Audubon Public Schools

Environmental Science

Curriculum Guide

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Course Description

Grade 9: Environmental Science

All freshmen with the exception of Honors students will be required to take Environmental Science.The goal of Environmental Science is to provide students with the scientific principles, concepts, and methodologies required to understand the interrelationships of the natural world, to identify and analyze environmental problems both natural and human-made, to evaluate the relative risks associated with these problems, and to examine alternative solutions for resolving and/or preventing them. Environmental Science is interdisciplinary; it embraces a wide variety of topics from different areas of study. Units covered in this class include: I. Earth Systems and Human Population, II. Ecology and Biodiversity, III. Land Use, Soil, and Agriculture, IV. Water Resources, V. Atmosphere, Weather, Climate, and Climate Change, and VI. Energy and Waste Management.

Throughout the course, attention will be drawn to how humans are affecting the Earth around us, both positively and negatively. Through class activities that encourage problem solving, discussion, research and cooperative activities, students will further develop and expand their skills in critical thinking and decision-making.

Overview / Progressions

Grade 9: Environmental Science

Overview		Earth and Space Sciences	Life Sciences	Physical Sciences
Unit 1	**Focus standards (Objectives)**	ESS2.A ESS3.A ESS3.C ETS1.B ETS1.C	none	none
Unit 2	**Focus standards (Objectives)**	ESS3.C	LS1.C LS2.A LS2.B LS2.C	PS3.B PS3.D
Unit 3	**Focus standards (Objectives)**	ESS3.C	LS4.B LS4.C LS4.D	none
Unit 4	**Focus standards (Objectives)**	ESS2.A ESS2.C ESS2.D ESS2.E ESS3.A, ESS3.B ESS3.C	none	none

Unit 5	**Focus standards (Objectives)**	ESS1.B ESS2.A ESS3.A ESS3.C ESS3.D	none	none
Unit 6	**Focus standards (Objectives)**	ESS3.A ETS1.B	none	PS3.A

Environmental Science	**Grade 9**	**Unit 1**	**Marking Period 1 (first 3 weeks)**

Environmental Science Unit 1-Science as a Process; Principles for Studying Our Environment: (15 Instructional Days)
In this introductory unit of the course students will begin to develop the scientific tools and understandings needed to study the Environment. Students are introduced to the ways that human activities affect Earth's systems. Students begin to use practices to understand the significant and complex issues surrounding human uses of land, energy, mineral, air, and water resources and the resulting impacts on the development of these resources. A central question is whether overpopulation is the root cause of many of the environmental problems we face today and what role does the overuse of natural resources play.

In this unit of study students are expected to demonstrate the ability to analyze and interpret data and design solutions. Students are also expected to use these practices to demonstrate understanding of the core ideas.

Overarching Essential Questions	**Overarching Enduring Understandings**
• How does science help us to understand the natural world? • How do scientists uncover, research and solve environmental problems? • How does the human population affect the environment?	• We can use science to study and understand the complex interactions between humans and our environment.

• How can we best balance our own needs and interests with the health of the environment?	• Technological advances have greatly changed the way we all live and has triggered a remarkable and unprecedented increase in our population size. • Humans impact the global environment more than any other species.
Student Learning Objectives	
Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.	**HS-ESS2-2**
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.	**HS-ESS3-1**
Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.	**HS-ESS3-2**
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	**MS-ESS3-3**
Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.	**MS-ESS3-4**
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	**HS-ETS1-2**

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
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. **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	**ESS3.A: Natural Resources** • All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **ESS2.A: Earth Materials and Systems** • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes **ESS3.C: Human Impacts on Earth Systems** • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	**Stability and Change** • Feedback (negative or positive) can stabilize or destabilize a system. **Influence of Engineering, Technology, and Science on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. **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.

based on mathematical models of basic assumptions. **<u>Constructing Explanations and Designing Solutions</u>** • Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. **<u>Analyzing and Interpreting Data</u>** • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	**<u>ETS1.B: Developing Possible Solutions</u>** • 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. **<u>ETS1.C: Optimizing the Design Solution</u>** • 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.	

Embedded English Language Arts/Literacy and Mathematics

English Language Arts/Literacy –

- Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
- Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks attending to special cases or exceptions defined in the text.
- Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.
- Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
- Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Mathematics –

- Use abstract and quantitative reasoning to analyze and interpret data in order to determine similarities and differences in findings of how well designed methods meet the criteria and constraints of solutions that could reduce a human impact on the environment.
- Understand the concept of a ratio and use ratio language to describe a ratio relationship between human impacts on environments and the impact of methods to minimize these impacts.
- Use variables to represent quantities when analyzing and interpreting data to determine how well designed methods meet the criteria and constraints of solutions that could reduce a human impact on the environment and construct simple equations and inequalities to solve problems by reasoning about the quantities.
- While analyzing data to determine how well designed methods meet the criteria and constraints of solutions that could reduce a human impact on the environment, solve multi step mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; covert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

- Use variables to represent numbers and write expressions for how the uneven distributions of Earth’s mineral, energy, and groundwater resources are the result of past and current geosciences processes. Convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
- Use variables to represent quantities for how the distribution of Earth’s mineral, energy, and groundwater resources are significantly changing as a result of removal by humans. Construct simple equations and inequalities to solve problems by reasoning about the quantities.

Three-Dimensional Teaching and Learning
With this introductory unit, students will begin by building on their prior knowledge that human activities affect the Earth. Students will describe how human activities have positive as well as negative impacts on land, ocean, atmosphere, and biosphere resources. Students will perform investigations to gather data showing how human populations impact our environment by using natural resources. Students will investigate the impact human population growth is having on our natural resources and look at comparing resource use among different parts of the world. Emphasis is on how natural resources, including land, ocean, atmosphere, biosphere, mineral, and fresh water, are limited and typically are nonrenewable, and how their distributions are significantly changing as a result of removal by humans. Students will use variables to represent quantities and construct simple equations and inequalities to solve problems by reasoning about the quantities. Students may use maps showing the current global distribution of different resources along with maps showing past global distribution of the same resources to gather data. Students could use these data to create mathematical expressions that could show the impact of current human consumption on possible future resource distribution (renewable and nonrenewable energy resources). In addition, students could use maps of different geosciences processes alongside other data to explain the uneven distributions of Earth’s resources.

Students will analyze maps, charts, and images of how natural resources are used and to differentiate nonrenewable and renewable resources.

Prior Learning
• Energy that humans use is derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. • A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). • Humans cannot eliminate environmental hazards but can take steps to reduce their impacts. • Populations live in a variety of habitats, and change in those habitats affects the organisms living there. • Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

- **Part A: How does science help us to understand the natural world?**

Concepts	Formative Assessment
• Environmental Scientists study how the natural world works, and how humans and the environment affect each other. • Science is both an organized and methodical way to study the natural world and the knowledge gained from such studies. • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by	*Students who understand the concepts are able to:* • Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

differences in such factors as climate, natural resources, and economic conditions.	

Part B: How do scientists uncover, research and solve environmental problems?

Concepts	Formative Assessment
• Cause and effect relationships may be used to predict how increases in human population and per-capita consumption of natural resources impact Earth's systems. • The consequences of increases in human populations and consumption of natural resources are described by science. • Science does not make the decisions for the actions society takes. • Scientific knowledge can describe the consequences of human population and per-capita consumption of natural resources impact Earth's systems but does not necessarily prescribe the decisions that society takes.	*Students who understand the concepts are able to:* • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. • Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Part C: How does the human population affect the environment?

Concepts	Formative Assessment
• Increases in human population and per-capita consumption of natural resources impact Earth's systems. • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	*Students who understand the concepts are able to:* • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

• Cause and effect relationships may be used to predict how increases in human population and per-capita consumption of natural resources impact Earth's systems. • The consequences of increases in human populations and consumption of natural resources are described by science. • Science does not make the decisions for the actions society takes. • Scientific knowledge can describe the consequences of human population and per-capita consumption of natural resources impact Earth's systems but does not necessarily prescribe the decisions that society takes.	• Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. • Ask questions to identify and clarify a variety of evidence for an argument about the factors that have caused human impact on our environment. • Ask questions to clarify human activities impact on natural processes and natural resources.

Part D: How can we best balance our own needs and interests with the health of the environment?	
Concepts	**Formative Assessment**
• The consequences of increases in human populations and consumption of natural resources are described by science. • Science does not make the decisions for the actions society takes, but can guide solutions. • Scientific knowledge can describe the consequences of human population and per-capita consumption of natural resources impact Earth's systems but does not necessarily prescribe the decisions that society takes.	*Students who understand the concepts are able to:* • Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. • Use cost-benefit analysis to identify possible solutions.

Modifications:
- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.   - Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).   - Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, Google Meet, experts from the community helping with a project, journal articles, and biographies).   - Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).   - Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.   - Use project-based science learning to connect science with observable phenomena.   - Structure the learning around explaining or solving a social or community-based issue.   - Provide ELL students with multiple literacy strategies.

Leveraging English Language Arts/Literacy and Mathematics
English Language Arts/Literacy –

- Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
- Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks attending to special cases or exceptions defined in the text.
- Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.
- Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
- Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Mathematics –

- Use abstract and quantitative reasoning to analyze and interpret data in order to determine similarities and differences in findings of how well designed methods meet the criteria and constraints of solutions that could reduce a human impact on the environment.
- Understand the concept of a ratio and use ratio language to describe a ratio relationship between human impacts on environments and the impact of methods to minimize these impacts.
- Use variables to represent quantities when analyzing and interpreting data to determine how well designed methods meet the criteria and constraints of solutions that could reduce a human impact on the environment and construct simple equations and inequalities to solve problems by reasoning about the quantities.
- While analyzing data to determine how well designed methods meet the criteria and constraints of solutions that could reduce a human impact on the environment, solve multi-step mathematical problems posed with positive and negative rational numbers in

any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; covert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

- Use variables to represent numbers and write expressions for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geosciences processes. Convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Samples of Open Education Resources for this unit:

USGS Educational Resources for Secondary Grades (7–12): This web site contains selected USGS educational resources that may be useful to educators in secondary school grades. Many of these resources can be used directly in the classroom or will be useful in classroom lessons or demonstration activities preparation, or as resources for teacher education and curriculum development.

NOAA Education Resources: This website contains access to curriculum resources, professional development opportunities, student opportunities, and outreach events.

Online Textbook: Environmental Science: Your World Your Turn: This is the online version of the textbook for this class.

National Center for Case Study Teaching In Science: This is a great resource when using case studies to highlight important concepts.

Differentiation

504	• preferential seating • extended time on tests and assignments • reduced homework or classwork • verbal, visual, or technology aids	• modified textbooks or audio-video materials • behavior management support • adjusted class schedules or grading • verbal testing
Enrichment	• Utilize collaborative media tools • Provide differentiated feedback • Opportunities for reflection	• Encourage student voice and input • Model close reading • Distinguish long term and short term goals
IEP	• Utilize "skeleton notes" where some required information is already filled in for the student • Provide access to a variety of tools for responses • Provide opportunities to build familiarity and to practice with multiple media tools • Graphic organizers	• Leveled text and activities that adapt as students build skills • Provide multiple means of action and expression • Consider learning styles and interests • Provide differentiated mentors
ELLs	• Pre-teach new vocabulary and meaning of symbols • Embed glossaries or definitions • Provide translations • Connect new vocabulary to background knowledge	• Provide flash cards • Incorporate as many learning senses as possible • Portray structure, relationships, and associations through concept webs • Graphic organizers
At-risk	• Purposeful seating • Counselor involvement • Parent involvement	• Contracts • Alternate assessments • Hands-on learning

21st Century Skills	
• Creativity • Innovation • Critical Thinking	• Problem Solving • Communication • Collaboration
Integrating Technology	
• Chromebooks • Internet research • Online programs	• Virtual collaboration and projects • Presentations using presentation hardware and software

Environmental Science	**Grade 9**	**Unit 2: The Dynamic Living World: Ecosystems**	**Marking Period 1 and 2 (40 instructional days)**

		Interactions, Interdependence, and Energy Transformations	

Environmental Science Unit 2-The Dynamic Living World: Ecosystems Interactions, Interdependence, and Energy Transformations : (40 Instructional Days) Students will gain an understanding of how the natural world functions. Students construct explanations for the role of energy in the cycling of matter in organisms and ecosystems. Students also understand organisms' interactions with each other and their physical environment and how organisms obtain resources. Students utilize the crosscutting concepts of matter and energy and systems, and system models to make sense of ecosystem dynamics. Students formulate answers to the question "how and why do organisms interact with each other (biotic factors) and their environment (abiotic factors), and what affects these interactions?" Secondary ideas include the interdependent relationships in ecosystems; dynamics of ecosystems; and functioning, resilience, and social interactions. Students use mathematical reasoning and models to make sense of carrying capacity, factors affecting biodiversity and populations, the cycling of matter and flow of energy through systems. The crosscutting concepts of scale, proportion, and quantity are organizing concepts. Students are expected to use mathematical reasoning and models to demonstrate proficiency with the disciplinary core ideas.

