Science

Stonington Public Schools

Environmental Science:

Human Impact

Stonington Public Schools

Environmental Science: Human Impact

BOE Approved: October 16, 2025

Superintendent: Mary Anne Butler
Assistant Superintendent: Tim Smith
Board of Education Members:
Farouk Rajab- *Chairman*
Kevin Agnello
Sara Baker
Meghan Blanchette
Chris Donahue
Katie Gauthier
Dan Kelley

Curriculum Writing Team:
Rachel Thomas-Shapiro- Teacher
Jennifer Bausch- Secondary Curriculum Coordinator

Science Vision Statement

The Stonington K-12 Science curriculum provides a comprehensive, problem-based education focused on the Next Generation Science Standards. The curriculum fosters

- High-quality authentic science education for every student
- Fluency in the Science and Engineering practices
- A recognition of the full implications of the scientific world
- The utilization of scientific concepts and phenomena to consider, connect, communicate and convince
- Rigorous and relevant learning environments

Students will become scientifically literate citizens able to contribute to a rapidly advancing, STEM-driven world, taking action in local, national and global issues.

Curriculum Philosophy

Students can expect
High Interest
Inclusivity
Accessibility to all
Opportunities for autonomy
Respectful relationships

Instruction is
Differentiated & Equitable
Student-centered
Data-driven
Mindful of social & emotional competencies
Performance based

EVOLVE
STONINGTON PUBLIC SCHOOLS
Future Focused

Content is
Relevant & Authentic
Dynamic
Invaluable
Appropriately challenging
Coherent

Curriculum Philosophy from a Student Perspective

Students in Stonington Public Schools will engage with an inclusive, evolving curriculum that will drive students to understand themselves as learners. While learning their individual strengths through a variety of experiences, students will build the self-awareness, self-management, and entrepreneurship needed to have knowledgeable voices and make positive impacts on the modern world.

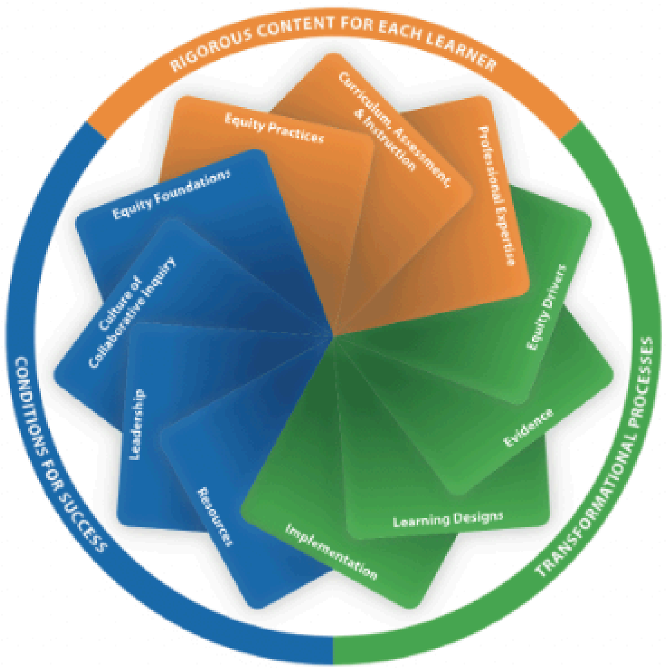
Curriculum Philosophy from an Instructional Perspective

Instruction in Stonington Public Schools will utilize culturally, socially and emotionally conscious practices to include multiple perspectives. It will be meaningful to students by incorporating multifaceted pedagogical approaches including inquiry, collaboration, and reflection. Instruction will provide all students opportunities to respond, equitable assessments, and constructive feedback. Teachers will engage in dynamic and reflective practices to advance their craft.

Curriculum Philosophy from a Content Perspective

Content in Stonington Public Schools will be constantly adapting to reflect current and relevant information along with the state and national standards for each discipline. Through a rich, authentic, and coherent curriculum, students will learn that the past informs the future. The curriculum will be complex and will provide optimum challenges for all students with the goal of preparing knowledgeable, solution driven, productive citizens who are ready and prepared for the diverse global community.

All graduates of Stonington Public Schools will possess the self-leadership skills for post-secondary success in enrollment, enlistment, or employment.

Curriculum Equity Statement	
Board of Education Goal 2: Future-Focused Teaching and Learning Stonington Public Schools will prepare every student for their own educational journey by implementing forward-thinking practices that foster equity and inclusion to allow all students access to educational programming.	
	Learning results in equitable and excellent outcomes for ***all*** students when educators… • Prioritize high-quality curriculum and instructional materials, assess student learning, and understand curriculum and its implementation through instruction. • Understand their students' historical, cultural, and societal contexts, embrace student assets through instruction, and foster relationships with students, families, and communities. • Establish expectations for equity, create structures to ensure equitable access to learning, and sustain a culture of support for all students and staff. • Prioritize equity in professional learning practices, identify and address their own biases and beliefs, and collaborate with diverse colleagues. ("Standards for Professional Learning - Standards 2022")

Stonington High School

Mission Statement

Stonington High School establishes a motivating, challenging, and equitable environment that educates all students to their highest levels of academic achievement. Our curriculum and culture promote diversity, critical thinking, and collaboration among students, staff, families, and the community. Our students identify their strengths, hone interdisciplinary and self-leadership skills and explore their interests leading them to become active, responsible, and productive citizens in an ever-changing global society.

