

UNIT 2

Extreme Living



How do people use technology to survive in regions with different climates?

SCALE

Stanford Center for Assessment,
Learning & Equity



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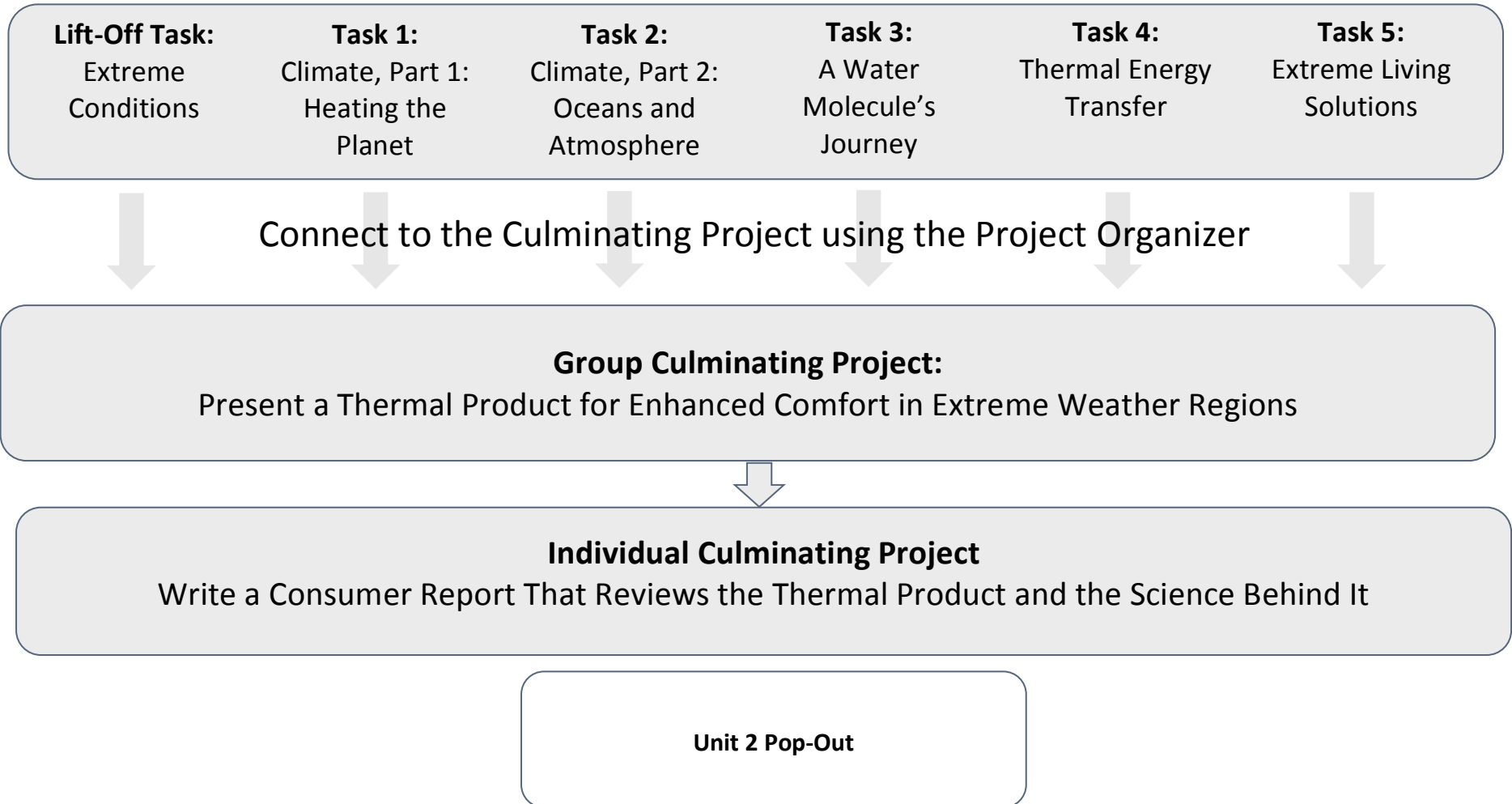
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Stanford NGSS Integrated Curriculum: An Exploration of a Multidimensional World
Unit 2: Extreme Living

Essential Question: How do people use technology to survive in regions with different climates?

Total Number of Instructional Days: 38.5



6th Grade Science Unit 2: Extreme Living

Unit Overview

Storyline for Unit 2

In some regions of the world, nature can be pretty extreme! Despite these extreme climate conditions, humans are somehow able to flourish in seemingly inhospitable regions on Earth. In this unit, students consider factors that create regions with extreme climates, and how people can use technology to survive in those regions.

In the Lift-Off Task, students analyze photos of humans living in extreme climates and begin to generate questions about this phenomenon. These questions guide students throughout the unit as they continue to make sense of extreme climates, and use scientific ideas to design products that make living in these regions possible.

In the next two tasks, students explore the causes for extreme climates like the ones introduced in the Lift-Off. To begin this exploration, students consider first the Sun because it is the key energy source behind all mechanisms that determine regional climates. In Task 1, students use physical and computer simulation models to visualize the Sun-Earth system. Through these models, they will notice that the Sun does not heat all parts of the Earth equally because of the tilt of the Earth as it orbits around the Sun. This is a major cause for the extreme climate in the regions students chose for their culminating project.

In Task 2, through the use of demonstrations and video simulations, students delve into how the unequal heating they explored in Task 1 causes patterns of atmospheric and oceanic circulation that act to redistribute the Sun's energy around the Earth, further affecting regional climate patterns. By the end of this task, students will be able to add to their explanation of their region's extreme climate from Task 1.

In Task 3, students further examine another important process that regulates climates—the water cycle. Here, students do a kinesthetic activity to simulate the journey of a water molecule, allowing them to explore the places where water is found and how it travels. In the end, students will apply their knowledge to consider how the water cycle contributes to the climate conditions in their chosen region for their culminating project.

Until now, students have thought about the context for their design problem—the causes of different climates around the world. Remaining in their task for the project is for students to design a product that makes it possible to live in a region with extreme climate. In order to design such a product, students need to understand the concept of temperature. In Task 4, students plan and conduct investigations to figure out what happens at the molecular level and what factors affect temperature change. This lays a foundation for students to envision the type of product they will design for their culminating project and the factors they should consider.

In Task 5, students use new ideas developed from their own investigations to design their products! Throughout this task, students engage with a series of guided steps to help them brainstorm, design, build, test, and revise a prototype that makes it possible to live in a region with extreme temperatures. By the end of the task, students will have a clear idea of the product they want to present as their culminating project, including an understanding of the science behind how it works, and the engineering process required to build a final product.

Once students have completed all tasks and their Project Organizer, they can begin work on their culminating project. As students have already chosen a region with an extremely hot or cold climate, their job is to design a product that makes it more comfortable for people to live in this region, and then to present their product in a format of their choice. After presenting, each student then writes a consumer report to review the science behind why the product is needed and how the product works, again in a format of their choice.

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Unit Overview**

Three-Dimensional Breakdown of the Performance Expectations

This unit was developed to align with, teach, and assess students’ understanding and skills related to these Performance Expectations. Below, we have mapped out the disciplinary core ideas, crosscutting concepts, and science and engineering practices addressed in this unit. Aspects of the dimensions that are not explicitly addressed in this unit are crossed out.

Performance Expectations	Scientific and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.</p>	<p>Asking Questions and Defining Problems</p> <ul style="list-style-type: none"> Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. 	<p>ETS1.A: Defining and Delimiting Engineering Problems</p> <ul style="list-style-type: none"> The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. 	<p>No CCC listed</p>
<p>MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.</p> <p>[Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.]</p> <p>[Assessment Boundary: Assessment does not include the</p>	<p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop and use a model to describe phenomena. 	<p>ESS2.C: The Roles of Water in Earth’s Surface Processes</p> <ul style="list-style-type: none"> Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. <p>ESS2.D: Weather and Climate</p> <ul style="list-style-type: none"> Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. The ocean exerts a major influence on weather and climate by absorbing 	<p>Systems and System Models</p> <ul style="list-style-type: none"> Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

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<p>dynamics of the Coriolis effect.]</p>		<p>energy from the sun, releasing it over time, and globally redistributing it through ocean currents.</p>	
<p>MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. [Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]</p>	<p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop a model to describe unobservable mechanisms. 	<p>ESS2.C: The Roles of Water in Earth's Surface Processes</p> <ul style="list-style-type: none"> Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. Global movements of water and its changes in form are propelled by sunlight and gravity. 	<p>Energy and Matter</p> <ul style="list-style-type: none"> Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.
<p>MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. [Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]</p>	<p>Planning and Carrying Out Investigations</p> <ul style="list-style-type: none"> Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. 	<p>PS3.A: Definitions of Energy</p> <ul style="list-style-type: none"> Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. <p>PS3.B: Conservation of Energy and Energy Transfer</p> <ul style="list-style-type: none"> The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. 	<p>Scale, Proportion, and Quantity</p> <ul style="list-style-type: none"> Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.
<p>MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal</p>	<p>Designing Solutions</p> <ul style="list-style-type: none"> Apply scientific ideas or principles to design, construct, and test a 	<p>PS3.A: Definitions of Energy</p> <ul style="list-style-type: none"> Temperature is a measure of the average kinetic energy of particles 	<p>Energy and Matter</p> <ul style="list-style-type: none"> The transfer of energy can be tracked as energy flows through

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<p>energy transfer.* [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]</p>	<p>design of an object, tool, process, or system.</p>	<p>of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.</p> <p>PS3.B: Conservation of Energy and Energy Transfer</p> <ul style="list-style-type: none"> Energy is spontaneously transferred out of hotter regions or objects and into colder ones. 	<p>a designed or natural system.</p>
<p>MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.</p>	<p>Analyzing and Interpreting Data</p> <ul style="list-style-type: none"> Analyze and interpret data to determine similarities and differences in findings. 	<p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. <p>ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. 	<p>No CCC listed</p>

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Connections to Common Core Math and ELA Standards:

Over the course of this unit, students will gain knowledge and skills in science, as well as in math and English-Language Arts. Below we list the Common Core ELA and Math standards for middle school and 6th grade that are relevant to the curriculum tasks in this unit. Within the curriculum, there are opportunities to incorporate components of the following ELA and Math Standards:

Middle School and 6th Grade Common Core ELA Standards		Unit Task
Key Ideas and Details	CCSS.ELA-Literacy.RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts.	Task 2 Task 4
	CCSS.ELA-Literacy.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.	Task 1 Task 3 Task 4 Task 5
Integration of Knowledge and Ideas	CCSS.ELA-Literacy.RST.6-8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	Task 2 Task 4
Research to Build and Present Knowledge	CCSS.ELA-Literacy.WHST.6-8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.	Lift-Off Task Task 1 Task 5 Culminating Project
	CCSS.ELA-Literacy.WHST.6-8.8: Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.	Lift-Off Task Task 1 Task 5 Culminating Project
Presentation of Knowledge and Ideas	CCSS.ELA-Literacy.SL.8.5: Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.	Task 1 Task 2 Task 5 Culminating Project

Middle School and 6th Grade Common Core Math Standards		Unit Task
Mathematical Practice	CCSS.MATH.MP.2: Reason abstractly and quantitatively.	Task 1 Task 2 Task 4 Task 5 Culminating Project
Summarize and Describe Distributions	CCSS.MATH.CONTENT.6.SP.B.5: Summarize numerical data sets in relation to their context.	Task 2 Task 4 Task 5 Culminating Project

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Connections to English Language Development (ELD) Standards:

We acknowledge that language development is a key component of disciplinary understanding and helps to support more rigorous and equitable outcomes for diverse students. This curriculum thus takes into account both the receptive and productive language demands of the culminating projects and strives to increase accessibility by including scaffolds for language development and pedagogical strategies throughout learning tasks. We aim to support language acquisition through the development of concept maps; utilizing sentence frames; implementing the Critique, Correct, Clarify technique; employing the Stronger Clearer strategy; and fostering large and small group discussions.

The California ELD Standards are comprised of two sections: the standards and a rubric. Outlined below are the standards from Section One that are met within this curriculum. For additional information, please refer to: https://www.pausd.org/sites/default/files/pdf-faqs/attachments/SS_ELD_6.pdf.

6th Grade ELD Standards		
Part I: Interacting in Meaningful Ways	A: Collaborative	1. Exchanging information and ideas with others through oral collaborative discussions on a range of social and academic topics
		2. Interacting with others in written English in various communicative forms (print, communicative technology, and multimedia)
		3. Offering and justifying options, negotiating with and persuading others in communicative exchanges
		4. Adapting language choices to various contexts (based on task, purpose, audience, and text type)
	B: Interpretive	5. Listening actively to spoken English in a range of social and academic contexts
		6. Reading closely literary and informational texts and viewing multimedia to determine how meaning is conveyed explicitly and implicitly through language
		7. Evaluating how well writers and speakers use language to support ideas and arguments with details or evidence depending on modality, text type, purpose, audience, topic, and content area
		8. Analyzing how writers and speakers use vocabulary and other language resources for specific purposes (to explain, persuade, entertain, etc.) depending on modality, text type, purpose, audience, topic, and content area
	C: Productive	9. Expressing information and ideas in formal oral presentations on academic topics
		10. Writing literary and informational texts to present, describe, and explain ideas and information, using appropriate technology
		11. Justifying own arguments and evaluating others' arguments in writing
		12. Selecting and applying varied and precise vocabulary and other language resources to effectively convey ideas
Part II: Learning About How English Works	A: Structuring Cohesive Texts	1. Understanding text structure
		2. Understanding cohesion
	B: Expanding and Enriching Ideas	3. Using verbs and verb phrases
		4. Using nouns and noun phrases
		5. Modifying to add details
	C: Connecting and Condensing Ideas	6. Connecting ideas
		7. Condensing ideas

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Connections to Environmental Awareness:

Over the course of this curriculum, students will explore content related to various environmental principles and concepts that examine the interactions and interdependence of human societies and natural systems. In accordance with the *Education and the Environment Initiative (EEI)*, tasks throughout this curriculum explore many of *California's Approved Environmental Principles and Concepts*.

While this unit does focus on how humans survive within natural systems, it does not explicitly examine the how humans impact natural systems. In later units, we will outline the EEI principles relevant to the unit in this section of the unit overview.

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Teacher Materials List

Unit Essential Question: *How do people use technology to survive in regions with different climates?*

Overall Unit – All Tasks

- Unit 2, Task Cards Student Version, Lift-Off and Tasks 1 through 5
- Culminating Project Student Task Card
- Project Organizer
- Projector with Audio (for video or images, whenever needed)

Lift-Off Task (2 days, based on 45-minute periods)

Per Student

- Task Card Student Version: Lift-Off
- Post-Its (Optional)
- Task Card Student Version: Culminating Project
- Project Organizer

Per Group

- Poster paper and markers
- Computers or Tablets (for research)

Whole Class

- Poster paper and markers
- *See Instructions in Lift-Off for other optional materials to use for the class concept map

Task 1 (4.5 days, based on 45-minute periods)

Per Student

- Task Card Student Version: Task 1
- Project Organizer

Per Group

- Flashlight, Penlight, or Other Light Source
- Styrofoam Ball (at least 4 inches in diameter)
- 2 Toothpicks or Skewers
- Rubber Band
- Computer
- Computers or Tablets (for research)

Whole Class

- Large poster that says “Weather”
- Large poster that says “Climate”

Task 2 (8 days, based on 45-minute periods)

Per Student

- Task Card Student Version: Task 2
- Project Organizer
- 3” x 5” index card
- Article: *How Do Air and Water Move Around Our Planet?*

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Teacher Materials List

Per Group

- Two large poster papers and markers
- World Map handout

Whole Class

- Projector/Speakers
- Helium-filled mylar balloon (ideally 2 balloons)
- Straw (or chopstick to partially deflate helium balloon)
- Electric heating pad (or hair dryer as alternative)

Task 3 (4 days, based on 45-minute periods)

Per Student

- Task Card Student Version: Task 3
- Project Organizer
- Dice
- Optional: 3 Post-Its

Per Group

- Poster Paper
- Markers

Whole Class

- Water Molecule Journey Station Cards (2-3 per station) – Hang as posters around the room

Task 4 (5 days, based on 45-minute periods)

Per Student

- Task Card Student Version: Task 4
- Project Organizer

Per Group (Options of Materials to Provide Student Groups)

- Heat Source
 - Bin or Tub of Hot water
 - Heating Pad
- Any materials that can melt: Butter, Gummy Bear, Chocolate, Crayons, Candle Wax, etc.
- Aluminum Foil
- Wax Paper
- Cardboard
- Tape
- Plastic Knife
- Scissors

Whole Class

- Projector and Speakers
- 2 large beakers of same size
- Hot water
- Cold water
- 2 different colors of food coloring

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Teacher Materials List

Task 5 (6 days, based on 45-minute periods)

Per Student

- Task Card Student Version: Task 5
- Project Organizer
- Post-Its (At least 3)

Per Group

- Poster Paper (2)
- Markers
- Computers or tablets for research and to re-watch Task 4 *Conduction* video
- Options of materials to build and test prototypes
 - Heat Sources
 - Heating Pads
 - Hot Water in Containers
 - Thermometers
 - Timers
 - Tape
 - Aluminum Foil
 - Newspaper
 - Cardboard
 - Plastic Bags
 - Different kinds of Cloth
 - Bubble Wrap
 - Foam
 - Any additional materials you or students may want to bring from home

Culminating Project (9 days, based on 45-minute periods)

Product Presentation

- Materials to build physical prototype (See Task 5 Materials List)
- Poster Paper
- Color pencils/markers or computer graphics
- Presentation software (e.g., PowerPoint, Prezi, etc.)

Consumer Report

- Blank Paper or Computer Program
- Color pencils/markers or computer graphics

6th Grade Science Unit 2: Extreme Living
Building on Prior Knowledge

While Unit 1 focused heavily on life science, this unit engages students in the intersection of Earth Science, Physical Science, and Engineering. In this unit, students consider what factors create regions with extreme climates and how people can use thermal technology to survive in those regions. In this culminating project, students are asked to select a region with an extreme hot or cold climate and design a device that can make living in that climate more tolerable.

The integrated model requires students to access and use a wide range of ideas from prior grades. This content knowledge spans seven different Disciplinary Core Ideas in this unit: ESS2.C: The Roles of Water in Earth’s Surface Processes, ESS2.D: Weather and Climate, PS3.A: Definitions of Energy, PS3.B: Conservation of Energy and Energy Transfer, ETS1.A: Defining and Delimiting Engineering Problems, ETS1.B: Developing Possible Solutions, and ETS1.C: Optimizing the Design Solution.

As students explore these core ideas, they build on their skills in the following science and engineering practices: Asking Questions and Defining Problems, Developing and Using Models, Planning and Carrying Out Investigations, Analyzing and Interpreting Data, and Designing Solutions. In addition to science and engineering practices, students also continue to build on their knowledge of the following crosscutting concepts: Patterns; Scale, Proportion, and Quantity; Systems and System Models; and Energy and Matter.

*This summary is based on information found in the NGSS Framework.

K-8 Progression of Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts for Unit 2

Disciplinary Core Ideas	K-2	3-5	6-8
ESS2.C The Roles of Water in Earth’s Surface Processes	Water is found in many types of places and in different forms on Earth.	Most of Earth’s water is in the ocean and much of the Earth’s freshwater is in glaciers or underground.	Water cycles among land, ocean, and atmosphere, and is propelled by sunlight and gravity. Density variations of seawater drive interconnected ocean currents.
ESS2.D Weather and Climate	Weather is the combination of sunlight, snow or rain, and temperature in a particular region and time. People record weather patterns over time.	Climate describes patterns of typical weather conditions over different scales and variations. Historical weather patterns can be analyzed.	Complex interactions determine local weather patterns and influence climate, including the role of the ocean.
PS3.A Definitions of Energy	N/A	Moving objects contain energy. The faster the object moves, the more energy it has. Energy can be converted from one form to another form.	Energy changes to and from each type and can be tracked through physical or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter.
PS3.B Conservation of Energy and Energy Transfer	Content found in PS3.D (Sunlight warms the Earth’s surface).		
ETS1.A Defining and Delimiting Engineering Problems	A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. Asking questions, making	Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for	The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that

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	observations, and gathering information are helpful in thinking about problems. Before beginning to design a solution, it is important to clearly understand the problem.	solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	are likely to limit possible solutions.
ETS1.B Developing Possible Solutions	Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people.	Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.	A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Models of all kinds are important for testing solutions.
ETS1.C Optimizing the Design Solution	Because there is always more than one possible solution to a problem, it is useful to compare and test designs.	Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.