Overarching Essential Questions	**Overarching Enduring Understandings**
• How do changes in population size relate to environmental conditions? • How do organisms obtain energy and nutrients from their environment? • How do organisms affect one another's survival and the environment? • Why is an organism's habitat critical for its survival? • How do human activities impact the Earth's ecosystems?	• Life on Earth depends upon interactions among organisms and between organisms and their environments. (Ecosystems have carrying capacities resulting from biotic and abiotic factors. The tension between resource availability and organisms populations affects the abundance of species in a given ecosystem)

	• Energy from the sun travels through the food web within almost every ecosystem on Earth. (Plants use the energy from the sun to make sugars through photosynthesis. Within individual organisms, food is broken down through cellular respiration) • Every organism has a role within an ecosystem. Matter and energy cycle through ecosystems in food webs. (Photosynthesis and cellular respiration provide most of the energy for life. Only a small fraction of energy consumed is passed along in a food web) • Organism's habitat relates to its populations survival. (If a biological or physical disturbance occurs within an ecosystem, including through human activity, the ecosystem may or may not return to it original state)
Student Learning Objectives	
Illustrate how interactions among living systems and with their environment result in the movement of matter and energy.	**LS2.A**

Graph real or simulated populations and analyze the trends to understand consumption patterns and resource availability, and make predictions as to what will happen to the population in the future.	**LS2.A**
Provide evidence that the growth of populations are limited by access to resources, and how selective pressures may reduce the number of organisms or eliminate whole populations of organisms.	**LS2.A**
Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.	**LS2.A**
Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.	**LS2.B, PS3.B**
Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.	**LS2.B, LS1.C**
Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.	**LS2.C**

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• **Using Mathematics and Computational Thinking** Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using	• **LS2.A: Interdependent Relationships in Ecosystems.** Ecosystems have carrying capacities, which are limits to the numbers of organisms and	• **Scale, Proportion, and Quantity:** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

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 • **<u>Developing and Using Models</u>** 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). • **<u>Engaging in Argument from Evidence</u>** 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	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. • **<u>LS2.B: Cycles of Matter and Energy Transfer in Ecosystems:</u>** Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. • **<u>PS3.D: Energy in Chemical Processes.</u>** The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary)	• **<u>Energy and Matter :</u>** Energy drives the cycling of matter within and between systems. • **<u>Systems and System Models.</u>** 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. • **<u>Stability and Change.</u>** Much of science deals with constructing explanations of how things change and how they remain stable. • **<u>Cause and Effect:</u>** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

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.	• **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. • **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. As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in	

	different ways to form different products.	

Embedded English Language Arts/Literacy and Mathematics

English Language Arts/Literacy –

- Cite specific textual evidence to support analysis of science and technical texts supporting explanations of factors that affect carrying capacity of ecosystems at different scales.
- Develop and write explanations of factors that affect carrying capacity of ecosystems at different scales by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
- Cite specific textual evidence to support how factors affect biodiversity and populations in ecosystems of different scale, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Write explanatory texts based on scientific procedures/experiments to explain how different factors affect biodiversity and populations in ecosystems at different scales.
- Assess the extent to which the claim that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem, is supported by reasoning and evidence.
- Integrate and evaluate multiple sources of information presented in diverse formats and media in order to address claims that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- Evaluate the validity of evidence and reasoning that support claims that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Mathematics –

- Represent the factors that affect carrying capacity of ecosystems at different scales symbolically and manipulate the representing symbols. Make sense of quantities and relationships between different factors that affect carrying capacity of ecosystems at different scales.
- Use a mathematical model to describe factors that affect carrying capacity of ecosystems at different scales. Identify important quantities in factors that affect carrying capacity of ecosystems at different scales and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Use units as a way to understand how factors affect the carrying capacity of ecosystems at different scales. Choose and interpret units consistently in formulas to determine carrying capacity. Choose and interpret the scale and origin in graphs and data displays showing factors that affect carrying capacity of ecosystems at different scales.
- Define appropriate quantities for the purpose of descriptive modeling of factors that affect carrying capacity of ecosystems at different scales.

- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities representing factors that affect carrying capacity of ecosystems at different scales.
- Represent the factors that affect biodiversity and populations in ecosystems symbolically and manipulate the representing symbols. Make sense of quantities and relationships between different factors and their effects on biodiversity and populations in ecosystems.
- Use a mathematical model to describe the factors that affect biodiversity and populations in ecosystems. Identify important quantities in factors that affect biodiversity and populations in ecosystems and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Use units as a way to understand factors that affect biodiversity and populations in ecosystems.
- Define appropriate quantities for the purpose of descriptive modeling of the factors that affect biodiversity and populations in ecosystems.
- Represent claims that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem symbolically and manipulate the representing symbols. Make sense of quantities and relationships between complex interactions in ecosystems and ways in which ecosystems remain stable and ways in which they change.
- Represent data relating to complex interactions in ecosystems and their effects on stability and change in ecosystems with plots on the real number line (graph).
- Evaluate reports of complex interactions and their effects on stability and change in ecosystems based on data showing numbers and types of organisms in stable conditions and in changing conditions.

Three-Dimensional Teaching and Learning

Students will learn that energy drives the cycling of matter through an ecosystem. They will use this information to understand the effect that biological disturbances have on ecosystems. Students investigate organisms' interactions with each other and their physical environment and how organisms obtain resources.

Students will then apply their knowledge of matter cycling and energy flowing in ecosystems as they examine the effects of these processes on populations, carrying capacity, community structure, and biodiversity. The unit contains the ideas that ecosystems have carrying capacities that limit the number of organisms and populations they can support, based on factors such as the availability of living and nonliving resources and challenges such as predation, competition, and disease. In order to build an understanding of the factors that limit carrying capacities of organisms and populations, students could view and analyze quantitative data from graphs, charts, simulations, and historical data sets of population changes to determine cause-and-effect relationships that lead to change over time. Emphasis will be on having students make quantitative analysis and comparisons of the relationships among interdependent factors, including boundaries, resources, climate, and competition. Data will be presented at different scales, and students should use units as a way to understand the factors that affect carrying capacity of ecosystems at different scales. Students will also generate charts, graphs, and histograms from data sets.

Mathematical and computational representations will be used to show that 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.

Students will use quantitative analysis (e.g., graphs and other data displays with appropriate units and scale) to compare and determine how relationships among interdependent factors such as disease, competition, predation, and shelter affect the carrying capacity of ecosystems at different scales. Examples of different scales could be data sets showing the population dynamics of an ecosystem in a jar, predator–prey oscillation studies, introduction of invasive species into an ecosystem, or changes as a result of the natural process of succession.

Prior Learning

Life science

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- Growth of organisms and population increases are limited by access to resources.
- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.
- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.
- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.

Earth and space science

- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources.
- Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.
- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Physical science

- In a chemical process, atoms that make up the original substances are regrouped into different molecules, and the new substances have different properties from those of the reactants.
- In a chemical process, the total number of each type of atom is conserved, and thus the mass does not change.
- The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy; others store energy.
- The chemical reaction by which plants produce complex food molecules requires energy input from sunlight. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and to release oxygen.

Part A: How do changes in population size relate to environmental conditions?	
Concepts	**Formative Assessment**
• Ecosystems have carrying capacities, which are limits to the number 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, completion, 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. • 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.	*Students who understand the concepts are able to:* • Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. • Use the concept of orders of magnitude to represent how factors affecting biodiversity and populations in ecosystems at one scale relate to those factors at another scale.

• 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. • Using the concept of orders of magnitude allows one to understand how a model of factors affecting biodiversity and populations in ecosystems at one scale relates to a model at another scale.	

Part B: How do organisms obtain energy and nutrients from their environment?

Concepts	Formative Assessment
• Photosynthesis and cellular respiration provide most of the energy for life processes. • 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. • The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.	*Students who understand the concepts are able to:* • Support claims for the cycling of matter and flow of energy among organisms in an ecosystem using conceptual thinking and mathematical representations of phenomena. • Use a mathematical model to describe the conservation of atoms and molecules as they move through an ecosystem. • Use a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and to show how matter and energy are conserved as matter cycles and energy flows through ecosystems.

• Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. • At each link in an ecosystem, matter and energy are conserved. • 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. • 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.	

Part C: How do organisms affect one another's survival and the environment?	
Concepts	**Formative Assessment**
• Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite.	*Students who understand the concepts are able to:*

• This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. • 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.	• Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. • Use quantitative analysis to compare relationships among interdependent factors and represent their effects on the carrying capacity of ecosystems at different scales.

Part D: Why is an organism's habitat critical for its survival?	
Concepts	**Formative Assessment**
• 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. • Using the concept of orders of magnitude allows one to understand how a model of factors affecting biodiversity and populations in ecosystems at one scale relates to a model at another scale.	*Students who understand the concepts are able to:* • Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. • Use the concept of orders of magnitude to represent how factors affecting biodiversity and populations in ecosystems at one scale relate to those factors at another scale.

Part E: How do human activities impact the Earth's ecosystems?	
Concepts	**Formative Assessment**
• 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. • Much of science deals with constructing explanations of how things change and how they remain stable. • 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. • Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability	*Students who understand the concepts are able to:* • Evaluate the evidence that supports the contention that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. • Construct explanations of how modest biological or physical changes versus extreme changes affect stability and change in ecosystems.

Modifications:
• Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).

- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, Zoom, Google Meet experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.

Leveraging English Language Arts/Literacy and Mathematics
English Language Arts/Literacy – • Cite specific textual evidence in order to analyze the impact individual species have upon an entire ecosystem. • Develop and write explanations of factors that affect carrying capacity of ecosystems at different scales. **Mathematics –**

- Represent the factors that affect carrying capacity of ecosystems at different scales symbolically and manipulate the representing symbols. Make sense of quantities and relationships between different factors that affect carrying capacity of ecosystems at different scales.
- Use a mathematical model and online simulator manipulate populations based upon various factors in an ecosystem.
- Use a mathematical model to investigate the impacts of bio magnification through a food web.
- Complete an analysis of biodiversity using Simpson's Biological Indicator.

Samples of Open Education Resources for this unit:

USGS Educational Resources for Secondary Grades (7–12): This web site contains selected USGS educational resources that may be useful to educators in secondary school grades. Many of these resources can be used directly in the classroom or will be useful in classroom lessons or demonstration activities preparation, or as resources for teacher education and curriculum development.

NOAA Education Resources: This website contains access to curriculum resources, professional development opportunities, student opportunities, and outreach events.

Online Textbook: Environmental Science: Your World Your Turn: This is the online version of the textbook for this class.

National Center for Case Study Teaching In Science: This is a great resource when using case studies to highlight important concepts.

Bunny Population Growth Activity: Students collect data during a simulation and use it to support their explanation of natural selection in a rabbit population and how populations change over time when biotic or abiotic factors change.

African Lions Activity: Students using the data presented to make a prediction regarding the zebra population during the periods of increase rainfall. Students will create a representation of the data that illustrates both the lion population and zebra population during the same time period

Animal Behavior: Students will make detailed observations of an organism's behavior and then design and execute a controlled experiment to test a hypothesis about a specific case of animal behavior. Students will record observations, make sketches, collect and analyze data, make conclusions, and prepare a formal report.

