High School Environmental Science Curriculum

Table of Contents

Unit 1a:Geosphere

Topics

1a1: ESS 1-6: Origin of the earth and how do we know about it.
1a 2: ESS 2-3: Parts of the geosphere and how the different parts interact with each other.
1a 3: ESS2-1, ESS 1-5 : Plate tectonics and large scale interactions (start with seafloor spreading)

Unit 1b : Geosphere - Human Interactions
Topics

1b1: ESS 3-1: How do natural disasters in the geosphere affect us?
1b2: ESS 3-1: What are the resources that we get from the geosphere (natural resource distribution)?
1b3: ESS 3-2 ETS 1.B : How does mining affect the different parts of the earth ? How can we reduce the impacts of mining/ resource extraction?

Unit 2a:Hydrosphere
Topics

2a1. ESS 1-6, ESS 2-7: Origin of the hydrosphere
2a 2 ESS 3-1: How does the water interact with the different parts of the earth?
2a3. ESS 2-1 and ESS 2-5: Properties of water and its effects on earth's materials and surface processes

Unit 2b : Hydrosphere-Human Interactions
Topics

2b1: ESS 3-1, ESS 3-3, ESS 3-4 : Distribution of water, water scarcity and solutions
2b2: ESS 2-2, ESS 3-2 , ESS 3-4: Water pollution and solutions (This is the Meaningful Watershed Educational Experience, which meets the Environmental Literacy Graduation Requirement & the action project can be used for 9th grade service learning).
2b3: ESS 3-1: Natural disasters related to hydrosphere (hurricanes, floods, drought). How can we reduce the impacts of these natural disasters?

Unit 3a:Atmosphere
Topics

3a1 : ESS 2-7 Origin and composition of the atmosphere
3a2: ESS 2-2 : Atmosphere and earth's energy budget
3 a3: ESS 2-4 Transfer of energy between the atmosphere and the different parts of the earth (Global wind circulation)
3a4 : ESS 2-4, ESS 3-5 : Atmospheric composition and flow of energy into and out of Earth's systems (Greenhouse effect)
3a5: LS 2-5, ESS 2-6 : Model carbon cycling among atmosphere, hydrosphere and geosphere (carbon cycle)

Unit 3b: Atmosphere and human interaction
Topics
3b1 : ESS 3-6: Causes and effects of air pollution on earth's systems (emphasize ocean acidification) and human health
3b2: ESS 3-4: ETS 1-2 Solutions to reduce air pollution

Unit 4a: Climate Change
Topics

4a1. ESS2-4: Natural causes of climate change
4a2 ESS3-6: Man-made causes of climate change: How does human activity impact earth's systems, contributing to climate change?
4a3 ESS3-1: Effects of climate change on geosphere, atmosphere, hydrosphere and biosphere

Unit 4b Climate- Human Interaction
Topics

4b1: ESS3-5 : By researching and analyzing data, how can we predict the future impact of global climate change
4b2: ESS 3-4: Solutions to adapt to and mitigate climate change

Unit 5a: Biosphere
Topics

5a 1: LS 2-6 ESS 3-3 Biomes: How do biotic and abiotic factors interact with each other and the importance of biodiversity

Unit 5b: Biosphere-Human Interaction
Topics

5b LS 4-6, LS 2-7, ESS 3-3: Human impacts on biodiversity and solutions to mitigate adverse impacts of human activities on biodiversity

- Habitat loss- dams
- Invasive species
- Pollution
- Population growth
- Overuse of resources

Unit 1a: Geosphere

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
The earth has been shaped by various factors since its origin. Scientists use evidence to explain earth's planetary history.	How do people reconstruct and date events in Earth's planetary history?

Topic 1a1:Origin of the earth and how do we know about it.

Performance Expectations	Evidence Statements	Objectives	Phenomenon
HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.] **SEP: Construct Explanation** **CCC: Stability and change**	**1.Articulating the explanation of phenomena** a. Students construct an account of Earth's formation and early history that includes that: i. Earth formed along with the rest of the solar system 4.6 billion years ago. ii. The early Earth was bombarded by impacts just as other objects in the solar system were bombarded. iii. Erosion and plate tectonics on Earth have destroyed much of the evidence of this bombardment, explaining the relative scarcity of impact craters on Earth. **2. Evidence** a. Students include and describe the following evidence in their explanatory account: i. The age and composition of Earth's oldest rocks, lunar rocks, and meteorites as determined by radiometric dating; ii. The composition of solar system objects; iii. Observations of the size and distribution of impact craters on the surface of Earth and on the surfaces of solar system objects (e.g., the moon, Mercury, and Mars); and iv. The activity of plate tectonic processes, such as volcanism, and surface processes, such as erosion, operating on Earth. **3 Reasoning** a. Students use reasoning to connect the evidence to	1. Use/ create a model to construct an account of how the earth formed and how various factors changed the earth over time. 2. Describe how and why scientists use radiometric dating to gather evidence about the age of the earth. ● 3. Describe how observations of other planetary surfaces and their patterns of impact craters can be used to infer that Earth had many impact craters early in its history. 4. Describe the effects of plate tectonic processes, such as volcanism, and surface processes, such as erosion, operating on Earth constantly shape/ change the earth.	How did the earth form and evolve over time? What evidence do we have to explain the origin and evolution of earth? Background:https://www.washingtonpost.com/news/speaking-of-science/wp/2017/03/06/dear-science-how-do-we-know-how-old-the-earth-is/

	construct the explanation of Earth's formation and early history, including that: i. Radiometric ages of lunar rocks, meteorites and the oldest Earth rocks point to an origin of the solar system 4.6 billion years ago, with the creation of a solid Earth crust about 4.4 billion years ago. ii. Other planetary surfaces and their patterns of impact cratering can be used to infer that Earth had many impact craters early in its history. iii. The relative lack of impact craters and the age of most rocks on Earth compared to other bodies in the solar system can be attributed to processes such as volcanism, plate tectonics, and erosion that have reshaped Earth's surface, and that this is why most of Earth's rocks are much younger than Earth itself.	5. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. Assessment: Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.	

Topic 1a2:Parts of the geosphere and how the different parts interact with each other.

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
Earth's surface is a complex and dynamic set of interconnected systems—principally the geosphere, hydrosphere, atmosphere, and biosphere—that interact over a wide range of temporal and spatial scales. All of Earth's processes are the result of energy flowing and matter cycling within and among these systems. For example, the motion of tectonic plates is part of the cycles of convection in Earth's mantle, driven by outflowing heat and the downward pull of gravity, which result in the formation and changes of many features of Earth's land and undersea surface.	How do the major parts of the geosphere interact with each other? How does matter and energy cycle and affect the interactions between the parts of the geosphere?