Vision of the Graduate

I will possess the cognitive, academic, interpersonal, and self-leadership skills needed for post-secondary success in enrollment, enlistment, or employment. Through the 4-Cs, I will acquire an extensive core body of knowledge and essential experiences necessary to achieve my future aspirations.

Convince	Communicate	Consider	Connect
Be a critical thinker, using a variety of relevant evidence to support a position or present an idea to a chosen audience with clarity and confidence. Collaborate with others, resolve conflicts, and respect differing ideas. Assess personal interests, strengths and needs.	Use clear language and/or other forms of expression effectively to convey ideas collaboratively with others in a respectful manner. Build relationships with humility, honesty and trust. Self advocate and persist.	Analyze and evaluate information, data, and feedback to develop innovative options to solve challenging situations and/or problems. Recognize one's influence and take the perspectives of others Move ahead despite obstacles, take risks, cope with challenges and show strength of character.	Use knowledge from all disciplines and/or technology to be a participative and productive, and responsible contributor to society. Empathize and work with others in the school, the community and the world. Explore, share and achieve passions and goal.

Environmental Science: Human Impact

Critical Areas of Focus (Course Description)
This course offers foundational scientific knowledge and insights into the functioning of our world from an environmental perspective. Students will investigate climate change, focusing on its impact on temperature, as well as issues related to adaptation and extinction. The course will also examine the effects of sea level rise on coastal communities. This course meets the ½ credit ESS recommendation Prerequisite: Biology Length 1/2 year, Credit ½

Pacing Guide		
Unit 1	Unit 2	Unit 3
Speciation & Extinction Due to Climate Change	Changing Sea Levels	Sustainable Agriculture
15 classes @ 80 minutes	15 classes @ 80 minutes	11 classes @ 80 minutes (occurs throughout the course)

4C- Consider

Unit One

Name of Unit:	Length of unit: (number of classes/minutes per meeting)
Speciation & Extinction Due to Climate Change	~15 classes @ 80 minutes

Content Standards Addressed in the Unit:

Next Generation Science Standards

Earth and Space Science: Earth's Systems
HS-ESS2-7: Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

Life Science: From Molecules to Organisms: Structures and Processes
HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Life Science: Ecosystems: Interactions, Energy, and Dynamics
HS-LS2-6: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*

Life Science: Biological Evolution: Unity and Diversity
HS-LS4-1: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
HS-LS4-2: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment .
HS-LS4-4: Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
HS-LS4-5: Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Beginning July 1, 2023, ***Section 263 of Public Act 22-118*** requires, rather than allows, climate change to be taught as part of the science requirement in a public school's program of instruction. Pursuant to Conn. Gen. Stat. § 10-16b(d), the SBE must make available curriculum materials that include climate change consistent with the Next Generation Science Standards.

OpenSciEd® It is highly suggested to follow Connecticut's Model Science Curriculum OpenSciEd for this unit. https://openscied.org/instructional-materials/b-5-common-ancestry-speciation/

This unit is anchored by the unusual sightings of polar, brown, and black bears in Wapusk National Park. Students investigate why this is so unusual and consider what this means for the bears as the Arctic warms. Lesson Set 1 focuses on bear thermoregulation and how speciation occurred over geologic time. In Lesson Set 2 students learn about hybridization of bears as an alternative future for the bears. They consider the speed at which extinction and speciation events occurred in the past compared with changes occurring today. Students research ways humans protected other species from extinction and debate what role humans should play in protecting Arctic bears from extinction.

Big Ideas:	**Essential Question(s):**
• Changes in the environment affect populations. • Changes in past populations can be used to predict future populations.	• What happens to populations as their environment changes? • What will happen to populations in the future?
Students will know:	**Students will be able to:**
• The coverage and duration of Arctic sea ice is changing, leading to less sea ice habitat for polar bears in areas with seasonally available ice. • Polar bears are adapted to the Arctic ecosystem and rely on Arctic sea ice. • Based on their adaptations, the polar bears are most at risk for population declines as the environment changes. • Based on their adaptations, brown bears may expand	• Develop and revise models to explain and predict the interactions of Arctic bear populations with their environment. • Construct and evaluate arguments using evidence. • Evaluate competing solutions to prevent extinction. • Find patterns in data at different scales that affect the survival of Arctic bears as the climate changes. • Develop and revise models about the effect of climate

their range as the Arctic warms. ● Polar and brown bears are likely to interact more as the environment changes. ● In interactions with brown bears around food, polar bears run away. ● When polar bears exercise, they overheat easily. ● Polar bear adaptations, including a variation of the NOS3 gene, cause polar bears to get hot. ● Other mammals, like humans, can regulate heat through sweating and other mechanisms. ● Polar bears can cool off when there is snow, but without it they get too hot and pass out. ● Genetic differences in thermoregulation may lead to brown bears dominating over polar bears in a warming Arctic. ● We have evidence that polar, brown, and black bears have a lot of similarities and differences based on anatomy and behavior. ● We can use trees to communicate our hypotheses about relationships among bear species. ● Polar bears and brown bears are more genetically similar to each other than they are to any other bear species. ● Polar bears and brown bears share a more recent common ancestor than they do with other bears ● The Arctic has undergone glacial and interglacial periods, creating selective pressures for bears. ● Small bear populations may have been isolated in areas that kept ice year round during interglacial periods. ● Natural selection acted on genetic variations present in isolated populations of bears over thousands of generations. ● Speciation occurred in the common ancestor bear after	change on the long-term survival of Arctic bear populations. ● Make, defend, and evaluate claims about the relationship between thermoregulation and bear behavior. ● Infer mechanisms of bear speciation at scales that cannot be studied directly. ● Construct and revise arguments about how brown and polar bears split from a common ancestor. ● Construct and revise arguments about the causes of mass extinction events on Earth. ● Integrate and evaluate information from multiple sources about ways to prevent the extinction of particular species. ● Evaluate possible solutions for protecting polar bears from extinction.