Biodiversity: Students use this lab to represent how biodiversity stops a disease from spreading.

Leaf Photosynthesis NetLogo Model: This Java-based NetLogo model allows students to investigate the chemical and energy inputs and outputs of photosynthesis through an interactive simulation.

Surviving Winter in the Dust Bowl (Food Chains and Trophic Levels): This is one of 30 lessons from the NSTA Press book Scientific Argumentation in Biology. The lesson engages students in an argumentation cycle based on an engaging scenario in which their group is a farm family trying to survive a dust bowl winter with limited food and water resources. The family has a bull, a cow, and limited amounts of water and wheat. Students are presented with four options that include various combinations of eating or keeping the animals alive and eating the wheat. Within this scenario, the lesson provides data on nutritional requirements of cows and humans, along with nutritional contents of wheat, milk, and beef. Students then use this data to construct an argument for the best strategy to allow their family to survive. As they construct this argument, students build and apply knowledge of food chains, trophic levels, interdependence among organisms, and energy transfers within ecosystems. This lesson is intended for middle or high school students. Teachers are encouraged to refer to the preface, introduction, student assessment samples, and appendix provided in the full book for important background on the practice of argumentation and resources for classroom implementation.

Of Microbes and Men: Students will develop a model to show the relationships among nitrogen and the ecosystem including parts that are not observable but predict observable phenomena. They will then construct an explanation of the effects of the environmental and human factors on this cycle.

Differentiation		
504	- preferential seating - extended time on tests and assignments - reduced homework or classwork - verbal, visual, or technology aids	- modified textbooks or audio-video materials - behavior management support - adjusted class schedules or grading - verbal testing
Enrichment	- Utilize collaborative media tools - Provide differentiated feedback - Opportunities for reflection	- Encourage student voice and input - Model close reading - Distinguish long term and short term goals
IEP	- Utilize “skeleton notes” where some required information is already filled in for the student - Provide access to a variety of tools for responses - Provide opportunities to build familiarity and to practice with multiple media tools - Graphic organizers	- Leveled text and activities that adapt as students build skills - Provide multiple means of action and expression - Consider learning styles and interests - Provide differentiated mentors
ELLs	- Pre-teach new vocabulary and meaning of symbols - Embed glossaries or definitions - Provide translations - Connect new vocabulary to background knowledge	- Provide flash cards - Incorporate as many learning senses as possible - Portray structure, relationships, and associations through concept webs - Graphic organizers

At-risk	• Purposeful seating • Counselor involvement • Parent involvement	• Contracts • Alternate assessments • Hands-on learning

21st Century Skills	
• Creativity • Innovation • Critical Thinking	• Problem Solving • Communication • Collaboration

Integrating Technology	
• Chromebooks • Internet research • Online programs	• Virtual collaboration and projects • Presentations using presentation hardware and software

Environmental Science	**Grade 9**	**Unit 3: Biodiversity**	**Marking Period 2**

Unit 3: Biodiversity (35 Instructional Days)

In this Unit students investigate the role the environment plays in organism's survival and reproduction. Students construct explanations for the processes of natural selection and evolution and then communicate how that has led to the huge diversity of living

organisms on Earth. Students evaluate evidence of the conditions that may result in new species and understand the role of genetic variation in natural selection. Students will construct explanations, analyze and interpret data to make sense of the relationship between the environment and natural selection. Students also develop an understanding of the factors causing natural selection of species over time. They will also demonstrate and understand how multiple lines of evidence contribute to the strength of scientific theories of natural selection. Students also investigate the importance of biodiversity and humans' impacts on biodiversity. Students create or revise a simulation to test solutions for mitigating adverse impacts of human activity on biodiversity. Models will provide support for students' conceptual understanding of systems and their ability to develop design solutions for reducing the impact of human activities on the environment and maintaining biodiversity.

Overarching Essential Questions	**Overarching Enduring Understandings**
● What role does the environment play that has resulted in such diversity of life on Earth? ● How does natural and artificial selection lead to adaptations of populations? ● Why is it so important to take all of the antibiotics in a prescription if I feel better? ● How are species affected by changing environmental conditions? ● Should we care when a species goes extinct? What impacts are humans having on biodiversity?	● Biodiversity on Earth is a result of the evolution of species through Earth's long history. ● Both natural and artificial selection results from certain traits giving some individuals advantages. Therefore traits that positively affect survival become more common in a population. ● Species can change over time in response to changes in the environment. This evolution results primarily from genetic variation among individuals. ● Biodiversity is increased by the formation of new species through evolution and reduced by extinctions (both natural and human caused)

	• Sustaining biodiversity is essential to supporting life on Earth.
Student Learning Objectives	
Develop an explanation based on evidence for how natural selection leads to adaptation of populations.	**HS-LS4-4**
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.	**HS-LS4-5**
Make predictions about the effects of artificial selection on the genetic makeup of a population over time.	**HS-LS4.C**
Create a simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.	**HS-ESS3-3** **LS4.D**
Evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	**HS-LS2-7**
Conduct a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.	**HS-LS4-6**
Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.	**HS-ETS1-3**

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data • Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • 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. **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	**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. • The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. **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	**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 . **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. **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

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. **<u>Engaging in argument from Evidence</u>** • 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. **<u>Obtaining, Evaluating, and Communicating Information</u>** • Obtaining, evaluating, and communicating information in 9–12	those organisms that are better able to survive e and reproduce in that environment. • Natural selection leads to adaptation, which 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. • Adaptation also means that the distribution of traits in a population can change when conditions change. • 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.	

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).	• 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. **LS4.D: Biodiversity and Humans** • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). • 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.	

	<u>ETS1.B: Developing Possible Solutions</u> • 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. **<u>ESS3.C: Human Impacts on Earth Systems</u>** • The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources	

Embedded English Language Arts/Literacy and Mathematics
English Language Arts/Literacy ● Evaluate data to verify claims about the impacts of human activities on the environment and biodiversity, verifying the data when possible and corroborating or challenging conclusions with other sources of information. ● Conduct short as well as more sustained research projects to determine the impacts of human activities on the environment and biodiversity, synthesizing information from multiple sources. ● Synthesize information from a range of sources about the impacts of human activities on the environment and biodiversity into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. ● Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on the impacts of human activity on biodiversity and how to mitigate these impacts. ● Conduct short as well as more sustained research projects to determine the impacts of human activity on biodiversity and how to mitigate these impacts. ● Evaluate data presented in diverse formats in order to determine the impacts of human activity on biodiversity and how to mitigate these impacts. ● Evaluate data to verify claims about the impacts of human activities on biodiversity and how to mitigate these impacts.

- Synthesize information from a range of sources into a coherent understanding of the impacts of human activities on biodiversity and how to mitigate these impacts.

Mathematics

- Represent symbolically the relationships among management of natural resources, the sustainability of human populations, and biodiversity, and manipulate the representing symbols. Make sense of quantities and relationships among management of natural resources, the sustainability of human populations, and biodiversity.
- Use a mathematical model to describe the management of natural resources, the sustainability of human populations, and biodiversity. Identify important quantities in relationships among management of natural resources, the sustainability of human populations, and biodiversity, and map their relationships using tools. Analyze these relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Represent symbolically the impacts of human activities on the environment and biodiversity, and manipulate the representing symbols. Make sense of quantities and relationships of the impacts of human activities on the environment and biodiversity
- Use units to understand the impacts of human activities on the environment and biodiversity and to guide the solution of multistep problems to reduce these impacts. Choose and interpret units consistently in formulas to determine the impacts of human activities on the environment and biodiversity. Choose and interpret the scale and origin in graphs and data displays showing impacts of human activities on the environment and biodiversity.
- Use a mathematical model to describe the impacts of human activities on the environment and biodiversity. Identify important quantities in the impacts of human activities on the environment and biodiversity and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

Three-Dimensional Teaching and Learning
This unit builds on previous units. Earlier in the course, students learned that ecosystems have limits, which result from challenges such as predation, competition, and disease that limit the number of organisms in the population. Also in earlier units, students learned how resource availability has guided the development of human population. Students learned how environmental factors affect expression of traits and the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depend on both genetic and environmental factors. These ideas support students' current learning, in which they are developing an understanding that phenotypic variation can influence the chances of survival.

Students begin this unit by developing an understanding of the way natural selection leads to adaptation in a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. Students should make sense of quantities and relationships between specific biotic and abiotic differences in ecosystems and their contributions to a change in gene frequency over time that leads to adaptation of populations, paying attention to proportional increases in organisms with advantageous heritable traits.

Students should use data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations. To enhance understanding, students should examine scientific text and cite specific textual evidence to support analysis and explanations for how natural selection leads to change in populations over time. Students need to connect current learning to past events to enhance understanding that scientific knowledge is based on natural laws that operate today as they did in the past and will continue to do so in the future.

Students will build on their knowledge of the factors that contribute to the variations of different traits within a population. Students should examine how individuals possessing certain forms of inherited traits may have a survival advantage over others in the population. Increased survival and reproductive success in these individuals can cause advantageous traits to become more common in the population. In other words, the population adapts to its environment. This process of change over time, as the environment "selects" for advantageous forms of heritable traits, is called natural selection and leads to biodiversity.

In previous units, students learned that photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes, and that 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.

Students also have an understanding of how 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. This included examining how modest biological or physical disturbances or extreme fluctuations in conditions affect ecosystems. Anthropogenic changes causing disruptions to biodiversity in ecosystems and stability and resilience were also considered.

These understandings will support students as they continue to explore human dependence on Earth's resources and the nature and effects of human interactions with their environment.

In this unit we turn our attention to how humans depend on the living world for resources and other benefits provided by biodiversity. Students must know that the sustainability of human societies and the biodiversity that supports them require responsible management of natural resources. Change and rates of change in biodiversity and environmental conditions should be quantified and modeled by students over short and long periods of time. Students should keep in mind that some system changes are irreversible. Deforestation of tropical rain forests and desertification of grasslands are examples of changes students might research. In their research, students should synthesize information from multiple sources and evaluate claims about the impacts of human activity on biodiversity based on analysis of evidence.

Modern civilization depends on major technological systems. New technologies can have deep impacts on society and the environment, both anticipated and unanticipated. Examples of impacts include extinction of species and loss of habitat. These changes can lead to a decrease in biodiversity. To address these concepts, students should create a computational simulation or mathematical model illustrating the relationships among management of natural resources, the sustainability of human populations, and biodiversity. Simulations should model change and rates of change in those relationships. When possible, students should symbolically and quantitatively represent natural resource management, sustainability of human populations, and biodiversity. Students should also map relationships discovered, considering limitations on measurement when reporting quantities or data.

Students will learn that natural and anthropogenic changes in the physical environment contribute to changes in biodiversity. Changes may include species expansion, invasive species, and extinction. Because humans depend on the living world for resources and other benefits provided by biodiversity, adverse human activities such as overpopulation, exploitation of resources, habitat destruction, pollution, introduction of invasive species, and human impact on climate change must be addressed. Students should understand that sustaining biodiversity is critical to maintaining functional ecosystems. Students might collect data on growth patterns (exponential, logistic) and carrying capacity. Students could use data to make informed decisions about how environmental issues affect their communities politically, economically, and ecologically.

In this unit, students are tasked with designing and evaluating a solution for a proposed problem related to threatened or endangered species. As they consider a design solution, they should know that technological advances by modern civilizations have solved, and sometimes caused, problems related to human interactions with the environment. This may set the context for a discussion of limits of technological solutions. 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. Students may need to determine long- and short-terms goals of a potential solution, while considering that new technologies can have deep impacts on society and the environment, including some that were not anticipated.

Students might use empirical evidence of decreasing populations to differentiate between specific causes and effects. Students could choose an adverse practice and research solutions to associated problems. Solutions for minimizing adverse effects should account for a range of constraints such as cost, safety, reliability, and aesthetics, as well as social, cultural, and environmental impacts, since practical solutions are more likely to be implemented by society. Students can use physical models and computer simulations to aid in the engineering process, test potential solutions, and refine designs.

Prior Learning

Physical science

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy; others store energy.

Life science

- Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- Growth of organisms and population increases are limited by access to resources.

- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations or organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions very across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.
- Food webs are models that demonstrate how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.
- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.
- Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.

Earth and space sciences-

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things.
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things.
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Part A: What role does the environment play that has resulted in such diversity of life on Earth?

Concepts	Formative Assessment
• 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. • Given Earth’s diversity of ecosystems this natural selection has led to the biodiversity we observe.	*Students who understand the concepts are able to:* • Use data to differentiate between cause and correlation and to make claims about how specific biotic and abiotic differences in ecosystems contribute to change in gene frequency over time, leading to adaptation of populations..

Part B: How does natural and artificial selection lead to adaptations of populations?

Concepts	Formative Assessment
• 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. • 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. • Empirical evidence is required to differentiate between cause and correlation and make claims about the process of evolution.	*Students who understand the concepts are able to:* • Develop 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, 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. • Use evidence to explain the influences of: (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, on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species.

Part C: Why is it so important to take all of the antibiotics in a prescription if I feel better?	
Concepts	**Formative Assessment**
• Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population	*Students who understand the concepts are able to:*

and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. • The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. • 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. • Adaptation also means that the distribution of traits in a population can change when conditions change. • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.	• 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. • Analyze shifts in numerical distribution of traits and, using these shifts as evidence, support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. • Observe patterns at each of the scales at which a system is studied to provide evidence for causality in explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

•Part D: How are species affected by changing environmental conditions?	
Concepts	**Formative Assessment**

• 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. • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). • 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. • Sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth.	*Students who understand the concepts are able to:* • Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. • Quantify and model change and rates of change in the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

Part E: Should we care when a species goes extinct? What impacts are humans having on biodiversity?	
Concepts	**Formative Assessment**
• 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,	*Students who understand the concepts are able to:* • Create or revise a simulation based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and

pollution, introduction of invasive species, and climate change. • 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. • When evaluating solutions, it is important to take into account a range of constraints—including costs, safety, reliability, and aesthetics—and to consider social, cultural, and environmental impacts.	tradeoff considerations to test a solution to mitigate adverse impacts of human activity on biodiversity. • Use empirical evidence to make claims about the impacts of human activity on biodiversity. • Break down the criteria for the design of a simulation to test a solution for mitigating adverse impacts of human activity on biodiversity into simpler ones that can be approached systematically based on consideration of trade-offs. • Design a solution for a proposed problem related to threatened or endangered species or to genetic variation of organisms for multiple species. • Analyze costs and benefits of a solution to mitigate adverse impacts of human activity on biodiversity.

Modifications:
• Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, Google Meet, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).

- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.

Leveraging English Language Arts/Literacy and Mathematics
English Language Arts/Literacy – • Evaluate data to verify claims about the impacts of human activities on the environment and biodiversity, verifying the data when possible and corroborating or challenging conclusions with other sources of information. • Conduct short as well as more sustained research projects to determine the impacts of human activities on the environment and biodiversity, synthesizing information from multiple sources. • Synthesize information from a range of sources about the impacts of human activities on the environment and biodiversity into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. • Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on the impacts of human activity on biodiversity and how to mitigate these impacts. • Conduct short as well as more sustained research projects to determine the impacts of human activity on biodiversity and how to mitigate these impacts. • Evaluate data presented in diverse formats in order to determine the impacts of human activity on biodiversity and how to mitigate these impacts. • Evaluate data to verify claims about the impacts of human activities on biodiversity and how to mitigate these impacts.

- Synthesize information from a range of sources into a coherent understanding of the impacts of human activities on biodiversity and how to mitigate these impacts.

Mathematics

- Represent symbolically the relationships among management of natural resources, the sustainability of human populations, and biodiversity, and manipulate the representing symbols. Make sense of quantities and relationships among management of natural resources, the sustainability of human populations, and biodiversity.
- Use a mathematical model to describe the management of natural resources, the sustainability of human populations, and biodiversity. Identify important quantities in relationships among management of natural resources, the sustainability of human populations, and biodiversity, and map their relationships using tools. Analyze these relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Represent symbolically the impacts of human activities on the environment and biodiversity, and manipulate the representing symbols. Make sense of quantities and relationships of the impacts of human activities on the environment and biodiversity
- Use units to understand the impacts of human activities on the environment and biodiversity and to guide the solution of multistep problems to reduce these impacts. Choose and interpret units consistently in formulas to determine the impacts of human activities on the environment and biodiversity. Choose and interpret the scale and origin in graphs and data displays showing impacts of human activities on the environment and biodiversity.
- Use a mathematical model to describe the impacts of human activities on the environment and biodiversity. Identify important quantities in the impacts of human activities on the environment and biodiversity and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

Samples of Open Education Resources for this unit:

USGS Educational Resources for Secondary Grades (7–12): This web site contains selected USGS educational resources that may be useful to educators in secondary school grades. Many of these resources can be used directly in the classroom or will be useful in classroom lessons or demonstration activities preparation, or as resources for teacher education and curriculum development.

NOAA Education Resources: This website contains access to curriculum resources, professional development opportunities, student opportunities, and outreach events.

Online Textbook: Environmental Science: Your World Your Turn: This is the online version of the textbook for this class.

National Center for Case Study Teaching In Science: This is a great resource when using case studies to highlight important concepts.

Evolution Webquest: In this Evolution WebQuest, students investigate evidence for evolution. Teams are responsible for learning about fossil evidence, structural evidence, and genetic evidence for evolution and presenting this information to the class.

HHMI Pocket Mouse Evolution: This activity serves as an extension to the HHMI short film The Making of the Fittest: Natural Selection and Adaptation and a means of reinforcing the concepts of variation and natural selection. Students explain how variation, selection, and time fuel the process of evolution by comparing, integrating, and evaluating sources of information presented in different media or formats. They analyze and organize data, comparing and contrasting various types of data sets (both self-generated and archival).

Bunny Population Growth: Students will develop and use models to simulate the growth of a rabbit population in order to support explanations about the role of limiting factors and variation in maintaining or destroying the population.

Cost-Benefit Analysis Primer: Students read this explanation about how cost-benefit analysis is derived and applied in order to apply this model to design solutions related to human sustainability. Students then read the application of CBA to water sanitation.

Carbon Stabilization Wedge: Students play this game in order to evaluate competing design solutions for developing, managing, and utilizing energy resources based on cost-benefit ratios.

Rainforest carbon cycling and biodiversity: Students apply this model to simulate how atmospheric CO_2 concentrations, which influence global climate, increase with

National Climate Assessment: Students explore the simulations found at this website in order to create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. Stormwater Calculator or the Water Erosion Prediction Project: Students apply the stormwater runoff calculator to determine the impacts of land use change, precipitation variations, and other parameters on runoff. Alternatively, Catch It If You Can: students are scaffolded through the process of calculating stormwater runoff by exploring and applying this case study. The Bean Game: Exploring Human Interactions with Natural Resources: This activity explores the various influences of human consumption of natural resources over time. (use this as a primer for making a computational model). NSA Challenge: Recycling for a Cleaner World: Students will develop a strategy to increase recycling and waste diversion for their school. Reefs at Risk: and NOAA Coral Reefs at Risk: Students access and explore a series of interactive maps displaying coral reef data from around the globe and develop hypotheses related to the impacts of climate change (i.e. increased levels of carbon dioxide in our atmosphere) on coral reef health. . Know Your Energy Costs: The goal of this activity is to become aware of how much energy you use at school — and the financial and environmental costs.

Differentiation		
504	• preferential seating • extended time on tests and assignments • reduced homework or classwork • verbal, visual, or technology aids	• modified textbooks or audio-video materials • behavior management support • adjusted class schedules or grading • verbal testing
Enrichment	• Utilize collaborative media tools • Provide differentiated feedback • Opportunities for reflection	• Encourage student voice and input • Model close reading • Distinguish long term and short term goals

IEP	- Utilize “skeleton notes” where some required information is already filled in for the student - Provide access to a variety of tools for responses - Provide opportunities to build familiarity and to practice with multiple media tools - Graphic organizers	- Leveled text and activities that adapt as students build skills - Provide multiple means of action and expression - Consider learning styles and interests - Provide differentiated mentors
ELLs	- Pre-teach new vocabulary and meaning of symbols - Embed glossaries or definitions - Provide translations - Connect new vocabulary to background knowledge	- Provide flash cards - Incorporate as many learning senses as possible - Portray structure, relationships, and associations through concept webs - Graphic organizers
At-risk	- Purposeful seating - Counselor involvement - Parent involvement	- Contracts - Alternate assessments - Hands-on learning
21st Century Skills		
- Creativity - Innovation - Critical Thinking		- Problem Solving - Communication - Collaboration
Integrating Technology		

• Chromebooks • Internet research • Online programs	• Virtual collaboration and projects • Presentations using presentation hardware and software

Environmental Science	**Grade 9**	**Unit 4: Earth's Dynamic Systems, Resources, Pollution and Sustainability**	**Marking Period 3 (45 instructional days)**

Environmental Science Unit 4-Earth's Dynamic Systems, Resources, Pollution and Sustainability : (45 Instructional Days)

In this unit students study land, water and air resources to illustrate how Earth's interacting systems cause feedback effects on other Earth systems. In this unit of study, planning and carrying out investigations, analyzing and interpreting data, developing and using models, and engaging in arguments from evidence are key practices to explore the dynamic nature of Earth systems and resources.

Students use simulations to illustrate the relationships among management of natural resources (land, water air), the sustainability of human populations, and investigate ways to mitigate adverse impacts of human activity. They study the relationships among Earth systems and how those relationships are being modified due to human activity, and evaluate technological solutions that reduce impacts of human activities on natural systems.

Students also analyze and interpret data and design solutions to build on their understanding of the ways that human activities affect Earth's systems. The emphasis of this unit is the significant and complex issues surrounding human uses of land, water and air resources and the resulting impacts of these uses.

Overarching Essential Questions	Overarching Enduring Understandings
• How do we monitor the health of the environment (our life support system of land, water and air)? • How and why are Earth's natural resources of air, water and land limited? • What impact do the resources of land, water and air have on our lives and the lives of all living things? • What are the impacts of human activities on natural systems and how can they be reduced?	• Humans depend upon Earth's land, water, atmosphere and biosphere for many resources. These resources are limited, distributed unevenly, and a result of Earth' geological processes. • The land, water and air of our planet are part of complex Earth systems and cycles that have a direct impact on our daily lives and the lives of all living things on Earth. • Human activity affects Earth's natural resources in a variety of ways and more than any other species. • We need to use Earth's finite resources in a sustainable way.

Student Learning Objectives	
Analyze data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.	**HS-ESS2-2**
Plan and conduct an investigation of the properties of land, air and water resources and their effects on Earth materials and surface processes.	**HS-ESS2-5**
Construct evidence about the simultaneous co-evolution of Earth's systems and life on Earth.	**HS-ESS2-7**

Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, have influenced human activity.	**HS-ESS3-1**
Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.	**HS-ESS3-4**
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.	**HS-ETS1-3**

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. ● Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	**ESS2.A: Earth Materials and Systems** • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **ESS2.D: Weather and Climate** • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's radiation into space.	**Stability and Change** • Feedback (negative or positive) can stabilize or destabilize a system. **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. **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Influence of Science, Engineering, and Technology on Society and the Natural World**

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. **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	**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. **ESS2.E Biogeology** • The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it. **ESS3.A: Natural Resources** • Resource availability has guided the development of human society. **ESS3.B: Natural Hazards** • Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes	• 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.

also come from current scientific or historical episodes in science. ● Construct an oral and written argument or counter-arguments based on data and evidence. **<u>Constructing Explanations and Designing Solutions</u>** 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.	of human populations and have driven human migrations. **<u>ESS3.C: Human Impacts on Earth Systems</u>** • Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. **<u>ETS1.B: Developing Possible Solutions</u>** • 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.	