Science and Engineering Practices	K-2	3-5	6-8
Asking Questions and Defining Problems*	Asking questions and defining problems in K-2 builds on prior experiences and progresses to simple descriptive questions that can be tested.	Asking questions and defining problems in 3-5 builds on prior experiences and progresses to specifying qualitative relationships. <ul style="list-style-type: none"> • Use prior knowledge to 	Asking questions and defining problems in 6-8 builds on prior experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

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	<ul style="list-style-type: none"> Define a simple problem that can be solved through the development of a new or improved object or tool. 	<p>describe problems that can be solved.</p> <ul style="list-style-type: none"> Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. 	<ul style="list-style-type: none"> Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
Developing and Using Models*	<p>Modeling in K-2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.</p> <ul style="list-style-type: none"> Develop and/or use a model to represent amounts, relationships, relative scales (bigger/smaller), and/or patterns in the natural and designed world(s). 	<p>Modeling in 3-5 builds on prior experiences and progresses to building and revising simple models and using models to represent events and design solutions.</p> <ul style="list-style-type: none"> Develop and/or use models to describe and/or predict phenomena. Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. 	<p>Modeling in 6-8 builds on prior experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.</p> <ul style="list-style-type: none"> Develop and use a model to describe phenomena. Develop and use a model to describe unobservable mechanisms.
Planning and Carrying Out Investigations*	<p>Planning and carrying out investigations in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.</p> <ul style="list-style-type: none"> Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. 	<p>Planning and carrying out investigations in 3-5 builds on prior experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.</p> <ul style="list-style-type: none"> Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. 	<p>Planning and carrying out investigations in 6-8 builds on prior experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.</p> <ul style="list-style-type: none"> Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.
Analyzing and Interpreting Data*	<p>Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations.</p>	<p>Analyzing data in 3-5 builds on prior experiences and progresses to introducing quantitative approaches to collecting data and conducting</p>	<p>Analyzing data in 6-8 builds on prior experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic</p>

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Building on Prior Knowledge

	<ul style="list-style-type: none"> Compare predictions (based on prior experiences) to what occurred (observable events). 	<p>multiple trials of qualitative observations. When possible and feasible, digital tools should be used.</p> <ul style="list-style-type: none"> Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings. 	<p>statistical techniques of data and error analysis.</p> <ul style="list-style-type: none"> Analyze and interpret data to determine similarities and differences in findings.*
Designing Solutions*	<p>Designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in designing solutions.</p> <ul style="list-style-type: none"> Generate and/or compare multiple solutions to a problem. 	<p>Designing solutions in 3-5 builds on prior experiences and progresses to the use of evidence in designing multiple solutions to design problems.</p> <ul style="list-style-type: none"> Apply scientific ideas to solve design problems. 	<p>Designing solutions in 6-8 builds on prior experiences and progresses to include designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.</p> <ul style="list-style-type: none"> Apply scientific ideas or principles to design an object, tool, process or system.

*These SEPs are summatively assessed using the Culminating Project or a Task-Specific Rubric.

Crosscutting Concepts	K-2	3-5	6-8
Patterns*	<p>Students recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.</p> <ul style="list-style-type: none"> Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. 	<p>Students identify similarities and differences in order to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and to use these patterns to make predictions.</p> <ul style="list-style-type: none"> Patterns of change can be used to make predictions. Patterns can be used as evidence to support an explanation. 	<p>Students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data.</p> <ul style="list-style-type: none"> Patterns can be used to identify cause-and-effect relationships.
Scale, Proportion, and Quantity*	<p>Students use relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects. They use standard units to measure length.</p> <ul style="list-style-type: none"> Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). 	<p>Students recognize natural objects and observable phenomena exist from the very small to the immensely large. They use standard units to measure and describe physical quantities such as weight, time, temperature, and volume.</p> <ul style="list-style-type: none"> Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. 	<p>Students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes. They</p>

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			<p>represent scientific relationships through the use of algebraic expressions and equations.</p> <ul style="list-style-type: none"> Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.
<p>Systems and System Models*</p>	<p>Students understand objects and organisms can be described in terms of their parts; and systems in the natural and designed world have parts that work together.</p> <ul style="list-style-type: none"> Systems in the natural and designed world have parts that work together. 	<p>Students understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions.</p> <ul style="list-style-type: none"> A system can be described in terms of its components and their interactions. 	<p>Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.</p> <ul style="list-style-type: none"> Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.
<p>Energy and Matter*</p>	<p>Students observe objects may break into smaller pieces, be put together into larger pieces, or change shapes.</p> <ul style="list-style-type: none"> Objects may break into smaller pieces, be put together into larger pieces, or change shapes. 	<p>Students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change.</p> <ul style="list-style-type: none"> Matter is transported into, out of, and within systems. Energy can be transferred in various ways and between objects. 	<p>Students learn matter is conserved because atoms are conserved in physical and chemical processes. They also learn that within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.</p> <ul style="list-style-type: none"> Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.

*These CCCs are summatively assessed using the Culminating Project or a Task-Specific Rubric.

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Progression of Knowledge from Kindergarten – 8th grade

ESS2.C. The Role of Water in Earth’s Surface Processes: In Kindergarten through second grade, students begin to gather information about where water can be found on Earth, whether it be in solid or liquid form. In fifth grade, students analyze more specific data about the reservoirs that they identified in K-2 and make the distinction between freshwater and saltwater. By graphing the amount of water in oceans, lakes, rivers, glaciers, groundwater, and polar ice caps, they are able to realize that nearly all of Earth’s water is in the ocean and most freshwater is in glaciers or underground, not rivers and lakes. While these Performance Expectations lay the foundation by showing students where water is located on Earth, the middle school Performance Expectations take a great leap in this DCI. In this unit, students move towards examining how water cycles amongst Earth systems, what causes water to cycle, and how the movement of water results in weather patterns and ocean currents. In seventh and eighth grade, students continue to explore this DCI as they examine how water causes weathering and erosion that change land’s features. Because of the vast number of Performance Expectations, students engage in a wide variety of Science and Engineering Practices and Crosscutting Concepts.

The following is the progression of the Performance Expectations for this DCI:

- 2-ESS2-3** Obtain information to identify where water is found on Earth and that it can be solid or liquid.
- 5-ESS2-2** Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.
- MS-ESS2-2** Construct an explanation based on evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales.
- MS-ESS2-4** Develop a model to describe the cycling of water through Earth’s systems driven by energy from the sun and the force of gravity.
- MS-ESS2-5** Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
- MS-ESS2-6** Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

ESS2.D. Weather and Climate: Students do not engage with this DCI until the third grade. In third grade, students begin to distinguish between weather and climate by using data to describe weather patterns for one PE and gathering information to describe climate conditions for another PE. Because of the nature of this content, students are focusing on the CCC of Patterns at this level. This sets the stage for them to explore the actual mechanisms behind weather and climate at the middle school level. In this unit, students use models to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine climates. In the next unit, students will build on this knowledge to move away from climate and consider how interactions of air masses result in specific weather conditions. Because the middle school PEs deal more with the causes of weather and climate, students emphasize the CCCs of Systems and System Models and Cause and Effect at this grade band.

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The following is the progression of the Performance Expectations for this DCI:

- 3-ESS2-1** Represent data in tables and graphical displays to describe typical weather conditions for a particular season.
- 3-ESS2-2** Obtain and combine information to describe climates in different regions of the world.
- MS-ESS2-5** Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
- MS-ESS2-6** Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

PS3.A. Definitions of Energy: Students do not engage with this DCI until the fourth grade. In third through fifth grade, students begin to connect motion with energy, asking questions like: What is energy and how is it related to motion? How is energy transferred? Because energy is a difficult concept for students to conceptualize at this age, these performance expectations deal mostly with experiential knowledge. By the end of this grade band, students will understand that the faster a given object is moving, the more energy it possesses, and if it collides with another object, it can transfer some of that energy in motion. While these contexts are very different from those in this unit, this prior knowledge helps students begin to associate kinetic energy with motion and energy transfer with heat—two core concepts for this unit. In this unit, students investigate how temperature is a measure of the average kinetic energy particles of matter and this depends on the types, states, and amounts of matter present. They then use this knowledge to design a device that maximizes or minimizes thermal energy transfer. In later middle school units, students will return to other more tangible concepts of energy and motion through other PEs (not shown below). Because of the variety in contexts around energy, students engage in a wide variety of Science and Engineering Practices and Crosscutting Concepts for this DCI.

The following is the progression of the Performance Expectations for this DCI:

- 4-PS3-1** Use evidence to construct an explanation relating the speed of an object to the energy of that object.
- 4-PS3-2** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
- 4-PS3-3** Ask questions and predict outcomes about the changes in energy that occur when objects collide.
- MS-PS3-3** Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*
- MS-PS3-4** Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample

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PS3.B. Conservation of Energy and Energy Transfer: In Kindergarten through second grade, students are first introduced to the idea of energy transfer by making observations of how sunlight warms the Earth’s surface and designing a device that can minimize this energy transfer. In third – fifth grade, students broaden their definition of energy from light and heat to include other indicators of energy (e.g., motion, sound, or electrical energy). As they investigate these types of energy, they also conceptualize how energy can be transferred between objects, resulting in different types of observable evidence. For example, when moving objects collide, energy is transferred to the surrounding air, producing heat and sound. This set the foundation for Unit 1, in which students used their knowledge of observable forms of energy to consider how energy transfers between objects are also associated with changes in kinetic energy. In this unit, students still explore energy transfer, but specifically focus on thermal energy transfer. While there is a clear focus on the CCC of Energy and Matter in this DCI, students also build their understanding of Cause and Effect and Scale, Proportion, and Quantity at different grade levels. Throughout all grade bands, there is a focus on the SEPs of Asking Questions, Planning and Carrying Out Investigations, and Designing Solutions.

The following is the progression of the Performance Expectations for this DCI:

- K-PS3-1** Make observations to determine the effect of sunlight on Earth’s surface.
- K-PS3-2** Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.
- 4-PS3-2** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents.
- 4-PS3-3** Ask questions and predict outcomes about the changes in energy that occur when objects collide.
- 4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
- MS-PS3-3** Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
- MS-PS3-4** Plan an investigation to determine the relationships among the energy transferred and the change in the average kinetic energy of the particles as measured by the temperature of the sample.
- MS-PS3-5** Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

ETS1.A. Defining and Delimiting Engineering Problems: In Kindergarten through second grade, students first begin to approach situations as problems to be solved through engineering. They learn to ask questions and gather information to clearly understand a problem. In third through fifth grade, students build on understanding the problem to also identifying criteria and constraints surrounding the problem. In this sixth grade unit, students take this process a step further by defining criteria and constraints more precisely, including consideration of scientific principles and other relevant knowledge. In Kindergarten to second grade, students focus on the science and engineering practice of Asking Questions in order to help them with the practice of Defining Problems, which continues to be the main focus in subsequent grades.

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The following is the progression of the Performance Expectations for this DCI:

- K-2-ETS1-1** Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
- 3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- MS-ETS1-1** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

ETS1.B. Developing Possible Solutions: In Kindergarten through second grade, students begin communicating multiple designs in the form of diagrams and sketches. By third to fifth grade, students move from mere drawings to actually testing out their designs to see how they perform under different conditions. Students then use this data to make improvements. As in Kindergarten through second grade, students practice the idea that communication of designs with peers is an essential part of the design process. In this sixth grade unit, students move towards using data from testing solutions to inform improvements, focusing on the idea that parts of different solutions can be used to make an even better solution. In later units and grade levels, students will focus on another PE associated with this DCI (not shown below), which asks students to use systematic processes to evaluate solutions for how well they meet criteria and constraints. At the different grade levels, students engage in a variety of different science and engineering practices: Developing Models in K-2, Designing Solutions (specifically comparing solutions) in 3-5, and Analyzing and Interpreting Data and Engaging in Argument From Evidence in 6-8. This is representative of the different practices students are engaging with, described above.

The following is the progression of the Performance Expectations for this DCI:

- K-2-ETS1-2** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- 3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- MS-ETS1-3** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

ETS1.C. Optimizing the Design Solution: In Kindergarten through second grade, students begin to understand that because there are always multiple solutions to a problem, it is useful to compare and test designs. Students in third through fifth grade take this skill and use findings from those tests to determine which solution best meets criteria and constraints that they identified through ETS1.A. In accordance with the progression students follow in middle school for ETS1.B, students in this eighth grade unit move towards using data and analysis to identify best characteristics and inform a new and better solution. Thus, it makes sense that at all grade levels, students focus on Science and Engineering Practices related to testing and analyzing: Planning and Carrying Out Investigations and Analyzing and

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Interpreting Data. At the eighth grade level, students will take these skills further to develop models that will generate data to test ideas about designed systems (PE not shown below).

The following is the progression of the Performance Expectations for this DCI:

- K-2-ETS1-3** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.
- 3-5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- MS-ETS1-3** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

**6th Grade Science Unit 2: Extreme Living
Culminating Project**

Unit Essential Question: *How do people use technology to survive in regions with different climates?*

Introduction

In the Lift-Off Task, students observed pictures of places that seem inhospitable! How are people able to live in regions with freezing temperatures or scorching heat? In this project, the students’ task is to help make it possible for people to live in these places. As a group, students select a region with an extremely hot or extremely cold climate. After exploring the causes of such an extreme climate, each group will design a product that makes it more comfortable for people to live in this region, and present it in the format of their choice. These could be a variety of products, from clothing to buildings to heating/cooling devices. After presenting their products, each student will then write a consumer report to review the science behind why the product is needed and how the product works. This can also be in the format of their choice (e.g., written report, flyer, video, blog, etc.)

3-Dimensional Assessment

PS3.A: Definitions of Energy

- Temperature is a measure of the average kinetic energy of particles of matter, which depends on the types, states, and amounts of matter present.

PS3.B: Conservation of Energy and Energy Transfer

- The amount of energy transfer needed to change the temperature of a sample depends on the nature of the matter, the size of the sample, and the environment.
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

ESS2.C: The Roles of Water in Earth’s Surface Processes

- Propelled by sunlight and gravity, water cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation, crystallization, precipitation, and downhill flows.

ESS2.D: Weather and Climate

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. The ocean absorbs energy from the sun, leading to variations in density that drive a pattern of ocean currents.

ETS1.A: Defining and Delimiting Engineering Problems

- The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful.

ETS1.B: Developing Possible Solutions

- During the process of evaluating solutions, sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.

ETS1.C: Optimizing the Design Solution

- Identifying the characteristics of the design that performed the best in tests provides useful information for the redesign process—some characteristics may be incorporated into the new design.

Science and Engineering Practices

Disciplinary Core Ideas

Crosscutting Concepts

Asking Questions and Defining Problems

- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.

Developing and Using Models

- Develop and use a model to describe phenomena.
- Develop a model to describe unobservable mechanisms.

Analyzing and Interpreting Data

- Analyze and interpret data to determine similarities and differences in findings.

Designing Solutions

- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system.

Patterns

- Patterns can be used to identify cause-and-effect relationships.

Scale, Proportion, and Quantity

- Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

Systems and System Models

- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

Energy and Matter

- Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.
- The transfer of energy can be tracked as energy flows through a designed or natural system.

*To maintain the authenticity of the Culminating Project, the SEP of MS-PS3-4 (Planning and Carrying Out Investigations) is instead assessed in Task 4.

Time Needed (Based on 45-Minute Periods)

9 days at end of unit

- Group Project: 4 periods (includes 1 presentation day)
- Individual Project: 5 periods
 - First draft: 3 periods
 - Feedback: 1 period
 - Revision: 1 period

6th Grade Science Unit 2: Extreme Living

Culminating Project

Materials

Product Presentation

- Materials to build physical prototype (See Task 5 Materials List)
- Poster Paper
- Color pencils/markers or computer graphics
- Presentation software (e.g., PowerPoint, Prezi, etc.)

Consumer Report

- Blank Paper or Computer Program
- Color pencils/markers or computer graphics

Instructions for the Culminating Project

1. Introduce the Culminating Project at the end of the Lift-Off task, including both group and individual components outlined in the Challenge.
2. Read over the Culminating Project Task Card with the students. We recommend only reading the Challenge and Group Project Criteria for Success at this time in order to not overwhelm students with information.
 - Review some potential formats for their group presentation (poster presentation, Powerpoint, Prezi, physical demonstration of product, etc.)
 - Take questions for clarification.
 - Optional: As a class, brainstorm a list of some possible products that might make living in extreme conditions more comfortable. The purpose of this exercise is to emphasize that there is a large range of products (e.g., clothing items, types of homes, heating/cooling devices, etc.)
3. Remind students as they complete the Project Organizer that they will be planning pieces of their presentation and recording scientific concepts they will likely use for their individual project. However, there is nothing wrong with students going back and changing their ideas over the course of the unit. The students won't fully design their presentation until the end of the unit, so changes made during the imaginative and creative time is acceptable and to be expected.
4. Make sure the students fill out the Project Organizer after each task as this will help them think about parts of their presentation along the way. This process allows students to both apply and document relevant scientific concepts as they progress through the unit. This will inform both their group and individual projects.
 - We recommend that students complete the Project Organizer individually, with the exception of choosing a region after the Lift-Off Task as a group. They might discuss ideas first as a group, but should then respond individually. It is important to allow students time to process concepts on their own and generate their own ideas, which can be used later when it comes to developing their group project.
5. The table below summarizes how the Project Organizer guides the students through developing different components of their product presentation (group product) and consumer report (individual product).

**6th Grade Science Unit 2: Extreme Living
Culminating Project**



Task	Project Organizer	Group and Individual Culminating Project
<p>Lift Off Extreme Conditions</p>	<ul style="list-style-type: none"> Choose a region as a group. Define the problem, identify the criteria for a successful solution, and identify the constraints of solving this problem. 	<ul style="list-style-type: none"> Group: A description of why it is difficult to live in this region Individual: A definition of the problem the product addresses, including criteria and constraints
<p>Task 1 Climate, Part 1 – Heating the Earth</p>	<ul style="list-style-type: none"> Research the region you selected. <ul style="list-style-type: none"> Where is it located on Earth? How can its location explain the typical temperature in a region? Draw a Sun-Earth model to show and explain a major cause of your region’s climate. 	<ul style="list-style-type: none"> Group: A description of the region’s climate and causes of this climate Individual: A detailed description of the region’s climate, including models that show how unequal heating and rotation of Earth play a role
<p>Task 2 Climate, Part 2 – Oceans and Atmosphere</p>	<ul style="list-style-type: none"> Construct a model to explain how atmospheric and oceanic circulation affect the climate in your region. 	<ul style="list-style-type: none"> Group: A description of the region’s climate and causes of this climate Individual: A detailed description of the region’s climate, including models that show how patterns of atmospheric and oceanic circulation play a role
<p>Task 3 A Water Molecule’s Journey</p>	<ul style="list-style-type: none"> What are some ways that water is a part of your region’s climate? Using words or a model, describe the processes that create the water conditions in your region. 	<ul style="list-style-type: none"> Group: A description of the region’s climate and causes of this climate Individual: A detailed description of the region’s climate, including models that show how the water cycle plays a role
<p>Task 4 Thermal Energy Transfer</p>	<ul style="list-style-type: none"> Will your product need to help people stay warm or cool down? Would this require increasing or decreasing the kinetic energy of the particles? Explain. Based on your explorations, how might you be able to make this possible? What factors should your product consider? 	<ul style="list-style-type: none"> Group: An explanation of how the device works, including descriptions of temperature, thermal energy transfer, and kinetic energy of particles Individual: A description of the original prototype, including the proportional relationships from Task 4 investigations that inspired the design
<p>Task 5 Extreme Living Solutions</p>	<ul style="list-style-type: none"> Draw a labeled diagram of your final product. Show how thermal energy transfer is either minimized or maximized. Explain how it works. Describe how you combined best characteristics from different designs to create a product that best meets your criteria and constraints. Cite the data that supported your decisions. 	<ul style="list-style-type: none"> Group: An explanation of how the device works, including descriptions of temperature, thermal energy transfer, and kinetic energy of particles Individual: A labeled diagram of the product that uses a model and written description to explain how it works to minimize or maximize thermal energy transfer

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Culminating Project

6. After all the learning tasks and the Project Organizer are completed, students can start to design their product presentation in the format of their choice. The Project Organizers and Group Project Criteria for Success should be used as reference to remind students to include all the components of their presentation.
 - As always, we recommend the use of group roles for Culminating Project work time (See “How to Use This Curriculum” for details). We recommend changing the roles every work day.
 - Below is a list of some possible products students may design, but keep in mind that it is likely students will come up with a variety of other ideas:
 - i. For extreme cold: houses with double-paned windows, concrete walls inside of houses with large windows to absorb and retain heat from the sun, building insulation in walls, insulated gloves, hot water bottles, quilts or clothing with pattern of insulation pockets, thick curtains, thermos, radiator foil, solar ovens, etc.
 - ii. For extreme heat: houses with double-paned windows, wind towers, white washed houses, cooling domes, water trenches beneath huts for evaporative cooling, small windows, dugouts, reflective clothing, loose-fitting clothing, water-wicking clothing, ice chest, insulated cups, etc.
7. Once student groups have presented their products (either through class-wide presentations or a gallery walk), students are ready to begin their individual project. Each student will create a consumer report that explains the science behind why their product is needed and how the product works. This can be in the format of their choice (e.g., written report, flyer, video, blog, etc.) but must meet all the criteria in the student handout. Because of the variety in format options, no template is provided for this individual project.
8. Conduct a peer review of the consumer reports after students have completed a first draft.
 - Copy the Consumer Report Peer Review Feedback form found in the Student Instructions. Another option is to use the Student 3-Dimensional Individual Project Rubric.
 - Assign each student a partner, preferably a partner from a different group.
 - Students switch drafts and assess them using the peer review feedback form.
 - Remind each student to give one positive comment and one constructive comment for each section on the checklist.
 - Allow students time to present their feedback to their partner, so their partner may ask clarifying questions if needed.
9. After receiving feedback, allow students time to complete a final draft based on the feedback they received.

Assessment

The Project Organizer can be formatively assessed using:

- *Criteria of your choice*. We recommend using the 3-Dimensional Assessment matrix from the Unit Overview to inform your criteria.

The Group Culminating Project will be summatively assessed using:

- The *Group Project Criteria for Success* Checklist

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Culminating Project

The Individual Culminating Project will be summatively assessed using:

- The *3-Dimensional Individual Project Rubric*.
- Keep in mind that the Proficient level indicates that the student has successfully demonstrated understanding of the criteria. Because we are in the early stages of NGSS adoption, it may take multiple opportunities throughout the course of the year for students to reach Proficient.
- If you wish to give students a numeric score, you could take the average score of all of their rubrics or add up rubric scores to give students a summation out of the total. Because of the note above, this scoring may not correlate to traditional grading systems.
- While we recommend scoring all of the project criteria with the rubrics for each student, we understand the burden of that level of scoring.
 - One option is to select the rubrics that you wish to focus on for this project and use those to assess each student's individual project.
 - Another option is to review the Proficient level of each of the project's rubrics and use the descriptions to generally analyze all student work for trends.

**6th Grade Science Unit 2: Extreme Living
Project Organizer**

Unit Essential Question: *How do people use technology to survive in regions with different climates?*

You will be designing a product that makes it more comfortable for people to live in a region with an extreme climate. After each task, you will return to the table below to organize what you learn as you go through the unit. By the end of the five tasks, you will have all this information to use for your culminating project. For each activity, be sure to include answers to **ALL** the questions provided.

