ROBBINSVILLE PUBLIC SCHOOLS

OFFICE OF CURRICULUM AND INSTRUCTION

SCIENCE:

ENVIRONMENTAL SCIENCE

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BOARD OF EDUCATION INITIAL ADOPTION DATE:
August, 2017

Robbinsville Public School District's Mission Statement

The mission of the Robbinsville School District is to prepare today's students to successfully meet the challenges of tomorrow.

Robbinsville High School's Mission Statement

Robbinsville High School of Mercer County, is a community of diverse students, involved parents, and dedicated professionals devoted to lifelong learning.

Our mission is to provide academically challenging and technologically advanced small-learning environments that foster the development of young adults as responsible, respectful, and successful contributors to a global society.

Course Philosophy

The Robbinsville School District Science Department has designed the environmental science curriculum to be suitable for senior level students. As an interdisciplinary subject, environmental science builds primarily on foundational knowledge developed in the core sciences of physics, chemistry, and biology, as well as quantitative skills developed in various math courses. Just as importantly, the study of environmental science inherently involves exploring connections to social sciences such as history, sociology, economics, and political science. Given this interdisciplinary approach, senior level students are particularly well prepared to explore both the scientific and social issues central to resolving environmental problems. The science department therefore believes the course will prepare students to become globally conscious critical thinkers who can make informed decisions about their impacts on the planet.

Course Description

Environmental Science is a laboratory-based course covering the interaction between human society and the major components of our planet's four systems: the biosphere, geosphere, hydrosphere, and atmosphere. The course is designed to provide students with hands-on experiences and explorations of central themes in environmental science. As such, it presents a framework for understanding the varied destructive effects humans have on the planet and for considering potential solutions to these issues.

Course Materials:

May include, but are not limited to, the following:

- Holt *Environmental Science* textbook and associated resources
- "The Habitable Planet" (www.learner.org/courses/envsci/)
- PHET interactive simulations
- Student -designed lab investigations
- Teacher -created POGILS and handouts

Major Topics in Environmental Science

HUMAN POPULATION AND SUSTAINABILITY
Demography
Human Population Growth
Environmental Justice
Sustainable Design

BIOSPHERE
Ecosystem Dynamics
Biomes and Climate
Organism Interactions
Invasive Species
Endangered Species
Deforestation

GEOSPHERE
Earth's History
Plate Tectonics
Mining and Geologic Resources

HYDROSPHERE
Water Cycle
Water Resources
Water Pollution
Global Water Crisis
Oceanography
Ocean Acidification

ATMOSPHERE
Layers of Atmosphere
Weather and Climate
Carbon Emissions
Air Pollution
Climate Change

Unit 1: Human Population and Sustainability

Instructional Time: Approximately 15 class periods

Stage 1 – Desired Results

Rationale:

In the introductory unit of study, the discussion of all subsequent environmental issues is framed within the contexts of human societal concerns and population growth. At their core, all environmental issues are fundamentally caused by human action, and likewise impact society in nuanced ways. Developing an awareness of such issues and proposing solutions therefore requires considering a broad range of social factors, including rapid human population growth, socioeconomic disparities, and the impacts of globalization on both humans and the planet. Further, designing sustainable solutions to mitigate environmental issues requires balancing the needs of human society with the needs of the planet. Although this unit will begin the course, the theme of sustainability will reemerge in more specific contexts within every subsequent unit.

Students *ask questions, define problems, and engage in arguments using evidence* to make claims about human interactions with the environment. They *use mathematics and computational thinking* to develop an understanding of the connection between human population growth and concerns over environmental sustainability. Additionally, they begin to *construct explanations and design potential solutions* to minimize human encroachment of the planet's natural resources. The crosscutting concept of *cause and effect* is emphasized in exploring connections between population growth and environmental degradation. *Systems and systems models* are emphasized as students generate large scale understandings of global phenomena based on various inputs and outputs. Finally, factors influencing *stability and change* of both human populations and the ecosystem are explored.

Performance Expectations:

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.
Resource availability has guided the development of human society.

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions.

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*
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.

Possible Phenomena:

- Tragedy of the Commons: Students will simulate how individuals tend to consume resources in a manner that is destructive for all in the long-run. This will frame the discussion of regulation of resource consumption at a global scale.
- China's 'One-Child' Policy: As an introduction to population issues, the controversial policy put in place by the Chinese government can be critically analyzed. Students can generate and answer questions about why the policy was first created, what impacts it had on the population, and whether other countries should explore similar options.

Standards to be addressed:

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Mathematics

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
HSS-IC.A.1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

Enduring Understandings / Big Ideas	**Problem(s) / Essential Questions**
Students will understand that: ● Rapid human population growth has adverse effects on society and the environment. ● Unregulated consumption of resources poses long-term threats to human society and the environment.	● Why is excessive human population growth a potential threat? ● How can natural resources be managed? ● Do my decisions impact the planet?

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems ● Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) **Using Mathematics and Computational Thinking** ● Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-ESS3-3) ● Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-ESS3-6) **Constructing Explanations and Designing Solutions** ● Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS3-1) ● Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ESS3-4) **Engaging in Argument from Evidence** ● Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical	**ESS3.A: Natural Resources** ● Resource availability has guided the development of human society. (HS-ESS3-1) ● 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. (HS-ESS3-2) **ESS3.B: Natural Hazards** ● Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1) **ESS3.C: Human Impacts on Earth Systems** ● The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3) ● Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4) **ETS1.B: Developing Possible Solutions** ● When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary to HS-ESS3-2),(secondary*	**Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3- 1) **Systems and System Models** ● When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-ESS3-6) **Stability and Change** ● Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-3) ● Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)