Embedded English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Cite specific textual evidence of the availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.
- Use empirical evidence to write an explanation for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- Evaluate data to verify claims about the impacts of human activities on the environment and biodiversity, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
- Conduct short as well as more sustained research projects to determine the impacts of human activities on the environment and biodiversity, synthesizing information from multiple sources.
- Synthesize information from a range of sources about the impacts of human activities on the environment and biodiversity into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
- Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on the impacts of human activity on biodiversity and how to mitigate these impacts.
- Conduct short as well as more sustained research projects to determine the impacts of human activity on biodiversity and how to mitigate these impacts.
- Evaluate data presented in diverse formats in order to determine the impacts of human activity on biodiversity and how to mitigate these impacts.
- Evaluate data to verify claims about the impacts of human activities on biodiversity and how to mitigate these impacts.
- Synthesize information from a range of sources into a coherent understanding of the impacts of human activities on biodiversity and how to mitigate these impacts.
- Cite specific textual evidence to support a technological solution that reduces the impacts of human activities on natural systems, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Evaluate the validity of hypotheses, data, analysis, and conclusions in a science or technical text about the impact of human activities on natural systems, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
- Integrate and evaluate multiple sources of information presented in diverse formats and media in order to evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- Read multiple sources in order to refine design solutions to reduce impacts of human activities on natural systems and create a coherent understanding of the problem.

Mathematics

- Represent how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity symbolically and manipulate the representing symbols. Make sense of quantities and relationships between availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.

• Use units as a way to understand the relationships between availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity. Choose and interpret units consistently in formulas to determine relationships between availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.
• Choose and interpret the scale and the origin in graphs and data displays representing relationships between availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.
• Define appropriate quantities for the purpose of descriptive modeling of relationships between availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.
• Choose a level of accuracy appropriate to limitations on measurement when reporting quantities showing relationships between availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.
• Represent symbolically the relationships among management of natural resources, the sustainability of human populations, and biodiversity, and manipulate the representing symbols. Make sense of quantities and relationships among management of natural resources, the sustainability of human populations, and biodiversity.
• Use a mathematical model to describe the management of natural resources, the sustainability of human populations, and biodiversity. Identify important quantities in relationships among management of natural resources, the sustainability of human populations, and biodiversity, and map their relationships using tools. Analyze these relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
• Represent symbolically the impacts of human activities on the environment and biodiversity, and manipulate the representing symbols. Make sense of quantities and relationships of the impacts of human activities on the environment and biodiversity
• Use units to understand the impacts of human activities on the environment and biodiversity and to guide the solution of multistep problems to reduce these impacts. Choose and interpret units consistently in formulas to determine the impacts of human activities on the environment and biodiversity. Choose and interpret the scale and origin in graphs and data displays showing impacts of human activities on the environment and biodiversity.
• Use a mathematical model to describe a solution to mitigate adverse impacts of human activity on biodiversity. Identify important quantities in the impacts of human activities on the biodiversity and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

Three-Dimensional Teaching and Learning

Students analyze data, using tools, technologies, and models to make claims about relationships between changes to Earth's surface and feedback.

Students actively explore the properties of the soil, air and water and its effects on Earth materials and surface properties by planning and conducting investigations. Initially they identify evidence needed to answer a question related to the properties of water and its effects on Earth materials and surface properties. The evidence may be related to the properties, such as heat capacity of water, density of water in its liquid and solid states, and the polar nature of a water molecule due to its molecular structure. The evidence may be related to the effect of the properties of water on energy transfer that causes patterns of temperature, the movement of air, the movement and availability of water at Earth's surface. The evidence may be related to mechanical effects of water on Earth's materials that can be used to infer the effect of water on Earth's surface properties. Some examples include stream transportation and deposition, erosion using variations in soil moisture content, and expansion of water as it freezes. Finally, the evidence may be related to the chemical effects of water on Earth materials that can be used to infer the effect of water on Earth's surface processes. This may include the properties of solubility, the reaction of water on iron, and the properties of water that lower the melting temperature of most solids, and decreases the viscosity of melted rock. Next, students plan out their investigation to align their data collection methods with the evidence they are seeking. For example, they may decide to investigate the mechanical nature of running water on sediment transport and deposition by changing the slope of a stream table. Once their protocol has been designed, they run their investigation and collect data. They analyze and interpret the data, and if necessary, they modify the protocol and run the investigation again.

Students will continue their study of Earth's systems by examining the history of the atmosphere. Students should research the early atmospheric components and the changes that occurred due to plants and other organisms removing carbon dioxide and releasing oxygen. By studying the carbon cycle, students should revisit the idea that matter and energy within a closed system are conserved among the hydrosphere, atmosphere, geosphere, and biosphere. Students should extend their understanding of how human activity affects the concentration of carbon dioxide in the environment and therefore climate. Students' experiences should include synthesizing information from multiple sources and developing quantitative models based on evidence to describe the cycling of carbon among the ocean, atmosphere, soil, and biosphere. Students should understand how biogeochemical cycles provide the foundation for living organisms.

Environmental factors have affected human populations over the course of history. Resource availability, natural disasters, and other geologic events have driven global development of societies, sizes of human populations, and human migrations. Student understanding of these relationships could be enhanced by examining and citing evidence from text or other investigations that show correlations between human population distribution and regional availability of resources such as fresh water, fertile soils, and clean air.

Prior Learning
Physical Science • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). • The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • When the motion energy of an object changes, there is inevitably some other change in energy at the same time. • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. • Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

• When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.

• The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.

• A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.

• However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Life science

• Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.

• In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. Growth of organisms and population increases are limited by access to resources.

• Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

• Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

• Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

• Biodiversity describes the variety of species found in Earth’s terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem’s biodiversity is often used as a measure of its health.

• The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.

• Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.

• Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.

• Natural selection leads to the predominance of certain traits in a population, and the suppression of others.

• In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.

• Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.

Earth and space science

• Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches.

• All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms.

• The planet’s systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth’s history and will determine its future.

• Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth’s plates have moved great distances, collided, and spread apart.

• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.

• The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

• Global movements of water and its changes in form are propelled by sunlight and gravity.

• Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.

• Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.

• Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.

• Because these patterns are so complex, weather can only be predicted probabilistically.

• The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

• Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.

• Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

• Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

Part A: How do we monitor the health of the environment (our life support system of land, water and air)?	
Concepts	**Formative Assessment**
• Understand how critical our land, water and air are to all life on Earth. • Investigate how we use our land and soil. • 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. • The properties include water's exceptional capacity to absorb, store, and release large amounts of energy; cohesion; expand upon freezing, dissolve and transport materials. • Investigate the importance of our atmosphere • Changes in the atmosphere occur due to human activity. • The total amount of energy and matter in closed systems is conserved. • Cycling of resources among and between the hydrosphere, atmosphere, geosphere, and biosphere is conserved.	*Students who understand the concepts are able to:* • Conduct an investigation of the properties of land, water and air and its effects on Earth materials and surface processes. • Develop a model based on evidence to describe the cycling of resources among the hydrosphere, atmosphere, geosphere, and biosphere. • Develop a model based on evidence to illustrate the biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere, providing the foundation for living organisms.

Part B: How and why are Earth's natural resources of air, water and land limited?	
Concepts	**Formative Assessment**

• 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. • Empirical evidence is required to differentiate between cause and correlation and make claims about how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activities.	*Students who understand the concepts are able to:* • Construct an explanation based on valid and reliable evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. • Use empirical evidence to differentiate between how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Part C: What impact do the resources of land, water and air have on our lives and the lives of all living things?	
Concepts	**Formative Assessment**
• Changes to Earth's environments can have different impacts (negative and positive) for different living things. • Typically as human populations and per capita consumption of natural resources increase, so do the negative impacts on Earth, unless the activities and technologies involved are engineered otherwise. • Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.	*Students who understand the concepts are able to:* • Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment focused on land, soil, water and air.

• The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.	

Part D: What are the impacts of human activities on natural systems and how can they be reduced?	
Concepts	**Formative Assessment**
• Resource vitality has guided the development of human society. • The sustainability of human societies and the biodiversity that supports them require responsible management of natural resources. • Change and rates of change can be quantified and modeled over very short or very long periods. • Some system changes are irreversible.	*Students who understand the concepts are able to:* • Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. • Quantify and model change and rates of change in the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

• Modern civilization depends on major technological systems. • New technologies can have deep impacts on society and the environment including some that are not anticipated.	

Modifications:
• Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, Zoom, Google Meet experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies.

Leveraging English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

• Cite specific textual evidence of the availability of natural resources such as land, water and air and their influence on human activity.

• Use empirical evidence to write an explanation for how the availability of natural resources have influenced human activity.

• Evaluate data to verify claims about the impacts of human activities on the environment.

• Conduct short as well as more sustained research projects to determine the impacts of human activities on the environment and biodiversity, synthesizing information from multiple sources.

• Synthesize information from a range of sources about the impacts of human activities on the environment and biodiversity into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

• Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on the impacts of human activity on biodiversity and how to mitigate these impacts.

• Conduct short as well as more sustained research projects to determine the impacts of human activity on biodiversity and how to mitigate these impacts.

• Read multiple sources in order to refine design solutions to reduce impacts of human activities on natural systems and create a coherent understanding of the problem.

Mathematics

• Represent how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity symbolically and manipulate the representing symbols. Make sense of quantities and relationships between availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.

• Use units as a way to understand the relationships between availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity. Choose and interpret units consistently in formulas to determine relationships between availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.

• Choose and interpret the scale and the origin in graphs and data displays representing relationships between availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.

• Define appropriate quantities for the purpose of descriptive modeling of relationships between availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.

• Choose a level of accuracy appropriate to limitations on measurement when reporting quantities showing relationships between availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.

• Represent symbolically the relationships among management of natural resources, the sustainability of human populations, and biodiversity, and manipulate the representing symbols. Make sense of quantities and relationships among management of natural resources, the sustainability of human populations, and biodiversity.

• Use a mathematical model to describe the management of natural resources, the sustainability of human populations, and biodiversity. Identify important quantities in relationships among management of natural resources, the sustainability of human populations, and biodiversity, and map their relationships using tools. Analyze these relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

• Represent symbolically the impacts of human activities on the environment and biodiversity, and manipulate the representing symbols. Make sense of quantities and relationships of the impacts of human activities on the environment and biodiversity

• Use units to understand the impacts of human activities on the environment and biodiversity and to guide the solution of multistep problems to reduce these impacts. Choose and interpret units consistently in formulas to determine the impacts of human activities on the environment and biodiversity. Choose and interpret the scale and origin in graphs and data displays showing impacts of human activities on the environment and biodiversity.

Samples of Open Education Resources for this unit:

USGS Educational Resources for Secondary Grades (7–12): This web site contains selected USGS educational resources that may be useful to educators in secondary school grades. Many of these resources can be used directly in the classroom or will be useful in classroom lessons or demonstration activities preparation, or as resources for teacher education and curriculum development.

NOAA Education Resources: This website contains access to curriculum resources, professional development opportunities, student opportunities, and outreach events.

Online Textbook: Environmental Science: Your World Your Turn: This is the online version of the textbook for this class.

National Center for Case Study Teaching In Science: This is a great resource when using case studies to highlight important concepts.

MY NASA DATA: Students select satellite datasets to answer questions related to system interactions and feedbacks.

Finding the Crater: Students "visit" different K-T boundary sites, evaluate the evidence found in the cores at each site, find these sites on a map, and predict where the impact crater is located.

Images of Change: Students explore these images of the impacts of climate change over time to develop explanations from evidence of how an impact in one component of the Earth system has effects in other components of the Earth system.

Climate Reanalyzer: Students use the Environmental Change Model of the Climate Reanlyzer to study the feedbacks in the climate system.

USGS Realtime Water data and Climate data: Students create and run an investigation to determine the relationship between streamflow and precipitation data, or another parameter.

Greenhouse Effect: Students explore the atmosphere during the ice age and today. What happens when you add clouds? Change the greenhouse gas concentration and see how the temperature changes. Then compare to the effect of glass panes. Zoom in and see how light interacts with molecules. Do all atmospheric gases contribute to the greenhouse effect?

Earth Systems Activity: Students model the carbon cycle and it's connection with Earth's climate. .

Carbon Stabilization Wedge: Students play this game in order to evaluate competing design solutions for developing, managing, and utilizing energy resources based on cost-benefit ratios.