Performance Expectations	Evidence Statements	Objectives	Phenomenon
Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. **SEP: Developing and Using Models** **CCC: Energy and Matter**	**1 Components of the model** a. Students develop a model (i.e., graphical, verbal, or mathematical) in which they identify and describe* the components based on both seismic and magnetic evidence (e.g., the pattern of the geothermal gradient or heat flow measurements) from Earth's interior, including: i. Earth's interior in cross-section and radial layers (crust, mantle, liquid outer core, solid inner core) determined by density; ii. The plate activity in the outer part of the geosphere; iii. Radioactive decay and residual thermal energy from the formation of the Earth as a source of energy; iv. The loss of heat at the surface of the earth as an output of energy; and v. The process of convection that causes hot matter to rise (move away from the center) and cool matter to fall (move toward the center). **2 Relationships** a. Students describe* the relationships between components in the model, including: i. Energy released by radioactive decay in the Earth's crust and mantle and residual thermal energy from the formation of the Earth provide energy that drives the	1.Construct/ use a model to identify the structural and compositional layers of the geosphere determined by density (specifically call out the differences between the outer core and inner core). 2. Construct/ use a model to illustrate earth's internal heat source and how the energy is transferred between the layers (radioactive decay, thermal energy and convection current, discuss earth's magnetic field) and the heat is released at the surface.	Where does the energy and matter in volcanoes come from? HS-ESS2-1 Fire and Iceland …

	flow of matter in the mantle. ii. Thermal energy is released at the surface of the Earth as new crust is formed and cooled. iii. The flow of matter by convection in the solid mantle and the sinking of cold, dense crust back into the mantle exert forces on crustal plates that then move, producing tectonic activity. iv. The flow of matter by convection in the liquid outer core generates the Earth's magnetic field. v. Matter is cycled between the crust and the mantle at plate boundaries. Where plates are pushed together, cold crustal material sinks back into the mantle, and where plates are pulled apart, mantle material can be integrated into the crust, forming new rock. **3 Connections** a. Students use the model to describe* the cycling of matter by thermal convection in Earth's interior, including: i. The flow of matter in the mantle that causes crustal plates to move; ii. The flow of matter in the liquid outer core that generates the Earth's magnetic field, including evidence of polar reversals (e.g., seafloor exploration of changes in the direction of Earth's magnetic field); iii. The radial layers determined by density in the interior of Earth; and iv. The addition of a significant amount of thermal energy released by radioactive decay in Earth's crust and mantle.	3. Construct / use a model to illustrate how matter is recycled at the surface due to convection current.	

Topic 1a3: Plate tectonics and large scale interactions (start with seafloor spreading)

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
The ages of oceanic crust changes with increasing distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust changes with increasing distance away from a central ancient core (a result of past plate interaction). that crustal materials of different ages are arranged on Earth's surface in a pattern that can be attributed to plate tectonic activity and formation of new rocks from magma rising where plates are moving apart. The Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.	Why do we have rocks of different ages? What evidence can we gather to explain why we have rocks of different ages? How can we model the scale at which constructive and destructive processes shape our earth continental and oceanic features?

Performance Expectations	Evidence Statements	Objectives	Phenomenon
HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. [Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages of oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust decreasing with distance away from a	1 Identifying the given explanation and the supporting evidence a . Students identify the given explanation, which includes the following idea: that crustal materials of different ages are arranged on Earth's surface in a pattern that can be attributed to plate tectonic activity and formation of new rocks from magma rising where plates are moving apart. b Students identify the given evidence to be evaluated. 2 Identifying any potential additional evidence that is relevant to the evaluation a Students identify and describe* additional relevant evidence (in the form of data, information, models, or other appropriate	Investigate the age of ocean floor rocks and gather evidence for plate tectonics. Analyze patterns to infer where new crust is created. Analyze patterns to infer the boundary between two plates that are moving apart. Gather and evaluate evidence to support the claim that the age of the rocks increase as they move away from the mid-ocean ridge. Students will gather and evaluate evidence of the past and current movements of continental and oceanic crust and the theory	

central ancient core of the continental plate (a result of past plate interactions).]	forms) that was not provided but is relevant to the explanation and to evaluating the given evidence, including: i. Measurement of the ratio of parent to daughter atoms produced during radioactive decay as a means for determining the ages of rocks; ii. Ages and locations of continental rocks; iii. Ages and locations of rocks found on opposite sides of mid-ocean ridges; and iv. The type and location of plate boundaries relative to the type, age, and location of crustal rocks. 3 Evaluating and critiquing a . Students use their additional evidence to assess and evaluate the validity of the given evidence. b Students evaluate the reliability, strengths, and weaknesses of the given evidence along with its ability to support logical and reasonable arguments about the motion of crustal plates. 4 Reasoning/synthesis a Students describe* how the following patterns observed from the evidence support the explanation about the ages of crustal rocks: i. The pattern of the continental crust being older than the oceanic crust; ii. The pattern that the oldest continental rocks are located at the center of continents, with the ages decreasing from their centers to their margin; and iii. The pattern that the ages of oceanic crust are greatest nearest the continents and decrease in age with proximity to the mid-ocean ridges.	of plate tectonics to explain the ages of crustal rocks.	

	b Students synthesize the relevant evidence to describe* the relationship between the motion of continental plates and the patterns in the ages of crustal rocks, including that: i. At boundaries where plates are moving apart, such as mid-ocean ridges, material from the interior of the Earth must be emerging and forming new rocks with the youngest ages. ii. The regions furthest from the plate boundaries (continental centers) will have the oldest rocks because new crust is added to the edge of continents at places where plates are coming together, such as subduction zones. iii. The oldest crustal rocks are found on the continents because oceanic crust is constantly being destroyed at places where plates are coming together, such as subduction zones.		
HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as	1 Components of the model a Students use evidence to develop a model in which they identify and describe the following components: i. Descriptions and locations of specific continental features and specific ocean-floor features; ii. A geographic scale, showing the relative sizes/extents of continental and/or ocean-floor features; iii. Internal processes (such as volcanism and tectonic uplift) and surface processes (such as weathering and erosion); and iv. A temporal scale showing the relative times over which processes act to produce continental and/or ocean-floor features. 2 Relationships	Use evidence to create/ develop a model and identify and describe the locations and geographic scales of continental and oceanic features. Use a model to describe how internal processes (such as volcanism and tectonic uplift) and surface processes (such as weathering and erosion); show changes on a temporal scale showing the relative times over which processes act to produce continental and/or ocean-floor features. Use the model to describe the relationship between the causal agents in building up Earth's surface over time.	

weathering, mass wasting, and coastal erosion).] [Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.]	a In the model, students describe the relationships between components, including: i. Specific internal processes, mainly volcanism, mountain building or tectonic uplift, are identified as causal agents in building up Earth's surface over time. iv. The rate at which the features change is related to the time scale on which the processes operate. Features that form or change slowly due to processes that act on long time scales (e.g., continental positions due to plate drift) and features that form or change rapidly due to processes that act on short time scales (e.g., volcanic eruptions) are identified. 3 Connections a Students use the model to illustrate the relationship between 1) the formation of continental and ocean floor features and 2) Earth's internal and surface processes operating on different temporal or spatial scales.	Use a model to analyze the rate at which the features change as it relates to the time scale on which the processes operate. Students use/ develop a model to show the connections between the formation of continental and ocean floor features and Earth's internal and surface processes operating on different temporal or spatial scales.	

Unit 1b : Geosphere - Human Interactions

Topic 1b1: How do natural disasters in the geosphere affect us?

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. Modern civilization depends on major technological systems.	What are the natural disasters associated with the geosphere? How do natural disasters in the geosphere affect the size of human populations? How has technology mitigated the effects of natural disasters associated with the geosphere?