<p>Lift-Off Task: Extreme Conditions</p>	<p>Research a few different regions with an extreme climate (too hot or too cold). <u>As a group</u>, choose one of these regions to focus on for your culminating project and describe the extreme climate there. Then <u>individually</u>,</p> <ul style="list-style-type: none"> <input type="checkbox"/> Define the problem: Why is it difficult to live in this region? <input type="checkbox"/> Identify the criteria for a successful solution: How will you know your product has solved the problem? <input type="checkbox"/> Identify the constraints of solving this problem: What might make it hard to solve this problem?
<p>Task 1: Climate, Part 1 – Heating the Earth</p>	<p>Research the region you selected.</p> <ul style="list-style-type: none"> <input type="checkbox"/> Where is it located on Earth? <input type="checkbox"/> How can its location on Earth explain the typical temperature in the region? <input type="checkbox"/> Draw a Sun-Earth model to show and explain a major cause of your region’s climate.

**6th Grade Science Unit 2: Extreme Living
Project Organizer**



<p>Task 2: Climate, Part 2 – Oceans and Atmosphere</p>	<p>For the region you selected:</p> <ul style="list-style-type: none"><input type="checkbox"/> Construct a model to explain how atmospheric and oceanic circulation affect the climate in your region.

**6th Grade Science Unit 2: Extreme Living
Project Organizer**

<p>Task 3: A Water Molecule's Journey</p>	<p>Think about the region you selected.</p> <ul style="list-style-type: none"> <input type="checkbox"/> What are some ways that water is a part of your region's climate? <input type="checkbox"/> Using words or a model, describe the processes that create the water conditions in your region.
<p>Task 4: Thermal Energy Transfer</p>	<p>Think about the climate in the region you selected.</p> <ul style="list-style-type: none"> <input type="checkbox"/> Will your product need to help people stay warm or cool down? <input type="checkbox"/> Would this require increasing the kinetic energy of the particles or decreasing the kinetic energy of the particles? Explain. <input type="checkbox"/> Based on your explorations, how might you be able to make this possible? What factors should your product consider?

**6th Grade Science Unit 2: Extreme Living
3-Dimensional Individual Project Rubric**

Overview: The following rubrics can be used to assess the individual project: a Consumer Report for a Thermal Product. Each rubric is aligned to one section of the *Individual Project Criteria for Success*, located on the Culminating Project Student Instructions. *If student provides no assessable evidence (e.g., “I don’t know” or leaves answer blank), then that student response cannot be evaluated using the rubric and should be scored as a zero.

Below we provide an alignment table that details the dimensions assessed for each criterion.

	Student Criteria for Success	Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
1	<input type="checkbox"/> A definition of the problem the product addresses: <ul style="list-style-type: none"> ○ Where is the region and why is it difficult to live there? ○ What criteria would make a successful solution to this problem? ○ What makes it difficult to solve this problem? 	Asking Questions and Defining Problems <ul style="list-style-type: none"> ● Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. 	ETS1.A: Defining and Delimiting Engineering Problems <ul style="list-style-type: none"> ● The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. 	N/A
2	<input type="checkbox"/> A detailed description of the climate in that region, including model(s) that show: <ul style="list-style-type: none"> ○ Why the location of the region on Earth results in its extreme temperature 	Developing and Using Models <ul style="list-style-type: none"> ● Develop and use a model to describe phenomena. 	ESS2.D: Weather and Climate <ul style="list-style-type: none"> ● Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography. 	N/A
3	<input type="checkbox"/> A detailed description of the climate in that region, including model(s) that show: <ul style="list-style-type: none"> ○ How atmospheric and oceanic circulation affect the climate in your region 	N/A	ESS2.C: The Roles of Water in Earth’s Surface Processes <ul style="list-style-type: none"> ● Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. ESS2.D: Weather and Climate <ul style="list-style-type: none"> ● Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local 	Systems and System Models <ul style="list-style-type: none"> ● Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

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			<p>and regional geography, all of which can affect oceanic and atmospheric flow patterns.</p> <ul style="list-style-type: none"> The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. 	
4	<input type="checkbox"/> A detailed description of the climate in that region, including model(s) that show: <ul style="list-style-type: none"> The processes that create the water conditions in your region 	<p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop and use a model to describe unobservable mechanisms. 	<p>ESS2.C: The Roles of Water in Earth’s Surface Processes</p> <ul style="list-style-type: none"> Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. Global movements of water and its changes in form are propelled by sunlight and gravity. 	<p>Energy and Matter</p> <ul style="list-style-type: none"> Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.
5	<ul style="list-style-type: none"> *For at least one of the above bullets, cite patterns in data that allowed you to figure out these cause-and-effect relationships 	N/A	<p>ESS2.C: The Roles of Water in Earth’s Surface Processes</p> <ul style="list-style-type: none"> See above 3 rows <p>OR</p> <p>ESS2.D: Weather and Climate</p> <ul style="list-style-type: none"> See above 3 rows 	<p>Patterns</p> <ul style="list-style-type: none"> Patterns can be used to identify cause-and-effect relationships.
6	<ul style="list-style-type: none"> Describe your original design: What proportional relationships from the Task 4 investigations inspired the original design of your product? 	<p>N/A</p> <p>*Assessed with a Task-Specific Rubric in Task 4</p>	<p>PS3.A: Definitions of Energy</p> <ul style="list-style-type: none"> Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. <p>PS3.B: Conservation of Energy and Energy Transfer</p> <ul style="list-style-type: none"> The amount of energy transfer needed to change the temperature of a matter 	<p>Scale, Proportion, and Quantity</p> <ul style="list-style-type: none"> Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

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			sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.	
7	<ul style="list-style-type: none"> ○ What data from various tests led you to make improvements for your final design? 	<p>Analyzing and Interpreting Data</p> <ul style="list-style-type: none"> ● Analyze and interpret data to determine similarities and differences in findings. 	<p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> ● There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. ● Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. <p>ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> ● Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. 	N/A
8	<ul style="list-style-type: none"> ☐ A labeled diagram of your product that explains how it works, including: <ul style="list-style-type: none"> ○ A description of how your product helps individuals stay warm or stay cool ○ A model that shows how your product affects energy transfer and the kinetic energy of particles 	<p>Designing Solutions</p> <ul style="list-style-type: none"> ● Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system. 	<p>PS3.A: Definitions of Energy</p> <ul style="list-style-type: none"> ● Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. <p>PS3.B: Conservation of Energy and Energy Transfer</p> <ul style="list-style-type: none"> ● Energy is spontaneously transferred out of hotter regions or objects and into colder ones. 	<p>Energy and Matter</p> <ul style="list-style-type: none"> ● The transfer of energy can be tracked as energy flows through a designed or natural system.

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Rubric 1: Student defines the problem of living in a region with extreme temperatures, including criteria of success and constraints that might limit possible solutions.

- Dimensions Assessed: SEP – Asking Questions and Defining Problems, DCI – ETS1.A: Defining and Delimiting Engineering Problems

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
<p>Student does not define the problem of living in a region with extreme temperatures and/or includes inaccurate or irrelevant criteria of success and constraints that might limit possible solutions.</p>	<p>Student accurately defines the problem of living in a region with extreme temperatures, including accurate criteria of success OR constraints that might limit possible solutions.</p>	<p>Student accurately defines the problem of living in a region with extreme temperatures, including accurate criteria of success but partial constraints that might limit possible solutions.</p>	<p>Student accurately defines the problem of living in a region with extreme temperatures, including accurate and complete criteria of success and constraints that might limit possible solutions.</p>
<p>Look Fors:</p> <ul style="list-style-type: none"> • Student leaves out a definition of the problem. • And/or the student identifies criteria of success and constraints that are inaccurate or irrelevant. For example, they might identify a criterion of success that aligns with the opposite conditions (ie. keeping someone cool in extreme cold) or an unrealistic constraint as the ability to manipulate weather. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student accurately explains that living in regions of extreme temperature poses problems for human bodies’ survival and objects they need (ex: food). • Student accurately defines the criteria for success OR at least one constraint. See <i>Advanced Look-Fors</i> for options. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student accurately explains that living in regions of extreme temperature poses problems for human bodies’ survival and objects they need (ex: food). • Student accurately defines the criteria for success. For example, student explains that keeping someone/something warm or cool would indicate a successful solution. • Student also accurately defines one, but not multiple constraints. See <i>Advanced Look-Fors</i> for options. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student accurately explains that living in regions of extreme temperature poses problems for human bodies’ survival and objects they need (ex: food). • Student accurately defines the criteria for success. For example, student explains that keeping someone/something warm or cool would indicate a successful solution. • Student also accurately and completely defines any constraints. For example, safety considerations, limited amount of resources available, cost, etc.

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Rubric 2: Student develops and uses a model to describe how the unequal heating of Earth’s surface leads to variations in climates around the world.

- Dimensions Assessed: SEP – Developing and Using Models, DCI – ESS2.D: Weather and Climate

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
<p>Student develops and uses a model to inaccurately describe how the unequal heating of Earth’s surface leads to variations in climates around the world.</p> <p>OR</p> <p>Student partially describes how the unequal heating of Earth’s surface leads to variations in climates around the world but does not use a visual model.</p>	<p>Student develops and uses a model to incompletely describe how the unequal heating of Earth’s surface leads to variations in climates around the world.</p> <p>OR</p> <p>Student completely describes how the unequal heating of Earth’s surface leads to variations in climates around the world but does not use a visual model.</p>	<p>Student develops and uses a model to mostly describe how the unequal heating of Earth’s surface leads to variations in climates around the world.</p>	<p>Student develops and uses a model to completely describe how the unequal heating of Earth’s surface leads to variations in climates around the world.</p>
<p>Look Fors:</p> <ul style="list-style-type: none"> • Student draws a model that inaccurately describes this concept. For example, student shows that different areas of the Earth are farther away from the Sun at different points in its orbit, which causes different climates. <p>OR</p> <ul style="list-style-type: none"> • Student partially describes this concept in words (See <i>Developing and Proficient Look-Fors</i>) but does not create a visual model. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student draws a model that incompletely describes this concept, using pictures, arrows, and captions. • For example, student shows the Earth at a tilt and the Sun OR with arrows and captions, shows that the Sun’s rays hit an un-tilted Earth at different angles. However, student model has major errors, is missing some of the components/interactions in the <i>Advanced Look-Fors</i>, and/or does not include relevant examples. <p>OR</p> <ul style="list-style-type: none"> • Student completely describes this concept in words (See <i>Advanced Look-Fors</i>) but does not create a visual model. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student draws a model that partially describes this concept, using pictures, arrows, and captions. • For example, student may show the Earth at a tilt and the Sun. With arrows and captions, student shows that the tilt of the Earth causes the Sun’s rays to hit Earth at different angles. Student explains that this leads to some regions with more intense sunlight and warmer climates at certain times of year. However, student model may have minor errors, is missing one of the above components/interactions, or does not include relevant examples. See <i>Advanced Look-Fors</i> for relevant examples. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student draws a model that completely describes this concept, using pictures, arrows, and captions. • For example, student shows the Earth at a tilt and the Sun. With arrows and captions, student shows that the tilt of the Earth causes the Sun’s rays to hit Earth at different angles. Student explains that this leads to some regions with more intense sunlight and warmer climates at that time of year. For example, the equator always gets the most direct sunlight resulting in warmer climates, whereas the Poles get the least direct sunlight resulting in colder climates. In December, the southern hemisphere gets more direct sunlight than the northern hemisphere. This results in different seasons.

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Rubric 3: Student develops a model to explain how patterns of atmospheric and oceanic circulation determine their region’s climate.

- Dimensions Assessed: SEP – Developing and Using Models, DCI – ESS2.C: The Roles of Water in Earth’s Surface Processes and ESS2.D: Weather and Climate, CCC – Systems and System Models

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
<p>Student develops a model to inaccurately explain how patterns of atmospheric and oceanic circulation determine their region’s climate.</p> <p>OR</p> <p>Student does not develop a visual model to explain how patterns of atmospheric and oceanic circulation determine their region’s climate.</p>	<p>Student develops a model to incompletely explain how patterns of atmospheric and oceanic circulation determine their region’s climate.</p> <p>OR</p> <p>Student develops a model to completely explain how patterns of atmospheric and oceanic circulation determine climates, but it is not specific to their region.</p>	<p>Student develops a model to mostly explain how patterns of atmospheric and oceanic circulation determine their region’s climate.</p>	<p>Student develops a model to completely explain how patterns of atmospheric and oceanic circulation determine their region’s climate.</p>
<p>Look Fors:</p> <ul style="list-style-type: none"> • Student draws a model that inaccurately explains these patterns specific to their region, using pictures, arrows, and captions. For example, student model only shows that ocean circulation is driven by wind, but does not include any description of where this wind comes from. <p>OR</p> <ul style="list-style-type: none"> • Student explains these patterns specific to their region with at least partial accuracy, but no visual model is present (ie. no pictures or arrows). 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student draws a model that incompletely explains these patterns specific to their region, using pictures, arrows, and captions. • For example, student explains that due to differential heating caused by the tilt of the Earth, but does not explain that water in the ocean near the equator is warmer than water near the Poles. The student does not explain that temperature differences drive the ocean currents, and thus demonstrates only minimal understanding of how the ocean and atmosphere impact regional climates. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student draws a model that mostly explains these patterns specific to their region, using pictures, arrows, and captions. • For example, student explains that due to differential heating caused by the tilt of the Earth, water in the ocean near the equator is warmer than water near the Poles. This temperature difference sets up a convection cell in the ocean which drives ocean currents. However, the student neglects to explain how air circulates through the atmosphere, and thus develops a partial concept of why specific regions have particular climates. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student draws a model that completely explains these patterns specific to their region, using pictures, arrows, and captions. • For example, student explains that due to differential heating caused by the tilt of the Earth, water in the ocean near the equator is warmer than water near the Poles. This temperature difference sets up a convection cell in the ocean which drives ocean currents. A similar mechanism forces air to circulate in the atmosphere. When the motion of water and air is combined with the Earth’s rotation, specific regional temperature patterns emerge.

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Rubric 4: Student develops a model to describe how water is cycled through Earth systems via various processes driven by energy from the Sun and the force of gravity.

- Dimensions Assessed: SEP – Developing and Using Models, DCI – ESS2.C: The Roles of Water in Earth’s Surface Processes, CCC – Energy and Matter

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
<p>Student develops an inaccurate model to describe how water is cycled through Earth systems via various processes. OR Student partially describes how water is cycled through Earth systems via various processes driven by energy from the Sun and the force of gravity, but no model is present.</p>	<p>Student develops an incomplete model to describe how water is cycled through Earth systems via various processes. OR Student completely describes how water is cycled through Earth systems via various processes driven by energy from the Sun and the force of gravity, but no model is present.</p>	<p>Student develops a partial model to describe how water is cycled through Earth systems via various processes driven by energy from the Sun or the force of gravity.</p>	<p>Student develops a complete model to describe how water is cycled through Earth systems via various processes driven by energy from the Sun and the force of gravity.</p>
<p>Look Fors:</p> <ul style="list-style-type: none"> • Student draws a model that describes the water cycle as it relates to their region, but does so with major inaccuracies or major missing components (See <i>Advanced Look-Fors</i> for accurate descriptions). <p>OR</p> <ul style="list-style-type: none"> • Student partially describes the water cycle as it relates to their region, but no model is present. Or the model partially describes the generic water cycle but it is not specific to the region. See <i>Proficient Look-Fors</i> for components of a complete description. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student draws a model that incompletely describes the water cycle as it relates to their region, using pictures, arrows, and captions. Model is missing many components and/or interactions. Model also does not identify the Sun or gravity as the energy/forces that drive the cycling of water. <p>OR</p> <ul style="list-style-type: none"> • Student completely describes the water cycle as it relates to their region, but no model is present. Or the model completely describes the generic water cycle but is not specific to the region. See <i>Advanced Look-Fors</i> for components of a complete description. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student draws a model that partially describes the water cycle as it relates to their region, using pictures, arrows, and captions. • In their model, student shows most of the components of the system (i.e. relevant reservoirs for water). Student also shows and explains most relevant interactions (i.e., transpiration, evaporation, condensation, precipitation, and/or surface runoff). • In the model, student explicitly describes how the cycling of water is driven by energy from the Sun OR the force of gravity, but not both. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student draws a model that completely describes the water cycle as it relates to their region, using pictures, arrows, and captions. • In their model, student shows all the components of the system (i.e. relevant reservoirs for water). Student also shows and explains all relevant interactions (i.e., transpiration, evaporation, condensation, precipitation, and/or surface runoff). • In the model, student explicitly describes how the cycling of water is driven by energy from the Sun and the force of gravity.

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Rubric 5: Student cites patterns to describe a cause and effect relationship that explains regional climate conditions.

- Dimensions Assessed: DCI – ESS2.C: The Roles of Water in Earth’s Surface Processes and/or ESS2.D: Weather and Climate, CCC – Patterns
- Students may choose to describe patterns related to the Sun-Earth system, atmospheric and oceanic circulation, or the water cycle.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
<p>Student cites irrelevant patterns to inaccurately describe a cause and effect relationship that explains regional climate conditions.</p>	<p>Student cites relevant patterns but does not explicitly connect them to a cause and effect relationship that explains regional climate conditions.</p>	<p>Student cites relevant patterns to accurately describe one cause and effect relationship that explains regional climate conditions.</p>	<p>Student cites relevant patterns to accurately describe multiple cause and effect relationships that explain regional climate conditions.</p>
<p>Look Fors:</p> <ul style="list-style-type: none"> • Student cites irrelevant patterns to describe one cause and effect relationship. These patterns might be completely irrelevant to all the climate concepts, or the patterns might be connected to the wrong concept. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student cites relevant patterns (See <i>Advanced Look-Fors</i> for examples) but does not explicitly connect them to the relevant cause and effect relationship. For example, after all the models, student makes a general statement that these are all supported by patterns in data, and then cites sun angles and temperatures for regions in northern and southern hemispheres. This does not explicitly name the Earth’s tilt as the connection required to explain the cause and effect relationship between the Sun’s angle and regional temperatures. 	<p>Look-Fors</p> <ul style="list-style-type: none"> • Student cites relevant patterns to describe one cause and effect relationship. See <i>Advanced Look-Fors</i> for examples. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student cites relevant patterns to describe multiple cause and effect relationships. For example, student cites patterns in sun angles and temperatures for regions in northern and southern hemispheres to describe the cause and effect relationship between tilt of the Earth and unequal heating. Student also cites patterns in oceanic circulation and temperatures for specific regions to describe the cause and effect relationship between oceanic circulation and climate.

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Rubric 6: Student describes the proportional relationships among energy transfer, the type of matter, the mass, and change in temperature, including how these relate to the kinetic energy of particles.

- Dimensions Assessed: DCI – PS3.A: Definitions of Energy and PS3.B: Conservation of Energy and Energy Transfer, CCC – Scale, Proportion, and Quantity

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
<p>Student inaccurately describes the proportional relationships among energy transfer, the type of matter, the mass, and/or change in temperature.</p>	<p>Student incompletely describes the proportional relationships among energy transfer, the type of matter, the mass, and/or change in temperature.</p>	<p>Student mostly describes the proportional relationships among energy transfer, the type of matter, the mass, and/or change in temperature, including how these relate to the kinetic energy of particles.</p>	<p>Student completely describes the proportional relationships among energy transfer, the type of matter, the mass, and change in temperature, including how these relate to the kinetic energy of particles.</p>
<p>Look Fors:</p> <ul style="list-style-type: none"> • To describe the inspiration for their original design, student describes relationships from their Task 4 investigations with major errors (See <i>Advanced Look-Fors</i> for detailed description of relationships). For example, student states that the more mass a sample has, the less thermal energy is needed to change its temperature. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • To describe the inspiration for their original design, student describes at least one of the relationships from their Task 4 investigations, but it may be lacking detail or have minor errors (See <i>Advanced Look-Fors</i> for detailed description of relationships). • Student does not discuss the kinetic energy of particles. 	<p>Look-Fors</p> <ul style="list-style-type: none"> • To describe the inspiration for their original design, student accurately describes at least one of the relationships from their Task 4 investigations (See <i>Advanced Look-Fors</i> for detailed description of relationships). • Student discusses the kinetic energy of particles within the context of the relationship they describe. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • To describe the inspiration for their original design, student accurately describes all of the relationships from their Task 4 investigations: the more mass a sample has, the more thermal energy transfer is needed to change the temperature; the type of matter affects the amount of thermal energy transfer needed to change the temperature of the sample. • Student discusses the kinetic energy of particles within both of these relationships. For example, a sample with more mass means more thermal energy transfer is needed because there are more particles in the sample.

Additional Notes:

- An additional rubric is provided in Task 4 to assess the SEP of this Performance Expectation MS-PS3-4, Planning and Carrying Out Investigations.

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Rubric 7: Student redesigns a thermal product to better meet the criteria for success, referencing the relevant test data of different products to explain why they combine best characteristics.

- Dimensions Assessed: SEP – Analyzing and Interpreting Data; DCI – ETS1.B: Developing Possible Solutions and ETS1.C: Optimizing the Design Solution

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
<p>Student redesigns a thermal product to better meet the criteria for success, but does not explain why they combine best characteristics.</p> <p>OR</p> <p>Student redesign a thermal product that shows no improvement from original design OR does not combine best characteristics from other designs to better meet the criteria for success.</p>	<p>Student redesigns a thermal product to better meet the criteria for success, but does not reference the relevant test data of different products to explain why they combine best characteristics.</p>	<p>Student redesigns a thermal product to better meet the criteria for success, referencing at least one piece of relevant test data of different products to explain why they combine best characteristics.</p>	<p>Student redesigns a thermal product to better meet the criteria for success, referencing all of the relevant test data of different products to explain why they combine best characteristics.</p>
<p>Look Fors:</p> <ul style="list-style-type: none"> • Student’s thermal product shows clear improvement that combines best characteristics from different designs (from own and other groups). However, student provides no explanation of why it combined these design features. <p>OR</p> <ul style="list-style-type: none"> • Student’s thermal product does not show any improvements or does not combine best characteristics from different designs. For example, student might just say that their design was the best and needed no improvements. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student’s thermal product shows clear improvement that combines best characteristics from different designs (from own and other groups). • Student explains why they combined these design features, but does not reference any data. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student’s thermal product shows clear improvement that combines best characteristics from different designs (from own and other groups). • Student explains why they combined these design features, but only cites one piece of relevant data to justify their redesign. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student’s thermal product shows clear improvement that combines best characteristics from different designs (from own and other groups). • Student explains why they combined these design features, using multiple pieces of data to justify their redesign. This explanation and data will vary depending on the types of designs different groups come up with.