National Climate Assessment: Students explore the simulations found at this website in order to create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

Stormwater Calculator or the Water Erosion Prediction Project: Students apply the stormwater runoff calculator to determine the impacts of landuse change, precipitation variations, and other parameters on runoff.

The Bean Game: Exploring Human Interactions with Natural Resources: This activity explores the various influences of human consumption of natural resources over time. (use this as a primer for making a computational model).

NSA Challenge: Recycling for a Cleaner World: Students will develop a strategy to increase recycling and waste diversion for their school.

Earth: Planet of Altered States: Watch a segment of a NASA video and discuss how the earth is constantly changing.

USGS Educational Resources for Secondary Grades (7–12): This web site contains selected USGS educational resources that may be useful to educators in secondary school grades. Many of these resources can be used directly in the classroom or will be useful in classroom lessons or demonstration activities preparation, or as resources for teacher education and curriculum development.

NOAA Education Resources: This website contains access to curriculum resources, professional development opportunities, student opportunities, and outreach events.

Differentiation		
504	• preferential seating • extended time on tests and assignments • reduced homework or classwork • verbal, visual, or technology aids	• modified textbooks or audio-video materials • behavior management support • adjusted class schedules or grading • verbal testing
Enrichment	• Utilize collaborative media tools • Provide differentiated feedback • Opportunities for reflection	• Encourage student voice and input • Model close reading • Distinguish long term and short term goals

IEP	● Utilize "skeleton notes" where some required information is already filled in for the student ● Provide access to a variety of tools for responses ● Provide opportunities to build familiarity and to practice with multiple media tools ● Graphic organizers	● Leveled text and activities that adapt as students build skills ● Provide multiple means of action and expression ● Consider learning styles and interests ● Provide differentiated mentors
ELLs	● Pre-teach new vocabulary and meaning of symbols ● Embed glossaries or definitions ● Provide translations ● Connect new vocabulary to background knowledge	● Provide flash cards ● Incorporate as many learning senses as possible ● Portray structure, relationships, and associations through concept webs ● Graphic organizers
At-risk	● Purposeful seating ● Counselor involvement ● Parent involvement	● Contracts ● Alternate assessments ● Hands-on learning
21st Century Skills		
● Creativity ● Innovation ● Critical Thinking		● Problem Solving ● Communication ● Collaboration
Integrating Technology		

● Chromebooks ● Internet research ● Online programs	● Virtual collaboration and projects ● Presentations using presentation hardware and software

Environmental Science	Grade 9	Unit 5: Human Activity and Climate Change	Marking Period 4 (20 instructional days)

Environmental Science Unit 5- Human Activity and Climate Change : (20Instructional Days) In this unit of study, students evaluate claims, analyze and interpret data, and develop and use models to explore the core ideas centered on the Earth's climate system. Students evaluate the validity and reliability of claims in published materials to understand the factors that influence climate systems and the impacts humans are having on those systems. They will use quantitative models to describe how variations in the flow of energy into and out of the Earth's systems result in changes in climate, and how carbon is cycled through all of the Earth's spheres. They analyze geoscience data to make the claim that one change to Earth's surface can cause changes to other Earth systems, such as the climate system. Finally, students analyze geoscience data and the results from global

climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. The crosscutting concepts of cause and effect, stability and change, energy and matter, and structure and function are used as an organizing concept for these disciplinary core ideas.	
Overarching Essential Questions	**Overarching Enduring Understandings**
• What factors influence the climates we have on Earth today? Have those climates always been as we have them today? • What happens if we change the chemical composition of our atmosphere? • How does carbon cycle among the hydrosphere, atmosphere, geosphere, and biosphere? • What happens to solar energy as it moves through the atmosphere and strikes a surface? • What is the current rate of global or regional climate change and what are the associated future impacts to Earth's systems?	• Radiation from the sun and its interaction with the atmosphere, water and land are the foundation for Earth's climate systems. • Humans are altering the chemical composition of the atmosphere largely through the burning of fossil fuels which adds carbon to the atmosphere. • Global climate models are used to predict future climate systems. • Decisions to reduce the impact of global climate changes depend upon our understanding of climate science, engineering capabilities and social dynamics.
Student Learning Objectives	
Use a model to describe how variations in the flow of energy into and out of Earth's systems interact with land, water and atmosphere to result in climate.	**HS-ESS2-4**
Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.	**HS-ESS2-2**

Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.	**HS-ESS2-6**
Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.	**HS-ESS3-5**

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Use a model to provide mechanistic accounts of phenomena. **Scientific Knowledge is Based on Empirical Evidence**	**ESS1.B: Earth and the Solar System** • Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. **ESS2.A: Earth Materials and System**	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Stability and Change** • Feedback (negative or positive) can stabilize or destabilize a system. **Energy and Matter** Energy drives the cycling of matter within and between systems. **Influence of Engineering, Technology, and Science on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were

• Science arguments are strengthened by multiple lines of evidence supporting a single explanation. **Analyzing and Interpreting Data** Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **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.	• The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. **ESS2.D: Weather and Climate** • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's reradiation into space. **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.	not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

• Construct an oral and written argument or counter-arguments based on data and evidence.		

Embedded English Language Arts/Literacy and Mathematics
English Language Arts/Literacy • Cite specific textual evidence related to our knowledge of feedbacks in the Earth system, attending to the research methodologies the author employed to generate the evidence. • Cite specific textual evidence describing how different climate models were created while attending to the specific data including in the model and the resolution of the models. • Refer to journal articles related to a component of the climate system, synthesize the information and tie it back to the research back to the functioning of the entire climate system. • Refer to journal articles written by scientists describing the research included in the creation of climate models. Synthesize the information and share it with your classmates. • Select a digital media to display the solution to a climate change issue. • Focusing on an aspect of the climate system, select a digital media format, and create a presentation that accurately explains the functioning of that particular aspect of the climate system. **Mathematics** • Represent symbolically an explanation for how variations in the flow of energy into and out of Earth's systems result in changes in climate, and manipulate the representing symbols. Use symbols to make sense of quantities and relationships about how variations in the flow of energy into and out of Earth's systems result in changes in climate, symbolically and manipulate the representing symbols. • Use a mathematical model to explain how variations in the flow of energy into and out of Earth's systems result in changes in climate. Identify important quantities in variations in the flow of energy into and out of Earth's systems result in changes in climate

and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
• Use units as a way to understand problems and to guide the solution of multistep problems about how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret units consistently in formulas representing how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret the scale and the origin in graphs and data displays representing how variations in the flow of energy into and out of Earth's systems result in changes in climate.
• Define appropriate quantities for the purpose of descriptive modeling of how variations in the flow of energy into and out of Earth's systems result in changes in climate.
• Choose a level of accuracy appropriate to limitations on measurement when reporting quantities to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
• Represent symbolically the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere, and manipulate the representing symbols. Make sense of quantities and relationships in the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
• Use a mathematical model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. Identify important quantities in the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
• Use units as a way to understand the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere; choose and interpret units consistently in formulas representing the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere; choose and interpret the scale and the origin in graphs and data displays representing the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
• Define appropriate quantities for the purpose of descriptive modeling of the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
• Choose a level of accuracy appropriate to limitations on measurement when reporting quantities showing the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
• Define appropriate quantities for the purpose of descriptive modeling of relationships among changes in climate and its influence on human activity.

Three-Dimensional Teaching and Learning

This unit of study focuses on weather and climate and the cause-and-effect relationships between human activity and the climate system. Students develop an understanding of how the foundation for Earth's global climate systems is the radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. They also examine how cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the Earth. These phenomena cause a cycle of ice ages and other gradual climate changes. Students conduct research to locate and analyze data sets showing these phenomena.

In order to determine how changes in the atmosphere due to human activity have increased the carbon dioxide concentrations and affected climate, students should look at cycles of differing timescales and their effects on climate. Geoscience data is used to explain climate change over a wide-range of timescales. Students might also explore Earth's climate history through an analysis of datasets such as the Keeling Curve or Vostok ice core data.

Students analyze data, using tools, technologies, and models to make claims about relationships between changes to Earth's surface and feedback mechanisms. For example, students examine data from the Earth's weather patterns to model how some weather patterns and Earth events are related to the use of natural resources such as carbon-based resources. Examples of feedback include how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, thus reducing the amount of sunlight reflected from Earth's surface, which in turn increases surface temperatures and further reduces the amount of ice. Students then provide and explain examples (such as CO2 emissions, ozone depletion, changing weather patterns, etc.) of the negative and positive feedback that can stabilize and destabilize the environment. Students cite examples of new technologies (such as gasoline cars, hydrogen-fuel-cell cars, biofuel cars, solar power, alternative energy, etc.) and consider their impacts on society and the environment. Students also consider the inorganic carbon cycle and geologic processes.

Through computer simulations and other studies, important discoveries are still being made about how the ocean, atmosphere, and biosphere interact and are modified in response to human activities. Students describe the boundaries of Earth's systems by looking at models, data sets, or graphics showing temperatures and currents of the ocean and atmosphere. They should identify evidence to support the claim that human activity can modify Earth's systems, especially the climate system.

Students will continue their study of Earth's systems by examining the history of the atmosphere. Students should research the early atmospheric components and the changes that occurred due to plants and other organisms removing carbon dioxide and releasing oxygen. By studying the carbon cycle, students should revisit the idea that matter and energy within a closed system are conserved among the hydrosphere, atmosphere, geosphere, and biosphere. Students should extend their understanding of how human activity affects the concentration of carbon dioxide in the environment and therefore climate. Students' experiences should include synthesizing information from multiple sources and developing quantitative models based on evidence to describe the cycling of carbon among the ocean, atmosphere, soil, and biosphere. Students should understand how biogeochemical cycles provide the foundation for living organisms.

Environmental factors have affected human populations over the course of history. Resource availability, natural disasters, and other geologic events have driven global development of societies, sizes of human populations, and human migrations. Student understanding of these relationships could be enhanced by examining and citing evidence from text or other investigations that show correlations between human population distribution and regional availability of resources such as fresh water, fertile soils, and clean air.

Prior Learning
Physical science • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

• The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

• Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.

• A system of objects may also contain stored (potential) energy, depending on their relative positions.

• Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

• When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

• The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

• Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

• The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.

• Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.

• When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object’s material and the frequency (color) of the light.

• The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.

• A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.

• However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Life science

• Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

• Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.

• Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

• Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

• Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.

• Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.

Earth and space science

• All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.

• The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

• Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.

• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.

• The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

• Global movements of water and its changes in form are propelled by sunlight and gravity.

• Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.

• Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.

• Because these patterns are so complex, weather can only be predicted probabilistically.

• The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

• Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.

• Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.

• Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

• Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever

climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

Part A: What factors influence the climates we have on Earth today? Have those climates always been as we have them today?	
Concepts	**Formative Assessment**
• Develop an understanding of how the foundation for Earth's global climate systems is the radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. • Examine how cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the Earth. • Analyze phenomena cause a cycle of ice ages and other gradual climate changes. •Conduct research to locate and analyze data sets showing these phenomena.	*Students who understand the concepts are able to:* • Construct an explanation based on valid and reliable evidence for the causes of current and past climates and weather. • Use a computational representation to illustrate the relationships among Earth systems and climate. • Analyze and describe the inputs and outputs of Earth systems that impact climate and weather.

Part B: What happens if we change the chemical composition of our atmosphere?	
Concepts	**Formative Assessment**

• The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. • Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. • The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. •Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	*Students who understand the concepts are able to:* • Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. • Use empirical evidence to differentiate between how variations in the flow of energy into and out of Earth's systems result in climate changes. • Use multiple lines of evidence to support how variations in the flow of energy into and out of Earth's systems result in climate changes. .

Part C: How does carbon cycle among the hydrosphere, atmosphere, geosphere, and biosphere?	
Concepts	**Formative Assessment**
• Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. • The total amount of energy and matter in closed systems is conserved. •The total amount of carbon cycling among and between the hydrosphere, atmosphere, geosphere, and biosphere is conserved.	*Students who understand the concepts are able to:* •Analyze a model based on evidence to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

Part D: What happens to solar energy as it moves through the atmosphere and strikes a surface?	
Concepts	**Formative Assessment**
• When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X- rays, gamma rays) can ionize atoms and cause damage to living cells.	*Students who understand the concepts are able to:* • Evaluate the validity and reliability of multiple claims in published materials about the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

• Cause-and-effect relationships can be suggested and predicted for electromagnetic radiation systems when matter absorbs different frequencies of light by examining what is known about smaller scale mechanisms within the system.	• Suggest and predict cause-and-effect relationships for electromagnetic radiation systems when matter absorbs different frequencies of light.