Performance Expectations	Evidence Statements	Objectives	Phenomenon
HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and	Articulating the explanation of phenomena a Students construct an explanation that includes: i. Specific cause and effect relationships between environmental factors (natural hazards, and features of human societies including population size and migration patterns; and ii. That technology in modern civilization has mitigated some of the effects of natural hazards. 2 Evidence a Students identify and describe the evidence to construct their explanation, including: i. Natural hazard occurrences that can affect human activity and have significantly altered the sizes and distributions of human populations in particular regions; Students use a variety of valid and reliable	Explain the causes of natural disasters associated with the geosphere and the effects of the natural disaster on human population size and migration patterns. Use a variety of valid and reliable sources for the evidence, potentially including theories, simulations, peer review, or students' own investigations to explain how technology has mitigated the effects of natural disasters associated with the geosphere. Students gather evidence to describe reasoning for how the evidence allows for the distinction between causal and correlational relationships between natural disasters and human	

droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]	sources for the evidence, potentially including theories, simulations, peer review, or students' own investigations. 3 Reasoning a Students use reasoning that connects the evidence, along with 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, to describe: i. The effect of natural hazards, changes in climate, and the availability of natural resources on features of human societies, including population size and migration patterns; and ii. How technology has changed the cause and effect relationship between the development of human society and natural hazards, b Students describe reasoning for how the evidence allows for the distinction between causal and correlational relationships between environmental factors and human activity.	activity.	

Topic 1b2 : What is the relationship between natural resource distribution and human population?

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
Resource availability has guided the development of human society and this has affected the different parts of the earth	What is the relationship between natural resource distribution and human population? How has technology in modern civilization has mitigated some of the effects of the availability of natural resources on human activity?

Performance Expectations	Evidence Statements	Objectives	Phenomenon
HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate	1 Articulating the explanation of phenomena a Students construct an explanation that includes: i. Specific cause and effect relationships between natural resources and features of human societies including population size and migration patterns; and ii. That technology in modern civilization has mitigated some of the effects of the availability of natural resources on human activity. 2 Evidence a Students identify and describe the evidence to construct their explanation, that features of human societies that have been affected by the availability of natural resources; and evidence of the dependence of human populations on technological systems to acquire natural resources and to modify physical settings.	Explain the cause and effect relationship between the distribution of mineral resources and fossil fuels and human population size and migration patterns. Explain how technology has mitigated some of the effects of the availability of mineral resources and fossil fuels and human population size and migration patterns. Gather evidence to construct an explanation about how the dependence of human populations on technological systems to acquire natural resources and to modify physical settings has impacts on the environment. Analyze data to describe reasoning for how the evidence allows for the	

that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised	3 Reasoning a Students use reasoning that connects the evidence, along with 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, to describe: the availability of natural resources on features of human societies, including population size and migration patterns; and ii. How technology has changed the cause and effect relationship between the development of human society and natural resources. Students describe reasoning for how the evidence allows for the distinction between causal and correlational relationships between environmental factors and human activity.	distinction between causal and correlational relationships between mineral resources, fossil fuel and human activity.	

Topic 1b3: How does mining affect the different parts of the earth?
How can we reduce the impacts of mining/ resource extraction?

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
As the more accessible ores are mined to depletion, mining operations are forced to access lower grade ores. Accessing these ores requires increased use of resources that can cause increased waste and pollution. Surface mining is the removal of large portions of soil and rock, called overburden, in order to access the ore underneath. Mining wastes include the chemicals, soil and rocks that are moved to gain access to the ore and the waste. Mining helps to provide low cost energy and minerals necessary to make products. The mining of coal can destroy habitats, contaminate groundwater, and release dust particles and greenhouse gases. As reserves get smaller, due to a lack of easily accessible reserves, it becomes necessary to access coal through. As mining affects all the earth's systems we need to find ways to mitigate the effects of mining. 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. 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.	How do different types of mining affect different parts of the earth and evaluate solutions to mitigate the effects of each type of mining?

Performance Expectations	Evidence Statements	Objectives	Phenomenon
HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]	1 Supported claims Students describe the nature of the problem each design solution addresses. b Students identify the solution that has the most preferred cost-benefit ratios. 2 Identifying scientific evidence a Students identify evidence for the design solutions, including: i. Societal needs for that energy or mineral resource; ii. The cost of extracting or developing the energy reserve or mineral resource; iii. The costs and benefits of the given design solutions; and iv. The feasibility, costs, and benefits of recycling or reusing the mineral resource, if applicable. 3 Evaluation and critique a Students evaluate the given design solutions, including: i. The relative strengths of the given design solutions, based on associated economic, environmental, and geopolitical costs, risks, and benefits; ii. The reliability and validity of the evidence used to evaluate the design solutions; and iii. Constraints, including cost, safety, reliability, aesthetics, cultural effects,	Describe the environmental problems associated with different types of mining. Identify the different solutions to mitigate the effects of each type of mining. Evaluate each solution based on criteria and constraints. Use logical arguments to make a claim about the effectiveness of a solution based on evaluation of the design solutions, costs , benefits, empirical evidence and scientific ideas. Debate the claim with peers.	

	environmental effects. 4 Reasoning/synthesis a Students use logical arguments based on their evaluation of the design solutions, costs and benefits, empirical evidence, and scientific ideas to support one design over the other(s) in their evaluation. b Students describe that a decision on the "best" solution may change over time as engineers and scientists work to increase the benefits of design solutions while decreasing costs and risks.		

Unit 2a: Hydrosphere

Topic 2a1:Origin of the Hydrosphere

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
Water is a polar molecule and thus has exceptional properties that are vital to the existence of life and the interactive nature of each of Earth's systems. 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. **(high specific heat capacity, water is less dense as a solid than a liquid, water is the universal solvent)**	**1. What are the properties of water?** **2. How does water affect living and nonliving parts of the earth's systems?** **3. What is polarity and how is it related to the properties of water?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
HS-ESS 2-5 **Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.**	**Observable features of the student performance by the end of the course:** **1. Identifying the phenomenon to be investigated** a. Students describe* the phenomenon under investigation, which includes the following idea: a connection between the properties of water and its effects on Earth materials and surface processes. **2. Identifying the evidence to answer this question** a. Students develop an investigation plan and describe* the data that will be collected and the evidence to be derived from the data, including: i. Properties of water, including: a) The heat capacity of water; b) The density of water in its solid and liquid states; and c) The polar nature of the water molecule due to its molecular structure. ii. The effect of the properties of water on energy transfer that causes the patterns of temperature, the movement of air, and the movement and availability of water at Earth's surface. iii. Mechanical effects of water on Earth materials that can be used to infer the effect of water on Earth's surface processes. Examples can include: a) Stream transportation and deposition using a stream table, which can be used to infer the ability of water to transport and deposit materials; b) Erosion using variations in soil moisture content, which can be used to infer the ability of water to prevent or facilitate movement of Earth materials; and c) The expansion of water as it freezes, which can be used to infer the ability of water to break rocks into smaller pieces. iv. Chemical effects of water on Earth materials that can be used to infer the effect of water on Earth's surface processes. Examples can include: a) The solubility of different materials in water, which	1. Students will design an experiment to illustrate the properties of water in order to identify why water is vital to each of earth's systems.	Jesus lizard running on water https://www.youtube.com/watch?v=45yabrnryXk

	can be used to infer chemical weathering and recrystallization; b) The reaction of iron to rust in water, which can be used to infer the role of water in chemical weathering; c) Data illustrating that water lowers the melting temperature of most solids, which can be used to infer melt generation; and d) Data illustrating that water decreases the viscosity of melted rock, affecting the movement of magma and volcanic eruptions. b. In their investigation plan, students describe* how the data collected will be relevant to determining the effect of water on Earth materials and surface processes. **3 Planning for the Investigation** a. In their investigation plan, students include a means to indicate or measure the predicted effect of water on Earth's materials or surface processes. Examples include: i. The role of the heat capacity of water to affect the temperature, movement of air and movement of water at the Earth's surface; ii. The role of flowing water to pick up, move and deposit sediment; iii. The role of the polarity of water (through cohesion) to prevent or facilitate erosion; iv. The role of the changing density of water (depending on physical state) to facilitate the breakdown of rock; v. The role of the polarity of water in facilitating the dissolution of Earth materials; vi. Water as a component in chemical reactions that change Earth materials; and vii. The role of the polarity of water in changing the melting temperature and viscosity of rocks. b. In the plan, students state whether the investigation will be conducted individually or collaboratively. **4 Collecting the data** a. Students collect and record measurements or indications of the predicted effect of a property of water on Earth's materials or surface.		