considerations). (HS-ESS3-2)	*HS-ESS3-4)*	

Stage 2 – Assessment Evidence	
Performance Tasks ● 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. ○ Students will construct a timeline correlating human population growth to social and evolutionary developments ○ Students will model human population growth (graphs, age-structure diagrams) ○ Students will develop a cause and effect chart linking social developments to environmental concerns ● Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios ○ Students will calculate their individual ecological footprints based on daily resource consumption using online calculators ○ Students will conduct a critical analysis of the costs and benefits of modern renewable energy technology ● Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. ○ Students will simulate the 'Tragedy of the Commons' using a lab game, collect data, and make a CER with peer feedback, revision, and teacher feedback ○ Students will utilize data on global resource distribution to make claims about socioeconomic disparities and their link to environmental issues A final performance assessment for this unit should include the following criteria: ○ Use mathematics and computational	**Other Evidence:** ● Daily formative assessment should include use of do nows, exit tickets, and review games ○ Informal assessments conducted through Google Forms, Google Classroom, Kahoot, and other platforms in which teacher is able to give direct feedback and remediation to student understanding ○ Teacher will adjust subsequent lessons as needed based on this data ● Group-based lab & Peer Oriented Guided Inquiry Learning (POGIL) approach will be employed in the vast majority of lessons ○ Whole class discussion will be employed to introduce collaborative learning tasks, and review them at the end ○ Teacher check-ins during collaborative group learning ● Individual formal assessment should include one quiz (multiple choice and short answer) on human population dynamics and basic terms in environmental science

thinking, construct explanations and design solutions, and engage in argument from evidence to explore the relationship between human society, population growth, and environmental issues Suggested Performance Task that can meet the criteria: ● Population issues in a specific country ○ Design a public awareness campaign about population issues facing a chosen country, and how a growing population is affecting the country's environment and resource use ○ Present practical solutions to the excessive population growth in that country ○ Rubric will be designed to correlate with performance expectations and will be differentiated based on the level of the class	

Stage 3 – Learning Plan
Learning Activities: See activities & assessments mentioned above. On a daily basis, class will begin using some form of hook, followed by a class discussion and introduction to key terms and concepts, then followed by a student-centered class engagement activity. The majority of class activities will be group-based and student centered. This unit will begin with a simulation of the 'Tragedy of the Commons', an economic principle which emphasizes that individuals tend to consume resources in a manner that benefits them in the short term, but harms everyone in the long run. When applied to natural resources, this economic principle provides a framework for understanding the need to regulate consumption at a global level. Next, students will explore their own usage of resources using online ecological footprint calculators. In doing so, they will begin to develop an understanding that individual actions impact global phenomena. From here, the focus will shift to analyzing the impacts of rapid human population growth on the sustainability of human societies and the planet's natural resources. Students will complete station based lab activities to model rapid human population growth, as well as investigate the causes and effects of this growth on the planet. They will also analyze current population data, including age-structure diagrams and fertility rates, to make predictions about future population growth concerns. The culminating performance assessment in this unit will require students to choose a specific country that has a population crisis of some form. They will research this country's history, current population dynamics, and potential environmental concerns to create a public awareness campaign designed to educate citizens about the population issues and propose practical solutions. Before and after all group activities, there will always be an introductory and concluding discussion. Students will be grouped into cooperative lab groups and allowed to explore tasks at their own pace. Differentiation will

be based on student grouping and frequency of teacher guidance and assistance. Higher groups will be given less guidance and more opportunity to explore supplementary scenarios.

Technology and the Nature of Science:
The unit emphasizes that science is not only an ongoing endeavor to understand the world, but also one that intrinsically impacts human society. Scientific arguments must be rooted in empirical evidence, and are strengthened by multiple lines of evidence. Technological advances based on scientific understandings and rationality can mitigate human impacts on the planet.

Know-What are the basics?:
- Human population (growth factors, age-structure diagrams, etc.)
- Sustainability and resource management
- Tragedy of the Commons
- Ecological footprint
- Environmental justice

Possible Preconceptions/Misconceptions:

Misconceptions may include:
- Human population growth is only a problem in certain countries
- Socioeconomic disparities are minimal, and are not linked to environmental concerns
- Resources we use are renewable and can be easily regenerated

How do I reinforce or build literacy or mathematics skills?
- Concept mapping
- Cause and effect charts
- Composing CERs based on quantitative and qualitative data
- Generating and graphing quantitative data
- Predicting future trends based on current data

Unit 2: Biosphere, Ecology, and Biodiversity

Instructional Time: Approximately 10 class periods

Stage 1 – Desired Results

Rationale:

Earth is the only known planet capable of supporting life on any significant scale. The sustained interaction between living organisms and their abiotic environment is a critical component of the planet's ability to continually support life. As an extension of student knowledge from Biology, the second unit will therefore focus on the 'biosphere', all life that exists on the planet. Here, emphasis will first be placed on understanding the delicate balance that exists in the large scale interactions between organisms as well as with their abiotic surroundings. Human survival directly relies on this balance, yet society continues to disrupt it. As such, the unit will conclude by assessing human threats to biodiversity, and the potential ramifications of losses in biodiversity to the stability of human society and the planet.

Students *use mathematics and computational thinking* to quantitatively analyze biological populations, and their change as a result of human actions. Additionally, they *construct explanations and design potential solutions* to minimize human threats to biodiversity, and *engage in argument from evidence* to make claims about these threats and potential solutions. The crosscutting concept of *cause and effect* is emphasized in studying the interdependent relationships among all organisms in the ecosystem. *Scale, proportion, and quantity* is emphasized as students explore the multifaceted effects of slight changes at various scales. Finally, factors influencing *stability and change* of ecosystem balance is explored.

Performance Expectations:

HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. [Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.]

HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
[Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.]

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.]

HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. [Clarification Statement: Examples of changes in ecosystem conditions could include modest

biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. [Clarification Statement: Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

Possible Phenomena:

- Rachel Carson and *Silent Spring*: In this landmark work of environmental literature, Carson explores the effects of the chemical DDT on the entire ecosystem. This case study acts an excellent introduction to the concepts of ecosystem interactions and the effects of disruptions on the entire ecosystem.
- Extinction events: Throughout the history of the planet, scientists have estimated that there have been at least five major extinction events caused by various natural factors. However, they now suggest we are in the sixth extinction event in which fifty percent of all species may be lost in the next century. Comparing the natural extinction events to the present 'anthropocene' or man-made extinction provides insight into factors related to the stability and change of ecosystems and loss of biodiversity.