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Rubric 8: Student shows and explains how their design uses scientific principles to minimize or maximize thermal energy transfer.

- Dimensions Assessed: SEP –Designing Solutions, DCI – PS1.B Chemical Reactions, CCC – Energy and Matter

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
<p>Student inaccurately shows and/or explains how their design uses scientific principles to minimize or maximize thermal energy transfer.</p> <p>OR</p> <p>Student’s design does not minimize or maximize thermal energy transfer.</p>	<p>Student incompletely shows and/or explains how their design uses scientific principles to minimize or maximize thermal energy transfer.</p>	<p>Student partially shows and explains how their design uses scientific principles to minimize or maximize thermal energy transfer.</p>	<p>Student completely shows and explains how their design uses scientific principles to minimize or maximize thermal energy transfer.</p>
<p>Look Fors:</p> <ul style="list-style-type: none"> • Student’s diagram and/or explanation inaccurately describes a relevant product that minimizes or maximizes thermal energy transfer. For example, student might draw a diagram that shows thermal energy moving from cold to hot and does not explain the product in terms of kinetic energy of particles. <p>OR</p> <ul style="list-style-type: none"> • Student’s design does not actually minimize or maximize thermal energy transfer (i.e. buying an electric heater). 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student’s diagram and/or explanation accurately describes a relevant product that minimizes or maximizes thermal energy transfer to keep people/objects warm or cool, depending on the region. • Paragraph, labels, and/or captions describe limited scientific principles behind how the product works or do so with major inaccuracies. See <i>Advanced Look-Fors</i> for an example of a correct diagram and explanation. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student’s diagram accurately shows a relevant product that minimizes or maximizes thermal energy transfer to keep people/objects warm or cool, depending on the region. • Paragraph, labels, and/or captions describe most of the scientific principles behind how the product works. • However, their diagram and explanation of their product may be missing some detail about one of the following concepts: thermal energy transfers from hot to cold, why thermal energy transfer is minimized/maximized in terms of kinetic energy of particles. See <i>Advanced Look-Fors</i> for an example of a correct diagram and explanation. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student’s diagram accurately shows a relevant product that minimizes or maximizes thermal energy transfer to keep people/objects warm or cool, depending on the region. For example, a diagram of double-paned windows in a cold region might use arrows to show how thermal energy transfer from the <u>warm</u> region in the house <u>to the cold</u> region outside is minimized. • Paragraph, labels, and/or captions describe the scientific principles behind how the product works, including descriptions of thermal energy transfer and the kinetic energy of particles. For example, student explains that the air pocket between the two windowpanes minimizes thermal energy transfer between the inside and outside of the house. Because air particles are spread so far apart, kinetic energy of the particles is transferred less easily.

6th Grade Science Unit 2: Extreme Living
Lift-Off Task: Extreme Conditions



Unit Essential Question: *How do people use technology to survive in regions with different climates?*

Introduction

In some regions of the world, nature can be pretty extreme! Despite these extreme climate conditions, humans are somehow able to survive seemingly inhospitable regions on Earth. In this Lift-Off Task, students analyze photos of humans living in extreme climates and begin to generate questions about this phenomenon. These questions will guide students throughout the unit as they continue to make sense of extreme climates and use scientific ideas to design products that make living in these regions more bearable.

Alignment Table

Performance Expectations	Scientific and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	Asking Questions and Defining Problems <ul style="list-style-type: none"> Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. 	ETS1.A: Defining and Delimiting Engineering Problems <ul style="list-style-type: none"> The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. 	No CCC listed

<p>Additional Crosscutting Concepts (*depending upon student-generated questions)</p> <ul style="list-style-type: none"> Scale, Proportion, and Quantity <ul style="list-style-type: none"> Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. Systems and System Models <ul style="list-style-type: none"> Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. Energy and Matter <ul style="list-style-type: none"> Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. The transfer of energy can be tracked as energy flows through a designed or natural system.
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6th Grade Science Unit 2: Extreme Living**Lift-Off Task: Extreme Conditions****Equity and Groupwork**

- Share and listen to broad and diverse student contributions.
- Make connections between each other's ideas.
- Work together to co-construct a concept map.

Language

- Use connector words to link ideas.
- Generate and write questions about the phenomenon.
- Organize key questions in a concept map.

Learning Goals

This learning task introduces students to the phenomenon of humans surviving in extreme climates and prompts them to begin generating questions that will guide them through the unit. More specifically, the purpose is to:

- Individually generate a list of questions about humans living in extreme climates, using observations from the images.
- Make connections between related questions.
- Generate possible answers to questions, using prior knowledge.
- Research and select a region with extreme weather and define the problem, including criteria and constraints.

Content Background for Teachers

In this task, students are introduced to examples of humans living in extreme climate conditions. While there are other extreme climate conditions besides temperature, we focus on extreme heat and extreme cold in this unit because of the thermal energy focus of the physical science content. Humans that live in extreme heat need to use various technologies to survive in this type of climate. For example, some people wear robes that allow air to flow through and cool the body. Others build homes surrounded by boulders, with large eaves for shading and insulated windows, so the house stays cool throughout the day. Humans that live in extreme cold also use technologies to survive in this type of climate. Most relevant to this unit are those that use insulators. For example, igloos use thick layers of ice as insulators to retain any body heat inside. Down jackets similarly act as a fantastic insulator by creating lots of tiny air pockets to trap warm air and retain heat. For more information on extreme climates and human technologies used to survive them, read the teacher versions for each task in this unit.

In this task, students create a concept map, which is a graphical tool that helps to organize and represent knowledge and questions, and is an effective academic language instruction tool. In this task, students will likely add only basic ideas relating to climate and technology. As students learn more about climate and thermal technologies, they will add more complex questions and ideas to this concept map. If your students have not had previous experience making concept maps, please see the instructions in Part B below for strategies on teaching this skill.

Academic Vocabulary

- Climate
- Extreme
- Problem
- Criteria

6th Grade Science Unit 2: Extreme Living**Lift-Off Task: Extreme Conditions**

- Constraint

*Additional academic vocabulary will vary by class

Time Needed (Based on 45-Minute Periods)

2 Days

- Introduction, Part A and Part B: 1 period
- Class Concept Map, Project Overview, and Project Organizer: 1 period

Materials

- Unit 2, Lift-Off Task Student Version

Part B

- Poster paper and markers
- Post-Its (Optional)

Part C

- Class Poster Paper and markers
- *See Instructions below for other optional materials to use for the class concept map

Connecting to the Culminating Project

- Culminating Project Handout
- Project Organizer Handout
- Computers or Tablets (for research)

Instructions

1. Introduce students to the unit by reading or projecting the Unit Essential Question aloud.
2. Humans are able to survive in a wide variety of climates around the world. Some of these climates are very extreme! In this activity, students think about if they can imagine living in such extreme conditions.
3. First have students make some observations as they compare the photos in their student guides. The photos on the left show buildings and clothing in an extremely hot environment, and the photos on the right show buildings and clothing in an extremely cold environment.
 - You can have students do this independently, in pairs, or in groups.

Part A

1. In this section of the task, students will generate questions to help them make sense of the phenomenon—humans surviving in extreme climates. Using these self-generated questions throughout the unit will help them get a better understanding of what causes extreme climates and what technologies humans can use to survive within them.
2. Have students complete this section individually in their student guide.
 - For students who need more support, encourage them to look back at the pictures, and consider any questions they have.

6th Grade Science Unit 2: Extreme Living

Lift-Off Task: Extreme Conditions

- Here is a list of some potential questions students might generate: “What is the climate like in the photos on the left? What is the climate like in the photos on the right? Why can’t our bodies survive in extreme temperatures? Why do people live in these areas? Why do people wear black robes in hot weather? How could a house made of house possibly help keep people warm? Why do rocks surround the house in the desert? Why does the desert house have a long eave on one side? Why do puffy jackets help keep you warm? ”

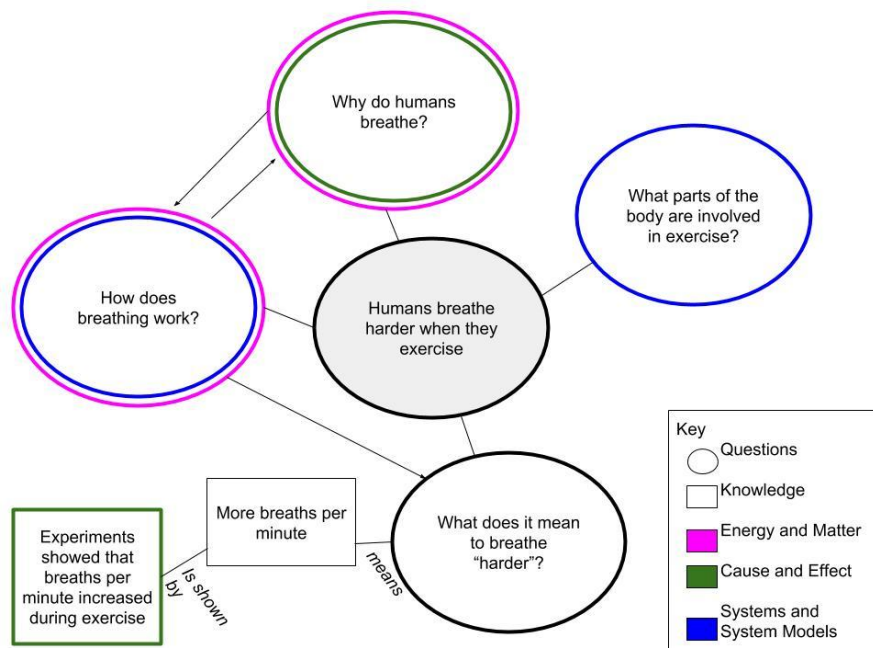
Part B:

1. In this part of the task, students create a concept map as a group.
 - Remind students to refer to the directions on their student guide to help them make their concept map. First, students should compare each member’s list of questions and record/connect key questions on a piece of poster paper. They will then draft possible answers to the questions, using prior knowledge.
 - Remind students that there are no right or wrong questions or predictions, so students feel encouraged to contribute any and all questions and ideas they think of.
 - Because this is a collaborative task, it is recommended that you remind students of group work norms and assign group roles, such as Resource Manager, Facilitator, Recorder, and Harmonizer (See “How to Use this Curriculum” for more details).
2. Students will display their posters on a wall and then walk around and look at each group’s ideas. One suggestion for gallery walks is for students to interact with the posters in some way. For example, students are required to initial or leave post-its on three questions that they are also excited about on other posters.

How to Concept Map

For students with less experience making concept maps, we have detailed a strategy below for introducing concept mapping using more familiar content. An example is also provided, but this will vary depending on what your students come up with as you make your own model.

1. Write the phenomenon in the middle of the poster, in this case “Humans breathe harder when they exercise.”
2. Ask students to share questions they might ask to



6th Grade Science Unit 2: Extreme Living**Lift-Off Task: Extreme Conditions**

make sense of this phenomenon and make a list of these questions on the board.

3. Model the process of reviewing the list and finding similarities amongst the questions.
 - Place these key questions on the concept map poster, modeling how to put similar questions near each other on the poster. Circle these to signify that these are questions, not content knowledge.
4. Ask students to look at the key questions and see if any of the questions are connected: Would answering one question lead to one of the other questions? Model making these connections by drawing arrows between the circles.
5. In this Lift-Off task, students will only be drafting possible answers to the questions, not actually gathering and recording learned concepts. However, throughout the unit, they will be adding content they have learned. Model this by recording a student's prior knowledge to one of the questions, using boxes to signify that these are pieces of content knowledge rather than questions.
 - Use connector words to identify the relationships between the content boxes (See image above for an example).
6. Optional: To emphasize crosscutting concepts using a concept map, make a key of different colors for the crosscutting concepts emphasized in this unit. Identify questions that clearly show evidence of the different crosscutting concepts and circle them with the corresponding colors. Explain to students how you made that choice by pointing out the language that hints at that crosscutting concept. *Note: not all boxes and circles will necessarily have a crosscutting concept.

Part C

1. Construct a whole-class concept map that begins to help students make sense of the phenomenon of humans surviving in extreme climates.
 - Start with the phenomenon in the middle.
 - Then ask students to share out the questions that were most common across all the posters in the classroom. As you record questions on the poster, organize them based on connections you see. Draw circles around each question (as you add to the concept map throughout the unit, you'll also be adding concepts learned, which can be written in boxes to distinguish them from the questions).
 - Ask students to identify any connections they see between the questions and record these as lines between the questions.
 - Recommended: Give pairs of students think time to come up with 1-2 connections to add to the class concept map and call on pairs using equity sticks. This encourages more equitable participation in this class-wide activity.
 - The purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content but will also help their oral and written language development.

6th Grade Science Unit 2: Extreme Living**Lift-Off Task: Extreme Conditions**

- This whole class concept map will be revisited at the end of each task, asking students questions like: Are there any new questions you have about the phenomenon? Are there any connections you want to add or change? What is your reason for that addition/revision? Are there more connections we can make between the questions/ideas already on the map? Do you want to add any new ideas/concepts to the map?
2. Because this concept map will be added to and revised throughout the unit, here are some practical options for implementation.
- If you have access to white board paper, we encourage you to use these for class posters since it will allow you and your students to make revisions throughout the unit.
 - Another option is to use smaller pieces of paper for each class and project using a document camera; this will save space as opposed to doing large class posters.
 - We highly recommend students keep their own version of this concept map in their notebooks, adding questions and concepts as they go through the unit.
3. Once the draft concept map is complete, introduce students to the crosscutting concepts for this unit. We recommend posting posters of each crosscutting concept in your classroom (See beginning of teacher guide for templates).
- The crosscutting concepts for this unit are: Scale, Proportion, and Quantity; Systems and System Models; and Energy and Matter. Assign a color for each crosscutting concept that can be used throughout the unit.
 - Have students analyze the class concept map for as many examples of the crosscutting concepts as they can find. Depending on the questions they have, they may be able to find an example of each of the crosscutting concepts or perhaps just some.
 - We recommend modeling this process by picking a question, identifying the crosscutting concept, and tracing the circle in the corresponding color. Explain the key words that helped you identify the crosscutting concept in this question. Some identifying words that students might look for are:
 - **Scale, Proportion, and Quantity:** These could be phrases such as, “is proportional to”, “compared to”, “has a ratio of”, “is bigger/smaller than”, “is longer/shorter than”, etc.
 - **Systems and Systems Models:** These could be phrases such as, “is a part of” “connects to,” “interacts with,” “is made up of,” “works together with,” etc.
 - **Energy and Matter:** These could be phrases such as, “energy is transferred/flows,” “is conserved,” “is important for,” “is needed,” etc.

Connecting to the Culminating Project

1. Hand out the Culminating Project Task Card and read the Challenge and Group Project Criteria for Success aloud as a class.
 - Review some potential formats for their group presentation (poster presentation, Powerpoint, Prezi, physical demonstration, etc.)
 - Take questions for clarification.
 - Optional: As a class, brainstorm a list of some possible products that might make living in extreme conditions more comfortable. The purpose of this exercise is to emphasize that there is a large range of products (e.g., clothing items, types of homes, heating/cooling devices, etc.)

6th Grade Science Unit 2: Extreme Living**Lift-Off Task: Extreme Conditions**

2. Pass out their Project Organizer and explain that they will complete a section of this after each task in class. After students research and decide on a region as a group, they should independently complete the rest of the Lift-Off Task section of the Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.
 - Students have been tasked to design a product that makes it more comfortable for people to live in a region with an extreme climate. The student prompt is as follows: Research a few different regions with an extreme climate (too hot or too cold). As a group, choose one of these regions to focus on for your culminating project and describe the extreme climate there. Then individually,
 - ✓ Define the **problem**: Why is it difficult to live in this region?
 - ✓ Identify the **criteria** for a successful solution: How will you know your product has solved the problem?
 - ✓ Identify the **constraints** of solving this problem: What might make it hard to solve this problem?

Reflection

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:
 - At the beginning of this task, you made a list of all the questions you have about humans surviving in extreme climates. Look back at your list: after learning from your peers, how can you add to your list? What kinds of things did you initially leave out? Use the class concept map to help you.
 - In this unit, we will be focusing on three crosscutting concepts: **Scale, Proportion, and Quantity**: Proportional relationships among different quantities tell us about the magnitude of processes; **Systems and System Models**: Models can be used to represent systems and their interactions; and **Energy and Matter**: The transfer of energy drives the motion or cycling of matter, and it can be tracked as it flows through a system. Looking at your class concept map, give one example of how a crosscutting concept came up in today’s task.
 - Now that you understand what project you’ll be working on over the course of this unit, what else do you need to know? What additional questions do you have?
2. There are no right answers but encourage students to look back at their initial lists and their class concept map. They should not change their initial responses, but rather use this reflection space to add to their questions and ideas based on what they have learned through this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and the gathering of knowledge and skills for their final project.

6th Grade Science Unit 2: Extreme Living
Task 1: Climate Part 1 – Heating the Planet



Unit Essential Question: *How do people use technology to survive in regions with different climates?*

Introduction

In the Lift-Off task, students saw photos of people living in extreme climates and began to generate questions about these extreme climates and how people are able to survive there. In the next two tasks, students will explore what causes such extreme climates. To begin this exploration, students must start with the Sun because it is the key energy source behind all mechanisms that determine regional climates. In this task, students use physical and computer simulation models to visualize the Sun-Earth system. Through these models, they will notice that the Sun does not heat the Earth equally because of the tilt of the Earth as it orbits around the Sun. This unequal heating causes patterns of atmospheric and oceanic circulation that students will delve into in the next task. By the end of this task, students will be able to dispute a common misconception about seasons and explain why the region they chose for their culminating project has such extreme temperatures.

Alignment Table

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.</p> <p>[Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.]</p> <p>[Assessment Boundary: Assessment does not include</p>	<p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop and use a model to describe phenomena. 	<p>ESS2.D: Weather and Climate</p> <ul style="list-style-type: none"> Weather and climate are influenced by interactions involving sunlight. These interactions vary with latitude. <p>*The other elements of the DCIs associated with this PE will be addressed in Task 2.</p>	<p>Systems and System Models</p> <ul style="list-style-type: none"> Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

6th Grade Science Unit 2: Extreme Living
Task 1: Climate Part 1 – Heating the Planet

the dynamics of the Coriolis effect.]			
Supplementary Crosscutting Concepts <ul style="list-style-type: none"> • Patterns <ul style="list-style-type: none"> ○ Patterns can be used to identify cause and effect relationships. • Scale, Proportion, and Quantity <ul style="list-style-type: none"> ○ Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. 			
Equity and Groupwork <ul style="list-style-type: none"> • Participate in group roles to use physical and computer simulation models. • Discuss and compare observations with partners and group members. • Use the <i>Stronger Clearer</i> method to give and receive feedback. 			
Language <ul style="list-style-type: none"> • Compare and contrast weather and climate. • Describe observations of a model. • Describe a phenomenon using a written explanation and a model. • Use the <i>Stronger Clearer</i> method to improve language. 			

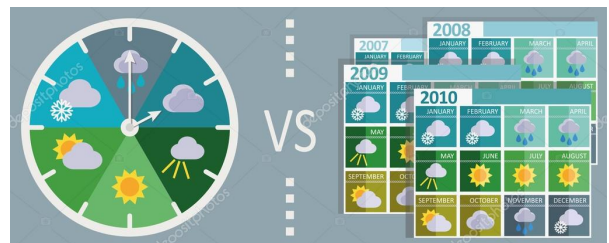
Learning Goals

This learning task asks students to develop and use models to describe how unequal heating and rotation of the Earth help determine regional climates. More specifically, the purpose is to:

- Engage prior knowledge to differentiate weather and climate.
- Explore the Sun-Earth system using physical and computer simulation models.
- Explain why it is not wise to take a ski trip in New Zealand in December.
- Use the *Stronger Clearer* method to improve an explanation and model.
- Apply knowledge of the Sun-Earth system to explain typical temperatures in their chosen region.

Content Background for Teachers

In this task, students begin to explore the mechanisms that determine regional climates. First, students need to activate prior knowledge about the difference between weather and climate. Weather is what we actually see day-to-day: sunny, rainy, snowy, or foggy days. It describes conditions on a specific day in a specific area. Climate, however, is the average conditions in a general region. We will be focusing mainly on climate in this unit, but we will also focus on weather events in later units.

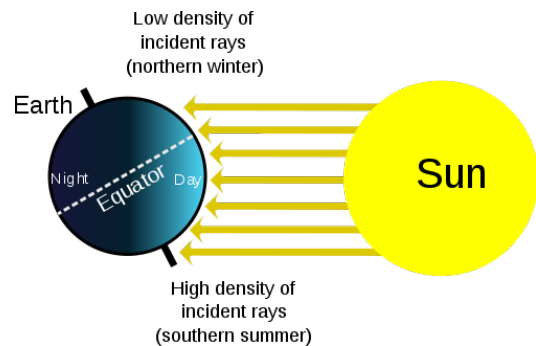


In this task, students first focus on the Sun-Earth system because the Sun ultimately determines all climates on Earth. The Sun warms the planet, drives the water cycle, and causes all patterns of atmospheric and oceanic circulation—these are all factors in determining a region’s climate. Because climate science is so complex, we have split this Performance Expectation into two tasks. This task focuses on that first step of the Sun warming Earth.