Part E: What is the current rate of global or regional climate change and what are the associated future impacts to Earth's systems?

Concepts	Formative Assessment
• 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. • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • 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. • Both physical models and computers can be used in various ways to aid the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test ways of solving a problem or to see which one is most efficient or economical, and in making a persuasive	*Students who understand the concepts are able to:* • Create or revise a simulation based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations to test a solution to mitigate adverse impacts of human activity on climate systems. • Use empirical evidence to make claims about the impacts of human activity on climate. • Design a solution for a proposed problem related to climate change. • Analyze costs and benefits of a solution to mitigate adverse impacts of human activity on climate systems.

presentation to a client about how a given design will meet his or her needs. • 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.	

Modifications:

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, Zoom, Google Meet experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.

Leveraging English Language Arts/Literacy and Mathematics
English Language Arts/Literacy • Cite specific textual evidence related to our knowledge of feedbacks in the Earth system, attending to the research methodologies the author employed to generate the evidence. • Cite specific textual evidence describing how different climate models were created while attending to the specific data including in the model and the resolution of the models. • Refer to journal articles related to a component of the climate system, synthesize the information and tie it back to the research back to the functioning of the entire climate system. • Refer to journal articles written by scientists describing the research included in the creation of climate models. Synthesize the information and share it with your classmates. • Select a digital media to display the solution to a climate change issue. • Focusing on an aspect of the climate system, select a digital media format, and create a presentation that accurately explains the functioning of that particular aspect of the climate system. **Mathematics** • Represent symbolically an explanation for how variations in the flow of energy into and out of Earth's systems result in changes in climate, and manipulate the representing symbols. Use symbols to make sense of quantities and relationships about how variations in the flow of energy into and out of Earth's systems result in changes in climate, symbolically and manipulate the representing symbols. • Use a mathematical model to explain how variations in the flow of energy into and out of Earth's systems result in changes in climate. Identify important quantities in variations in the flow of energy into and out of Earth's systems result in changes in climate

and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

• Use units as a way to understand problems and to guide the solution of multistep problems about how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret units consistently in formulas representing how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret the scale and the origin in graphs and data displays representing how variations in the flow of energy into and out of Earth's systems result in changes in climate.

• Define appropriate quantities for the purpose of descriptive modeling of how variations in the flow of energy into and out of Earth's systems result in changes in climate.

• Choose a level of accuracy appropriate to limitations on measurement when reporting quantities to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

• Represent symbolically the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere, and manipulate the representing symbols. Make sense of quantities and relationships in the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

• Use a mathematical model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. Identify important quantities in the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

• Use units as a way to understand the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere; choose and interpret units consistently in formulas representing the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere; choose and interpret the scale and the origin in graphs and data displays representing the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

• Define appropriate quantities for the purpose of descriptive modeling of the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

• Choose a level of accuracy appropriate to limitations on measurement when reporting quantities showing the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

• Define appropriate quantities for the purpose of descriptive modeling of relationships among changes in climate and its influence on human activity.

Samples of Open Education Resources for this unit:

USGS Educational Resources for Secondary Grades (7–12): This web site contains selected USGS educational resources that may be useful to educators in secondary school grades. Many of these resources can be used directly in the classroom or will be useful in classroom lessons or demonstration activities preparation, or as resources for teacher education and curriculum development.

NOAA Education Resources: This website contains access to curriculum resources, professional development opportunities, student opportunities, and outreach events.

Online Textbook: Environmental Science: Your World Your Turn: This is the online version of the textbook for this class.

National Center for Case Study Teaching In Science: This is a great resource when using case studies to highlight important concepts.

MY NASA DATA: Students select satellite datasets to answer questions related to system interactions and feedbacks.

Glaciers: Students will explain how environmental conditions (temperature and precipitation) impact glacial mass budget; identify where snow accumulates in a glacier and justify why.

Solar Variability & Orbital Cycles: Students select scientific readings and datasets and identify relationships among solar variability, orbital cycles, and Earth's climate over various time scales. Modification of OER: Ice Cores and Orbital variations: Students apply the output of this visualization to develop a model of orbital changes as related to Earth's temperature over deep time.

Climate Reanalyzer: Students use the data on this website to assess diurnal, monthly, seasonal, and annual changes in the weather and climate parameters. Alternatively, data may be acquired from NASA NEO or NASA Giovanni.

Climate Modeling 101: Students use the information in this tutorial to understand how climate models are created and interpreted. They apply what they learn to the climate model outputs they interpret.

Paleoclimate Data Access: Students select from various paleoclimate datasets. After they understand how the data was collected and how it is interpreted, they display and analyze the data. They interpret the data and seek relationships among the datasets in order to understand changes in the Earth's climate over time.

USGS Realtime Water data and Climate data: Students create and run an investigation to determine the relationship between streamflow and precipitation data, or another parameter.

Greenhouse Effect: Students explore the atmosphere during the ice age and today. What happens when you add clouds? Change the greenhouse gas concentration and see how the temperature changes. Then compare to the effect of glass panes. Zoom in and see how light interacts with molecules. Do all atmospheric gases contribute to the greenhouse effect?

Earth Systems Activity: Students model the carbon cycle and it's connection with Earth's climate. .

Carbon Stabilization Wedge: Students play this game in order to evaluate competing design solutions for developing, managing, and utilizing energy resources based on cost-benefit ratios.

National Climate Assessment: Students explore the simulations found at this website in order to create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

Differentiation		
504	• preferential seating • extended time on tests and assignments • reduced homework or classwork • verbal, visual, or technology aids	• modified textbooks or audio-video materials • behavior management support • adjusted class schedules or grading • verbal testing

Enrichment	● Utilize collaborative media tools ● Provide differentiated feedback ● Opportunities for reflection	● Encourage student voice and input ● Model close reading ● Distinguish long term and short term goals
IEP	● Utilize "skeleton notes" where some required information is already filled in for the student ● Provide access to a variety of tools for responses ● Provide opportunities to build familiarity and to practice with multiple media tools ● Graphic organizers	● Leveled text and activities that adapt as students build skills ● Provide multiple means of action and expression ● Consider learning styles and interests ● Provide differentiated mentors
ELLs	● Pre-teach new vocabulary and meaning of symbols ● Embed glossaries or definitions ● Provide translations ● Connect new vocabulary to background knowledge	● Provide flash cards ● Incorporate as many learning senses as possible ● Portray structure, relationships, and associations through concept webs ● Graphic organizers
At-risk	● Purposeful seating ● Counselor involvement ● Parent involvement	● Contracts ● Alternate assessments ● Hands-on learning

21st Century Skills	
● Creativity ● Innovation	● Problem Solving ● Communication

• Critical Thinking	• Collaboration
Integrating Technology	
• Chromebooks • Internet research • Online programs	• Virtual collaboration and projects • Presentations using presentation hardware and software

Environmental Science	Grade 9	Unit 6: Human Activity and Energy Resources	Marking Period 4 (15 instructional days)

Environmental Science Unit 6: Human Activity and Energy Resources : (15 Instructional Days)

How is energy generated for human activity?

In this unit of study, students engage in argument from evidence, develop and use models, ask questions and define problems, construct explanations and design solutions, and evaluate information. This unit focuses on ideas surrounding energy and energy transformations as related to the needs for human activity. Students create a computational model to calculate the change in the energy use and consumption. Students analyze the benefits and costs of using various natural resources to produce electricity. At the basis of our energy needs is the need for resources to create energy, and therefore students evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. The crosscutting concepts of systems and system models, energy and matter, cause and effect, and stability and change are called out as an organizing concept for these disciplinary core ideas.

Overarching Essential Questions	Overarching Enduring Understandings
• What is energy? • What is the best energy source for a home? How would I meet the energy needs of a house of the future? • How can we use mathematics in decision-making about energy resources?	• Energy causes things to happen. Energy is defined as the ability to do work and depends on the motion and interactions of matter and radiation within that system. • All forms of energy production and other resource extraction have associated economic, social, environmental, and

	geopolitical costs and risks as well as benefits. • Analysis of costs and benefits is a critical aspect of decisions about technology.
Student Learning Objectives	
Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.	**HS-ESS3-2**
Investigate how all forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. .	**HS-ESS3-2**
Use models to illustrate that energy can be associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).	**HS-PS3-2**

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations). **Developing and Using Models** Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and use a model based on evidence to illustrate the relationships	**ESS3.A: Natural Resources** • All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **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. **PS3.A: Definitions of Energy** • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to	**Influence of Science, Engineering, and Technology on Society and the Natural World** • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. • Analysis of costs and benefits is a critical aspect of decisions about technology. **Addresses Questions About the Natural and Material World** • Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. • Science knowledge indicates what can happen in natural systems — not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. • Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. **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.

between systems or between components of a system.	another and between its various possible forms. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. • These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.	

Embedded English Language Arts/Literacy and Mathematics

English Language Art/Literacy

• Collect relevant data across a broad spectrum of sources about the distribution of energy in a system and assess the strengths and limitations of each source.
• Synthesize findings from experimental data into a coherent understanding of energy distribution in a system.
• Cite specific textual evidence to evaluate competing design solutions for developing, managing, and utilizing energy resources based on cost–benefit ratios.
• Evaluate the hypotheses, data, analysis, and conclusions of competing design solutions for developing, managing, and utilizing energy resources based on cost–benefit ratios, verifying the data when possible and corroborating or challenging conclusions with other design solutions.
• Integrate and evaluate multiple design solutions for developing, managing, and utilizing energy resources based on cost–benefit ratios in order to reveal meaningful patterns and trends.
• Evaluate the hypotheses, data, analysis, and conclusions of competing design solutions for developing, managing, and utilizing energy resources based on cost–benefit ratios, verifying the data when possible and corroborating or challenging conclusions with other design solutions.
• Synthesize data from multiple sources of information in order to create data sets that inform design decisions and create a coherent understanding of developing, managing, and utilizing energy resources.
• Make strategic use of digital media in presentations to support the claim that energy at the macroscopic scale can be accounted for as a combination of energy associated with motions of particles (objects) and energy associated with the relative position of particles (objects).
• Conduct short as well as more sustained research projects to describe energy conversions as energy flows into, out of, and within systems.
• Integrate and evaluate multiple sources of information presented in diverse formats and media to describe energy conversions as energy flows into, out of, and within systems.
• Evaluate scientific text regarding energy conversions to determine the validity of the claim that although energy cannot be destroyed, it can be converted into less useful forms.
• Assess the extent to which the reasoning and evidence in a text supports the author's claim that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
• Cite specific textual evidence to support the wave model or particle model in describing electromagnetic radiation, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
• Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text relating that electromagnetic radiation can be described either by a wave model or a particle model and that for some situations one model is more useful than the other, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., qualitative data, video multimedia) in order to address the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
• Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text describing the effects that different frequencies of electromagnetic radiation have when absorbed by matter, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
• Gather relevant information from multiple authoritative print and digital sources describing the effects that different frequencies of electromagnetic radiation have when absorbed by matter, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Mathematics
• Use a mathematical model to describe energy distribution in a system when two components of different temperature are combined. Identify important quantities in energy distribution in a system when two components of different temperature are combined and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
• Choose a level of accuracy appropriate to limitations on measurement when reporting quantities of the properties of water and their effects on Earth materials and surface processes.
• Use symbols to represent an explanation of the best of multiple design solutions for developing, managing, and utilizing energy and mineral resources and manipulate the representing symbols. Make sense of quantities and relationships in cost–benefit ratios for multiple design solutions for developing, managing, and utilizing energy and mineral resources symbolically and manipulate the representing symbols.
• Use a mathematical model to explain the evaluation of multiple design solutions for developing, managing, and utilizing energy and mineral resources. Identify important quantities in cost–benefit ratios for multiple design solutions for developing, managing, and utilizing energy and mineral resources and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
• Use units as a way to understand how the change in the energy of one component in a system can be calculated when the change in energy of the other component(s) and energy flows in and out of the system are known; choose and interpret units consistently in formulas representing how the change in the energy of one component in a system can be calculated when the change in energy of the other component(s) and energy flows in and out of the system are known; choose and interpret the scale and the origin in graphs and data displays representing that the energy of one component in a system can be calculated when the change in energy of the other component(s) and energy flows in and out of the system are known.
• Represent the conversion of one form of energy into another symbolically, considering criteria and constraints, and manipulate the representing symbols. Make sense of quantities and relationships in the conversion of one form of energy into another.