Standards to be addressed:

ELA/Literacy

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
HSS-IC.A.1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

HSS-IC.B.6 Evaluate reports based on data.

Enduring Understandings / Big Ideas	Problem(s) / Essential Questions
Students will understand that: ● Complex interactions between 'spheres' of the planet maintain stable conditions needed for all life ● All organisms rely on their environment for survival ● Large scale human activities have a disproportionately negative effect on both abiotic and biotic factors of the ecosystem	● How do abiotic conditions affect the biotic factors in an ecosystem? ● In what ways do organism interactions maintain the stability of the ecosystem? ● Why do species become endangered?

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking ● Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (HS-LS2-1) ● Use mathematical representations of phenomena or design solutions to support and revise explanations. (HS-LS2-2) ● Create or revise a simulation of a phenomenon, designed device, process, or system. (HS-LS4-6) **Constructing Explanations and Designing Solutions** ● Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-LS2-7) **Engaging in Argument from Evidence** ● Evaluate the claims, evidence, and reasoning behind currently accepted explanations or	**LS2.A: Interdependent Relationships in Ecosystems** ● Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. (HS-LS2-1),(HS-LS2-2) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** ● If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2),(HS-LS2-6) ● Moreover, anthropogenic changes (induced by human	**Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3- 1) **Scale, Proportion, and Quantity** ● The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1) ● Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2) **Stability and Change** ● Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-3) ● Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)

solutions to determine the merits of arguments. (HS-LS2-6) ● Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. (HS-LS2-8)	activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7) **LS4.C: Adaptation** ● Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS-LS4-6) **LS4.D: Biodiversity and Humans** ● Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary to HS-LS2-7),(HS-LS4-6.)* **ETS1.B: Developing Possible Solutions** ● When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and	

	aesthetics and to consider social, cultural and environmental impacts. (secondary to HS-LS2-7),(secondary to HS-LS4-6)	

Stage 2 – Assessment Evidence

Performance Tasks

- Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
  - Students will develop models of the food webs and pyramids in specific biomes
  - Students will create a plan for a self-sustaining terrarium with living organisms, and evaluate the interactions between biotic and abiotic factors

- Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
  - Students will create climatograms; graph data on the abiotic conditions in different biomes, and draw conclusions about how these conditions affect life
  - Students analyze the impacts of species interactions on population changes overtime

- Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
  - Students will graph data on the abiotic conditions in different biomes, and draw conclusions about how these conditions affect life
  - Students analyze the impacts of species interactions on population changes overtime
  - Students simulate the loss of biodiversity using a board game, and

Other Evidence:

- Daily formative assessment should include use of do nows, exit tickets, and review games
  - Informal assessments conducted through Google Forms, Google Classroom, Kahoot, and other platforms in which teacher is able to give direct feedback and remediation to student understanding
  - Teacher will adjust subsequent lessons as needed based on this data

- Group-based lab & Peer Oriented Guided Inquiry Learning (POGIL) approach will be employed in the vast majority of lessons
  - Whole class discussion will be employed to introduce collaborative learning tasks, and review them at the end
  - Teacher check-ins during collaborative group learning

- Individual formal assessment should include one quiz (multiple choice and short answer) on ecosystem dynamics, biomes, and organismal relationships

then compose a CER based on this data ● Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. ○ See above ● Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. ○ Students research an invasive species and propose possible solutions to reduce its effects on the environment A final performance assessment for this unit should include the following criteria: ○ Use mathematics and computational thinking, construct explanations and design solutions, and engage in argument from evidence about the effects of human activity on biodiversity Suggested Performance Task that can meet the criteria: ● Endangered Species Zoo Exhibit ○ Design a zoo exhibit to mimic the ideal abiotic and biotic environmental factors needed for an endangered species ○ Propose practical solutions to prevent the extinction of the species ○ Present a design pitch to inform a panel of investors ○ Rubric will be designed to correlate with performance expectations and will be differentiated based on the level of the class	

Stage 3 – Learning Plan
Learning Activities: See activities & assessments mentioned above. On a daily basis, class will begin using some form of hook, followed by a class discussion and introduction to key terms and concepts, then followed by a student-centered class engagement activity. The majority of class activities will be group-based and student centered. As a general structure, units will begin with activities that connect the overarching unit topic to student's daily lives to

stress the importance of the topic. Next, students will complete activities to explore the natural dynamics governing this system of the planet. Finally, students will assess human impacts on the system using guided inquiry.

Initially, the unit will focus on the stable interactions maintaining our planet's conditions. To introduce the concepts of abiotic and biotic factors, students will develop a plan to create a self-sustaining terrarium that must sustain living organisms (plants and worms) for an extended period of time. This will also introduce the 'spheres' of the planet, which interact continually to support life. Next, students will review key concepts related to ecosystem dynamics and organism interactions. They will develop models of organism interactions and food webs in specific biomes. The terrarium will also provide a reference point for these concepts, and students will construct explanations of how matter and energy flow through their terrarium. Students will also complete station based lab activities to explore the large scale climate patterns that influence species distributions.

From here, the focus will again shift to analyzing the negative impacts human activities are having on ecosystems and biodiversity. First, students will research an invasive species and propose solutions to limit its spread in the ecosystem. As a culminating performance assessment,students will choose an endangered species they are interested in preserving. They will research the species' abiotic and biotic environment and design a self-sustaining zoo habitat that will preserve the species indefinitely. Again, their terrarium designs will provide a reference point for consideration of necessary factors. Mathematical data will be used to support their designs. Finally, they will propose a practical solution to prevent the loss of their endangered species.

Before and after all group activities, there will always be an introductory and concluding discussion. Students will be grouped into cooperative lab groups and allowed to explore tasks at their own pace. Differentiation will be based on student grouping and frequency of teacher guidance and assistance. Higher groups will be given less guidance and more opportunity to explore supplementary scenarios.