6th Grade Science Unit 2: Extreme Living

Task 1: Climate Part 1 – Heating the Planet

Through models, students learn that the Earth is always tilted slightly (23 degrees) in the same direction. This means that at different times of year, as Earth orbits around the sun, sunlight will be angled more directly on certain parts of the Earth. For example, in North America in November, the northern hemisphere is angled away from the sun, which causes less direct sunlight and colder temperatures. In June, when the Earth is on the opposite end of its orbit, the northern hemisphere is angled more towards the sun, causing more direct sunlight and warmer temperatures. Thus, these changes in sunlight intensity as the Earth orbits the sun throughout a year are what cause seasons. This becomes the basis of the scenario in the *Explain*, as students consider why regions in different hemispheres experience different seasons at the same time of year. In general, students will also notice that because of the angle of the sun, the Poles receive less sunlight and are colder, whereas the equator receives lots of direct sunlight and is warmer.



These concepts around unequal heating of Earth are an essential foundation for students to understand before thinking about patterns of atmospheric and oceanic circulation in the next task.

Academic Vocabulary

- Weather
- Climate
- Equator
- Poles
- Hemisphere
- Season
- Temperature
- Latitude

Time Needed (Based on 45-Minute Periods)

4.5 Days

- Engage: 0.5 period
- Explore: 1.5 periods
- Explain: 0.5 period
- Elaborate: 1 period
- Evaluate and Reflection: 1 period

Materials

- Unit 2, Task 1 Student Version

Engage

- Large poster that says “Weather”
- Large poster that says “Climate”

Explore (Per group)

- Flashlight, Penlight, or Other Light Source

6th Grade Science Unit 2: Extreme Living
Task 1: Climate Part 1 – Heating the Planet

- Styrofoam Ball (at least 4 inches in diameter)
- 2 Toothpicks or Skewers
- Rubber Band
- Computer

Evaluate

- Project Organizer Handout
- Computers or Tablets (for research)

Instructions

Engage

1. Introduce Task 1: In the Lift-Off task, you saw examples of people living in extreme climates. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
 - Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.
2. Transition to Task 1: What causes these environments to have such extreme climates? What made some regions so hot and others so cold? In this task, we will investigate one of the major reasons behind a region’s climate.
 - Now pass out their Task 1 student guide.
3. Before students delve into the causes of climate, we need them to understand what climate is and how it is different from weather. They have learned about the difference between climate and weather in prior grades, so this activity serves to activate that prior knowledge.
4. To set up this activity, place a poster that says “Weather” in one corner and another poster that says “Climate” in the opposite corner. Have all students stand in the center of the room.
 - First have students turn to a partner and discuss what they think the difference is between weather and climate.
 - Then read each of the statements on their Student Guide aloud. After you read each statement, give students time to move to the “Weather” or “Climate” corner, depending on which they think the statement is describing. For each statement, call on at least one student to share their reasoning.
 - We encourage using equity sticks as a fair and equitable way to call on students (See “How To Use This Curriculum” for more details).
 - An answer key is provided below:

C = Climate W = Weather	Statements found in Student Version
W	It rained on May 8
C	Germany is a cold country.
C	Summer is hot.

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Task 1: Climate Part 1 – Heating the Planet

W	It is supposed to rain this weekend
C	Florida is hotter than Alaska
W	That was an amazing lightning storm last night
C	Cities near the ocean tend to be wet.
W	It might snow in Tahoe tomorrow
W	Today it was colder than usual.
C	1992 was one of the coldest summers on record.
W	There is a hurricane predicted to hit tomorrow.
W	The highest recorded temperature of all time was 136 degrees Fahrenheit in Libya.
C	It rains every October

- Once the activity is complete, have students return to their seats for a class discussion to define the difference between weather and climate. Come to a consensus on two definitions and have students record this in their Student Guides.
 - Again, we encourage using equity sticks to foster more equitable participation in class-wide discussions like these (See “How To Use This Curriculum” for more details).

Explore

- Now that students understand what we mean when we say “climate”, they are ready to explore one major reason for why climates around the world can be so different—the Sun-Earth system. In this activity, they use two models to answer the question: Does every part of Earth get the same amount of energy from the Sun all the time?
 - This activity gives students practice with the SEP of **Developing and Using Models** as they use physical and computer simulation models to describe how the Sun unequally heats Earth.
 - Students also emphasize the crosscutting concepts of **Systems and System Models** and **Scale, Proportion, and Quantity** as they use two models to visualize the Sun-Earth system, which is too large to be seen. These models show interactions between parts and the flow of energy within the Sun-Earth system.
- Students will work with two models—a physical model and a computer simulation model. You can run this activity in a few ways. Student groups can run through both simulations at their own pace, or you can have them do one at a time, pausing after each to debrief what they observed.
 - Regardless of the process you choose, we highly recommend modeling the set-up for both the models so students have an idea of how to build the ball-toothpick model and how to use the computer simulation.
 - Should you find that your students have misconceptions that all the Sun’s rays shine in only one direction and towards the Earth, you may choose to utilize a light source that shines in all directions (ie. a lamp), instead of a flashlight.
- Distribute the materials outlined in the Materials List above and assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Facilitator, Materials Manager, Harmonizer, and Recorder.

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Task 1: Climate Part 1 – Heating the Planet

- Ask the Facilitator to read the directions and to make sure everyone understands the task.
- Ask the Materials Manager to gather the materials needed to complete the task.
- Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone’s voice is heard.
- Ask the Recorder to make sure the group is recording their analysis in their Student Guide.

4. Sample Student Responses:

Physical Model:

Discussion Questions	Your Responses
In general, what locations on the Earth get more sunlight and what locations get less?	<i>Earth gets more direct sunlight at the Equator and less direct sunlight at the Poles.</i>
How do you think the different amounts of sunlight affect temperature in these areas?	<i>I think this makes it much warmer at the Equator than at the Poles.</i>
Why do you think the amount of sunlight that hits Earth varies by region?	<i>Earth is round so it hits more directly at the equator and spreads out more at the Poles. Also, the tilt of the Earth means that one half of Earth gets more direct sunlight than the other half at any given time.</i>

Computer Model:

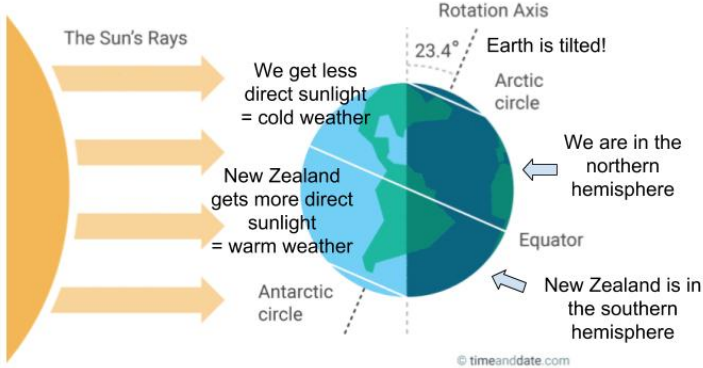
Time of Year	Location	Observations of the Sun’s Rays	How do you think this affects the temperature in the region at this time of year?
November	Northern Hemisphere	<i>Very Angled</i>	<i>It is colder during this time of year.</i>
June	Northern Hemisphere	<i>Direct</i>	<i>It is warmer during this time of year.</i>
June	Southern Hemisphere	<i>Very Angled</i>	<i>It is colder during this time of year.</i>
November	Southern Hemisphere	<i>Direct</i>	<i>It is warmer during this time of year.</i>
November	Equator	<i>Direct</i>	<i>It is warm during this time of year.</i>
June	Equator	<i>Direct</i>	<i>It is warm during this time of year.</i>

Discussion Questions:

- These discussion questions emphasize the supplementary CCC of **Patterns**, as students use patterns in their observations to identify cause and effect relationships between the Sun-Earth system and climates on Earth.
- a: What part of the world gets the most direct sunlight throughout the year? Why? *The equator because the Earth is a sphere, and the center of the sphere will be exposed towards the Sun more often, so it gets the most direct sunlight. The equator get perfectly direct sunlight twice per year (fall and spring), while the northern and southern hemispheres get direct sunlight only once per year.*

6th Grade Science Unit 2: Extreme Living
Task 1: Climate Part 1 – Heating the Planet

4. Possible Student Sample:

Written Explanation	Model
<p>Dear Friend,</p> <p>While it sounds wonderful to go skiing over winter break, I think you should pick a different location. Even though it is winter here in December, which means cold weather and skiing, it does not mean it is winter everywhere on Earth! Because the Earth is tilted, this means that one hemisphere is always getting more direct sunlight than the other. When it is winter here in the northern hemisphere, we are getting less direct sunlight because we are angled away from the Sun. This means that the southern hemisphere, where New Zealand is, is angled more towards the Sun, getting more direct sunlight. This means it is actually summer in New Zealand and the weather is warm! Hope this helps.</p> <p>Sincerely, Your Friend</p>	<p align="center">Position of Earth During December (Winter Break)</p>  <p>The Sun's Rays</p> <p>We get less direct sunlight = cold weather</p> <p>New Zealand gets more direct sunlight = warm weather</p> <p>Antarctic circle</p> <p>Rotation Axis</p> <p>23.4°</p> <p>Earth is tilted!</p> <p>Arctic circle</p> <p>We are in the northern hemisphere</p> <p>Equator</p> <p>New Zealand is in the southern hemisphere</p> <p align="right">© timeanddate.com</p>

Elaborate

- Students will now participate in a language routine known as *Stronger Clearer*. This activity gives students the opportunity to share their ideas, gather feedback, and revise their explanations and models. This protocol is especially useful at this stage since the practice of modeling is still difficult for many students and these are particularly complex concepts.
- Students will share with three different partners, allowing them to discuss feedback and record any notes each time. Once complete, students should be given time to individually revise their explanations and models based on their discussions. A protocol is provided in their student guide.
- The revised explanations and models are a good option for formative assessment. Collect student work to identify trends in students' ability to use models to describe how the tilt of the Earth causes unequal heating of the hemispheres. See "How to Use This Curriculum" for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.
- Optional: Debrief the scenario as a class, coming to consensus on why skiing in New Zealand in December is not a great idea. Co-construct a model on the board based on the discussion.
 - Again, we encourage using equity sticks to foster more equitable participation in class-wide discussions like these (See "How To Use This Curriculum" for more details).

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Task 1: Climate Part 1 – Heating the Planet

5. Return to the whole-class concept map from the Lift-Off Task.
 - In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See “How To Use This Curriculum” for more details).
 - Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
 - Draw circles around each question and boxes around each concept.
 - Write connector words to describe connections between the concept boxes.
 - For this task, students may begin to connect some of their previous question circles to concept boxes about the following: a key cause of climate - unequal heating of Earth by the Sun.
 - Have students analyze the additions to the class concept map for as many examples of this task’s crosscutting concept as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
 - **Systems and Systems Models:** These could be phrases such as, “is a part of” “connects to,” “interacts with,” “is made up of,” “works together with,” etc.
 - Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

Evaluate: Connecting to the Culminating Project

1. Students independently complete the Task 1 section of the Unit 2 Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.
2. Students have been asked to design a product that makes it more comfortable for people to live in a region with an extreme climate. Their prompt is as follows: Research the region you selected.
 - ✓ Where is it located on Earth?
 - ✓ How can its location on Earth explain the typical temperature in the region?
 - ✓ Draw a Sun-Earth model to show and explain a major cause of your region’s climate.

Reflection

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:
 - At the beginning of this task, you were given a list of statements to identify as relating to weather or climate. Would the modeling you did in the rest of this task relate to weather or climate? Why?

6th Grade Science Unit 2: Extreme Living

Task 1: Climate Part 1 – Heating the Planet

- In this task, we focused on the crosscutting concept of **Systems and System Models**: Models can be used to represent systems and their interactions. Where did you see examples of **System and System Models** in this task?
 - Now that you have learned more about a major cause of climates, what questions do you still have?
2. There are no right answers, but encourage students to look back at their student guides and their class concept map. They should not change their initial responses, but rather use this reflection space to add to their ideas and questions based on what they have learned through this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and gathering knowledge and skills for their final projects.

Assessment

1. You may collect students' Project Organizer and assess using:
 - *Criteria of your choice*. We recommend using the 3-Dimensional Assessment matrix at the beginning of this document to inform your criteria.
 - This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching as necessary.
2. You may also give students time to make revisions with one of the two options:
 - Students may make changes to their Project Organizer according to your comments OR
 - Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.

6th Grade Science Unit 2: Extreme Living
Task 2: Climate Part 2 – Oceans and Atmosphere



Unit Essential Question: *How do people use technology to survive in regions with different climates?*

Introduction

In Task 1, students developed a model to explain how the tilt of the Earth away from its axis of rotation leads to the unequal heating of the Earth by the Sun’s energy. In this task, students explore how unequal heating patterns around the Earth causes atmospheric (wind) and oceanic circulation (currents). To introduce this task, the Engage asks students to consider a seemingly discrepant phenomenon – why should two cities (Rome and New York City) at nearly identical latitudes in the Northern Hemisphere, experience such different average winter temperatures? Through exploration, reading, and modeling, students will be able to explain this phenomenon as they develop a more general mechanistic understanding for how the atmosphere and ocean help to redistribute the Sun’s energy around the Earth. By the end of this task, students will also be able to explain how atmospheric and oceanic circulation affect the climate of their chosen region for the Culminating Project. Understanding how and why air moves through the atmosphere and water moves through the oceans helps motivate the need to examine the water cycle more closely in Task 3.

Alignment Table

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.</p> <p>[Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations</p>	<p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop and use a model to describe phenomena. 	<p>ESS2.C: The Roles of Water in Earth’s Surface Processes</p> <ul style="list-style-type: none"> Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. <p>ESS2.D: Weather and Climate</p> <ul style="list-style-type: none"> Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional 	<p>Systems and System Models</p> <ul style="list-style-type: none"> Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

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Task 2: Climate Part 2 – Oceans and Atmosphere



<p>[Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.]</p>		<p>geography, all of which can affect oceanic and atmospheric flow patterns.</p> <p>ESS2.D: Weather and Climate</p> <ul style="list-style-type: none"> The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. 	
<p>Supplementary Crosscutting Concepts</p> <ul style="list-style-type: none"> Patterns <ul style="list-style-type: none"> Graphs, charts, and images can be used to identify patterns in data. Energy and Matter <ul style="list-style-type: none"> The transfer of energy can be tracked as energy flows through a natural system. 			
<p>Equity and Groupwork</p> <ul style="list-style-type: none"> Participate in group roles to discuss patterns in data and to develop models. Discuss and compare observations with partners and group members. Participate in a gallery walks to compare model ideas, and to borrow and credit ideas. 			
<p>Language</p> <ul style="list-style-type: none"> Describe observations of a demonstration. Explain a phenomenon using a written explanation and a model. Annotate a scientific article and learn new scientific terminology. Integrate ideas from a written text with those represented visually. Use a scaffolded approach to understand model development with a focus on model components, the representation of components, and the interaction between components. 			

Learning Goals

This learning task asks students to develop and use models to describe how weather and climate are influenced by the interactions involving sunlight, the ocean, the atmosphere, and how the oceans influence weather and climate by redistributing energy from the Sun through ocean currents. More specifically, the purpose is to:

- Engage prior knowledge regarding variations in patterns of global climate.
- Explore oceanic and atmospheric circulation using physical and video simulations.
- Use a reading to inform components and interactions of models for oceanic and atmospheric circulation.
- Develop a model to explain why Rome tends to have higher average annual winter temperatures than New York City.



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Task 2: Climate Part 2 – Oceans and Atmosphere

- Apply knowledge of oceanic and atmospheric circulation to explain how together they influence the climate of different geographical regions.

Content Background for Teachers

In this task, students first investigate the underlying mechanisms for oceanic and atmospheric circulation. Students then develop models to explain how wind and ocean currents help to redistribute the Sun's energy and ultimately influence the climate of different geographical regions.

First, students engage their prior knowledge about how differences in global climate are mainly due to unequal heating of the Earth by the Sun. Students likely already understand that in general, climate varies with latitude, with warmer regions closer to the equator (lower latitudes) due to higher incidence of direct sunlight, and cooler regions closer to the Poles (higher latitudes) (see figure 1).

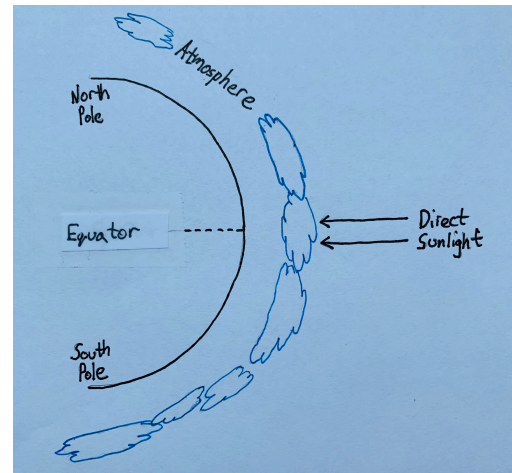


Figure 1

The *Engage* challenges students' initial prior knowledge by presenting data highlighting a seemingly discrepant phenomenon -- two cities, Rome and New York City, at similar latitudes, exhibit different average annual winter temperatures. Students are asked to explain why Rome has a warmer winter climate than New York City even though they are both located at 41-42°N.

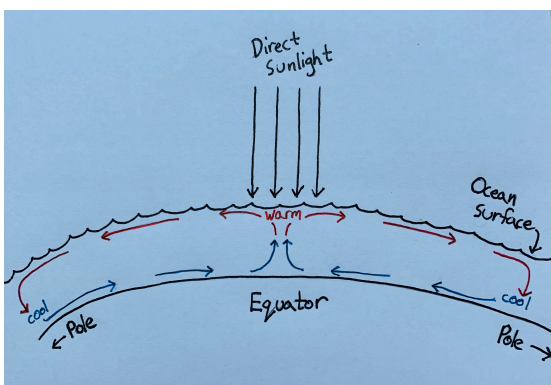


Figure 2

The *Explore* presents students with new data that pushes them to consider that there are more mechanisms at work in regulating climate across the Earth. First, students observe a video demonstrating how temperature differences drive the water movement. In this demonstration, food coloring acts as a visual aid to help students observe that warmer water (red food coloring) tends to rise and cooler water (blue food coloring) tends to sink. With time, the warmer water sinks as it cools, and the cooler water rises as it warms. This circulation pattern of sinking and rising water forms a **convection cycle or cell**, which partially accounts for the movement of water in the ocean (see figure 2)

A second *Explore* demonstration extends the idea of circulation/convection to the movement of gas, or air, in the atmosphere. By heating a partially-filled helium balloon, students can observe the balloon rise and then slowly sink once the balloon cools near the ceiling.

As well as reinforcing the same flow pattern seen with water, the balloon demonstration introduces the idea that density differential also contributes to the movement of substances. As the balloon is heated during the demonstration, it will appear to expand as the helium inside exerts pressure on the teacher or student's hand resting on the balloon. This feeling of increased pressure results from an increase in kinetic energy (higher

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temperature) and increased movement of helium particles inside the balloon. As the particles inside the balloon move around more quickly, they collide with each other more frequently, and move farther apart and collide with the balloon wall. Thus, the helium inside the heated balloon takes up more space inside the balloon and decreases its density. Density here refers to the number of particles in a given space -- if the particles in a substance are spread out more, but the mass of the substance does not change, then the substance has a lower density.

In the *Explain*, students use new information to revise their initial ideas of how oceanic and atmospheric circulation influences climate around the planet. By analyzing a reading passage and a series of diagrams, the idea of convection due to temperature and density differences is reinforced. The additional effects of salinity on density and ocean currents is also introduced as a way to describe the mechanism of ocean circulation near the Poles. Finally, students consider how oceanic and atmospheric circulation, caused by a combination of salient factors reinforced or introduced during the *Explain*, helps to explain why Rome and New York City have different winter climates.

Using a scaffolded modeling approach in the *Explain*, students identify the components, and the interactions between components of the oceanic and atmospheric circulation models separately. Then, they combine the components and interactions into one unifying model with an explicit focus on academic vocabulary in the *Elaborate*.

Conceptual Explanation for Phenomenon:

Water Movement - Greater heating near the equator leads to higher average air temperatures near the equator, closer to the surface of the Earth. The higher temperature air near the Earth's surface rises due to density differences and displaces air directly above it upward. As the warmer air rises and moves further away from the equator, it cools and sinks back down towards the Earth's surface, completing a convection current and resulting in the movement of air felt as wind.

Surface Ocean Currents - Wind pushing across the ocean surface causes waves which drive the movement of water and ocean currents near the ocean surface. Also, as wind blows across the ocean surface, the surface water cools, becomes denser, causing it to sink to lower depths in the ocean. As the cool water sinks, it displaces the water below, pushes water back up towards the surface where it warms and becomes less dense. This type of water movement or convection occurs closer to the equator.

Deep Ocean Currents - Near the Poles, where the water is generally cold across all depths, convection is driven mainly by salinity. As water near the surface freezes, the salt in the water is left behind. This makes the water beneath the ice denser and causes it to sink deeper into the ocean. As the more saline, more dense water sinks near the Poles, water is pushed away from the Poles, along the ocean floor, resulting in deep ocean currents. The process continues as the cold, salty water approaches the warmer waters near the equator once again, and rises to the surface.

Why is Rome warmer than New York City on average? - As a result of oceanic and atmospheric circulation, the heat concentrated near the equator becomes redistributed around the Earth. Therefore, along with latitude, regional climate depends in large part on one's proximity to surface and deep ocean currents. Areas near New York City experience warm surface currents coming up from the Gulf of Mexico and very cold deep currents coming down

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from Greenland. The intersection of these currents causes the water and the surrounding air to cool. Simultaneously, the intersection of these currents displace water eastward, away from North America, and towards Europe. Since there is relatively little land near the Arctic over Europe, there is very little cold deep ocean water mixing with the surface ocean currents near the Western European coast. Therefore, all the surface water that travels eastward across the Atlantic warms as it absorbs sunlight, until it finally reaches Western Europe, and cities like Rome.