	5 Refining the design a. Students evaluate the accuracy and precision of the collected data. b. Students evaluate whether the data can be used to infer the effect of water on processes in the natural world. c If necessary, students refine the plan to produce more accurate and precise data.		

Topic 2a2:Distribution of Earth's Water

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
- **Water is a vital natural resource and the distribution of this resource affects each of Earth's systems, as well as the migration and settlement of humans on earth.** - **Water is a limiting factor for organisms.**	1. **How is water geographically distributed on Earth?** 2. **What is the ratio of freshwater to saltwater?** 3. **How does the availability of water resources affect earth's systems?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
HS-ESS 3-1 **Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity**	**Observable features of the student performance by the end of the course:** **1 Articulating the explanation of phenomena** a Students construct an explanation that includes: i. Specific cause and effect relationships between environmental factors (the availability of natural resources) and features of human societies including population size and migration patterns; and ii. That technology in modern civilization has mitigated some of the effects of the availability of natural resources on human activity. **2 Evidence** a Students identify and describe* the evidence to construct their explanation, including: i. Features of human societies that have been affected by the availability of natural resources; and ii. Evidence of the dependence of human populations on technological systems to acquire natural resources and to modify physical settings. b Students use a variety of valid and reliable sources for the evidence, potentially including theories, simulations, peer review, or students' own investigations.	1. Students will identify the importance of water as a natural resource by identifying how water is distributed on Earth. 2. Students will create a model to illustrate the distribution of water on Earth. Students will use the model they create to identify the ratio of salt to freshwater and identify that the majority of freshwater is not available in liquid form. Students will use the model to demonstrate that freshwater is a limited natural resource.	Video: Distribution and uses of water on Earth https://mpt.pbslearningmedia.org/resource/buac19-35-sci-ess-distributionusewater/distribution-and-uses-of-water/

	3 Reasoning a Students use reasoning that connects the evidence, along with 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, to describe*: i. The effect of the availability of natural resources on features of human societies, including population size and migration patterns; and ii. How technology has changed the cause and effect relationship between the development of human society and natural resources. b Students describe* reasoning for how the evidence allows for the distinction between causal and correlational relationships between environmental factors and human activity.	g 3. Students will gather evidence to explain how various factors affect precipitation and therefore distribution of water. 4. Students will gather evidence to explain the causes and effects of global water scarcity and evaluate various solutions to address the issues.	

Topic 2a3:Water Pollution and Solutions

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
- **Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.** - **Human activities on land can have impacts on water quality.**	1. **How do human activities impact the hydrosphere?** 2. **What solutions can help mitigate the impacts of human activities on the hydrosphere?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. **HS-ESS3-4.** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.	**HS-ESS2-2** **Observable features of the student performance by the end of the course:** **1. Organizing data** a. Students organize data that represent measurements of changes in hydrosphere, cryosphere, atmosphere, biosphere, or geosphere in response to a change in Earth's surface. b. Students describe* what each data set represents. **2. Identifying relationships** a. Students use tools, technologies, and/or models to analyze the data and identify and describe* relationships in the datasets, including: i. The relationships between the changes in one system and changes in another (or within the same) Earth system; and ii. Possible feedbacks, including one example of feedback to the climate. b. Students analyze data to identify effects of human activity and specific technologies on Earth's systems if present.	**Wicomico River MWEE Lesson Plan** https://docs.google.com/document/d/1LJqIOxnzltsb2qyYQFtusO0Tdb2iQtMx/edit?usp=share_link&ouid=111379350032099110012&rtpof=true&sd=true Describe the importance of biodiversity in the Wicomico River ecosystem. Identify factors that affect the biodiversity of the Wicomico River ecosystem using graphs and other evidence. Identify and describe the relationships between species and the physical environment in an	How have human activities affected the water quality in Wicomico River and how can we solve the issues?

	3. Interpreting data a. Students use the analyzed data to describe* a mechanism for the feedbacks between two of Earth's systems and whether the feedback is positive or negative, increasing (destabilizing) or decreasing (stabilizing) the original changes. **HS-ESS3-4** **Observable features of the student performance by the end of the course:** 1. Using scientific knowledge to generate the design solution a. Students use scientific information to generate a number of possible refinements to a given technological solution. Students: i. Describe* the system being impacted and how the human activity is affecting that system; ii. Identify the scientific knowledge and reasoning on which the solution is based; iii. Describe* how the technological solution functions and may be stabilizing or destabilizing the natural system; iv. Refine a given technological solution that reduces human impacts on natural systems; and v. Describe* that the solution being refined comes from scientists and engineers in the real world who develop technologies to solve problems of environmental degradation. **2 Describing criteria and constraints, including quantification when appropriate** a. Students describe* and quantify (when appropriate): i. Criteria and constraints for the solution to the problem; and ii. The tradeoffs in the solution, considering priorities and other kinds of research-driven tradeoffs in explaining why this particular solution is or is not needed. **3 Evaluating potential refinements** a. In their evaluation, students describe* how the	ecosystem. Investigate the connection between human development, water quality and biodiversity by comparing various ecosystems around Schumaker Pond. Design a solution that involves reducing the negative effects of human activities on the environment and biodiversity, and that relies on scientific knowledge of the factors affecting changes and stability in biodiversity. Describe* and quantify (when appropriate) the criteria (amount of reduction of impacts and human activities to be mitigated) and constraints (for example, cost, human needs, and environmental impacts) for the solution to the problem, along with the tradeoffs in the solution. Evaluate the proposed solution for its impact on overall environmental stability and changes. Evaluate the cost, safety, and reliability, as well as social, cultural, and environmental impacts, of the proposed solution for a select human activity that is harmful to an ecosystem.	

	refinement will improve the solution to increase benefits and/or decrease costs or risks to people and the environment. b. Students evaluate the proposed refinements for: i. Their effects on the overall stability of and changes in natural systems; and ii. Cost, safety, aesthetics, and reliability, as well as cultural and environmental impacts.		