Technology and the Nature of Science:
In studying the complex relationships present in ecosystems of varying scales, scientific knowledge is constantly expanding based on new evidence. Scientists must continually gather evidence to make claims about changes to ecosystems, such as quantitatively studying the population changes of organisms. Technology provides a critical tool in conducting these studies, and again, new technology can mitigate the negative impacts of human activities on the biosphere.

Scientific Knowledge is Open to Revision in Light of New Evidence

- Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-2)
- Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation. (HS-LS2-6),(HS-LS2-8)

Know-What are the basics?:

- Biotic and abiotic factors
- Ecosystem dynamics (food web, food chain, energy pyramid, producers, consumers, decomposers)
- Species interactions (competition, mutualism, commensalism, parasitism, predation)
- Biomes and climate
- Invasive and endangered species

Possible Preconceptions/Misconceptions:
Students tend to believe that extinction events are rare, though there have been multiple large-scale extinction events. However, they also tend to minimize the effects of anthropogenic changes on organism populations.

Perhaps most importantly, students tend to neglect the importance of biodiversity in human applications in the twenty-first century.

Other misconceptions taken from AAAS Project 2061 may include:

- If a population in a food web is disturbed, there will be little or no effect on populations that are not within the linear sequence in the food web (Webb & Boltt, 1990).
- Varying the size of a population of organisms will affect only those populations of organisms that are directly connected to it in a feeding relationship, not organisms that are one or more steps removed/away from it (Griffiths & Grant, 1985; Webb & Boltt, 1990).

How do I reinforce or build literacy or mathematics skills?

- Concept mapping
- Developing written proposals
- Oral presentations
- Composing CERs based on quantitative and qualitative data
- Generating and graphing quantitative data
- Predicting future trends based on current data
- Using quantitative data to create models

Unit 3: Geosphere, Earth's History, and Geologic Resources

Instructional Time: Approximately 10 class periods

Stage 1 – Desired Results

Rationale:

Properly understanding the interactions between humans and the environment first requires appreciating the unique physical structure of the planet. Earth's internal and surface composition differ dramatically from other planets; these characteristics are essential in supporting and regulating all the interactions between the abiotic components of the geosphere, hydrosphere, and atmosphere. Moreover, the existence of massive geologic formations such as continents and oceans is absolutely necessary for the existence of life. Therefore, this unit will first involve using various types of geologic evidence to reconstruct major events in the history of Earth's formation on a large scale. Next, students will focus specifically on surface formations, applying the theory of plate tectonics to explain phenomena such as volcanoes, mountains, and islands. Lastly, students will focus on smaller scale aspects of the geosphere, briefly exploring the nature of rock and mineral resources that are essential to human society in the twenty-first century.

Students *analyze and interpret* geologic data pertaining to Earth's early formation, and *engage in argument from evidence* to construct claims about how the planet as a whole formed over billions of years. Additionally, they *develop and use models* of the planet's internal layers to explain the major geologic formations on the planet's surface. Lastly, they will *construct explanations and propose solutions* to reduce destructive human impacts on the geosphere, such as mining for minerals. The crosscutting concept *of structure and function* is emphasized as students explore the internal composition of the planet, and how this impacts its surface. Further, *energy and matter* is emphasized as variations in energy levels and elemental composition define the layers of the planet and their interactions; these factors subsequently result in recurring *patterns* of geologic formations. Finally, students investigate factors influencing the *stability and change* of the geosphere and the impacts these changes may have on both the environment and society.

Performance Expectations:

HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. [Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust decreasing with distance away from a central ancient core of the continental plate (a result of past plate interactions).]

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.]

HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] [Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.]

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice.]

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

Possible Phenomena:

- Continental Drift: To transition into the discussion on plate tectonics, students can explore the evidence that led Alfred Wegener to propose the Theory of Continental Drift in the early 1900s. Evidence includes similar rock formations on separate continents, similar fossils, and the shape of the continents. This case study also emphasizes the gradual evolution of scientific understandings as new evidence is discovered.
- Blood Diamonds: Many of the mineral resources taken for granted in Western nations are mined in the developing world. Some of these resources, like diamonds, are largely valued for superficial means, but others are necessary for their usage in modern technology. Reflecting upon the extraction of these resources therefore provides an important social connection to the theme of globalization.

Standards to be addressed:

ELA/Literacy

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a

new approach, focusing on addressing what is most significant for a specific purpose and audience.
WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
HSS-IC.A.1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population.
HSS-IC.B.6 Evaluate reports based on data.

Enduring Understandings / Big Ideas	**Problem(s) / Essential Questions**
Students will understand that: ● Earth's surface is shaped by ongoing geologic processes. ● Abiotic factors, such as rock and mineral formations, affect all living organisms. ● Geologic resources such as minerals are essential for human societies in the twenty first century	● How did Earth form? ● Is the planet's surface changing right now?

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models ● Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-3),(HS-ESS2-6) **Constructing Explanations and Designing Solutions** ● Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6)	**ESS2.A: Earth Materials and Systems** ● Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2) ● 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	**Patterns** ● Empirical evidence is needed to identify patterns. (HS-ESS1-5) **Energy and Matter** ● The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6) ● Energy drives the cycling of matter within and between systems. (HS-ESS2-3) **Structure and Function** ● The functions and properties of natural and designed

Analyzing and Interpreting Data ● Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ESS2-2) **Engaging in Argument from Evidence** ● Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1-5)	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. (HS-ESS2-4) **ESS1.C: The History of Planet Earth** ● Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5) ● Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.B: Plate Tectonics and Large-Scale System Interactions** ● Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. *(ESS2.B Grade 8 GBE) (secondary to HS-ESS1-5)*,(HS-ESS2-1) ● Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.E Biogeology** ● The many dynamic and delicate feedbacks between the biosphere and other Earth	objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5) **Stability and Change** ● Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7) ● Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2) ● Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1)

	systems cause a continual co-evolution of Earth's surface and the life that exists on it. (HS-ESS2-7) ● **ETS1.B: Developing Possible Solutions** ● When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (secondary to HS-LS2-7),(secondary to HS-LS4-6)	