thousands of generations, leading to polar bears that are adapted to polar environments and brown bears that are adapted to nonpolar environments. ● Polar bear populations will decline in the future because they evolved with adaptations for Arctic environments. When removed from those habitats, they overheat and cannot outcompete brown bears for food. ● Arctic brown bear populations will increase in the future, as there is less ice and they can use aggression and genetic diversity to find food, survive, and reproduce in more areas on land in the Arctic. ● The Arctic climate is likely changing too quickly for polar bears to adapt. ● We can use a model to generate evidence to support predictions. ● Five times in Earth's history, significant environmental changes that resulted in major shifts in global climate caused the extinction of at least 75% of all species at the time. ● Extinction is a significant threat to biodiversity, which is necessary for ecosystem resistance. ● There are similarities between environmental conditions that caused the mass extinctions and what Earth is like today. ● Unlike the previous 5 mass extinctions, current extinctions are primarily caused by human activities. ● Options for protecting endangered species from extinction include habitat conservation, breeding programs, species relocation, long-term storage of genetic material, and others. ● Not all species at risk of extinction can be protected in the same way.	

● Protecting species from extinction requires huge inputs of time, money, resources, and collaboration. ● Protecting polar bears from extinction is difficult because they are large, long-lived, reproduce slowly and cannot survive in warm climates.	

Significant tasks:

Significant task 1: How do changes in climate affect species?

After viewing a phenomenon such as 3 types of bears in one location, students can create a driving question board. Students can investigate changing Arctic environmental conditions and their relationship to Arctic bear populations. Students can then read about polar, brown, and black bears and consider how they may adapt to changing conditions. Students can investigate the stability of Arctic bear populations in different regions of the Arctic. Students can develop and share initial models about the future of different polar bear populations.

Timeline: ~ 3 classes @ 80 minutes

Significant task 2: How and why are species interacting and why might one dominate? (Lesson 2 & 3)
Students can investigate thermoregulation to figure out why polar bears might run away from brown bears. Students can construct claims about what will happen in polar and brown bear interactions in the future. Students can decide to investigate how similar/different the three species of bears are by reviewing anatomical and DNA evidence. They can build a characteristic tree of the polar, brown, and black bears with five other bear species. Students can figure out that polar bears are most similar to brown bears and that they share a more recent common ancestor than they do with other bears.

Timeline: ~ 4 classes @ 80 minutes

Significant task 3: How did the animals become different species?
Students can review the mechanism of natural selection and use it to connect evidence at different scales to explain how polar and brown bears split from a common ancestor. Students can investigate evidence from glacial cycles, fossils, and allele variations. Students can develop and revise an argument to explain the speciation of polar and brown bears. Students can decide to use what they know about the impact of glacial cycles on bears in the past to figure out what will happen to Arctic bears in the future.

Timeline: ~ 3 classes @ 80 minutes

Significant task 5: What will happen to populations as their environment changes? (lessons 5 & 6)
Students can develop a Gotta-Have-It Checklist and revise their initial consensus model using new evidence. Students can revisit the DQB and answer questions they have figured out, notice what questions are left unanswered, and add new questions.
Students can decide to investigate what will happen to polar bears in the future as the Arctic environment changes. Students can figure out the climate is likely changing too fast for polar bears to evolve and adapt to environmental changes. Students can wonder about other possibilities for polar bears and hear about a case where polar bears and brown bears mated and produced hybrid offspring. Students can use a model to generate evidence to help us predict hybrid fitness in the future.

Timeline: ~3 classes @ 80 minutes

Significant task 7: How do past patterns of extinction help us understand possible consequences of extinctions now and in the future? (lesson 7)

Students can investigate extinction rates for the whole Earth and wonder how this compares with events in the geologic past. Students can investigate the five mass extinctions in Earth's history and figure out that in each, a major event precipitated a significant shift in climate. Students can connect the past to what is happening today and update their Progress Trackers.

Timeline: ~ 2 classes @ 80 minutes

Significant task 8: What are our options for protecting species from extinction? (lessons 8 & 9)
Students can research and evaluate solutions used to protect species from extinction and present them to the class. Students can discuss if these solutions could work to protect the polar bear and if people should intervene. Students can write an individual argument with their position on whether humans should do something to save polar bears from extinction. Students can then complete a Transfer Task to evaluate claims about ways to protect endangered bumble bees to demonstrate how what they figured out throughout the unit about finding common ancestry, biological evolution, and extinction applies to other systems.