Topic 2a4: Natural Disasters Related to the Hydrosphere

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
- **Students will understand the impact of natural disasters associated with the hydrosphere, such as hurricanes, floods and droughts, on human activities.** - **Natural hazards have shaped the course of human history; they have significantly altered the sizes of human populations and have driven human migrations.**	1. **How are natural disasters associated with the hydrosphere affecting human activities?** 2. **How can we prepare for large-scale floods and droughts?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.	**Observable features of the student performance by the end of the course:** **1 Articulating the explanation of phenomena** a. Students construct an explanation that includes: i. Specific cause and effect relationships between environmental factors (natural hazards) and features of human societies including population size and migration patterns; and ii. That technology in modern civilization has mitigated some of the effects of natural hazards on human activity. **2 Evidence** a. Students identify and describe* the evidence to construct their explanation, including: i. Natural hazard occurrences that can affect human activity and have significantly altered the sizes and distributions of human populations in particular regions; b Students use a variety of valid and reliable sources for the evidence, potentially including theories, simulations, peer review, or students' own investigations.	1. Students will explain the specific cause and effect relationships between environmental factors (natural hazards = hurricanes, tornadoes, drought, floods) and features of human societies.	Hurricane Sandy Hurricane Sandy: Super Storm Slams East Coast States - YouTube Hurricane Katrina Hurricane Katrina Day by Day | National Geographic - YouTube

	3 Reasoning a. Students use reasoning that connects the evidence, along with 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, to describe*: i. The effect of natural hazards on features of human societies, including population size and migration patterns; and ii. How technology has changed the cause and effect relationship between the development of human society and natural hazards b. Students describe* reasoning for how the evidence allows for the distinction between causal and correlational relationships between environmental factors and human activity.		

Unit 3a: Atmosphere

Topic 3a1: Origin and composition of the atmosphere

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
- **The atmosphere is a dynamic system. The atmosphere is a result of interactions between living and nonliving parts of the earth.** - **Specific elements/ molecules interact as they move through the spheres of the earth and determine the life that can be supported there.** - **The composition of the layers of the atmosphere is determined by the elevation (gravity) and the temperature of the area.**	1. **How has the atmosphere evolved as a result of changes that are happening in the different parts of the earth?** 2. **What is the composition of the atmosphere and how do the elements/molecules of the atmosphere interact with each other and with the other spheres of the earth? Why is this interaction important to life on Earth?** 3. **What factors affect the different layers of the atmosphere?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. [Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in	Observable features of the student performance by the end of the course: 1. Developing the claim a Students develop a claim, which includes the following idea: that there is simultaneous coevolution of Earth's systems and life on Earth. This claim is supported by generalizing from multiple sources of evidence. 2. Identifying scientific evidence a Students identify and describe* evidence	Describe the different layers of the atmosphere, the factors that affect the different layers and how the different layers support life on earth. Gather evidence to support the claim that the earth's atmosphere resulted from the coevolution of Earth's systems and life on earth.	Banded Iron Formation

turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.]	supporting the claim, including: i. Scientific explanations about the composition of Earth's atmosphere shortly after its formation; ii. Current atmospheric composition ; iii. Evidence for the emergence of photosynthetic organisms; iv. Evidence for the effect of the presence of free oxygen on evolution and processes in other Earth systems; v. In the context of the selected example(s), other evidence that changes in the biosphere affect other Earth systems. 3. Evaluating and critiquing a. Students evaluate the evidence and include the following in their evaluation: i. A statement regarding how variation or uncertainty in the data (e.g., limitations, low signal-to-noise ratio, collection bias, etc.) may affect the usefulness of the data as sources of evidence; and ii. The ability of the data to be used to determine causal or correlational effects between changes in the biosphere and changes in Earth's other systems. 4. Reasoning and synthesis	Describe the different layers of the atmosphere, the factors that affect the different layers and how the different layers support life on earth.	

	a. Students use at least two examples to construct oral and written logical arguments. The examples: i. Include that the evolution of photosynthetic organisms led to a drastic change in Earth's atmosphere and oceans in which the free oxygen produced caused worldwide deposition of iron oxide formations, increased weathering due to an oxidizing atmosphere and the evolution of animal life that depends on oxygen for respiration; and ii. Identify causal links and feedback mechanisms between changes in the biosphere and changes in Earth's other systems.		

Topic 3a2: Atmosphere and earth's energy budget

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes **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.**	**How does the interaction between the sun and earths' systems allow life to exist on earth by balancing energy?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.	1 Organizing data a. Students organize data that represent measurements of changes in hydrosphere, cryosphere, atmosphere, biosphere, or geosphere in response to a change in Earth's surface. b Students describe* what each data set represents. 2 Identifying relationships a Students use tools, technologies, and/or models to analyze the data and identify and describe* relationships in the datasets, including: i. The relationships between the changes in one system and changes in another (or within the same) Earth system; and ii. Possible feedbacks, including one	Describe the Global Energy Budget and how energy flows through the various parts of the earth's system. Describe the role that feedback mechanisms play in maintaining earth's energy budget	Why might the Arctic be warming twice as fast as the rest of the world?

	example of feedback to the climate. b Students analyze data to identify effects of human activity and specific technologies on Earth's systems if present. 3 Interpreting data a Students use the analyzed data to describe * a mechanism for the feedbacks between two of Earth's systems and whether the feedback is positive or negative, increasing (destabilizing) or decreasing (stabilizing) the original changes b Students use the analyzed data to describe * a particular unanticipated or unintended effect of a selected technology on Earth's systems if present. c Students include a statement regarding how variation or uncertainty in the data (e.g., limitations, accuracy, any bias in the data resulting from choice of sample, scale, instrumentation, etc.) may affect the interpretation of the data.		

Topic 3a3: Transfer of energy between the atmosphere and the different parts of the earth (Global wind circulation and ocean circulation)

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
A large part of the earth's climate is affected by atmospheric and oceanic circulation	**How does atmospheric circulation affect both weather and climate as well as heat transfer and the earth's overall heat budget?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.	1 Components of the model: a From the given model, students identify and describe* the components of the model relevant for their mechanistic descriptions. Given models include at least one factor that affects the input of energy, at least one factor that affects the output of energy, and at least one factor that affects the storage and redistribution of energy. Factors are derived from the following list: . a. Ocean circulation; Atmospheric circulation; b From the given model, students identify the relevant different time scales on which the factors operate. 2 Relationships a Students identify and describe* the relationships between components of the given model, and	Use models to describe how air circulates between the different parts of the Earth. Use models to describe how atmospheric and ocean circulation relate to heat transfer and affect Earth's weather and climate?	Air masses, Coriolis effect and Jet stream, ocean circulation, weather and climate.

	organize the factors from the given model into three groups: i. Those that affect the input of energy; ii. Those that affect the output of energy; and iii. Those that affect the storage and redistribution of energy b Students describe* the relationships between components of the model as either causal or correlational. 3 Connections a Students use the given model to provide a mechanistic account of the relationship between energy flow in Earth's systems and changes in climate, including: i. The specific cause and effect relationships between the factors and the effect on energy flow into and out of Earth's systems; and ii. The net effect of all of the competing factors in changing the climate.		