Stage 2 – Assessment Evidence	
Performance Tasks ● 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. ○ Students critically analyze evidence presented by scientists about the formation and history of the planet in a documentary ○ Students construct a timeline of the formation of the planet given geologic data collected by scientists ● 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. ○ Students use online simulations to explore the theory of plate tectonics and evidence for it ○ Students develop visual models of tectonic interactions to explain the	**Other Evidence:** ● Daily formative assessment should include use of do nows, exit tickets, and review games ○ Informal assessments conducted through Google Forms, Google Classroom, Kahoot, and other platforms in which teacher is able to give direct feedback and remediation to student understanding ○ Teacher will adjust subsequent lessons as needed based on this data ● Group-based lab & Peer Oriented Guided Inquiry Learning (POGIL) approach will be employed in the vast majority of lessons ○ Whole class discussion will be employed to introduce collaborative learning tasks, and review them at the end ○ Teacher check-ins during collaborative group learning ● Individual formal assessment should include

formation of mountains, volcanoes, islands, trenches, etc. ● 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. ○ See above ○ Students simulate convection currents using different temperatures of water, and apply their results to model Earth's internal convection currents ● Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. ○ Students simulate the process of mining using an online application, collect simulated data, and compose a CER about the effects of this process on the planet ● Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. ○ Students reflect on the processes involving in obtaining mineral resources like diamonds and propose legislative solutions to minimize their negative impacts A final performance assessment for this unit should include the following criteria: ○ Develop and use models, analyze and interpret data, and construct explanations Suggested Performance Task that can meet the criteria: ● Geologic Formation Travel Brochure ○ Research and collect information about a specific geologic formation (a specific volcano, island, mountain, etc.) ○ Synthesize this information with their background knowledge of geological	one quiz (multiple choice and short answer) on Earth's internal layers, the theory of plate tectonics, and tectonic plate boundaries

interactions to construct a model and explanation of how the site formed ○ Present this information in the form of a travel brochure ○ Rubric will be designed to correlate with performance expectations and will be differentiated based on the level of the class	

Stage 3 – Learning Plan

Learning Activities:
See activities & assessments mentioned above. On a daily basis, class will begin using some form of hook, followed by a class discussion and introduction to key terms and concepts, then followed by a student-centered class engagement activity. The majority of class activities will be group-based and student centered.As a general structure, units will begin with activities that connect the overarching unit topic to student's daily lives to stress the importance of the topic. Next, students will complete activities to explore the natural dynamics governing this system of the planet. Finally, students will assess human impacts on the system using guided inquiry.

As a whole, the unit will begin with a large scale examination of the planet before zooming down to smaller scale aspects of the geosphere. Initially, students will analyze modern explanations of the planet's early formation to develop an understanding of the unique composition of the planet. Next, they will use online tools and simulations to build background knowledge on the theory of plate tectonics, before developing their own models to explain geologic formations on Earth's surface. Lastly, they will concentrate on human reliance on geologic resources, reflecting on the social and environmental ramifications of this usage. As a culmination, students will work in groups to pick a specific geologic formation they are interested in, such as an island, volcano, or mountain chain. They will create an informational travel brochure that also explains how this specific site formed to general audiences.

Before and after all group activities, there will always be an introductory and concluding discussion. Students will be grouped into cooperative lab groups and allowed to explore tasks at their own pace. Differentiation will be based on student grouping and frequency of teacher guidance and assistance. Higher groups will be given less guidance and more opportunity to explore supplementary scenarios.

Technology and the Nature of Science:
As technology has progressed, the ability of scientists to explore the geological history of the planet has likewise increased. Modern theories about the formation of our planet use multiple coordinated lines of evidence to construct probable explanations of the planet's formation.

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-6)
- Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6)

Know-What are the basics?:

- Internal layers of Earth (core, mantle, crust)
- Tectonic Plates (lithosphere, oceanic crust, continental crust)
- Plate Boundaries (convergent, divergent, transform)
- Rocks and Minerals

Possible Preconceptions/Misconceptions:

In discussing the history of the planet, some students may be opposed to modern scientific explanations based on their cultural or religious beliefs. The instructor must carefully present the evidence for modern explanations, while emphasizing that the knowledge in this field is constantly expanding. Very few students are aware that the planet is estimated to have formed over 4 billion years ago. On the other hand, they tend to have background knowledge about the idea of tectonic plates, though their knowledge of specific plate interactions is generally limited. Finally, most students are completely unaware of how much modern life relies on simple geologic resources.

How do I reinforce or build literacy or mathematics skills?

- Concept mapping
- Developing written proposals
- KWL charts
- Venn Diagrams
- Composing CERs based on quantitative and qualitative data
- Generating and graphing quantitative data
- Predicting future trends based on current data
- Using quantitative data to create models

Unit 4: Hydrosphere and Water Resources

Instructional Time: Approximately 20 class periods

Stage 1 – Desired Results

Rationale:

In the search for potential life on other planets, the first question invariably is whether water can be found or not. Without water, there is no life as we know it; this simple substance is necessary for the survival of every single organism on the planet, from the simplest single celled bacteria to the most complex multicellular life forms. More than seventy percent of our planet's surface is covered in water. At the same time, this finite resource must be managed carefully, as millions of people still do not have access to clean drinking water. This unit will first focus on the various forms of water on the planet, and how water naturally cycles throughout it. Afterwards, the focus will shift to the human usage of water resources, and the implications of this usage on both the global ecosystem and society.

Students *develop and use models* to formulate integrated understandings of the hydrosphere's impact on other aspects of the planet. Additionally, they *plan and carry out investigations* to collect data connecting human actions to disruption of the planet's water resources, *analyze and interpret* this data, and *engage in argument from evidence* to make claims about these threats and potential solutions. The crosscutting concept of *cause and effect* is emphasized in studying the inherent connections between the spheres of the planet. *Structure and function* is emphasized as students explore the properties of water, and *energy and matter* is emphasized in exploring the cycling of water. Finally, students investigate factors influencing the *stability and change* of our planet's water resources, and subsequent impacts these changes may have on our lives.