Why is Rome even warmer than New York City during winter months? - During winter, the cold deep currents from the Arctic grow stronger because colder surface temperatures allow for greater formation of ice at the ocean surface. As this occurs, the amount of high salinity, denser water increases thus driving more cold ocean currents southward towards the warm water moving northward, along the eastern coast of North America from the equator. In areas near New York City, these currents mix and result in cooler average air temperatures during the winter. By contrast, areas near Western Europe do not experience a significant increase in cold deep ocean currents originating near the Arctic. Therefore, water reaching Western Europe is warmer, contains greater thermal energy, which is then transferred to the air, thus warming cities in this region, like Rome.

Beyond the PE's – It's also known that high atmospheric circulation patterns, known as jet streams, also help account for some of the variation in surface temperature differences between New York City and Rome. However, this explanation uses concepts beyond the PE's for this unit, and therefore they are not described here. If students explain the temperature differences between the cities by primarily describing patterns of atmospheric circulation, rather than ocean currents, invite them to pursue online resources as an alternative. Giving students this option helps reinforce how scientific understanding develops from sometimes competing and sometimes cooperating ideas, and that ideas gathering the most verified evidence tend to be accepted.

Understanding how patterns of atmospheric and oceanic circulation function to distribute heat around the Earth forms a productive foundation for students to then consider how water cycles between the land, ocean, and atmosphere.

Academic Vocabulary

- Latitude
- Temperature
- Heat
- Oceanic Circulation
- Ocean Current
- Atmospheric Circulation
- Wind
- Convection
- Convection Cell
- Coriolis Effect
- Particles
- Density
- Salinity

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Task 2: Climate Part 2 – Oceans and Atmosphere

Time Needed (Based on 45-Minute Periods)

8 Days

- Engage: 1 period
- Explore: 2 periods
- Explain: 2 periods
- Elaborate: 2 periods
- Evaluate and Reflection: 1 period

Materials

- Unit 2, Task 2 Student Version

Engage

- One 3" x 5" index card per student
- One large poster per group
- Markers

Explore

- Projector and speakers
- Youtube Video - <https://www.youtube.com/watch?v=bN7E6FCuMbY>
- Mylar balloon filled with helium (two balloons suggested)
- Straw (or chopstick, used to partially deflate helium balloon)
- Electric heating pad (or hair dryer as alternative)

Explain

- Article: *How Do Air and Water Move Around Our Planet?* per student

Elaborate

- One world map handout (with New York City and Rome labeled) per group, preferably enlarged to poster size
- One large poster per group
- Markers

Evaluate

- Project Organizer Handout

Instructions

Engage

1. Introduce Task 2: In Task 1, you figured out that because of the Earth's tilt and its position around the Sun, regions near the equator are warm, and that it gets cooler as you move further away from the equator. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
 - Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.

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Task 2: Climate Part 2 – Oceans and Atmosphere

2. Transition to Task 2: If you take two cities that are the same distance north of the equator, do you think their climate would be identical? Besides a region's distance from the equator, what else might affect the climate in a specific location? In this task, we will investigate a phenomenon related to these questions.
 - Now pass out their Task 2 student guide.
3. Students likely understand now that regions near the equator tend to receive the most incident sunlight, and therefore are warmer on average than areas north and south of the equator. Students may also believe that locations sharing similar latitudes will have similar climates because they are the same distance from the equator and therefore receive similar amounts of energy from the Sun. This activity serves to challenge that prior knowledge.
4. First project the world map highlighting the locations of New York City and Rome. Then, project a slide displaying the data in their Student Guide:
 - This exercise emphasizes the supplementary CCC of **Patterns** as students use the graphs to identify patterns in data.
5. Prompt students to consider the discrepancy in the displayed data.
 - *According to what you figured out in Task 1, why should they have nearly identical climates?*
 - *According to the data, do Rome and New York City have identical climates?*
6. Prompt students to individually read and respond to the prompt – *“Explain how the temperatures in January could be so different for two cities at nearly identical latitudes.”* Students should write their explanation on an index card.
7. In groups, prompt students to share their cards, by reading them aloud and then placing them on the table for all to see.
 - As a group, students must construct an explanation using ideas or parts of ideas from each individual index card. This will be the group's consensus explanation.
 - Ask each group to write their group explanation on a large poster paper.
8. Conduct a gallery walk.
 - Time permitting, encourage students to share comments and leave feedback on post-its for each poster.
 - As a class, ask for volunteers to share one strength for each group poster.
9. As a class, invite students to come up to point out patterns they notice in the data, and to indicate on the world map what they think may be happening.
 - Students may indicate that Rome seems to be separated from the Atlantic Ocean, and that it's nearer to a large body of water that may be warmer than the Atlantic Ocean.
 - Students may know that warm water usually moves up the eastern coast of the United States from the Gulf of Mexico. Push them to explain why the area around New York City is still cooler than Rome even with warm water from the Gulf of Mexico.

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Task 2: Climate Part 2 – Oceans and Atmosphere

10. Explain to students that their group explanation will be revisited later as more information is available, and that they will have opportunities to revise their explanations.

Note: The average annual temperature graphs for New York City and Rome come from the following online resources:

- New York City - https://www.holiday-weather.com/new_york_city/averages/#chart-head-temperature
- Rome - <https://www.holiday-weather.com/rome/averages/>

Consider using the same online resource to find average annual temperature data for other locations at similar latitudes should you think your students will be more motivated to think about locations closer to your school. However, to align closely with the performance expectation selected for this task, you will need to select coastal cities as these are most affected by ocean currents. Though you may notice a similar pattern using inland cities, the explanation for why they have different climates at similar latitudes has more to do with atmospheric circulation and less to do with ocean currents.

Explore

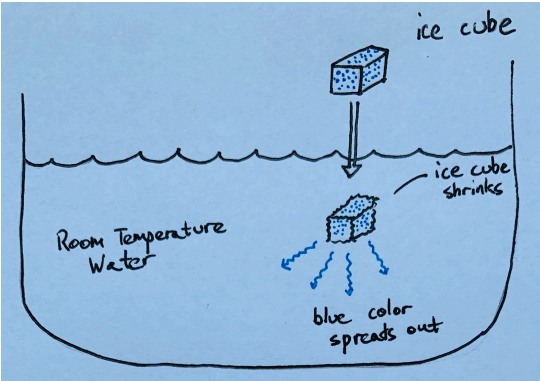
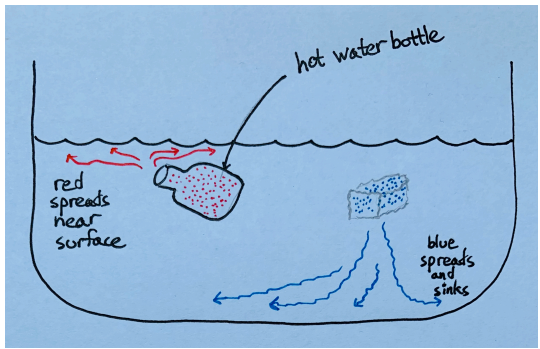
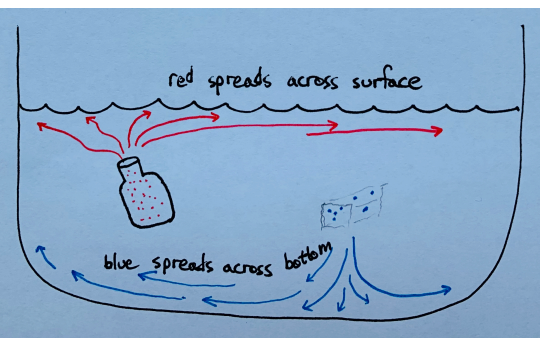
1. After students propose preliminary ideas about why New York City and Rome have such different average annual temperatures, this activity engages students with two models designed to help them think more about how movement in the ocean and atmosphere contributes to differences in regional climates.
 - Students will first be introduced to an Ocean Circulation Model using a video demonstration. (*Preparation Note* – You may also demonstrate the mixing of cold and hot water similar to what is shown in the video rather than show the video. Though this requires materials and greater preparation, students may find the experience more engaging and interactive.)
 - Students will then be introduced to an Atmospheric Circulation Model using a helium balloon demonstration.
 - These demonstrations emphasize the CCC of **Systems and System Models** as students see models that represent atmospheric and oceanic systems and their interactions.

Ocean Circulation Model

2. Load and cue the “Warm Air Rises – Cold Water Sinks, Warm Water Rises” video (<https://www.youtube.com/watch?v=bN7E6FCuMby>).
 - **Mute the sound** so the class does not hear the explanation for why cool water sinks and warm water rises. At this point, students will have difficulty understanding the role of density and how it relates to the temperature of water. Students will have a chance to consider density during the *Explain* activity.
3. Describe the context for the video
 - The person will first put an ice cube filled with blue food coloring into a tank of water
 - The tank contains room temperature water
 - The person will then place a bottle of hot water and red food coloring into the tank
4. Tell the class that you will play this video twice – once just to watch, and then again to watch and write down what they notice and wonder. Emphasize that this exploration is about gathering as much data as possible by observing what happens.

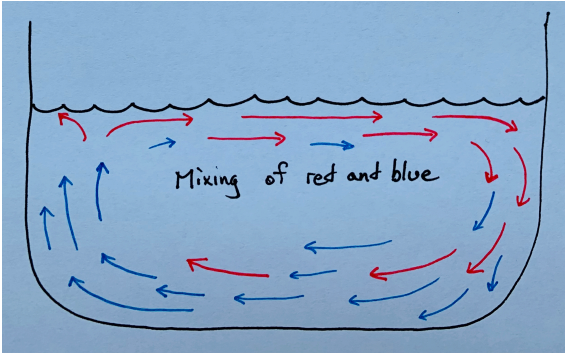
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5. Play the video from 1:20 until 2:15.
 - After the first viewing, ask students what they notice, and what the demonstration makes them wonder or think about.
 - Play the video a second time.
 - Prompt students to use the blank diagrams in their handbook to record their observations individually. See possible diagrams below:

Observations	
<p>What happens when the ice cube is first placed in the water tub?</p>	
<p>What happens when the hot water is first placed in the water tub?</p>	
<p>What happens after you wait a while?</p>	

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6. Ask students to discuss their observations with their group, and then to predict what the tank might look like after one hour has elapsed.
 - Remind students to write their predictions, in their handbook.
 - Remind students to write/draw an explanation for their prediction in their handbook.

Possible Student Prediction	
Possible Student Explanation	<p><i>After one hour, the hot water (red) will begin to cool and the cold water (blue) will begin to warm. As this happens, the red water from the surface will begin to sink, and the blue water near the bottom will begin to rise. Eventually, all the water will mix enough so that you cannot tell red from blue any longer.</i></p>

Atmospheric Circulation Model

7. Set up the helium balloon demonstration
 - Plug in a heating pad and set it to the highest setting.
 - Deflating the balloon:
 - Start with an inflated mylar helium balloon, and gently insert a straw into the bottom valve of the balloon.
 - Slide the straw in until you break the seal inside the valve, and you hear or notice helium starting to escape.
 - Gently squeeze the balloon allowing enough helium to escape so that the helium balloon only rises 1-2 feet above the ground.
 - Use light objects such as binder clips, paperclips, or post-its to weigh down the balloon slightly if it tends to rise too high.
 - *Preparation Note* – It may take a few minutes to deflate the balloon properly. If you do not have time to do this during class, consider preparing the balloon before class. However, be sure to always have a spare inflated balloon in case one pops, and also to show the class what the balloon looked like before removing helium.
 - Heating the balloon:
 - Remove any cloth insulation from around the heating pad to permit maximum heat transfer from the pad to the balloon surface.
 - Hold the partially deflated balloon down on the heating pad for 10-15 seconds.
 - Turn over the balloon to heat both sides.

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Task 2: Climate Part 2 – Oceans and Atmosphere

(*Observation Note* - You may begin to feel the walls of the balloon pushing back on your hand as the warm helium begins to expand. The balloon may even begin to make a crinkling sound as it expands. Bring this to students’ attention and explain that it feels like the balloon is getting bigger. Consider inviting one student to touch the balloon at this time.)

- When properly heated, the balloon should rise to the ceiling once you let go. It will likely then sink back down seconds later once the balloon cools down.
- *Preparation Notes* – Should your heating pad not reach a high enough temperature, you may also use a hot air dryer to heat the balloon. However, be sure that the dryer is turned off completely before releasing the balloon to avoid confusion about how wind from the dryer may be pushing the balloon higher.

8. Following the demonstration, prompt students to individually record their observations before and after heating, and then to explain what they think happened during the demonstration.
 - To help students construct explanations, it may help to recap and record some of the shared observations from the class. We encourage using equity sticks to foster more equitable participation in class-wide discussions like these (See “How To Use This Curriculum” for more details).

Possible Student Explanation	<i>As the balloon becomes partially deflated, the balloon surface looks wrinkly and you can easily press down on the surface of the balloon. At this point the balloon hovers or floats just above the ground. As you heat the balloon’s surface using the heating pad, the balloon begins to make crinkling sounds and the balloon’s surface appears to expand and press back out and against the hand holding it down on the heating pad. When you let go of the balloon, it rises into the air until it reaches the ceiling. If you wait long enough, the balloon begins to sink back down towards the ground.</i>
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Comparing Models

9. Prompt groups to compare and discuss their explanations for both models. Students should identify at least two similarities and two differences between the oceanic and atmospheric models.

Possible Similarities	<ol style="list-style-type: none"> 1. <i>There is up and down movement.</i> 2. <i>Movement up seems to be associated with warmer temperatures.</i> 3. <i>Movement down seems to be associated with cooler temperatures.</i>
Possible Differences	<ol style="list-style-type: none"> 1. <i>Oceanic circulation involves water, while atmospheric circulation involves air.</i> 2. <i>Because we added color to the water, we can actually see the different temperatures of water moving.</i> 3. <i>Because we contained the helium inside a balloon, we could see/feel what the helium inside the balloon was doing as the temperature changed.</i> 4. <i>The balloon seemed to move faster than the water.</i> 5. <i>We needed a heating pad to warm the balloon.</i> 6. <i>We didn’t warm part of the water with a heating pad – instead we put hot water into the room temperature water.</i>

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10. At this point, the main takeaway should be that warmer substances (water/helium) rise, and cooler substances sink. Though it is not necessary to push the idea of density differences at this stage, students may already be thinking about why the balloon felt like it was inflating when heated, but not when it was cool. Remind them of this and push to them to try to explain that phenomenon, but do not offer an explanation as this will come in the Explain activity.

Explain

- Now that students have observed how both water and air move as temperature changes, they are ready to uncover more of the mechanisms behind this movement, and then to apply their new understanding to figure out how New York City and Rome could have such different average winter temperatures.
 - Again, students emphasize the CCC of **Systems and System Models** as students use a reading to identify components and interactions of atmospheric and oceanic systems to begin building their own models.
 - Thus, students are also laying a foundation for the SEP of **Developing and Using Models** as they begin to think about the components and interactions in the oceanic and atmospheric systems. They will develop complete models in the *Elaborate*.
- Remind students of the original phenomenon from the *Engage*, and that in the *Explore* we observed how warm substances (water, helium) seem to rise, while cool substances seem to sink. Below are some facilitating questions to help prompt their initial thinking:
 - We observed some things during the Explore that may help us understand why New York City and Rome have such different climates even though they are at similar latitudes. Who can remind us of what we noticed?*
 - What was happening with the water in the ocean model demonstration?*
 - What was happening to the balloon in the atmospheric model demonstration?*
 - What new ideas do these observations make us think about?*
- Prompt groups to discuss the questions in their handbook tables, and then to explain (and/or draw) their initial ideas in the table as well.
 - Keep in mind that these are initial ideas that will likely change after completing the reading. Students are not expected to offer complete or correct responses at this point.
 - Optional Sentence stems include:
 - Water in the ocean moves because...
 - I think that the movement of water causes...
 - When water in the ocean moves...
 - Air in the atmosphere moves because...
 - I think that the movement of air causes...
 - When air in the atmosphere moves...
 - Possible responses may include:

6th Grade Science Unit 2: Extreme Living
Task 2: Climate Part 2 – Oceans and Atmosphere



<p>How do you think the movement of water in the ocean contributes to the temperature difference between Rome and New York City in January?</p>	<p>How do you think the movement of air in the atmosphere contributes to the temperature difference between Rome and New York City in January?</p>
<p><i>Since cold water seems to sink and warm water seems to rise, perhaps this is how water moves around in the oceans. The water near the surface is warmed by the Sun, but as it moves towards areas with less direct sunlight (away from the equator), then it cools and eventually sinks. Maybe as the water in the ocean moves around, warmer water somehow makes its way towards Rome and cooler water is found near NYC.</i></p>	<p><i>Near the equator, the air above the Earth’s surface receives more direct sunlight and thus warms up more than air away from the equator. Therefore, the air near the equator rises up and the air away from the equator is cooler and thus sinks back towards the Earth’s surface. Maybe as the air in the atmosphere moves around, warmer air finds its way towards Rome, while cooler air is found near NYC.</i></p>

4. Once most students have completed their tables, facilitate a class reading of the article, “How does air and water move around our planet?”
 - This activity involves a lengthy reading on how atmospheric and oceanic circulation operate. It is highly recommended that students employ an annotation strategy, such as “Mark It Up!” to better separate concepts.

5. After students complete the reading, they will participate in a scaffolded approach to modeling a complex phenomenon. This activity gives students the opportunity to identify the smaller parts of a complex system, to think about how to represent each part in a diagrammatic mode, and finally to consider how the parts interact with one another.
 - This protocol is especially useful at this stage since the practice of modeling is still difficult for many students and this is particularly complex content.
 - This process of identifying components in the reading and drawing corresponding representations helps students to comprehend the new scientific concepts in the reading.

6. Prompt students to first work individually to complete the Components section of the table.
 - Possible components for each system may include, but are not limited to:

	Oceanic Circulation System	Atmospheric Circulation System
<p>Components</p>	<ul style="list-style-type: none"> • surface water • deep water • temperature difference • density difference • convection • equator • Poles • sunlight • salt (or salinity) • wind • frozen water (or ice, iceberg) 	<ul style="list-style-type: none"> • sunlight • equator • Poles • temperature difference • density difference • convection • wind • Coriolis Effect

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Task 2: Climate Part 2 – Oceans and Atmosphere

- The variation in possible representations for these components is too diverse to be listed.
7. Once students have completed their component lists and at least attempted several representations on their own, facilitate a Gallery Walk. This activity allows to not only check for missing system components, but also as a way to share their ideas for representations.
- *Focus on equity* – reinforce the idea that sharing and borrowing ideas is acceptable in science as long as proper credit is given. Proper attribution for ideas helps safeguard against the feeling of “stealing ideas”. Other scientists often have ideas worth using in order to better understand how complex phenomena operate.
8. The Interactions portion of the table may be done in partners within their group.
- *Facilitator Note* – This part of the activity may take more scaffolding and explaining. Consider modeling how to do this by constructing a simpler diagram with just a few components such as surface water, deep water, and temperature. Ask a student to explain the relationship between these three parts, and diagram it while they talk.
 - For example, as warmer, higher temperature water tends to rise, cooler water tends to sink.
 - Then ask, “How can we add sunlight to this diagram?”
 - At this point, you may consider whether or not to continue modeling more interactions for the class, whether your students can do this in partners, or if they are prepared to do it individually.
9. Note on reading content:
- The section on atmospheric circulation intends to help students develop a simple single-cell model of how air circulates in the Earth’s atmosphere. This model assumes that the Earth does not rotate, and that the Earth is not tilted. For the sake of understanding that convection is driven by temperature, and thus density differences, this model is sufficient. To understand greater complexities in climate patterns, the more complex three-cell pattern is needed (Figure 3), but this is unnecessary and inappropriate at the middle school level. The single-cell model can be further developed into the three-cell model in high school.
 - Though this task focuses mainly on how bodies of water, ocean currents, and atmospheric circulation affect climate (see the performance expectation), it is true that landforms also impact local climates. For example, mountain ranges can block atmospheric circulation and thus create very wet regions on the windward side of mountains, while creating very dry, arid regions on the far side (leeward) of mountains. Due to time constraints, this idea is not taken up in the Explain activity.

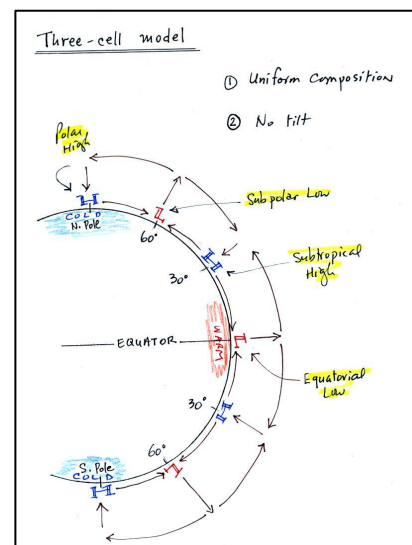


Figure 3

6th Grade Science Unit 2: Extreme Living

Task 2: Climate Part 2 – Oceans and Atmosphere

Elaborate

1. Now students can combine all the components and interactions together in order to describe how oceanic and atmospheric circulation influence climate. In this activity, students work in groups to create one model to explain how Rome could have higher average January temperatures than New York City.
 - This task allows students to practice the SEP of **Developing and Using Models** as they develop a complete model to describe why Rome has higher average winter temperatures than New York City.
 - This task also emphasizes the supplementary CCC of **Energy and Matter**: The transfer of energy can be tracked as energy flow through a natural system. In constructing an explanation for the phenomenon, students will need to consider how thermal energy moves through multiple complex systems.
2. Distribute materials to groups and assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Facilitator, Materials Manager, Harmonizer, and Reporter.
 - Ask the Facilitator to read the directions and to make sure everyone understands the task.
 - Ask the Materials Manager to gather the materials needed to complete the task.
 - Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone’s voice is heard.
 - Ask the Reporter to make sure the group is reporting all relevant components and interactions on their poster.
 - *Facilitator Note* - A blank world map is provided for students as a scaffold for this final model. Explain to students that it may be easier to first develop a model of how the two systems interact with one another to influence climate in general. Then, they can use the world map to show how the two systems interact differently to influence climate in various locations around the Earth, including near New York City and Rome.
2. To help groups construct their models:
 - Encourage students to construct several drawings depicting the movement of water and air separately near both cities.
 - Remind students that the phenomenon in the Engage indicates that the difference in average annual temperatures seems to be greater during winter. Though more difficult, it may help to remind students to think about seasonal variation (see Task 1) to help them account for this.
 - After allowing students to struggle and attempt various explanations, you might consider bringing the class back together in order to “take stock” of ideas. Write a list of ideas that the class generates. The class may need some further guidance to see which ideas are relevant. You can do this by circling relevant ideas from the longer list of generated ideas. Then, allow the groups to reconsider their explanation with the list of circled, relevant ideas.
 - Remind students to check their final model against the list of criteria.
3. The models are a good option for formative assessment. Collect group posters to identify trends in students’ ability to use models to describe how oceanic and atmospheric circulation influences climate. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.
 - For a full explanation see the “Content Background for Teachers” section above.