• Use a mathematical model of how energy at the macroscopic scale can be accounted for as a combination of energy associated with motions of particles (objects) and energy associated with the relative position of particles (objects). Identify important quantities representing how the energy at the macroscopic scale can be accounted for as a combination of energy associated with motions of particles (objects) and energy associated with the relative position of particles (objects), and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose. • Use a mathematical model to describe the conversion of one form of energy into another and to predict the effects of the design on systems and/or interactions between systems. Identify important quantities in the conversion of one form of energy into another and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose. • Use units as a way to understand the conversion of one form of energy into another; choose and interpret units consistently in formulas representing energy conversions as energy flows into, out of, and within systems; choose and interpret the scale and the origin in graphs and data displays representing energy conversions as energy flows into, out of, and within systems. • Define appropriate quantities for the purpose of descriptive modeling of a device to convert one form of energy into another form of energy.

Three-Dimensional Teaching and Learning
In this unit, students explore the disciplinary core ideas around energy resources while applying core ideas from physical science related to energy. Working from the premise that all forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs, risks, and benefits, students use cost–benefit ratios to evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources. For example, students might investigate solar and wind as a mode for capturing energy versus other traditional means of acquiring energy from natural resources such as coal and oil. Students will synthesize information from a range of sources into a coherent understanding of competing design solutions for extracting and utilizing energy and mineral resources. As students evaluate competing design solutions, they consider that new technologies could have deep impacts on society and the environment, including some that were not anticipated. Some of these impacts could raise ethical issues for which science does not provide answers or solutions. In their evaluations, students should make sense of quantities and relationships associated with developing, managing, and utilizing energy and mineral resources. Mathematical models can be used to explain their evaluations. Students might represent their understanding by

conducting a Socratic seminar as a way to present opposing views. Students should consider and discuss decisions about designs in scientific, social, and cultural contexts.

Prior Learning
Physical science • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). • The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. • Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). • Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. • A system of objects may also contain stored (potential) energy, depending on their relative positions.

• Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

• When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

• The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

• Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

• When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.

• The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.

• A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

• A sound wave needs a medium through which it is transmitted.

• When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.

• The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.

• A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.

• However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Life Science

• Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.

• In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.

• Growth of organisms and population increases are limited by access to resources.

• Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

• Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.

Earth and space science

• All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.

• The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

• Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

• Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.

• Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Part A: What is energy?	
Concepts	**Formative Assessment**
• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. • Energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. • Radiation is a phenomenon in which energy stored in fields moves across spaces. • Energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. • Cycling of resources among and between the hydrosphere, atmosphere, geosphere, and biosphere is conserved.	*Students who understand the concepts are able to:* • Develop and use models based on evidence to illustrate that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. • Use mathematical expressions to quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compressions of a spring) and how kinetic energy depends on mass and speed. • Use mathematical expressions and the concept of conservation of energy to predict and describe system behavior.

Part B: What is the best energy source for a home? How would I meet the energy needs of a house of the future?	
Concepts	**Formative Assessment**
• All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.	*Students who understand the concepts are able to:* • Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost benefit ratios, scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations).

• Models can be used to simulate systems and interactions, including energy, matter, and information flows, within and between systems at different scales. • Engineers continuously modify design solutions to increase benefits while decreasing costs and risks. • Analysis of costs and benefits is a critical aspect of decisions about technology. • Scientific knowledge indicates what can happen in natural systems, not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. • New technologies can have deep impacts on society and the environment, including some that were not anticipated. • Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. • Many decisions are made not using science alone, but instead relying on social and cultural contexts to resolve issues.	• Use models to evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost–benefit ratios, scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations).

Part C: How can we use mathematics in decision-making about energy resources?	
Concepts	**Formative Assessment**

• Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • The availability of energy limits what can occur in any system. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximation inherent in models. • Science assumes that the universe is a vast single system in which basic laws are consistent.	*Students who understand the concepts are able to:* • Develop and use models based on evidence to illustrate that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. • Use mathematical expressions to quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compressions of a spring) and how kinetic energy depends on mass and speed. • Use mathematical expressions and the concept of conservation of energy to predict and describe system behavior.

Modifications:
• Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques- auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).

- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, Zoom, Google Meet experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.

Leveraging English Language Arts/Literacy and Mathematics
English Language Art/Literacy • Collect relevant data across a broad spectrum of sources about the distribution of energy in a system and assess the strengths and limitations of each source. • Synthesize findings from experimental data into a coherent understanding of energy distribution in a system. • Cite specific textual evidence to evaluate competing design solutions for developing, managing, and utilizing energy resources based on cost–benefit ratios. • Evaluate the hypotheses, data, analysis, and conclusions of competing design solutions for developing, managing, and utilizing energy resources based on cost–benefit ratios, verifying the data when possible and corroborating or challenging conclusions with other design solutions. • Integrate and evaluate multiple design solutions for developing, managing, and utilizing energy resources based on cost–benefit ratios in order to reveal meaningful patterns and trends.

• Evaluate the hypotheses, data, analysis, and conclusions of competing design solutions for developing, managing, and utilizing energy resources based on cost–benefit ratios, verifying the data when possible and corroborating or challenging conclusions with other design solutions.

• Synthesize data from multiple sources of information in order to create data sets that inform design decisions and create a coherent understanding of developing, managing, and utilizing energy resources.

• Make strategic use of digital media in presentations to support the claim that energy at the macroscopic scale can be accounted for as a combination of energy associated with motions of particles (objects) and energy associated with the relative position of particles (objects).

• Conduct short as well as more sustained research projects to describe energy conversions as energy flows into, out of, and within systems.

• Integrate and evaluate multiple sources of information presented in diverse formats and media to describe energy conversions as energy flows into, out of, and within systems.

• Evaluate scientific text regarding energy conversions to determine the validity of the claim that although energy cannot be destroyed, it can be converted into less useful forms.

• Assess the extent to which the reasoning and evidence in a text supports the author's claim that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

• Cite specific textual evidence to support the wave model or particle model in describing electromagnetic radiation, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

• Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text relating that electromagnetic radiation can be described either by a wave model or a particle model and that for some situations one model is more useful than the other, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., qualitative data, video multimedia) in order to address the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

• Gather relevant information from multiple authoritative print and digital sources describing the effects that different frequencies of electromagnetic radiation have when absorbed by matter, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Mathematics

• Use a mathematical model to describe energy distribution in a system when two components of different temperature are combined. Identify important quantities in energy distribution in a system when two components of different temperature are combined and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

• Choose a level of accuracy appropriate to limitations on measurement when reporting quantities of the properties of water and their effects on Earth materials and surface processes.

• Use symbols to represent an explanation of the best of multiple design solutions for developing, managing, and utilizing energy and mineral resources and manipulate the representing symbols. Make sense of quantities and relationships in cost–benefit ratios for multiple design solutions for developing, managing, and utilizing energy and mineral resources symbolically and manipulate the representing symbols.

• Use a mathematical model to explain the evaluation of multiple design solutions for developing, managing, and utilizing energy and mineral resources. Identify important quantities in cost–benefit ratios for multiple design solutions for developing, managing, and utilizing energy and mineral resources and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

• Use units as a way to understand how the change in the energy of one component in a system can be calculated when the change in energy of the other component(s) and energy flows in and out of the system are known; choose and interpret units consistently in formulas representing how the change in the energy of one component in a system can be calculated when the change in energy of the other component(s) and energy flows in and out of the system are known; choose and interpret the scale and the origin in graphs and data displays representing that the energy of one component in a system can be calculated when the change in energy of the other component(s) and energy flows in and out of the system are known.

• Represent the conversion of one form of energy into another symbolically, considering criteria and constraints, and manipulate the representing symbols. Make sense of quantities and relationships in the conversion of one form of energy into another.

• Use a mathematical model of how energy at the macroscopic scale can be accounted for as a combination of energy associated with motions of particles (objects) and energy associated with the relative position of particles (objects). Identify important quantities representing how the energy at the macroscopic scale can be accounted for as a combination of energy associated with motions of particles (objects) and energy associated with the relative position of particles (objects), and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

• Use a mathematical model to describe the conversion of one form of energy into another and to predict the effects of the design on systems and/or interactions between systems. Identify important quantities in the conversion of one form of energy into another and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

• Use units as a way to understand the conversion of one form of energy into another; choose and interpret units consistently in formulas representing energy conversions as energy flows into, out of, and within systems; choose and interpret the scale and the origin in graphs and data displays representing energy conversions as energy flows into, out of, and within systems.

• Define appropriate quantities for the purpose of descriptive modeling of a device to convert one form of energy into another form of energy.

Samples of Open Education Resources for this unit:

USGS Educational Resources for Secondary Grades (7–12): This web site contains selected USGS educational resources that may be useful to educators in secondary school grades. Many of these resources can be used directly in the classroom or will be useful in classroom lessons or demonstration activities preparation, or as resources for teacher education and curriculum development.

NOAA Education Resources: This website contains access to curriculum resources, professional development opportunities, student opportunities, and outreach events.

Online Textbook: Environmental Science: Your World Your Turn: This is the online version of the textbook for this class.

National Center for Case Study Teaching In Science: This is a great resource when using case studies to highlight important concepts.

Carbon Stabilization Wedge: Students play this game in order to evaluate competing design solutions for developing, managing, and utilizing energy resources based on cost-benefit ratios.

One For All: A Natural Resources Game: Identify a strategy that would produce a sustainable use of resources in a simulation game. Draw parallels between the chips used in the game and renewable resources upon which people depend. Draw parallels between the actions of participants in the game and the actions of people or governments in real-world situations.

National Climate Assessment: Students explore the simulations found at this website in order to create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

Know Your Energy Costs: The goal of this activity is to become aware of how much energy you use at school — and the financial and environmental costs.

Energy Skate Park: Basics: Learn about conservation of energy with a skater gal! Explore different tracks and view the kinetic energy, potential energy and friction as she moves. Build your own tracks, ramps, and jumps for the skater.

Work and Energy Workbook Labs: The lab description pages describe the question and purpose of each lab and provide a short description of what should be included in the student lab report.

Radio Waves and Electromagnetic Fields: Phet simulation demonstrating wave generation, propagation and detection with antennas.

Refraction: simulation addressing refraction of light at an interface.

Wave Interference: Phet simulation of both mechanical and optical wave phenomena

Interaction of Molecules with Electromagnetic Radiation: Phet simulation exploring the effect of microwave, infrared, visible and ultraviolet radiation on various molecules.

Differentiation		
504	• preferential seating • extended time on tests and assignments • reduced homework or classwork • verbal, visual, or technology aids	• modified textbooks or audio-video materials • behavior management support • adjusted class schedules or grading • verbal testing
Enrichment	• Utilize collaborative media tools • Provide differentiated feedback • Opportunities for reflection	• Encourage student voice and input • Model close reading • Distinguish long term and short term goals
IEP	• Utilize "skeleton notes" where some required information is already filled in for the student • Provide access to a variety of tools for responses • Provide opportunities to build familiarity and to practice with multiple media tools • Graphic organizers	• Leveled text and activities that adapt as students build skills • Provide multiple means of action and expression • Consider learning styles and interests • Provide differentiated mentors
ELLs	• Pre-teach new vocabulary and meaning of symbols • Embed glossaries or definitions • Provide translations • Connect new vocabulary to background knowledge	• Provide flash cards • Incorporate as many learning senses as possible • Portray structure, relationships, and associations through concept webs • Graphic organizers

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