Performance Expectations:

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice.]

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.]

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical

cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

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 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.]

Possible Phenomena:

- Death of the Great Barrier Reef: Over the past three decades, almost half of the coral in the Great Barrier Reef has been lost to coral bleaching, due to slight changes in ocean acidity and water temperature. This case highlights the importance of water conditions to marine life, and the connections between water and other spheres of the planet.
- Water Bottles: If water is freely available throughout the country, why do people spend so much money on bottled water? Students can investigate the pros and cons of the bottled water industry to gain insight into the management of water resources, as well as the social implications of water.

Standards to be addressed:

ELA/Literacy

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and

data displays.
HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
HSS-IC.A.1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population.
HSS-IC.B.6 Evaluate reports based on data.

Enduring Understandings / Big Ideas	**Problem(s) / Essential Questions**
Students will understand that: ● Complex interactions between 'spheres' of the planet maintain stable conditions needed for all life ● All organisms, including humans, rely on a finite amount of water to survive ● The unique properties of water allow it to cycle throughout the planet in different forms ● Ocean conditions in particular are integral to maintaining the planet's abiotic and biotic conditions	● Why do scientists always look for water on other planets? ● How much water do we need? ● Why are coral reefs bleaching?

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models ● Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-3),(HS-ESS2-6) **Planning and Carrying Out Investigations** ● Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-ESS2-5) **Analyzing and Interpreting Data** ● Analyze data using tools,	**ESS2.A: Earth Materials and Systems** ● Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2) **ESS2.C: The Roles of Water in Earth's Surface Processes** ● The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	**Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3- 1) **Energy and Matter** ● The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6) ● Energy drives the cycling of matter within and between systems. (HS-ESS2-3) **Structure and Function** ● The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)

technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ESS2-2) **Engaging in Argument from Evidence** ● Construct an oral and written argument or counter-arguments based on data and evidence. (HS-ESS2-7)	**ESS2.D: Weather and Climate** ● The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2) ● Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6) **ESS2.E Biogeology** ● The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (HS-ESS2-7) **ETS1.B: Developing Possible Solutions** ● When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (secondary to HS-LS2-7),(secondary to HS-LS4-6)	**Stability and Change** ● Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7) ● Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)

Stage 2 – Assessment Evidence

Performance Tasks	**Other Evidence:**
● Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. ○ Students will conduct laboratory investigations of the unique properties of water and how these properties influence the water cycle ○ Students will develop teaching models of the water cycle ○ Students will design an investigation to approximate how much water is lost in Robbinsville township due to leaks ○ Students will model the layers of groundwater and how groundwater is polluted ○ Students design experiments to test how water pollution impacts plant and human life ● Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. ○ Students design a lab investigation to collect data about how various gases, including carbon dioxide, affect ocean water acidity ○ Students collect data on how ocean acidity affects coral reefs and other marine life ● Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. ○ See above ● Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. ○ Students plot data about oceanic conditions and correlate this data to marine animal distributions ● Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. ○ Students simulate an oil spill and design	● Daily formative assessment should include use of do nows, exit tickets, and review games ○ Informal assessments conducted through Google Forms, Google Classroom, Kahoot, and other platforms in which teacher is able to give direct feedback and remediation to student understanding ○ Teacher will adjust subsequent lessons as needed based on this data ● Group-based lab & Peer Oriented Guided Inquiry Learning (POGIL) approach will be employed in the vast majority of lessons ○ Whole class discussion will be employed to introduce collaborative learning tasks, and review them at the end ○ Teacher check-ins during collaborative group learning ● Individual formal assessment should include one quiz (multiple choice and short answer) on the properties of water, forms of water on the planet, and the water cycle

a solution to remove the oil from ocean waters while minimizing impacts on marine life ○ Students research and assess the effectiveness of a water saving device A final performance assessment for this unit should include the following criteria: ○ Develop and use models, plan and carry out investigations, analyze and interpret data, and engage in argument from evidence to explore global issues with water usage Suggested Performance Task that can meet the criteria: ● Water Crisis PSA Video ○ Design and collect data on multiple long term group investigations connecting human society to water resources (ocean acidification, water pollution and plants, water pollution and human health) ○ Synthesize this data and present an infomercial style PSA video to teach general audiences about the global mismanagement of water resources ○ Rubric will be designed to correlate with performance expectations and will be differentiated based on the level of the class	

Stage 3 – Learning Plan

Learning Activities:

See activities & assessments mentioned above. On a daily basis, class will begin using some form of hook, followed by a class discussion and introduction to key terms and concepts, then followed by a student-centered class engagement activity. The majority of class activities will be group-based and student centered.As a general structure, units will begin with activities that connect the overarching unit topic to student's daily lives to stress the importance of the topic. Next, students will complete activities to explore the natural dynamics governing this system of the planet. Finally, students will assess human impacts on the system using guided inquiry.

To start, students will use several online interactives to determine how many gallons of water their lifestyle requires on a daily basis, emphasizing the necessity of water for their survival. Next, they will complete activities and lab investigations to study the properties of water, forms of water on the planet, and develop a teaching model of the water cycle. These introductory activities serve to lay the framework for student knowledge of how the chemical properties of water allow it to naturally cycle and make it a unique

life-supporting substance.

With this understanding established, the focus will again shift to analyzing the negative impacts human activities are having on the planet's water supply. Students will work in groups to design multiple long-term investigations in this unit, including studying the effects of greenhouse gasses on ocean acidity, the effects of ocean acidity on coral reefs and marine life, as well as the impacts of water pollution on plant growth and human health. They will also simulate the impacts of oil spills on marine life, and design a solution to remove oil from polluted ocean waters. As a social connection, students will also view portions of a documentary on the global water crisis and assess how socioeconomic disparities are once again linked to environmental concerns. The culmination assessment will require students to present their investigation findings to a general audience through a PSA video, focusing on global water issues.