6th Grade Science Unit 2: Extreme Living**Task 2: Climate Part 2 – Oceans and Atmosphere**

4. Once students have completed their models, facilitate a Gallery Walk. This activity allows to identify errors or parts that are unclear before they move to their Project Organizer.
5. Optional: Debrief the scenario as a class, coming to consensus on why Rome has higher average January temperatures than New York City. Co-construct a model on the board based on the discussion.
 - Again, we encourage using equity sticks to foster more equitable participation in class-wide discussions like these (See “How To Use This Curriculum” for more details).
6. Return to the whole-class concept map from the Lift-Off Task.
 - In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See “How To Use This Curriculum” for more details).
 - Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
 - Draw circles around each question and boxes around each concept.
 - Write connector words to describe connections between the concept boxes.
 - For this task, students may begin to connect some of their previous question circles to concept boxes about the following: a key cause of geographic climate variation – distribution of heat (energy from sunlight) around the planet through ocean currents and atmospheric circulation.
 - Have students analyze the additions to the class concept map for as many examples of this task’s crosscutting concept as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
 - **Systems and Systems Models:** These could be phrases such as, “is a part of” “connects to,” “interacts with,” “is made up of,” “works together with,” etc.
 - Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deeper connections about science content, but will also help their oral and written language development.

Evaluate: Connecting to the Culminating Project

1. Students independently complete the Task 2 section of the Unit 2 Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.
2. Students have been asked to design a product that makes it more comfortable for people to live in a region with an extreme climate. Their prompt is as follows: Research the region you selected.

6th Grade Science Unit 2: Extreme Living

Task 2: Climate Part 2 – Oceans and Atmosphere

- ✓ Construct a model to explain how atmospheric and oceanic circulation affect the climate in your region.

Reflection

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:
 - At the beginning of this task, you were introduced to a phenomenon (New York City/Rome) that did not seem to follow expected climate patterns. By using models in this task, do you feel confident that you can explain the phenomenon to your parents? Why or why not?
 - In this task, we focused on the crosscutting concept of: **Systems and System Models**: Models can be used to represent systems and their interactions. Where do you see examples of **System and System Models** in this task?
 - Now that you have learned more about how oceanic and atmospheric circulation affect local climates, what questions do you still have?
2. There are no right answers, but encourage students to look back at their student guides and their class concept map. They should not change their initial responses, but rather use this reflection space to add to their ideas and questions based on what they have learned through this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and gathering knowledge and skills for their final projects.

Assessment

1. You may collect students' Project Organizer and assess using:
 - *Criteria of your choice*. We recommend using the 3-Dimensional Assessment matrix at the beginning of this document to inform your criteria.
 - This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching as necessary.
2. You may also give students time to make revisions with one of the two options:
 - Students may make changes to their Project Organizer according to your comments OR
 - Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.

How Do Air and Water Move Around Our Planet?

Explain Article

Atmospheric Circulation

As you learned in Task 1, the Sun heats the Earth more near the equator than at the Poles. This difference in heating around the globe is partly responsible for the pattern in how air moves around the atmosphere. Near the equator, where there is more direct sunlight, the air heats up more than near the Poles (see figure 1).

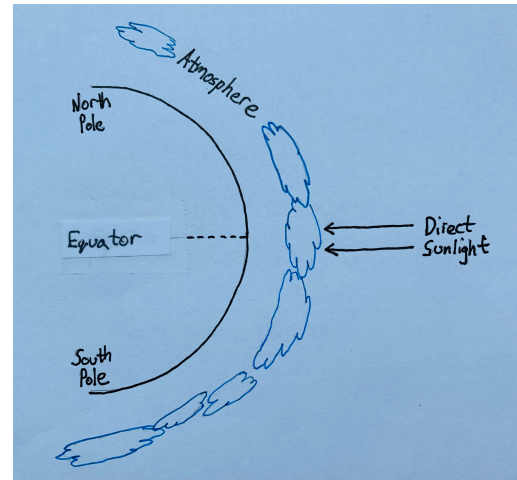


Figure 1

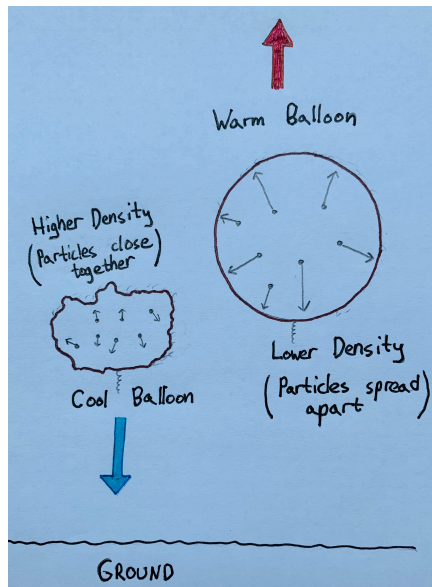


Figure 2

You might remember that during the helium-balloon demonstration (Explore), as the balloon was heated, the balloon looked and felt as though it was expanding. As the temperature of the particles inside the balloon increases, they gain more kinetic energy, and thus begin to move faster. Due to their increase in movement, the particles spread out more inside the balloon (see figure 2).

When objects or particles spread out in a limited space, we say they become less dense. Similar to the balloon, as air in the atmosphere heats up, particles in the air move faster, spread apart, resulting in air that is less dense. Just as we saw when the balloon rose when heated, warmer, less dense air also moves higher into the atmosphere (see figure 3).

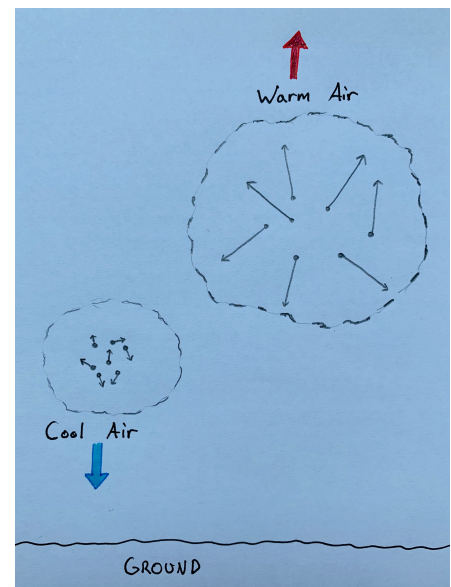


Figure 3

As the less dense air rises and continues to spread out, it begins to move away from the equator and towards the Poles where it is cooler. As the air moves towards the Poles, it cools, becomes denser, and sinks back down towards the Earth's surface. This brings cooler temperatures back to the Earth's surface further away from the equator (see figure 4).

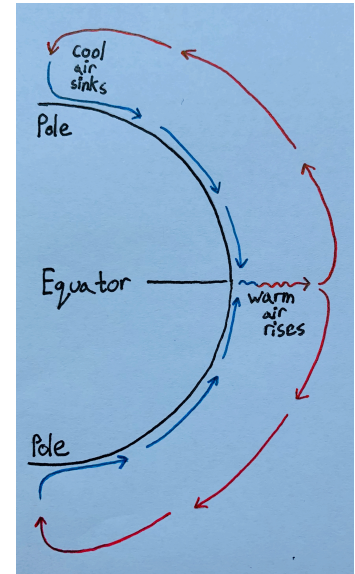


Figure 4

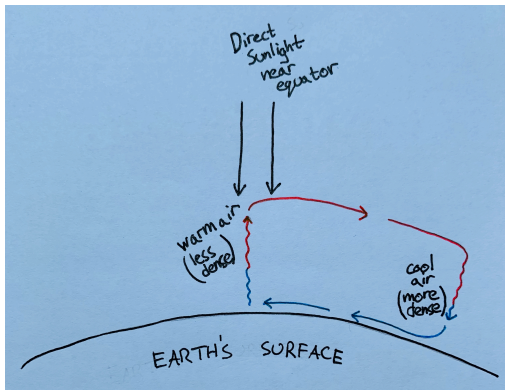


Figure 5

This pattern of air cycling or movement forms a **convection cell**, like the one shown to the left (see figure 5).

Remember also, that because the Earth is spinning, the air moving from the warmer equator towards the cooler Poles, also turns slightly with the spin of the Earth. Air that moves north from the equator turns in a clockwise pattern, while air traveling south from the equator turns in a counterclockwise pattern. The movement of the air due to Earth's spin is called the **Coriolis Effect** (figure 6).

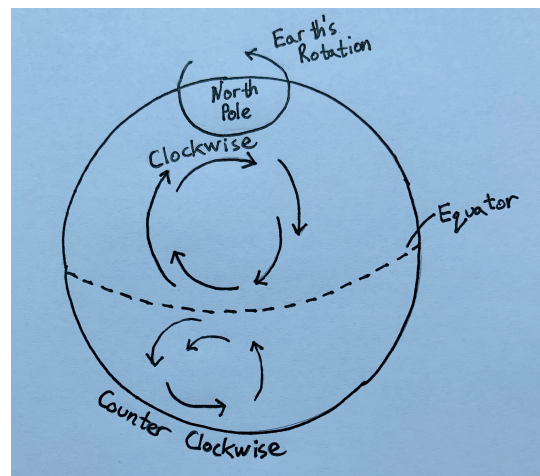


Figure 6

Oceanic Circulation

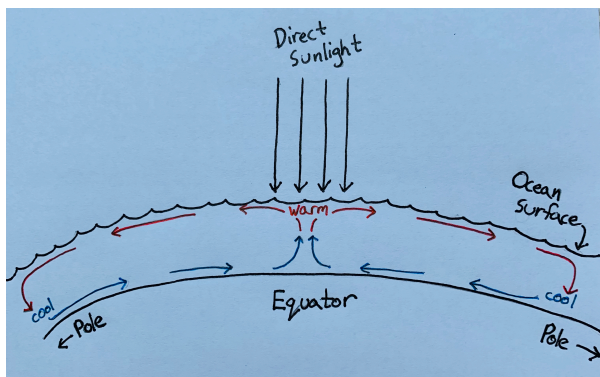


Figure 7

Similar to how air moves in response to temperature and density differences, water also forms a convection cell with warmer, less dense water rising and cooler, denser water sinking. As a result, water in the ocean moves and can form **ocean currents** (see figure 7). As we see in the diagram, ocean currents near the equator move warmer, less dense water towards the poles. Once water near the ocean surface reaches the poles, it cools, becomes denser and then sinks deeper into the ocean. This continuous cycle eventually pushes cold water back towards the surface near the equator to replace the water that has moved away.

Besides temperature differences, the movement of water near the ocean surface is also caused by the wind at the surface. Remember that warm air moves away from the equator and towards the cooler Poles. As this air moves, wind forms, which blows across the surface of Earth. As wind blows across the surface of the ocean, it cools the surface water, making it denser and causing it to sink deeper into the ocean (see figure 8).

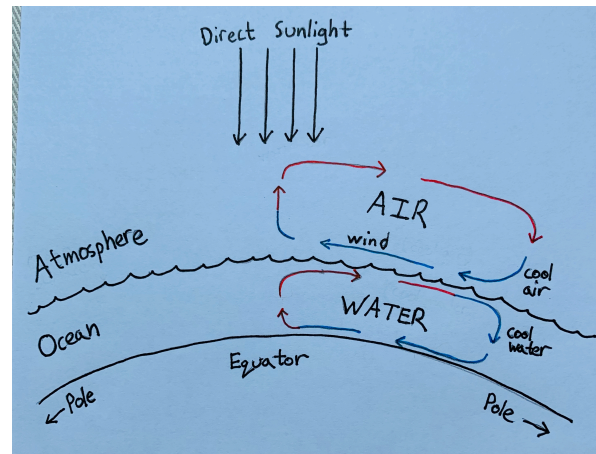


Figure 8

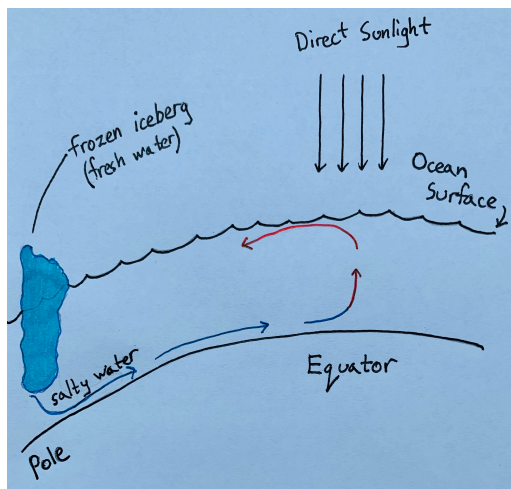


Figure 9

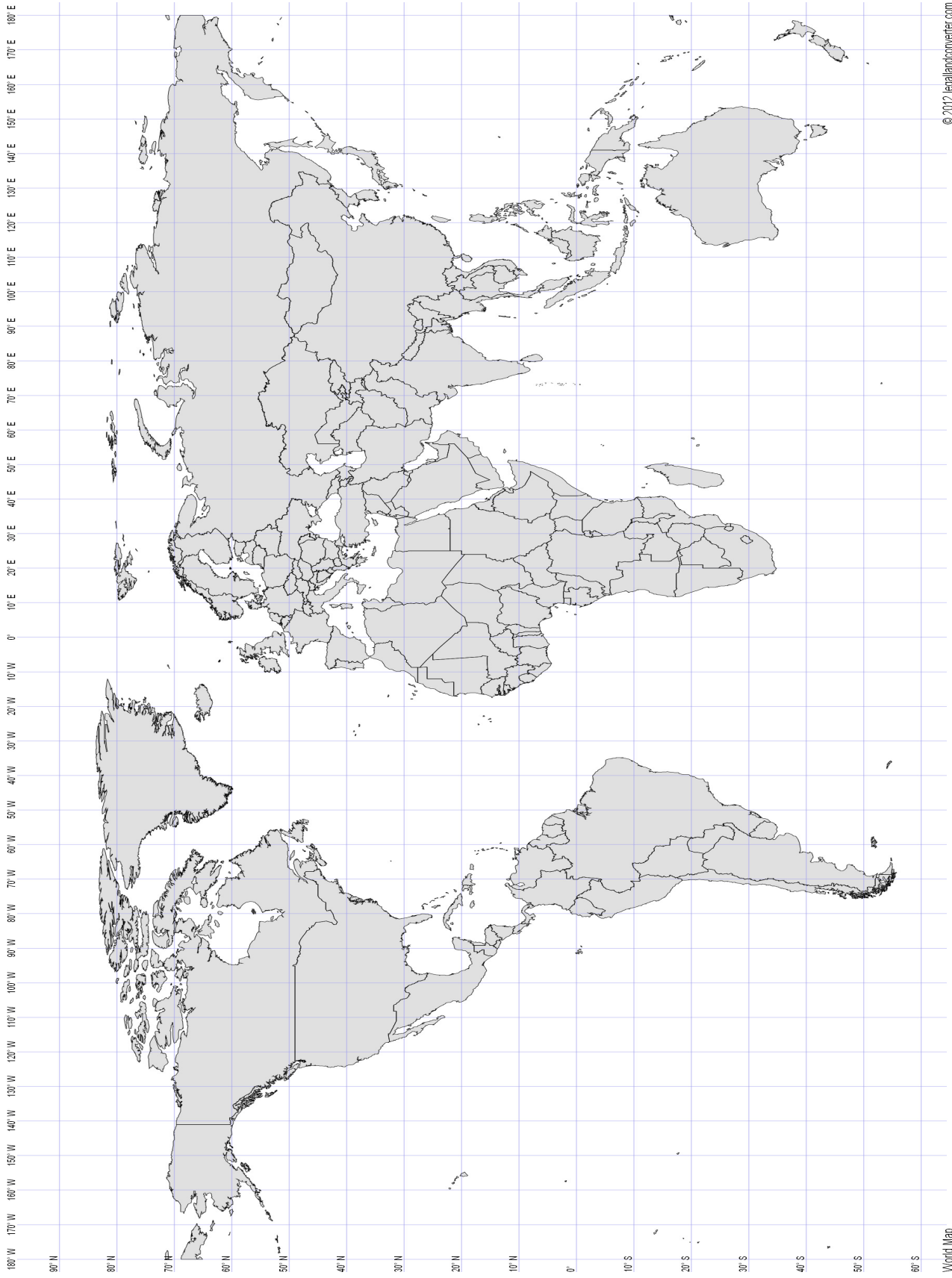
Finally, there is one more factor that affects ocean currents – **salinity**. Salinity is a measure of the amount of salt in water. Water that contains more salt also contains more particles of matter packed tightly together, thus making it denser. Therefore, very salty water tends to sink, while less salty water tends to rise. It is easiest to see how this works if we think about the Poles, where it gets very cold and the water at the surface begins to freeze. At the Poles, surface water freezes at 32F (0C), while salt gets left behind since salt water freezes at a lower temperature (28F, -6C). This salty water below the frozen surface becomes denser as more salt gets left behind, and it begins to sink. As the dense, salty water sinks near the Poles, it pushes cold water away from the Poles and back towards the equator where it warms once again (see figure 9).

Redistribution of Heat

At the equator, where the Sun's light is the most direct, there is more energy contained in the air and water. Atmospheric and oceanic circulation helps to move and redistribute this energy all around the Earth. Some parts of the Earth end up with higher or lower temperatures than you might expect because of wind and ocean currents. As we look at larger patterns of air and water movement on our planet, we gain a clearer picture of why we find certain temperatures and climates at specific locations.

World Map

Elaborate



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World Map

6th Grade Science Unit 2: Extreme Living
Task 3: A Water Molecule’s Journey



Unit Essential Question: *How do people use technology to survive in regions with different climates?*

Introduction

In the last two tasks, students explored what causes the different climates they can observe around the world. In this task, they delve into one important aspect of these climates—the water cycle. While students have been exposed to pieces of the water cycle in previous tasks, this task asks them to focus on the specific reservoirs for water, and the mechanisms that move water, allowing them to form a cohesive picture of the water cycle. In this task, students do a kinesthetic activity to take the journey of a water molecule, allowing them to explore the places where water can be found and how it travels. As students compare their journeys with other students, they will realize that water does not take a linear journey, but instead water continuously cycles throughout Earth’s systems. They then use these ideas to construct a poster model that shows the water cycle and dispel a common misconception associated with the evaporation of water. In the end, they will be able to apply their learning to consider how the water cycle creates some of the climate conditions in their chosen region for their culminating project.

Alignment Table

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>MS-ESS2-4. Develop a model to describe the cycling of water through Earth’s systems driven by energy from the sun and the force of gravity. [Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]</p>	<p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop a model to describe unobservable mechanisms. 	<p>ESS2.C: The Roles of Water in Earth’s Surface Processes</p> <ul style="list-style-type: none"> Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. Global movements of water and its changes in form are propelled by sunlight and gravity. 	<p>Energy and Matter</p> <ul style="list-style-type: none"> Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.
<p>Equity and Groupwork</p> <ul style="list-style-type: none"> Discuss and compare journeys with group members to combine information into one cohesive model. Participate in group roles to develop a model of the water cycle. Give and receive feedback. Discuss ideas within the <i>Critique, Correct, and Clarify</i> technique. 			

6th Grade Science Unit 2: Extreme Living**Task 3: A Water Molecule's Journey****Language**

- Use sequence language within written observations and a visual model.
- Compare and contrast journeys with group members.
- Use the *Critique, Correct, and Clarify* method to improve language and content.

Learning Goals

This learning task asks students to develop and use models to describe the cycling of water through Earth's systems. More specifically, the purpose is to:

- Engage prior knowledge of where water can be found on Earth.
- Explore the water cycle through a kinesthetic simulation.
- Explain the water cycle through a visual model.
- Use the *Critique, Correct, and Clarify* method to dispel a common misconception about the water cycle.
- Apply knowledge of the water cycle to explain climate conditions in a chosen region.

Content Background for Teachers

In this task, students explore the water cycle—the movement of water through Earth's systems, driven by energy from the Sun and the force of gravity. While commonly taught as a linear sequence, keep in mind that the water cycle really has no starting point because it is a cycle.

Most water on Earth is found in saltwater in Earth's oceans. The sun, which is the energy source that drives the water cycle, heats ocean water. This causes a process called evaporation, in which liquid water changes state into water vapor. This water vapor goes up into the atmosphere. Another way water gets into the atmosphere is through a process called transpiration, in which water evaporates from pores in the leaves of plants undergoing photosynthesis.