Topic 3a4: Atmospheric composition and flow of energy into and out of Earth's systems (Greenhouse Effect)

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
The earth's atmosphere is made up of gases. Certain gases in the atmosphere called greenhouse gases warm the planet and enable life on Earth.	**How is earth's heat (energy) budget affected by atmospheric composition? How do greenhouse gases trap heat and warm the planet?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. 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.	Components of the model: a From the given model, students identify and describe* the components of the model relevant for their mechanistic descriptions. Given models include at least one factor that affects the input of energy, at least one factor that affects the output of energy, and at least one factor that affects the storage and redistribution of energy. Factors are derived from the following list: Atmospheric composition (including amount of water vapor and CO2) and Human activities. b From the given model, students identify the relevant different time scales on which the factors operate. 2 Relationships a Students identify and describe* the relationships between components of the	Use models to illustrate the greenhouse effect caused by earth's environment.	Goldilocks planet https://science.nasa.gov/getting-know-goldilocks-planet-0

	given model, and organize the factors from the given model into three groups: i. Those that affect the input of energy; ii. Those that affect the output of energy; and iii. Those that affect the storage and redistribution of energy b Students describe* the relationships between components of the model as either causal or correlational. 3 Connections a Students use the given model to provide a mechanistic account of the relationship between energy flow in Earth's systems and changes in climate, including: i. The specific cause and effect relationships between the factors and the effect on energy flow into and out of Earth's systems; and ii. The net effect of all of the competing factors in changing the climate. 1 Organizing data a Students organize data (e.g., with graphs) from global climate models (e.g., computational simulations) and climate observations over time that relate to the effect of climate change on the physical parameters or chemical composition of the atmosphere. b Students describe* what each data set represents. 2 Identifying relationships a Students analyze the data and identify and describe* relationships within the datasets, including: i. Changes over time on multiple scales; and ii. Relationships between quantities in the given data. 3 Interpreting data a.Students use their analysis of the data to describe* a selected aspect of present or past climate and the associated chemical		

	composition of the atmosphere b.Students use their analysis of the data to predict the future effect of a selected aspect of climate change on the chemical composition of the atmosphere, geosphere c. Students describe* whether the predicted effect on the system is reversible or irreversible. d. Students identify one source of uncertainty in the prediction of the effect in the future of a selected aspect of climate change. e In their interpretation of the data, students: i. Make a statement regarding how variation or uncertainty in the data (e.g., limitations, accuracy, any bias in the data resulting from choice of sample, scale, instrumentation, etc.) may affect the interpretation of the data; and ii. Identify the limitations of the models that provided the simulation data and ranges for their predictions		

Topic 3a5: Model carbon cycling among atmosphere, hydrosphere and geosphere (carbon cycle)

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
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. **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.**	**How can we use models to describe how carbon moves between different earth's systems?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: Examples of models could include simulations and mathematical models.] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.]	1 Components of the model a Students use evidence to develop a model in which they identify and describe the relevant components, including: i. The inputs and outputs of photosynthesis; ii. The inputs and outputs of cellular respiration; and iii. The biosphere, atmosphere, hydrosphere, and geosphere. 2 Relationships a Students describe relationships between components of their model, including: i. The exchange of carbon (through carbon-containing compounds) between organisms and the environment; and	Use models to show how carbon cycles through the abiotic and biotic components of ecosystems and make carbon continually available to organisms. Describe human impacts on carbon cycle Model the carbon reservoirs and fluxes and consider what might happen as a result of increasing carbon dioxide produced by human activities.	Dinosaur breath https://www.teachengineering.org/activities/view/cub_carbon_lesson01_activity1

Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]	ii. The role of storing carbon in organisms (in the form of carbon-containing compounds) as part of the carbon cycle. 3 Connections a Students describe the contribution of photosynthesis and cellular respiration to the exchange of carbon within and among the biosphere, atmosphere, hydrosphere, and geosphere in their model. b Students make a distinction between the model's simulation and the actual cycling of carbon via photosynthesis and cellular respiration. Components of the model a Students use evidence to develop a model in which they: i. Identify the relative concentrations of carbon present in the hydrosphere, atmosphere, geosphere and biosphere; and ii. Represent carbon cycling from one sphere to another. 2 Relationships a In the model, students represent and describe the following relationships between components of the system, including: i. The biogeochemical cycles that occur as carbon flows from one sphere to another; ii. The relative amount of and the rate at which carbon is transferred between spheres; iii. The capture of carbon dioxide by plants; and iv. The increase in carbon dioxide concentration in the atmosphere due to human activity and the effect on climate. 3 Connections		

	a Students use the model to explicitly identify the conservation of matter as carbon cycles through various components of Earth's systems. b Students identify the limitations of the model in accounting for all of Earth's carbon.		

Unit 3b: Atmosphere and human interaction

Topic 3b1: Causes and effects of air pollution on earth's systems (emphasize ocean acidification) and human health

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	**How do human activities affect the atmosphere?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on	1 Representation a Students identify and describe the relevant components of each of the Earth systems modeled in the given computational representation, including system boundaries, initial conditions, inputs and outputs, and relationships that determine the interaction (e.g., the relationship between atmospheric CO2 and production of photosynthetic biomass and ocean acidification). 2 Computational modeling a Students use the given computational representation of Earth systems to illustrate and describe relationships among at least two of Earth's systems, including how the relevant components in each individual Earth system can drive changes in another, interacting Earth system.	Use model to describe how increase in carbon dioxide due to human activities results in ocean acidification which affects marine life Use model to describe how increase in carbon dioxide due to human activities can increase biomass that can affect human health Use a model to describe how increase in sulfur oxides due to human activities results in acid deposition and smog that affect human health and the environment.	Air pollution due to human activities. https://www.ted.com/talks/matthew_johnson_air_pollution_let_s_analyse_clean_and_deliver https://www.ted.com/talks/beth_gardiner_the_air_we_breathe_is_killing_us_but_it_doesn_t_have_to

land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [A	3 Analysis b Students use evidence from the computational representation to describe how human activity could affect the relationships between the Earth's systems under consideration.	Use a model to describe how increase in Nitrogen oxides NOx due to human activities results in acid deposition and smog that affect human health and the environment. Use a model to describe the causes and effects of ozone depletion and its impacts on human health and the environment.	

Topic 3b2: Solutions to reduce air pollution

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. **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.**	**What are some technological solutions that will reduce the effects of air pollution?** **What are some ways to evaluate/ refine the solutions?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*	Students use scientific information to generate a number of possible refinements to a given technological solution. Students: i. Describe* the system being impacted and how the human activity is affecting that system ; ii. Identify the scientific knowledge and reasoning on which the solution is based; iii. Describe* how the technological solution functions and may be stabilizing or destabilizing the natural system; iv. Refine a given technological solution that reduces human impacts on natural systems; and v. Describe* that the solution being refined comes from scientists and engineers in the real world who develop technologies to solve problems of environmental	Use evidence to evaluate the effectiveness of technological solutions to reduce the effects of air pollution on human and natural systems. Catalytic converter https://www.uen.org/lessonplan/vie Scrubbers	Air pollution solutions https://www.ted.com/talks/major_a_carter_greening_the_ghetto Geoengineering https://www.ted.com/talks/david_keith_a_critical_look_at_geoengineering_against_climate_change https://www.ted.com/talks/david_schurman_we_can_control_climate_but_should_we_the_ethics_of_geoengineering

	degradation. 2 Describing criteria and constraints, including quantification when appropriate a Students describe* and quantify (when appropriate): i. Criteria and constraints for the solution to the problem; and ii. The tradeoffs in the solution, considering priorities and other kinds of research-driven tradeoffs in explaining why this particular solution is or is not needed. 3 Evaluating potential refinements a In their evaluation, students describe* how the refinement will improve the solution to increase benefits and/or decrease costs or risks to people and the environment. b Students evaluate the proposed refinements for: i. Their effects on the overall stability of and changes in natural systems; and ii. Cost, safety, aesthetics, and reliability, as well as cultural and environmental impacts.		