Before and after all group activities, there will always be an introductory and concluding discussion. Students will be grouped into cooperative lab groups and allowed to explore tasks at their own pace. Differentiation will be based on student grouping and frequency of teacher guidance and assistance. Higher groups will be given less guidance and more opportunity to explore supplementary scenarios.

Technology and the Nature of Science:
Analyzing the interactions between the hydrosphere and other systems of the planet requires a continually nuanced and expanding view. Scientists must continually gather new evidence to make these claims. Moreover, just as the planet's systems are not isolated, scientific research must not be isolated but rather must consider the interaction of various factors to accurately understand the natural world. Technology provides a critical tool in conducting these studies, and again, new technology can mitigate the negative impacts of human activities on the planet's water.

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence. (HS-ESS2-3)
- Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (HS-ESS2-3)
- Science includes the process of coordinating patterns of evidence with current theory. (HS-ESS2-3)

Know-What are the basics?:

- Water Cycle (condensation, evaporation, precipitation, runoff, etc.)
- Sources of Water (oceans, freshwater, groundwater, glaciers, water vapor, etc.)
- Pollution sources (point vs. non-point)

Possible Preconceptions/Misconceptions:
Students do not usually realize that most of their water usage is 'hidden' in the foods they eat, the clothes they wear, and other such uses. Also, while students have a general understanding of the water cycle, they tend to confuse the scientific terminology easily so this should be reinforced carefully. Students also tend to overestimate the availability of freshwater on the planet, and are unaware of how many people do not have access to clean potable water.

How do I reinforce or build literacy or mathematics skills?

- Concept mapping
- Developing written proposals
- KWL charts
- Venn Diagrams
- Composing CERs based on quantitative and qualitative data

- Generating and graphing quantitative data
- Predicting future trends based on current data
- Using quantitative data to create models

Unit 5: Atmosphere, Air Pollution, and Climate Change

Instructional Time: Approximately 20 class periods

Stage 1 – Desired Results

Rationale:

As a culmination of the course, the final unit will focus on arguably the most delicate aspect of the planet's systems, the atmosphere. Just like life on the planet depends on the existence of water, all living things rely on and contribute to the maintenance of the thin layer of gasses we call Earth's atmosphere. Although composed of simple gases, the atmosphere plays a crucial role in regulating the planet's climate and therefore all abiotic and biotic conditions. All of the destructive human actions discussed in previous units affect the atmosphere, either directly or indirectly; this unit thus serves to connect all of these seemingly disparate phenomena to global climate change. The unit will begin with an exploration of the planet's atmospheric composition and how this composition has coevolved with life on the planet. Further, students will explore the natural processes governing the formation of global weather patterns. Finally, students will extensively explore the various evidences for climate change and potential solutions to this global crisis.

Students *develop and use models* that integrate all four spheres of the planet to fully explore the causes and implications of global climate change. Additionally, they *plan and carry out investigations* to collect data connecting human activity to the changes in climate patterns, *analyze and interpret* this data, and *engage in argument from evidence* to make claims about these threats and potential solutions. The crosscutting concept of *cause and effect* is emphasized in studying the inherent connections between the spheres of the planet as related to human influenced changes in climate patterns. *Structure and function* is emphasized as students explore the composition of the atmosphere as related to both weather and climate. Further, *energy and matter* is emphasized in exploring how increases in greenhouse gases leads to increased reabsorption of solar radiation. Finally, students investigate factors influencing the *stability and change* of our entire planet's climate patterns, and subsequent impacts these changes may have on the global society.

Performance Expectations:

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice.]

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]

HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based

forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

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 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.]

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

Possible Phenomena:

- Sunscreen and the atmosphere: While students generally understand that they should apply sunscreen when exposed to long periods of solar radiation, they often do not realize that the atmosphere already offers some protection against this radiation. This phenomenon can be used to begin introducing the multiple roles the atmosphere plays in sustaining life on the planet.
- Ice Ages: Climate patterns have changed historically, including the most recent Ice Age. As a case study, students can compare and contrast these historical climate changes to the modern anthropogenic changes in climate conditions.

Standards to be addressed:

ELA/Literacy

RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a

new approach, focusing on addressing what is most significant for a specific purpose and audience.
WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
HSS-IC.A.1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population.
HSS-IC.B.6 Evaluate reports based on data.

Enduring Understandings / Big Ideas	**Problem(s) / Essential Questions**
Students will understand that: ● Complex interactions between 'spheres' of the planet maintain stable conditions needed for all life ● Earth's atmosphere is composed of different gasses, which impact the planet's climate ● Weather patterns are predictable based on interactions between the atmosphere and hydrosphere ● Human activities are impacting climate conditions dramatically	● Why do we need to breathe? ● What causes weather patterns? ● What is the difference between weather and climate? ● Is there evidence for climate change?

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models ● Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-3),(HS-ESS2-6) **Planning and Carrying Out Investigations** ● Plan and conduct an investigation individually and	**ESS2.A: Earth Materials and Systems** ● Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2) ● 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	**Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3- 1) **Energy and Matter** ● The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6) ● Energy drives the cycling of

collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-ESS2-5)

Analyzing and Interpreting Data

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ESS2-2)

Engaging in Argument from Evidence

- Construct an oral and written argument or counter-arguments based on data and evidence. (HS-ESS2-7)

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. (HS-ESS2-4)

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2)
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6)

ESS2.E Biogeology

- The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (HS-ESS2-7)

ESS3.D: Global Climate Change

- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5)

ETS1.B: Developing Possible Solutions

- When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and

matter within and between systems. (HS-ESS2-3)

Structure and Function

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7)
- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)

	aesthetics and to consider social, cultural and environmental impacts. (secondary to HS-LS2-7),(secondary to HS-LS4-6)	