Timeline: ~ 4 classes @ 80 minutes

Common Learning Experiences:

- Opportunities to Respond: Active Engagement
- Current Events as applicable
- Cooperative Grouping
- Scientific Discourse
- Science and Engineering practices
- Computer simulations (pHet, Gizmos)
- Developing a Driving Question Board
- Systems and system modeling
- Form claims based on evidence and reasoning
- Mathematical calculations
- Exit Tickets
- Concept Quizzes
- Attending to Equity
- Supporting Emerging Multilingual Learners
- Supporting Universal Design for Learning
- Additional Guidance
- Alternate Activity
- Key Ideas
- Discussion callouts
- Suggested Interim Assessment Blocks (IABs) for NGSS Testing
  - ESS2-6 CO2 in the Atmosphere (1 question)
  - LS2-7 Roof Heat Control (1 question)
  - ESS3-4 Waste Diversion Programs
  - ESS3-5 Precipitation Trends

Key vocabulary:

Seasonally available ice, permanent ice, species*, adaptation*, population*, convergent, divergent, archipelago, thermoregulation, homeostasis, refute, common ancestry, speciation, glacial period, interglacial period, hybrid, family, mass extinction

Evidence of Understanding - Common Assessments

- Participation
- Investigation Data
- Infer:Genetic Information to Evolutionary Relationships
- CER: Speciation
- Science Notebook entries
- Hybridization Model
- Key extinctions graphic organizer
- CER: Best way to protect a species
- Transfer Task (wild bumble bees)

Teacher notes:

- Resources:
  - OpenSciEd:
- Anticipated Student Misconceptions:
  - Extinction is natural and unavoidable process that does not require human intervention.
  - Population decline always leads to extinction.
  - All species are equally vulnerable to extinction.
- Differentiation Strategies:
  - NGSS Appendix D - "All Standards, All Students": Making the Next Generation Science Standards Accessible to All Students
  - Tier 1 Universal Strategies
  - Tier 2 Targeted Strategies
  - Tier 3 Intensive Strategies
  - OpenSciEd units are designed to promote equitable access to high-quality science learning experiences for all students. Each unit includes strategies, which are integrated throughout the OpenSciEd routines and are intended to increase relevance and provide access to science learning for all students. OpenSciEd units support these equity goals through several specific strategies such as: 1) integrating Universal Design for Learning (UDL) Principles during the unit

design process to reduce potential barriers and increase accessibility for students to engage in learning experiences; 2) developing and supporting classroom agreements that encourage a safe learning culture; 3) supporting classroom discourse to promote students in developing, sharing, and revising their ideas; and 4) specific strategies for supporting emerging multilingual students in science classrooms.

- Safety Considerations:
  - *Note: Each teacher will identify the safety considerations that occur in each individual activity.*
  - *See ACS Chemical Hygiene Plan for specific safety precautions.*

- Prior Knowledge:
  - Many of the concepts were introduced during Biology (Grade 9).

- Interdisciplinary Connections:
  - Career Awareness
  - NGSS Connections: Earth, Chemistry & Physics connections
  - ISTE Standards: Empowered Learner, Digital Citizen, Knowledge Constructor, Innovative Designer
  - Common Core State Standards Connections:

    ELA/Literacy -
    - 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.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
    - SL.11-12.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and students canll-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

    Mathematics -
    - This unit requires students to develop mathematical models, use mathematical representations, develop algorithms, and use rates of change. Making mathematical models is a Standard for Mathematical Practice, and specific modeling standards appear throughout the high school standards.

    Social Emotional Learning: CASEL 5
    - Responsible Decision Making

- Identifying Problems
- Analyzing Situations
- Solving Problems
- Evaluating
- Ethical Responsibility

- Social Awareness
  - Respect for Others
- Self Management
  - Self-Motivation
  - Goal Setting
- Relationship Skills
  - Communication
  - Teamwork

Unit Two

Name of Unit: Changing Sea Levels	**Length of unit: (number of classes/minutes per meeting)** ~13 classes @ 80 minutes each
Content Standards Addressed in the Unit:	

Next Generation Science Standards

Physical Science: Energy
HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flow in and out of the system are known.
HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperatures are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Earth and Space Science: Earth's Systems
HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems.
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.
HS-ESS2-7 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

Earth and Space Science: Earth and Human Activity
HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
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 on Earth systems.
HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Beginning July 1, 2023, ***Section 263 of Public Act 22-118*** requires, rather than allows, climate change to be taught as part of the science requirement in a public school's program of instruction. Pursuant to Conn. Gen. Stat. § 10-16b(d), the SBE must make available curriculum materials that include climate change consistent with the Next Generation Science Standards.

OpenSciEd It is highly suggested to follow Connecticut's Model Science Curriculum OpenSciEd for this unit. https://openscied.org/instructional-materials/c-1-thermodynamics-in-earths-systems/

This unit is anchored by students exploring coastal communities that are affected by rising sea levels, which are forcing some communities to move. Students analyze data that show how sea level rise is historically connected to polar ice melt and temperature increases, and thorough data and investigation determine that the temperature increase is caused by humans releasing excess carbon dioxide into the atmosphere. They are introduced to two possible solutions and figure out how these solutions, along with decreasing carbon dioxide emissions, could help slow sea level rise. Students figure out how energy transfers on the molecular level as well as on the Earth-systems level through radiation, convection, and conduction.