Unit 4a: Climate Change

Topic 4a1: Natural causes of climate change

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
Earth and the Solar System ● Changes in Earth's orbit and tilt alter the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. **Earth Materials and Systems** ● The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. **Weather and Climate** ● The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. ● Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	**1. How can natural changes within Earth's systems cause changes in global and regional climate?** **2. What are the factors that affect the temperature and precipitation of an area?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
ESS2-4: Natural causes of climate change Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]	**Observable features of the student performance by the end of the course:** **1 Components of the model:** a. From the given model, students identify and describe* the components of the model relevant for their mechanistic descriptions. Given models include at least one factor that affects the input of energy, at least one factor that affects the output of energy, and at least one factor that affects the storage and redistribution of energy. Factors are derived from the following list: i. Changes in Earth's orbit and the orientation of its axis; ii. Changes in the sun's energy output; iii. Configuration of continents resulting from tectonic activity; iv. Ocean circulation; v. Atmospheric composition (including amount of water vapor and CO2); vi. Atmospheric circulation; vii. Volcanic activity; viii. Glaciation; ix. Changes in extent or type of vegetation cover; and x. Human activities. b. From the given model, students identify the relevant different time scales on which the factors operate. **2 Relationships** a. Students identify and describe* the relationships between components of the given model, and organize the factors from the given model into three groups: i. Those that affect the input of energy; ii. Those that affect the output of energy; and iii. Those that affect the storage and redistribution of energy b. Students describe* the relationships between components of the model as either causal or	1. Students will use a model to investigate how Earth's climate has changed throughout history. 2. Students conduct an investigation to explore how climate has changed over time. 3. Students will gather information about natural causes of climate change. 4. Students will use a model to investigate how changes in solar energy affects global climate.	Animation on Average Monthly Temperatures (https://www.extremetech.com/extreme/228329-animation-shows-advance-of-climate-change-with-horrifying-clarity) Data from latest IPCC report https://www.climate-lab-book.ac.uk/2021/ipcc-spm-figures/

	correlational. **3 Connections** a. Students use the given model to provide a mechanistic account of the relationship between energy flow in Earth's systems and changes in climate, including: i. The specific cause and effect relationships between the factors and the effect on energy flow into and out of Earth's systems; and ii. The net effect of all of the competing factors in changing the climate.		

Topic 4a2: Man Made Causes of Climate Change

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
Weather and Climate ● Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (secondary) **Global Climate Change** ● Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	How does human activity impact earth's systems, contributing to climate change?

Performance Expectations	Evidence Statements	Objectives	Phenomenon
ESS3-6: Man made causes of climate change Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]	**Observable features of the student performance by the end of the course:** **1. Representation** a. Students identify and describe* the relevant components of each of the Earth systems modeled in the given computational representation, including system boundaries, initial conditions, inputs and outputs, and relationships that determine the interaction (e.g., the relationship between atmospheric CO2 and production of photosynthetic biomass and ocean acidification). **2 Computational modeling** a. Students use the given computational representation of Earth systems to illustrate and describe* relationships among at least two of Earth's systems, including how the relevant components in each individual Earth system can drive changes in another, interacting Earth system. **3 Analysis** a. Students use evidence from the computational representation to describe* how human activity could affect the relationships between the Earth's systems under consideration.	1. Students will investigate the relationship between greenhouse gases and global temperatures.	Increases in GHG Emissions Animation of CO2 emissions 1800-2000 https://climate.nasa.gov/system/video_items/106_69_82_carbon-updated-abstract_4.mp4 Tracking Atmospheric CO2 Following carbon dioxide th…

Topic 4a3: Effects of climate change on geosphere, atmosphere, hydrosphere and biosphere

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. - 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. - Feedback (negative or positive) can stabilize or destabilize a system.	1. How does climate change impact the Earth's systems? 2. What causes positive and negative feedbacks in the global climate system?

Performance Expectations	Evidence Statements	Objectives	Phenomenon
HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected	**ESS2-2** **Observable features of the student performance by the end of the course:** **1 Organizing data** a. Students organize data that represent measurements of changes in hydrosphere, cryosphere, atmosphere, biosphere, or geosphere in response to a change in Earth's surface. b. Students describe* what each data set represents. **2 Identifying relationships** a. Students use tools, technologies, and/or models to analyze the data and identify and describe* relationships in the datasets, including: i. The relationships between the changes in one system and changes in another (or within the same) Earth system; and	1. Students will use models to gather and analyze data to determine how changes in one Earth system will create changes in other systems. 2. Students will explore the following impacts: a. Sea Level Rise	

from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.] **ESS3-1:** Effects of climate change on geosphere, atmosphere, hydrosphere and biosphere Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as	ii. Possible feedbacks, including one example of feedback to the climate. b. Students analyze data to identify effects of human activity and specific technologies on Earth's systems if present. **3 Interpreting data** a. Students use the analyzed data to describe* a mechanism for the feedbacks between two of Earth's systems and whether the feedback is positive or negative, increasing (destabilizing) or decreasing (stabilizing) the original changes. b. Students use the analyzed data to describe* a particular unanticipated or unintended effect of a selected technology on Earth's systems if present. c. Students include a statement regarding how variation or uncertainty in the data (e.g., limitations, accuracy, any bias in the data resulting from choice of sample, scale, instrumentation, etc.) may affect the interpretation of the data. **ESS3-1** **Observable features of the student performance by the end of the course:** **1. Articulating the explanation of phenomena** a. Students construct an explanation that includes: i. Specific cause and effect relationships between environmental factors (changes in climate) and features of human societies including population size and migration patterns; and ii. That technology in modern civilization has mitigated some of the effects of climate on human activity. **2 Evidence** a. Students identify and describe* the evidence to construct their explanation, including: i. Changes in climate that affect human activity (e.g., agriculture) and human populations, and that can drive mass migrations	b. Effects on Biosphere c. Effects on Human Health 3. Students will explore how changes in climate that can affect populations or drive mass migrations include changes to sea level	

volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]	ii. Evidence of the dependence of human populations on technological systems to acquire natural resources and to modify physical settings. b. Students use a variety of valid and reliable sources for the evidence, potentially including theories, simulations, peer review, or students' own investigations. **3 Reasoning** a. Students use reasoning that connects the evidence, along with 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, to describe*: i. The effect of changes in climate on features of human societies, including population size and migration patterns; and ii. How technology has changed the cause and effect relationship between the development of human society and climate. b. Students describe* reasoning for how the evidence allows for the distinction between causal and correlational relationships between environmental factors and human activity.		

Unit 4b Climate- Human Interaction

Topic 4b1:Predicting Future Climate Changes

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
- **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.** - **Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.**	**By researching and analyzing data, how can we predict the future impact of global climate change?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment	**Observable features of the student performance by the end of the course:** **1 Organizing data** a. Students organize data (e.g., with graphs) from global climate models (e.g., computational simulations) and climate observations over time that relate to the effect of climate change on the physical parameters or chemical composition of the atmosphere, geosphere, hydrosphere, or cryosphere. b Students describe* what each data set represents. **2 Identifying relationships** a. Students analyze the data and identify and describe* relationships within the datasets, including: i. Changes over time on multiple scales; and ii. Relationships between quantities in the given	1. Students will explore technologies to forecast future sea level rise 2. Students will use a model to predict future climate change.	What happens if all the ice melts (http://www.businessinsider.com/what-earth-would-look-like-if-ice-melted-world-map-animation-2015-2)

Boundary: Assessment is limited to one example of a climate change and its associated impacts.]	data. **3 Interpreting data** a. Students use their analysis of the data to describe* a selected aspect of present or past climate and the associated physical parameters (e.g., temperature, precipitation, sea level) or chemical composition (e.g., ocean pH) of the atmosphere, geosphere, hydrosphere or cryosphere. b. Students use their analysis of the data to predict the future effect of a selected aspect of climate change on the physical parameters (e.g., temperature, precipitation, sea level) or chemical composition (e.g., ocean pH) of the atmosphere, geosphere, hydrosphere or cryosphere. c. Students describe* whether the predicted effect on the system is reversible or irreversible. d. Students identify one source of uncertainty in the prediction of the effect in the future of a selected aspect of climate change. e. In their interpretation of the data, students: i. Make a statement regarding how variation or uncertainty in the data (e.g., limitations, accuracy, any bias in the data resulting from choice of sample, scale, instrumentation, etc.) may affect the interpretation of the data; and ii. Identify the limitations of the models that provided the simulation data and ranges for their predictions.		

