Board: Results of Climate Change; >Case Study: Analyzing Data Evidence in Ice; >Interactivity: Identifying Impact of Climate Change; >Editable Presentation: Measuring and Responding to Change
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. (HS-ESS3-5)	SE/TE: Figure 7-18: IPCC Data, 219 Figure 7-19: Increasing Temperatures, 220 Case Study: Analyzing Data Evidence in Ice, 221 Digital Resources: Chapter 7: Humans and Global Change >Lesson 3: Measuring and Responding to Change >Case Study: Analyzing Data Evidence in Ice; >Interactivity: Identifying Impact of Climate Change; >Editable Presentation: Measuring and Responding to Change

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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. (HS-ESS3-5)	SE/TE: Climate Change: The Data, 218-219 Figure 7-18: IPCC Data, 219 Climate Change Impacts, 220-221 Figure 7-19: Increasing Temperatures, 220 Performance-Based Assessment: Biodiversity in the Everglades, 230 Digital Resources: Chapter 7: Humans and Global Change >Lesson 3: Measuring and Responding to Change >Case Study: Analyzing Data Evidence in Ice; >Interactivity: Identifying Impact of Climate Change; > Editable Presentation: Measuring and Responding to Change
New technologies advance scientific knowledge. (HS-ESS3-5)	SE/TE: Climate Change: The Data, 218-219 Figure 7-18: IPCC Data, 219 Climate Change Impacts, 220-221 Figure 7-19: Increasing Temperatures, 220 Performance-Based Assessment: Biodiversity in the Everglades, 230 Digital Resources: Chapter 7: Humans and Global Change >Lesson 3: Measuring and Responding to Change >Case Study: Analyzing Data Evidence in Ice; >Interactivity: Identifying Impact of Climate Change; > Editable Presentation: Measuring and Responding to Change
Scientific Knowledge is Based on Empirical Evidence	
Science knowledge is based on empirical evidence. (HS-ESS3-5)	SE/TE: Climate Change: The Data, 218-219 Figure 7-18: IPCC Data, 219 Climate Change Impacts, 220-221 Figure 7-19: Increasing Temperatures, 220 Case Study: Analyzing Data Evidence in Ice, 221 Digital Resources: Chapter 7: Humans and Global Change >Lesson 3: Measuring and Responding to Change >Case Study: Analyzing Data Evidence in Ice; >Interactivity: Identifying Impact of Climate Change

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Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS3-5)	SE/TE: Climate Change: The Data, 218-219 Figure 7-18: IPCC Data, 219 Climate Change Impacts, 220-221 Figure 7-19: Increasing Temperatures, 220 Case Study: Analyzing Data Evidence in Ice, 221 Digital Resources: Chapter 7: Humans and Global Change >Lesson 3: Measuring and Responding to Change >Case Study: Analyzing Data Evidence in Ice; >Interactivity: Identifying Impact of Climate Change
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. (HS-ESS3-5)	SE/TE: Figure 7-18: IPCC Data, 219 Figure 7-19: Increasing Temperatures, 220 Case Study: Analyzing Data Evidence in Ice, 221 Designing Solutions, 222 Sustainable Development, 223-225 Performance-Based Assessment: Biodiversity in the Everglades, 230 Digital Resources: Chapter 7: Humans and Global Change >Lesson 3: Measuring and Responding to Change >Case Study: Analyzing Data Evidence in Ice; >Interactivity: Identifying Impact of Climate Change; > Editable Presentation: Measuring and Responding to Change
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. (HS-ESS3-5)	SE/TE: Figure 7-18: IPCC Data, 219 Climate Change Impacts, 220-221 Figure 7-19: Increasing Temperatures, 220 Case Study: Analyzing Data Evidence in Ice, 221 Digital Resources: Chapter 7: Humans and Global Change >Lesson 3: Measuring and Responding to Change >Case Study: Analyzing Data Evidence in Ice; >Interactivity: Identifying Impact of Climate Change

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Performance Expectation	
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.	SE/TE: Modeling Global Systems, 82-84 Lesson 3.1 Review, #6, 84 The Global Climate System, 86-88 Ocean Currents, 88-89 Changes in Climate, 90 Human Causes of Global Change, 206 Fossil Fuels and the Atmosphere, 208-209 Deforestation, 210 Development/Urbanization, 212 Lesson 7.2 Review, #3, #5, 217 Modeling With Data, 219 Climate Change Impacts, 220-221 Chapter 7 Assessment, #31, 233-234
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. (HS-ESS3-6)	SE/TE: Modeling With Data, 219 Chapter 7 Assessment, #31, 233
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 to HS-ESS3-6)	SE/TE: Fossil Fuels and the Atmosphere, 208-209 Modeling With Data, 219 Lesson 7.3 Review, #4, 222
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. (HS-ESS3-6)	SE/TE: Modeling, 80 Modeling With Data, 219
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. (HS-ESS3-6)	SE/TE: Lesson 3.1 Review, #6, 84 Chapter 7 Assessment, #35, 234