Big Ideas:	**Essential Question(s):**
• Based on historical data, temperature and sea level are rising.	• Why and how is the sea level rising? • How can we slow the flow of energy on Earth to protect vulnerable coastal communities?
Students will know:	**Students will be able to:**
• Sea levels are rising--some causes we find are local like storms and erosion, but something is affecting sea levels globally. Scientists predict that this will continue. • In chemistry we use ideas about energy and matter to explain confusing things that we see in the world. • Polar ice melt due to climate change is one explanation	• Throughout the unit, students will do the following: • Develop an energy transfer model based on evidence to illustrate how atmospheric carbon dioxide, more than any other factor, causes global temperature increases, polar ice melt, and sea level rise. • Use mathematical and computational thinking and

for why the sea level is rising. ● Over the last million years, global temperatures seem to increase around the same time that ice volumes decrease and sea levels increase. ● Scientists have to use indirect sources of evidence to figure out what Earth's climate was like in the past. ● Changes in the sunlight that reaches Earth's surface can affect climate. ● Changes in carbon dioxide due to plant growth or human activity can affect climate and can help explain current temperature increases. ● The presence of carbon dioxide somehow enhances the rate of warming in a closed water bottle system, which we can use to model Earth's atmosphere. ● Energy that enters a system with more carbon dioxide is less likely to exit that system compared to a system with less carbon dioxide. ● Earth's atmosphere is a mixture of many different types of gases, including carbon dioxide. ● The concentration of carbon dioxide in Earth's atmosphere has increased rapidly over time. Because it can last in the atmosphere for a very long time, we need to find another way to address sea level rise besides reducing CO_2 emissions. ● 'We estimate that if all of Greenland's land ice melted, Eh's sea levels would rise by almost 7 meters. If all of Antarctica's land ice melted, Earth's sea levels would rise by about 55 meters. ● A sea level rise of 7 or 55 meters, or even 0.5 meter, would cause many major cities and other places to be covered by water for at least part of the year. ● Earth's sea levels would not rise if Earth's sea ice melted, because this ice is already in the ocean. ● We have initial ideas about ways that ice sheets could be prevented from melting.	investigation to predict and explain the likely impact of matter transfer from the cryosphere to the hydrosphere. ● Apply scientific ideas to examine, explain, and ask questions about two design solutions for polar ice melt. ● Develop an energy transfer model that shows how microbeads could interrupt the feedback loop in which areas with melting polar ice reradiate more infrared light, which is absorbed by carbon dioxide, causing even greater temperatures and more polar ice melt. ● Consider and ask questions about the many feedback loops in and between Earth's systems. ● Evaluate complementary information about glacier melt from Inuit hunters and fishers and NASA scientists. ● Use mathematical thinking to derive and compare densities for water at different temperatures and salinities. ● Collaboratively design and plan an investigation using a computer model to produce simulated data as evidence to figure out what is happening at a particle level when two pieces of matter come in contact that are at different temperatures. ● Use digital tools to computationally analyze data to determine and predict the amount of ice melt when we know the mass and temperature of the water that's in contact with the ice. ● Develop and use particle and energy transfer models to provide mechanistic accounts for how the berm geoengineering solution can help reduce glacier melt. ● Develop the outlines of and use a computational climate model that reflects all the main ideas from the unit, in order to answer questions about the impacts of human activities.

• The Ilulissat Glacier is the single largest flow of melt in Greenland. The front edge of the glacier has been receding over many decades. • There are two proposed solutions. One is to build a huge underwater barrier between Disko Bay and Ilulissat Icefjord to prevent warm salty ocean water from coming into contact with the Ilulissat Glacier. The other is to spread thin layers of microbeads on Arctic ice in the summer months. • Rights holders have concerns about the suitability of these designs and their potential impacts. • Different materials absorb and reflect light energy differently. More reflective materials, like fresh ice or snow, have a high albedo. • When dark materials absorb visible light, their particles speed up and re-emit infrared light over time. • Carbon dioxide and other greenhouse gases transmit visible light, but absorb infrared light, trapping it in the Earth system. • Some questions are best answered by evidence gathered in the field. • Indigenous Knowledge is a systematic way of thinking. • Both the berm solution and cutting carbon emissions could slow the transfer of energy at the interface. • Density of a substance (or a sample) is its mass per unit volume. • When denser fluids are added above less dense fluids, the denser fluids sink. • When denser fluids are moved beneath less dense fluids, they tend to remain separated and flow independently of each other. • Changes in energy and matter happen together, including in convection, when energy transfers as substances move. • Energy transfer between two objects/samples initially at different temperatures will cause both to eventually reach the same final temperature, which will be between the initial temperatures.	

• The mass of each sample affects where the final temperature stabilizes (ΔT depends on m). • Energy is conserved. It flows between objects but is not created or destroyed. • Conduction is the transfer of energy through direct contact as particles collide. • The specific heat (c) of a substance or mixture tells us how much energy in calories is needed to change 1 gram of it by 1 °C. • Heat transfer Q into or out of a substance can be found by multiplying the specific heat, mass, and temperature change. • Because energy is conserved, the heat that transfers out of the water in our investigation flows to the ice. • 80 calories of energy are required to melt 1 gram of ice ($Q = 80 \cdot m$). • We can use our mathematical model to predict the amount of ice melt when we know the mass and temperature of the water it is in contact with. • We can build a mathematical model that will allow us to figure out how much ice melt the berm can prevent. • About 5×10^{18} calories of annual energy flow into the Ilulissat Glacier system could be prevented by the proposed berm solution, so the berm could theoretically stop glacier melt at that location. • We can expand our model to include a larger system (i.e., on the global scale, rather than the scale of a particular glacier). • Climate models work using equations for energy and matter transfer like those we developed. • They are based on assumptions and are therefore not perfectly predictive. • Models are improved as scientists get new information. • Climate models agree that Earth will continue to warm significantly if no changes are made. • Our computational model shows that solutions that decrease carbon dioxide in the atmosphere or energy	

reaching Earth's surface could prevent some sea level rise and its negative impacts on people. ● Heat pumps provide a possible solution to help limit carbon dioxide emissions while keeping homes safe and comfortable.art	