Topic 4b2: Solutions to adapt and mitigate to climate change

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. - 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.	1. How can we plan, evaluate and refine solutions to reduce the human impacts of climate change on natural systems? 2. How can humans adapt to and mitigate climate change?

Performance Expectations	Evidence Statements	Objectives	Phenomenon
ESS 3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global	**Observable features of the student performance by the end of the course:** **1. Using scientific knowledge to generate the design solution** a. Students use scientific information to generate a number of possible refinements to a given technological solution. Students: i. Describe* the system being impacted and how the human activity is affecting that system; ii. Identify the scientific knowledge and reasoning on which the solution is based; iii. Describe* how the technological solution functions and may be stabilizing or destabilizing the natural system; iv. Refine a given technological solution that reduces human impacts on natural systems; and v. Describe* that the solution being refined	1. Students will investigate their impact on Earth's climate system and begin exploring possible solutions. 2. Students will explore solutions by completing one or more activities: 3. Students will evaluate a technological solution for climate change that reduces impacts of human activities on natural systems.	Question: Is recycling and tree planting enough to reverse climate change impacts? https://arc-anglerfish-arc2-prod-pmn.s3.amazonaws.com/public/PGB2SBA65NEPZBLWBX3QBLM7HY.jpg https://www.vmcdn.ca/f/files/powellriverpeak/images/cartoons/2638_raeside_climate_change.jpg;w=960 The Big Picture https://imgc.allpostersimages.com/img/print/u-g-Q1BO4FD0.jpg?w=550&h=550&p=0 The Global Goals for Sustainability

temperatures by making large changes to the atmosphere or ocean).]	comes from scientists and engineers in the real world who develop technologies to solve problems of environmental degradation. **2. Describing criteria and constraints, including quantification when appropriate** a. Students describe* and quantify (when appropriate): i. Criteria and constraints for the solution to the problem; and ii. The tradeoffs in the solution, considering priorities and other kinds of research-driven tradeoffs in explaining why this particular solution is or is not needed. **3 Evaluating potential refinements** a. In their evaluation, students describe* how the refinement will improve the solution to increase benefits and/or decrease costs or risks to people and the environment. b. Students evaluate the proposed refinements for: i. Their effects on the overall stability of and changes in natural systems; and ii. Cost, safety, aesthetics, and reliability, as well as cultural and environmental impacts.		https://drpongo.files.wordpress.com/2016/02/global-goals-sdgs.jpg?w=900&h=721

Unit 5: Biodiversity

Topic 5a1:
Biomes: How do biotic and abiotic factors interact with each other and the importance of biodiversity

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability **The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.**	**How do organisms interact with the living and nonliving environments in different biomes?** **What is the importance of biodiversity?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
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. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.	Identifying the given explanation and the supporting claims, evidence, and reasoning. a . Students identify the given explanation that is supported by the claims, evidence, and reasoning to be evaluated, and which includes the following idea: 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. b From the given materials, students identify: i. The given claims to be evaluated; ii. The given evidence to be evaluated; and iii. The given reasoning to be evaluated. 2 Identifying any potential additional evidence that is relevant to the evaluation a Students identify and describe* additional evidence (in the form of data, information, or other appropriate forms) that was not provided but is relevant to the explanation and to evaluating the given claims, evidence, and reasoning: i. The factors that affect biodiversity; ii. The relationships between species and the physical environment in an ecosystem; and iii. Changes in the numbers of species and organisms in an ecosystem that has been subject to a modest or extreme change in ecosystem conditions. 3 Evaluating and critiquing a Students describe* the strengths and weaknesses of the given claim in accurately	Gather evidence to support 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. Gather evidence to support the claim that biodiversity is essential to sustain human populations. Create a simulation that contains representations of the relevant components, including: i. A natural resource in a given ecosystem; ii. The sustainability of human populations in a given ecosystem; iii. Biodiversity in a given ecosystem.	Biomes and biodiversity

	explaining a particular response of biodiversity to a changing condition, based on an understanding of the factors that affect biodiversity and the relationships between species and the physical environment in an ecosystem. b Students use their additional evidence to assess the validity and reliability of the given evidence and its ability to support the argument that resiliency of an ecosystem is subject to the degree of change in the biological and physical environment of an ecosystem. c Students assess the logic of the reasoning, including the relationship between degree of change and stability in ecosystems, and the utility of the reasoning in supporting the explanation of how: i. Modest biological or physical disturbances in an ecosystem result in maintenance of relatively consistent numbers and types of organisms. ii. Extreme fluctuations in conditions or the size of any population can challenge the functioning of ecosystems in terms of resources and habitat availability, and can even result in a new ecosystem. Representation a Students create a computational simulation (using a spreadsheet or a provided multiparameter program) that contains representations of the relevant components, including: i. A natural resource in a given ecosystem; ii. The sustainability of human populations in a given ecosystem; iii. Biodiversity in a given ecosystem.		

Unit 5b: Biosphere-Human Interaction

Topics 5b1: Human impacts on biodiversity and solutions to mitigate adverse impacts of human activities on biodiversity

Enduring Understanding (What overarching conceptual understanding do I want students to perceive?)	Essential Questions (What broad or topical conceptual question do I want students to be able to answer?)
The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.	**How are human activities biodiversity?** **What solutions to reduce human impacts on biodiversity?**

Performance Expectations	Evidence Statements	Objectives	Phenomenon
Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.	Using scientific knowledge to generate the design solution a Students design a solution that involves reducing the negative effects of human activities on the environment and biodiversity, and that relies on scientific knowledge of the factors affecting changes and stability in biodiversity. Examples of factors include but are not limited to: i. Overpopulation; ii. Overexploitation; iii. Habitat destruction; iv. Pollution; v. Introduction of invasive species; and vi. Changes in climate. b Students describe* the ways the proposed solution decreases the negative	Describe how human activities affect biodiversity (HIPPCO) Habitat loss Invasive species Pollution Population Increase Climate Change Overuse of resources Design evaluate and refine solutions for reducing the impacts of human activities on biodiversity	Amazon rainforest deforestation

Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity	effects of human activity on the environment and biodiversity. 2 Describing criteria and constraints, including quantification when appropriate a Students describe* and quantify (when appropriate) the criteria (amount of reduction of impacts and human activities to be mitigated) and constraints (for example, cost, human needs, and environmental impacts) for the solution to the problem, along with the tradeoffs in the solution. 3 Evaluating potential solutions a Students evaluate the proposed solution for its impact on overall environmental stability and changes. b Students evaluate the cost, safety, and reliability, as well as social, cultural, and environmental impacts, of the proposed solution for a select human activity that is harmful to an ecosystem. 4 Refining and/or optimizing the design solution a Students refine the proposed solution by prioritizing the criteria and making tradeoffs as necessary to further reduce environmental impact and loss of biodiversity while addressing human needs.		