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High School Engineering Design			
Engineering, Science, and the Application of Technology			
Performance Expectation			
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.		SE/TE: Case Study Wrap-Up: What would it take to make an artificial leaf?, #2, 298-299 Performance-Based Assessment: Data From the Corn Field, #3, 302-303	
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. (HS-ETS1-1)		SE/TE: Case Study Wrap-Up: What would it take to make an artificial leaf?, #2, 298-299 Performance-Based Assessment: Data From the Corn Field, #3, 302-303	
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. (HS-ETS1-1)		SE/TE: Case Study Wrap-Up: What would it take to make an artificial leaf?, #2, 298-299 Performance-Based Assessment: Data From the Corn Field, #3, 302-303	
▪ 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. (HS-ETS1-1)		SE/TE: Case Study Wrap-Up: What would it take to make an artificial leaf?, #1, 298-299 Performance-Based Assessment: Data From the Corn Field, #3, 302-303	
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. (HS-ETS1-1)		SE/TE: Case Study Wrap-Up: What would it take to make an artificial leaf?, #2, 298-299	

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Performance Expectation	
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.	SE/TE: Performance-Based Assessment: Investigating Hydroponics, 34-35 Case Study: Something is missing. But what?, 41, 62 Case Study: Can we make a working model of our living planet?, 77, 102 Case Study: Preventing the next epidemic, 681, 710 Performance-Based Assessment: Cholera in Haiti, 714-715 Performance-Based Assessment: Design a Zoo Exhibit, 862-863 Digital Resources: Chapter 4: Ecosystems >Lesson 3: Cycles of Matter>Exploration Lab: The Effect of Fertilizer on Algae
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. (HS-ETS1-2)	SE/TE: Case Study: Can we make a working model of our living planet?, 77, 102 Case Study: Preventing the next epidemic, 681, 710- Performance-Based Assessment: Cholera in Haiti, 714-715 Performance-Based Assessment: Design a Zoo Exhibit, 862-863 Digital Resources: Chapter 4: Ecosystems >Lesson 3: Cycles of Matter>Exploration Lab: The Effect of Fertilizer on Algae

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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. (HS-ETS1-2)	Performance-Based Assessment: Investigating Hydroponics, 34-35 Case Study: Something is missing. But what?, 41, 62 Case Study: Can we make a working model of our living planet?, 77, 102 Case Study: Preventing the next epidemic, 681, 710 Performance-Based Assessment: Cholera in Haiti, 714-715 Performance-Based Assessment: Design a Zoo Exhibit, 862-863 Digital Resources: Chapter 4: Ecosystems >Lesson 3: Cycles of Matter>Exploration Lab: The Effect of Fertilizer on Algae
Performance Expectation	
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.	SE/TE: Performance-Based Assessment: A New Kind of Drug: mRNA, #2, 466-467
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. (HS-ETS1-3)	SE/TE: Performance-Based Assessment: A New Kind of Drug: mRNA, #2, 466-467
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. (HS-ETS1-3)	SE/TE: Performance-Based Assessment: A New Kind of Drug: mRNA, #2, 466-467
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. (HS-ETS1-3)	SE/TE: Performance-Based Assessment: A New Kind of Drug: mRNA, #2, 466-467

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Performance Expectation	
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.	For supporting content, please see: SE/TE: Case Study: Biology and Technology Solve Problems, 7, 31 Performance-Based Assessment: Investigating Hydroponics, 34-35 Case Study: Can we make a working model of our living planet?, 77, 102 Performance-Based Assessment: Can Algal Blooms be Useful?, 136-137 Performance-Based Assessment: Using Cells to Clean up Pollution, 274-275 Performance-Based Assessment: A New Kind of Drug: mRNA, 466-467 Case Study: Preventing the next epidemic, 681, 710 Performance-Based Assessment: Cholera in Haiti, 714-715 Performance-Based Assessment: Design A Model of Interacting Systems, 896-897 Case Study: What's wrong with the water?, 903, 944
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. (HS-ETS1-4)	SE/TE: Performance-Based Assessment: Design A Model of Interacting Systems, 896-897
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. (HS-ETS1-4)	SE/TE: Case Study: Biology and Technology Solve Problems, 7, 31 Analyzing DNA, 509-510 CRISPR and DNA Editing, 512-513
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. (HS-ETS1-4)	For supporting content, please see: SE/TE: Case Study: Biology and Technology Solve Problems, 7, 31 Performance-Based Assessment: Design A Model of Interacting Systems, 896-897