Significant tasks:

Significant task 1: Why are sea levels rising? (lessons 1, 2, & 3)
Students can explore coastal communities that are affected by rising sea levels. We develop community agreements, a class consensus model, a Driving Question Board, and ideas for investigation. They can look at historical data of temperature, polar ice volume, sea level, and different possible causes. Students can discuss and create models to hypothesize the likely cause of current ice melt and sea level rise. An investigation, model, and/or readings about how increased CO_2 in the atmosphere causes warmer temperatures can occur.

Timeline: ~3 classes @ 80 minutes

Significant task 2: What would happen if the Earth's ice melted? (lessons 4, 5, 6, 7)
Students can develop a mathematical model to figure out the impact on sea level if Greenland and Antarctica's ice melted. Their answers can be evaluated using a simulation of sea levels. They should notice that the ice in the Arctic Ocean is not represented. An investigation to see if ice in water affects the water level when it melts should occur.
Students should use satellite images and modern design ideas to consider possible mitigations for glacier melt. They can design an investigation to test their ideas about how microbeads prevent ice melt. After reading and researching they can explain both how carbon dioxide causes temperature increases and how the beads can help prevent melt. Students can debate or write a CER explaining who should decide to use microbeads and if they should be used. After reading about feedback loops, they can take a short mid-unit assessment (How permafrost interacts with Earth systems) and make revisions to the Driving Question Board.

4C: Consider

Timeline: ~5 classes @ 80 minutes

Significant task 3: What is going on where the ice meets the water?   (lessons 8, 9)

Students should pose questions about the interface where glacial ice meets ocean water, and learn from Inuit and NASA experts to frame hypotheses about how proposed solutions would affect energy flows in the area. Next, they can create models of water at different conditions. Students can then investigate the mass and volume of water under these conditions, graph their results, and calculate densities.

Timeline: ~3 classes @ 80 minutes

Significant Task 4: How can we slow the flow of energy on Earth to protect vulnerable coastal communities? (lesson 10, 11, & 12)

Using investigations, simulations, and mathematical modeling, students can examine energy transfer when substances are in direct contact. We figure out that when two objects/samples at different temperatures are in contact with one another (berm). They should determine where the heat equation fits into the energy transfer model. They should realize that they do not know what affects the amount of ice melt other than incoming heat, so they should plan and conduct an investigation in which they measure both the temperature change of the water and the mass change of the melting ice. They should figure out from the slope of the best-fit line of the data that 80 calories of energy are required to melt 1 gram of ice and consider how this understanding might help us in addressing glacier melt and sea level rise.They can develop a model that helps further evaluate the berm solution and calculate the berm's impact on ice melt. They can brainstorm ideas for an expanded computational model that includes the Earth system beyond the glacier.

Timeline: ~6 classes @ 80 minutes

Significant Task 5: How can we model what will happen to Earth's climate if humans make changes?

Students can read about how scientists carry out and use climate modeling. They can use this understanding to develop questions about the computational model and then test them. They can discuss their results. After finalizing the Driving Question Board, students can complete a transfer task focused on indoor heating in a changing climate (examine heat pumps and plan an investigation to troubleshoot a heat pump that is malfunctioning).

Timeline: ~3 classes @ 80 minutes each

Culminating Experience: EN-ROADS Climate Solution Simulation: (3 day activity)
https://en-roads.climateinteractive.org/scenario.html?v=25.4.0

Common Learning Experiences:

- Opportunities to Respond: Active Engagement
- Current Events as applicable
- Cooperative Grouping
- Scientific Discourse
- Science and Engineering practices
- Computer simulations (pHet, Gizmos)
- Developing a Driving Question Board
- Systems and system modeling
- Form claims based on evidence and reasoning
- Mathematical calculations
- Exit Tickets
- Concept Quizzes
- Suggested Interim Assessment Blocks (IABs) for NGSS Testing
    - ESS2-6 CO2 in the Atmosphere (1 question)
    - LS2-7 Roof Heat Control (1 question)
    - ESS3-4 Waste Diversion Programs
    - ESS3-5 Precipitation Trends

Key vocabulary:
Sea Level Rise, Antarctica, Glacier, Albedo, Greenhouse Gases, Carbon Emissions, Density, Convection, Specific Heat, Energy Transfer, Heat Pump, Microbeads, Indigenous Knowledge, Mathematical Model, Climate Models, Energy Conservation, Temperature Change, Berm Solution

Evidence of Understanding - Common Assessments

- Participation
- Ice Melt and Sea Level Model
- Ice Melt Simulation
- Microbead debate or CER (4C)
- Density of Water graphs
- Temperature and Mass of Ice Investigation