Stage 2 – Assessment Evidence	
Performance Tasks ● Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. ○ Students will analyze and plot data connecting changes in global atmosphere composition to the evolution of living organisms ○ Students will compose a CER using evidence from their graph to explain how the atmosphere and life coevolved ● Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. ○ Students will design an interactive lesson on a given weather phenomenon, focusing on how energy transfers are involved ○ Students complete station lab activities to explore the processes impacting global climate changes, with a focus on the increase in carbon emissions ● Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. ○ Students complete station lab activities to collect data on the importance of Earth's atmosphere in sustaining conditions needed for life, and compose a CER explaining how changes to the	**Other Evidence:** ● Daily formative assessment should include use of do nows, exit tickets, and review games ○ Informal assessments conducted through Google Forms, Google Classroom, Kahoot, and other platforms in which teacher is able to give direct feedback and remediation to student understanding ○ Teacher will adjust subsequent lessons as needed based on this data ● Group-based lab & Peer Oriented Guided Inquiry Learning (POGIL) approach will be employed in the vast majority of lessons ○ Whole class discussion will be employed to introduce collaborative learning tasks, and review them at the end ○ Teacher check-ins during collaborative group learning ● Individual formal assessment should include one quiz (multiple choice and short answer) on the composition of the atmosphere, differences between weather and climate, and the human induced greenhouse gas effect

atmosphere would impact these conditions ● Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems ○ Students watch *An Inconvenient Truth* and assess the claims made therein ○ Students use data collected by international scientists to find correlations between rates of global temperature change and greenhouse gas emissions ○ Students use the above data to predict future trends ● Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. ○ See above ○ Students complete station lab activities to explore the processes impacting global climate changes, with a focus on the increase in carbon emissions ● Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. ○ Students collect data on vehicle emissions and their link to air pollution and climate change, and subsequently evaluate potential solutions to this issue A final performance assessment for this unit should include the following criteria: ○ Develop and use models, plan and carry out investigations, analyze and interpret data, and engage in argument from evidence to design a potential solution to mitigate the effects of global climate change	

Suggested Performance Task that can meet the criteria: ● Climate Change UN Proposal ○ Research and collect data related to a specific factor influencing global climate change ○ Synthesize this data to design a plausible solution to the crisis; solutions may involve new technology, government policies, or any other creative but practical idea ○ Consider the costs and benefits of the proposal, and present it to a 'panel' ○ Rubric will be designed to correlate with performance expectations and will be differentiated based on the level of the class	

Stage 3 – Learning Plan

Learning Activities:

See activities & assessments mentioned above. On a daily basis, class will begin using some form of hook, followed by a class discussion and introduction to key terms and concepts, then followed by a student-centered class engagement activity. The majority of class activities will be group-based and student centered.As a general structure, units will begin with activities that connect the overarching unit topic to student's daily lives to stress the importance of the topic. Next, students will complete activities to explore the natural dynamics governing this system of the planet. Finally, students will assess human impacts on the system using guided inquiry.

Initially, students will develop an understanding of the importance of Earth's atmosphere in sustaining life using an inquiry based lab activity. Next, they will explore the coevolution of life and atmospheric composition using data on gas composition throughout the planet's history; this will emphasize that the planet's atmospheric composition has changed slowly overtime to sustain life as we know it. Both of these activities lay the framework for students to understand the delicate role of the atmosphere in maintaining conditions on the planet. Before students can begin assessing the evidence for climate change, they will need to understand the critical difference between weather patterns and climate patterns, as this confusion tends to muddle the political debate surrounding climate issues. As such, students will develop interactive lessons on a weather phenomenon of their group's choice and then present these lessons to the class.

With the background understandings established, students will begin focusing on assessing the evidence for global climate change and the impacts of such change on both the planet and society. Students will work in groups to complete multiple station-based lab activities, but will also draw on their knowledge from previous units to form an integrated understanding of the systems involved in climate change. First, they will use scientific data on increases in carbon emissions and global temperature to find correlations and predict future changes. Subsequently, they will develop and assess a model of the human induced greenhouse gas effect to understand the basis of climate change. Finally, they will collect data and analyze the results of labs focusing on the human actions related to these changes. The culmination assessment will require students to focus on one specific factor causing climate change, research and collect data on this factor, and propose a plausible

solution to a mock ‘panel’ of the United Nations climate committee.

Before and after all group activities, there will always be an introductory and concluding discussion. Students will be grouped into cooperative lab groups and allowed to explore tasks at their own pace. Differentiation will be based on student grouping and frequency of teacher guidance and assistance. Higher groups will be given less guidance and more opportunity to explore supplementary scenarios.

Technology and the Nature of Science:
The controversy surrounding the issue of climate change highlights the ongoing need for unified scientific practices to generate multiple sources of evidence. At the same time, it should be clear that the impact of scientific knowledge in influencing societal decision making varies given socioeconomic and cultural restraints. Scientists must therefore consider the needs of society and work with non-scientific audiences. Again, technology provides a critical tool for scientists, and new technology is required to mitigate the negative impacts of human activities on the planet.

Scientific Investigations Use a Variety of Methods

- Science investigations use diverse methods and do not always use the same set of procedures to obtain data. (HS-ESS3-5)
- New technologies advance scientific knowledge. (HS-ESS3-5)

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence. (HS-ESS2-3)
- Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (HS-ESS2-3)
- Science includes the process of coordinating patterns of evidence with current theory. (HS-ESS2-3)

Know-What are the basics?:

- Atmospheric gasses
- Weather patterns versus climate patterns
- Greenhouse gasses

Possible Preconceptions/Misconceptions:
As a whole, students tend to minimize the importance of the atmosphere in their daily lives, which leads to a lack of concern for it. Time should be devoted to clarifying the roles of the atmosphere in sustaining life. Further, students have invariably heard of climate change, though most of them have very limited understandings of the underlying science. Many students tend to confuse weather patterns with climate change, reflecting the lack of understanding often present in mainstream discussions of the topic. Finally, political viewpoints on the issue are major influences in students’ willingness to accept the science. Framing the issue of climate change as an issue that affects human society and providing evidence of these effects may open students up to the general scientific consensus.
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How do I reinforce or build literacy or mathematics skills?

- Concept mapping
- Developing written proposals
- KWL charts
- Venn Diagrams
- Composing CERs based on quantitative and qualitative data

- Generating and graphing quantitative data
- Predicting future trends based on current data
- Using quantitative data to create models