- Transfer Task: Malfunctioning Heat Pumps
- Culminating Experience: EN-ROADS Climate Solutions

Teacher notes:

- Resources:
    - OpenSciEd:
- Anticipated Student Misconceptions:
    - Climate change is not human-caused.
    - A warming climate means warmer weather across the board.
    - Climate change will not affect people significantly, or will not affect people where we live.
- Differentiation Strategies:
    - NGSS Appendix D - "All Standards, All Students": Making the Next Generation Science Standards Accessible to All Students
    - Tier 1 Universal Strategies
    - Tier 2 Targeted Strategies
    - Tier 3 Intensive Strategies
- Safety Considerations:
    - *Note: Each teacher will identify the safety considerations that occur in each individual activity.*
    - *See ACS Chemical Hygiene Plan for specific safety precautions.*
- Prior Knowledge:
    - Students studied climate change in Grade 6.
- Interdisciplinary Connections:
    - Career Awareness
    - NGSS Connections: Earth, Chemistry & Physics connections
    - ISTE Standards: Empowered Learner, Digital Citizen, Knowledge Constructor, Innovative Designer
    - Common Core State Standards Connections: ELA/Literacy -

- 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.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and students canll-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

Mathematics -

- This unit requires students to use unit conversions, reason about equations that they collaboratively build from data, and mathematically model these using tools. Note that modeling is best interpreted not as a collection of isolated topics but in relation to other standards. Making mathematical models is a Standard for Mathematical Practice, and specific modeling standards appear throughout the high school standards.

Social Emotional Learning: CASEL 5

- Responsible Decision Making
  - Identifying Problems
  - Analyzing Situations
  - Solving Problems
  - Evaluating
  - Ethical Responsibility
- Social Awareness
  - Respect for Others
- Self Management
  - Self-Motivation
  - Goal Setting
- Relationship Skills
  - Communication
  - Teamwork

Unit Three

Name of Unit:	**Length of unit: (number of classes/minutes per meeting)**
Sustainable Agriculture	~11 classes @ 80 minutes

Content Standards Addressed in the Unit:

Next Generation Science Standards

Life Science: Ecosystems: Interactions, Energy, and Dynamics
HS-LS2-1: Use mathematical and computational thinking to support explanations of how environmental factors affect biodiversity.
HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems.
HS-LS2-3: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
HS-LS2-6: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain biodiversity and ecosystem services.
HS-LS2-4: Use mathematical representations to support the claim that the total mass of products equals the total mass of reactants in a chemical reaction.

Earth and Space Science: Earth's Systems
HS-ESS2-1: Develop a model to describe the cycling of Earth’s materials and the flow of energy that drives this process

Earth and Space Science: Earth and Human Activity
HS-ESS3-1: Construct an argument based on evidence about the simultaneous coevolution of Earth’s systems and life on Earth.
HS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Big Ideas:	**Essential Question(s):**
● Successful plant growth relies on several key environmental factors. ● Physical and chemical properties of soil influence ecosystems and agricultural practices. ● Sustainable gardening practices promote environmental health, enhance biodiversity, and ensure the longevity of our food systems.	● What are the key environmental factors that influence the successful growth of plants and how can we effectively manage these factors to optimize plant health and yield? ● How do the physical and chemical properties of soil influence ecosystems and agricultural practices? ● How can effective garden maintenance practices in greenhouses and raised beds contribute to sustainability.
Students will know:	**Students will be able to:**
● The ideal conditions for growing each of the selected plants (e.g., light, temperature, moisture). ● The seasonal timing for planting in a greenhouse setting. ● The importance of soil health and nutrients for plant development. ● The role of environmental factors in plant growth (e.g., sunlight, water, air). ● Common pests and diseases that affect these plants and how to manage them. ● Soil composition: minerals, organic matter, water, and air. ● The importance of pH level and nutrient content in soil health. ● Methods for analyzing soil samples (e.g., texture analysis, pH testing). ● The relationship between soil quality and environmental sustainability. ● Eco-friendly methods in garden maintenance. ● The role of soil quality and composition in plant growth. ● Techniques for efficient watering in greenhouses and	● Identify the key environmental factors necessary for the growth of tomatoes, radishes, beets, lettuces, and scapes in a greenhouse setting. ● Explain the importance of soil health and nutrient management for successful plant growth. ● Create a greenhouse planting plan that outlines the specific conditions required for each type of plant. ● Analyze the impact of seasonal changes on greenhouse planting and plant growth cycles. ● Identify common pests and diseases that affect greenhouse plants and propose management strategies. ● Evaluate the effectiveness of different growing conditions through observation and data collection in the greenhouse. ● Analyze and interpret soil samples to determine their composition and quality. ● Evaluate the impact of soil types on environmental health and agricultural sustainability.

raised beds. ● Sustainable methods for managing pests. ● The benefits of rotating crops in raised beds for soil health.	

Significant tasks:

These tasks occur throughout the semester

Significant task 1: Planting
Begin by discussing the seeds that were harvested in the fall. Present a PowerPoint or other instructional strategy, on the key factors for successful greenhouse and raised bed planting, focusing on each plant type (use plants that will be ready in the spring or in the fall: tomatoes, radishes, beets, lettuces, scapes). Next, students can work in small groups researching one of the plants. Each group will present their findings on the ideal growing conditions (light, water, soil type, temperature) and potential issues (pests) for their assigned plant. During the presentations, students should record the key factors for each plant type. Students can then individually create a detailed planting plan for a greenhouse or raised bed, including: the chosen plants, a chart listing the ideal conditions for each plant, a paragraph explaining how environmental factors will influence their growth. This plan and a short quiz will demonstrate their understanding of environmental science principles related to plant growth.

Once conditions permit, students will plant the seeds and monitor their growth.

Timeline: ~ 5 classes @ 80 minutes (planting and monitoring occur routinely throughout the semester)

Significant task 2: Soil Analysis
Begin with a thought-provoking question to lead a class discussion such as, "What is soil and what is it made of?" Students can then discuss their personal experiences with soil (gardening, farming, etc.) Pictures or video clips can be shown to show different soil types and the agriculture and ecology that occurs in the particular locations. Next, students can discover the key components in soil composition and their functions through direct instruction, reading or video. Students can then participate in an activity, such as Dirt Shake Activity, to demonstrate the different textures (sand, silt, clay). Next, the importance of pH and nutrient levels should be

discussed along with the terms macronutrients and micronutrients. Students can then analyze soil samples using various soil testing kits, measuring pH and identifying soil texture. Students can answer questions such as

- What do you observe about the color and texture of your soil sample?
- How does the pH level affect the ability of plants to absorb nutrients?
- How do these factors impact environmental health and agricultural practices?

As an assessment, students can be given specific soil samples to analyze. Once the data is determined it can be matched to the best agricultural fit.

Timeline: ~ 3 classes @ 80 minutes

Significant task 3: Garden Maintenance
Students can watch/listen to an introduction about different crop rotation methods. If time permits, a trip to a farm such as YellowFarm House can occur to see how a local farm employs these techniques. If a trip or guest speaker cannot occur, a farm case study can be analyzed.   They can explore the benefits of crop rotation in preventing soil depletion and managing pests, while also discussing various strategies for effective crop rotation. In a group activity, students can create a crop rotation plan for a hypothetical garden. They can also identify common garden pests and their effects on crops and learn eco-friendly management strategies. Students should also learn about beneficial insects. Students can create eco-friendly pest repellents to use in their gardens. Working in small groups, students can conduct a research project on various eco-friendly gardening methods (e.g., composting, organic gardening) and present their findings to the class. Students will maintain the greenhouse and raised beds throughout the semester, applying the concepts learned in class.

Timeline: ~3 classes @ 80 minutes

Common Learning Experiences:

- Opportunities to Respond: Active Engagement
- Current Events as applicable
- Cooperative Grouping
- Scientific Discourse
- Science and Engineering practices
- Developing a Driving Question Board

- Systems and system modeling
- Form claims based on evidence and reasoning
- Mathematical calculations
- Exit Tickets
- Concept Quizzes

Key vocabulary:
Greenhouse, Photosynthesis, Soil, Nutrients, Hydration, Temperature, Humidity, Pests, Companion Planting, Germination, Transplanting, Yield
Soil, Composition, pH Level, Nutrients, Texture, Erosion, Sustainability, Organic Matter, Soil Horizon,Microorganisms
Soil, Crop Rotation, Pest, Beneficial Insects, Eco-Friendly, Composting, Sustainability, Organic Gardening, Soil Health, Mulching, Integrated Pest Management (IPM), Biodiversity, Planting Zone, Harvesting, Irrigation, Nitrogen Fixation, Ecosystem, Nutrient Cycling, Weed Management, Sustainable Practices

Evidence of Understanding - Common Assessments
- Greenhouse planting plan
- Group research presentation
- Participation
  - Application of sustainable practices
- Plant growth quiz
- Soil Analysis
- Eco-friendly gardening report

Teacher notes:
- Resources:
  - OpenSciEd:
- Anticipated Student Misconceptions:
  - Plants can grow anywhere.
  - More water means healthier plants
  - All plants are ready to plant and harvest at the same time.
  - Soil is just dirt, rather than a complex ecosystem.

- Fertilizers are always beneficial
- All insects are harmful

- Differentiation Strategies:
    - NGSS Appendix D - "All Standards, All Students”: Making the Next Generation Science Standards Accessible to All Students
    - Tier 1 Universal Strategies
    - Tier 2 Targeted Strategies
    - Tier 3 Intensive Strategies

- Safety Considerations:
    - *Note: Each teacher will identify the safety considerations that occur in each individual activity.*
    - *See ACS Chemical Hygiene Plan for specific safety precautions.*

- Prior Knowledge:
    -

- Interdisciplinary Connections:
    - Career Awareness
    - NGSS Connections: Earth, Chemistry & Physics connections
    - ISTE Standards: Empowered Learner, Digital Citizen, Knowledge Constructor, Innovative Designer
    - Common Core State Standards Connections:

      ELA/Literacy -
        - 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.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
        - SL.11-12.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and students canll-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

      Mathematics -
        - MP.2 Reason abstractly and quantitatively.

- MP.4 Model with mathematics.

Social Emotional Learning: CASEL 5

- Responsible Decision Making
  - Identifying Problems
  - Analyzing Situations
  - Solving Problems
  - Evaluating
  - Ethical Responsibility
- Social Awareness
  - Respect for Others
- Self Management
  - Self-Motivation
  - Goal Setting
- Relationship Skills
  - Communication
  - Teamwork