When water vapor rises into the atmosphere, it cools, causing it to condense into clouds. When these clouds get heavy enough, gravity (another important force in the water cycle) pulls water down to the ground as rain, sleet, snow, or hail. This is known as precipitation, or in the case of snow, crystallization. Snow can accumulate as ice caps and glaciers, which can then melt and flow overland into various surface water reservoirs (i.e. rivers, lakes, streams, etc.). Rain can fall directly into these surface water reservoirs or the ocean, or it can fall onto land first, where due to gravity, it flows over the ground. This process is called surface runoff, and this water will eventually flow into surface water reservoirs or oceans. Alternatively, rain can seep into the soil and eventually become part of groundwater. Plants and animals also use water from all these reservoirs in order to survive and grow. When animals die, exhale, or excrete, this returns water to the cycle.



For more information on all of the components and interactions of the water cycle, please reference the *Explore* Station Cards provided.



6th Grade Science Unit 2: Extreme Living**Task 3: A Water Molecule's Journey****Academic Vocabulary**

- Atmosphere
- Surface Water
- Ground Water
- Glacier
- Ice Cap
- Evaporation
- Transpiration
- Condensation
- Precipitation
- Crystallization
- Surface Runoff
- Gravity
- Sun Energy

Time Needed (Based on 45-Minute Periods)

4 Days

- Engage: 0.5 period
- Explore: 1 period
- Explain: 1 period
- Elaborate: 0.5 period
- Evaluate and Reflection: 1 period

Materials

- Unit 2, Task 3 Student Version

Explore

- Water Molecule Journey Station Cards (2-3 per station) – Hang as posters around the room
- Tape
- Dice (1 per student)

Explain

- Poster Paper
- Markers
- Optional: Post-Its (3 per student)

Evaluate

- Project Organizer Handout

Instructions**Engage**

1. Introduce Task 3: In Tasks 1 and 2, you explored the causes of different climates around the world. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?

6th Grade Science Unit 2: Extreme Living**Task 3: A Water Molecule's Journey**

- Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.
2. Transition to Task 3: In this task, we will dig into one specific aspect of climate—water.
 - Now pass out their Task 3 student guide.
 3. This brainstorm activity asks students to call upon any prior knowledge they have about water on Earth. In pairs, students discuss the questions: What are some ways that water is a part of different climates? Where do we see water in different environments? They then make a list together in their Student Guides.
 - Encourage students to think back to how they defined climate at the beginning of Task 1 and picture different regions around the world. This should help spark ideas during their brainstorm.
 4. Share out ideas to create a class list on the board.
 - Students will come up with a range of different ideas, such as: rain, snow, hail, oceans, rivers, lakes, streams, ponds, etc. Some of the more difficult examples—like atmosphere, groundwater, plants, animals, etc.—may not come up during this brainstorm, but students will explore these ideas in the next section of the task.
 - We encourage using equity sticks to foster more equitable participation in class-wide discussions like these (See “How To Use This Curriculum” for more details).

Explore

1. In the rest of the task, students will focus on how water moves through Earth's systems and the role this plays in the climates people experience. To do this, they will take the journey of a water molecule by engaging in a kinesthetic modeling activity
 - This activity gives students practice at the SEP of **Developing and Using Models** as they use a kinesthetic model to explore the water cycle. Specific stations will also emphasize the CCC of **Energy and Matter** as students learn that the transfer of energy (i.e. energy from the sun) drives the cycling of water through Earth's systems.
2. Set up the stations around the room by posting 2-3 of each station card for students to visit. Explain the directions on their Student Guide. Then provide each student with a dice and assign each of them a station to start their journey.
 - Students will move from station to station by rolling the dice and reading the station card to find out where to go next. They should be recording information about each station and how/why they moved in the chart in their Student Guide. Continue this process until they have recorded 10 locations.
3. Possible Completed Chart
 - As you can see, students may or may not visit all stations and sometimes they will revisit a station. That is completely okay and helps them to see that this truly is a cycle, not a linear sequence.

6th Grade Science Unit 2: Extreme Living

Task 3: A Water Molecule's Journey

	Location and Description	Describe How You Travel To Your Next Location
1	Plants – Plants need water to grow.	The plant I was in died and decomposed, so I entered the soil.
2	Soil – Soils hold the water that all plants need to grow.	I was just the sort of molecule that plants needed to absorb through their roots, so now I go back into a plant.
3	Plants – Plants need water to grow.	An animal has eaten the plant I was in, so I go into an animal.
4	Animals – Animals need water to survive and do their daily activities.	The animal I was in released me as waste, so now I am in the soil.
5	Soil – Soils hold the water that all plants need to grow.	I gathered on the surface of the soil and so now I am part of surface water.
6	Surface Water – Surface water is any water found above the Earth's surface, such as lakes, rivers, streams, and creeks.	The sun heated my fellow water molecules and I from a liquid into a gas, so I am now a part of the atmosphere. This process was called evaporation and was driven by energy from the sun.
7	Atmosphere – The atmosphere is the air surrounding the Earth, which contains plenty of water in the form of water vapor (a gas).	As temperature decreased, I joined with other water molecules in the air to form a cloud. This is called condensation.
8	Clouds – Clouds are a visible mass of condensed water molecules.	The temperature decreased, and we became heavy enough, gravity pulled us down to the ground in the form of snow. This process is called crystallization.
9	Ice Caps and Glaciers – Glaciers and ice caps store freshwater in frozen form.	Energy from the Sun heated my friends and I from solid form into liquid form. Propelled by the force of gravity, we flow over the ground and into the ocean in a process called surface runoff.
10	Ocean – Oceans store most of the water on Earth.	The sun heated my fellow water molecules and I from a liquid into a gas, so I am now a part of the atmosphere. This process was called evaporation and was driven by energy from the sun.

Explain

- In this activity, students in each group compare their different journeys, identifying similarities and places where their paths diverged. The goal of this activity is for students to combine all their journeys to make a poster map that represents a comprehensive picture of the water cycle.
 - This activity gives students more practice at the SEP of **Developing and Using Models** as they co-construct a complete visual model to describe the water cycle they just explored. The last bullet point in the list of criteria asks students to emphasize the CCC of **Energy and Matter** as they identify the energy from the sun and the force of gravity that drive the cycling of water through Earth's systems.
- Make materials available to students and assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Facilitator, Materials Manager, Harmonizer, and Reporter.

6th Grade Science Unit 2: Extreme Living**Task 3: A Water Molecule's Journey**

- Ask the Facilitator to read the directions and to make sure everyone understands the task.
 - Ask the Materials Manager to gather the materials needed to complete the task.
 - Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone's voice is heard.
 - Ask the Reporter to make sure the group is reporting all relevant components and interactions on their poster.
2. Review the instructions with students. Make sure that students understand that their model should include pictures, words, and arrows, and should meet the list of criteria in their Student Guides. Take any questions before students begin.
 - While each student may not have visited all the stations, it is likely that amongst all the group members, all of the stations were visited.
 - Encourage students to return to the stations, as necessary, to gather more information that they feel was missing from each of their group members' journeys.
 3. If you feel your students need more support, one optional scaffold is to provide a word bank of terms students must use in their model. Use the list of Academic Vocabulary at the beginning of this Teacher Guide to help you decide on a bank of terms.
 4. We highly recommend doing a gallery walk at the end of this activity, so students can showcase their work and gather feedback.
 - Provide each student with a few post-its that they can use to leave specific feedback on different groups' posters as they do the gallery walk.
 - Some questions you might post on the board to prompt student feedback are: Are there any connections (arrows) missing? Are there any locations missing where water can be found? Are any of the major processes that move water missing? Are examples of energy and forces that drive the water cycle missing? Could there be more detail added?
 - Encourage students to also leave positive feedback when appropriate. You might model this by pointing out a poster that clearly describes how sunlight or gravity is involved in the water cycle.
 5. Once students receive feedback, give them an opportunity to revise their models as a group. These final posters are a great option for a quick formative assessment.
 - Collect the posters to assess groups' understanding of the water cycle. See "How to Use This Curriculum" for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.
 - You may also want to do a quick debrief as a class to review common strengths and any common issues across the posters before moving on to the next activity.

Elaborate

1. Now that students have a solid understanding of the water cycle, they are ready to tackle a common misconception—that water just disappears when it evaporates. Introduce the activity by reading the text from their Student Guide aloud: Imagine that your younger sibling is explaining to you what happens to puddles that dry on the sidewalk. Now that you have investigated the water cycle, critique their explanation using the *Critique, Correct, and Clarify* technique below.

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Task 3: A Water Molecule's Journey

- This activity gives students another opportunity to emphasize the CCC of **Energy and Matter** as they correct the sample to include the accurate source of energy that cycles water—the Sun.
2. Students will be using the language strategy known as *Critique, Correct, and Clarify* to critique the following explanation: *When a puddle dries on the sidewalk, the water disappears completely. This is because the air after a storm creates an energy that makes the water disappear. Water will only be created again by the sky during the next storm.*
- Students should follow the protocol in their student guide to critique the explanation in partners, individually write an improved explanation, and then discuss with a partner why they corrected the explanation.
 - Optional Sentence Stems to Provide:
 - i. When a puddle dries on the sidewalk...
 - ii. This happens because...
 - iii. Thus, the water is not disappearing, but is...
 - iv. The puddle can be created again if...
 - A possible student sample is provided below:
 - i. *Correct: When a puddle dries on the sidewalk, the water evaporates from liquid form into water vapor that goes up into the atmosphere. This happens because energy from the Sun heats up the water molecules until they transform from liquid to gas. Thus, the water is not disappearing, but is just taking a different form and continuing through the water cycle. This puddle can be created again if the water vapor in the atmosphere condenses into clouds and then comes back down to Earth as rain.*
 - ii. *Clarify: The original explanation inaccurately said that water disappeared. Water can't just disappear; it changes forms during the water cycle and is sometimes invisible to us as a gas in the air. It also said the storm creates an energy, but it is actually the Sun that is the energy that drives the whole water cycle. Also, water is not created by the sky. It is already in the atmosphere; it just needs to condense into clouds and then rain.*
3. The “Correct” and “Clarify” sections are good options for formative assessment. Collect student work to assess students’ understanding of how water cycles between Earth’s systems during evaporation. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.
- We also recommend sharing out a few corrected explanations and justifications after partners have discussed so students can share understanding and you can get an idea of where students are with these concepts.
 - Again, we encourage using equity sticks to foster more equitable participation in class-wide discussions like these (See “How To Use This Curriculum” for more details).
4. Return to the whole-class concept map from the Lift-Off Task.
- In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See “How To Use This Curriculum” for more details).

6th Grade Science Unit 2: Extreme Living**Task 3: A Water Molecule's Journey**

- Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
- Draw circles around each question and boxes around each concept.
- Write connector words to describe connections between the concept boxes.
- For this task, students may begin to connect some of their previous question circles to concept boxes about the following: how water cycles amongst Earth's systems.
- Have students analyze the additions to the class concept map for as many examples of this task's crosscutting concept as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
 - **Energy and Matter:** These could be phrases such as, "energy is transferred/flows," "is conserved," "is important for," "is needed," etc.
- Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

Evaluate: Connecting to the Culminating Project

1. Students independently complete the Task 3 section of the Unit 2 Project Organizer in class. Revisions can be done for homework, depending upon student's needs and/or class scheduling.
2. Students have been asked to design a product that makes it more comfortable for people to live in a region with an extreme climate. Their prompt is as follows: Think about the region you selected.
 - ✓ What are some ways that water is a part of your region's climate?
 - ✓ Using words or a model, describe the processes that create the water conditions in your region.

Reflection

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:
 - At the beginning of this task, you were asked to brainstorm ways that water can be a part of different climates and places that you can find water in environments. Look back at your initial list: after everything you have learned in this task, what could you add to this list? Record below.
 - In this task, we focused on the crosscutting concept of **Energy and Matter:** The transfer of energy drives the motion or cycling of matter, and it can be tracked as it flows through a system. Where did you see examples of **Energy and Matter** in this task?
 - Now that you have learned more about a major part of different climates—water—what questions do you still have?
2. There are no right answers, but encourage students to look back at their student guides and their class concept map. They should not change their initial responses, but rather use this reflection space to add to

6th Grade Science Unit 2: Extreme Living**Task 3: A Water Molecule's Journey**

their ideas and questions based on what they have learned through this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and gathering knowledge and skills for their final projects.

Assessment

1. You may collect students' Project Organizer and assess using:
 - *Criteria of your choice.* We recommend using the 3-Dimensional Assessment matrix at the beginning of this document to inform your criteria.
 - This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching as necessary.
2. You may also give students time to make revisions with one of the two options:
 - Students may make changes to their Project Organizer according to your comments OR
 - Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.

Water Molecule Journey Stations*Explore***You've arrived at: Plants!**

Plants need water to grow.

Potential routes from here:

- If the die reads 1 or 2: The plant you are in died and has decomposed to become part of the soil. Go to **soil**.
- If the die reads 3 or 4: An animal has eaten the plant you are in! Go to **animals**.
- If the die reads 5 or 6: You have evaporated from a leaf surface into the air. Go to **atmosphere**. This process is called transpiration.

You've arrived at: **Animals!**



Animals need water to survive and do their daily activities.

Potential routes from here:

- If the die reads 1 or 2: The animal that you are within died and has decomposed to become part of the soil. Go to **soil**.
- If the die reads 3 or 4: The animal that you are within exhaled (breathed out). Go to the **atmosphere**.
- If the die reads 5 or 6: The animal that you are within has released you as waste. Go to **soil**.

You've arrived at: **Surface Water**

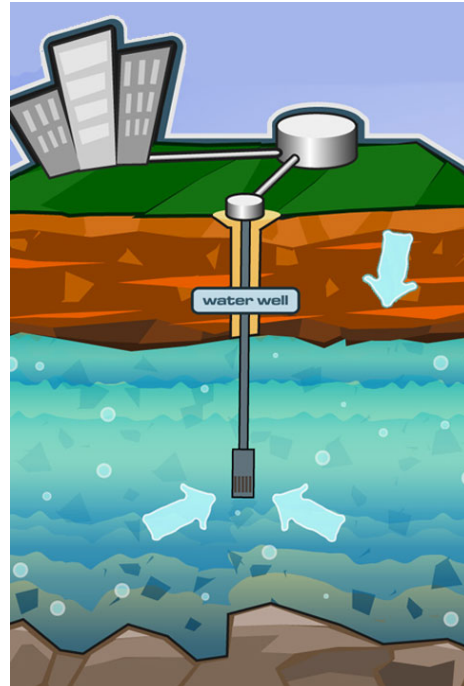


Surface water is any water found above the Earth's surface, such as lakes, rivers, streams, and creeks.

Potential Routes from here:

- If the die reads 1: The sun has heated you and your fellow water molecules from liquid water into water vapor (gas) and you are now part of the **atmosphere**! This process is called evaporation. The Sun is the energy source that makes the water cycle work because it gets water moving!
- If the die reads 2: An animal has consumed you. Go to **animals**!
- If the die reads 3: You are exactly the kind of molecule a plant needs! Go to **plants**!
- If the die reads 4: Gravity, an important force in the water cycle, propels you to flow downhill through rivers and streams to the **ocean**! This process is called surface runoff.
- If the die reads 5 or 6: You percolate deep underground and are stored in **groundwater**!

You've arrived at the: **Groundwater**



Groundwater is the water held underground in the soil or in pores and crevices in rock.

Potential Routes from here:

- If the die reads 1 or 2: You are absorbed by plant roots. Go to **plants!**
- If the die reads 3 or 4: The groundwater you are dissolved within travels and you become part of the **surface water!**
- If the die reads 5 or 6: The groundwater you are dissolved within travels and you become part of the **ocean!**

You've arrived at: **Soils!**



Soils hold the water that all plants need to grow.

Potential routes from here:

- If the die reads 1 or 2: You have percolated into the soil and became part of the **groundwater!**
- If the die reads 3 or 4: You gather on the surface and become part of the **surface water!**
- If the die reads 5 or 6: You are just the sort of molecule that plants need to absorb through their roots. You are now in a **plant!**

You've arrived at: the **Ocean!**



Oceans store most of the water on Earth.

Potential routes from here:

- If the die reads 1: Water is on the move! You have washed into the **groundwater!**
- If the die reads 2 or 3: You are just the sort of molecule that plants need. You are now in a **plant!**
- If the die reads 4, 5 or 6: The sun has heated you and your fellow water molecules from liquid water into water vapor (gas) and you are now part of the **atmosphere!** This process is called evaporation. The Sun is the energy source that makes the water cycle work because it gets water moving!

You've arrived at: **Clouds!**



Clouds are a visible mass of condensed water molecules.

Potential Routes from here:

- If the die reads 1 or 2: When you and other water molecules in the cloud get heavy enough, gravity pulls you down to the ground in the form of rain. This process is called precipitation. You combine with other water molecules in a lake. Go to **surface water**.
- If the die reads 3 or 4: When the temperature is very low and you and other water molecules in the cloud get heavy enough, gravity pulls you down to the ground in the form of snow. This process is called crystallization. Go to **ice caps and glaciers**.
- If the die reads 5 or 6: When you and other water molecules in the cloud get heavy enough, gravity pulls you down to the ground in the form of rain. This process is called precipitation. You rain directly into the ocean. Go to **ocean**.

You've arrived at the: **Atmosphere!**



The atmosphere is the air surrounding the Earth, which contains water in the form of water vapor (a gas).

Potential Routes from here:

- If the die reads 1 or 2: You have been absorbed by a **plant** through pores, or openings in its leaves.
- If the die reads 3 or 4: As temperature decreases, you join with other water molecules in the air to form a **cloud**. This is called condensation.
- If the die reads 5 or 6: As temperature decreases, you join with other water molecules on the ground to form frost or dew. This is called condensation. Go to **soil**.

You've arrived at: **Ice Caps and Glaciers!**



Glaciers and ice caps store freshwater in frozen form.

Potential Routes from here:

- If the die reads an odd number: Energy from the Sun has heated you and your fellow water molecules from solid form into liquid form. Propelled by the force of gravity, you flow over the ground into rivers and lakes in a process called surface runoff. Go to **surface water**.
- If the die reads an even number: Energy from the Sun has heated you and your fellow water molecules from solid form into liquid form. Propelled by the force of gravity, you flow over the ground into the **ocean** in a process called surface runoff. Go to **ocean**.

6th Grade Science Unit 2: Extreme Living

Task 4: Thermal Energy Transfer



Unit Essential Question: *How do people use technology to survive in regions with different climates?*

Introduction

So far in this unit, students have been thinking about the context for their design problem—the causes of different climates around the world. Their task for the culminating project is to design a product that makes it possible to live in one of these climates with extreme temperatures. In order to design such a product, they need a thorough understanding of temperature. In this task, students build on their experiential knowledge of temperature changes to try and figure out what is happening at the molecular level and what factors affect temperature changes. To do so, they plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in temperature of samples. This will lay the foundation for them to envision the type of product they will design for their culminating project and the factors they should consider.

Alignment Table

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.</p> <p>[Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.]</p> <p>[Assessment Boundary: Assessment does not include</p>	<p>Planning and Carrying Out Investigations</p> <ul style="list-style-type: none"> Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. 	<p>PS3.A: Definitions of Energy</p> <ul style="list-style-type: none"> Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. <p>PS3.B: Conservation of Energy and Energy Transfer</p> <ul style="list-style-type: none"> The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the 	<p>Scale, Proportion, and Quantity</p> <ul style="list-style-type: none"> Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

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calculating the total amount of thermal energy transferred.]		environment.	
Supplementary Crosscutting Concepts <ul style="list-style-type: none"> • Patterns <ul style="list-style-type: none"> ○ Patterns can be used to identify cause and effect relationships. 			
Equity and Groupwork <ul style="list-style-type: none"> • Discuss and compare observations and hypotheses with partners. • Participate in group roles to plan and carry out an investigation. 			
Language <ul style="list-style-type: none"> • Use sequence language to write a procedure. • Read and annotate an article. • Differentiate between related scientific terms and use appropriately in written and verbal contexts. 			

Learning Goals

This learning task asks students to plan and carry out an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in temperature of the sample. More specifically, the purpose is to:

- Engage prior experiences of thermal energy transfer.
- Explore the above relationships by planning and carrying out their own investigations.
- Explain the above relationships using evidence from their investigations and new scientific terminology.
- Elaborate on what they have learned to explain what is happening at the molecular level in a thermal energy transfer demonstration.
- Apply what they have learned about temperature to begin the initial design of their product.

Content Background for Teachers

In this task, students will be investigating concepts related to thermal energy transfer. When learning about thermal energy, one of the most difficult concepts is differentiating between temperature, thermal energy, and heat, and using these terms correctly. For more information on the differences between these terms, please reference the article in the *Explain* section of the Student Guide.

As students investigate thermal energy, they will find that the change in temperature of a sample is highly dependent on the types, states, and amounts of matter present. This also means that these factors affect the amount of energy transfer needed to change the temperature of an object. For example, an object with a lot of mass will take a lot more energy transfer to increase in temperature than an object with a small mass. The type of matter is also very important. For example, if a material is highly conductive, the kinetic energy of particles is more easily transferred and temperature will change more quickly.

Academic Vocabulary

- Temperature
- Thermal Energy
- Heat
- Energy Transfer

6th Grade Science Unit 2: Extreme Living**Task 4: Thermal Energy Transfer**

- Matter
- Particles
- Kinetic Energy
- Mass
- Dependent Variable
- Independent Variable
- Controlled Variables
- Procedure

Time Needed (Based on 45-Minute Periods)

5 Days

- Engage: 0.5 period
- Explore: 2 periods
- Explain: 1 period
- Elaborate: 0.5 period
- Evaluate and Reflection: 1 period

Materials

- Unit 2, Task 4 Student Version

Engage

- Projector and Speakers

Explore (Options of Materials to Provide Per Group)

- Heat Source
 - Bin or Tub of Hot water (electric kettle recommended to heat water consistently and quickly)
 - Heating Pad
- Any materials that can melt: Butter, Gummy Bear, Chocolate, Crayons, Candle Wax, etc.
- Aluminum Foil
- Wax Paper
- Cardboard
- Tape
- Plastic Knife
- Scissors

Elaborate (Per Class)

- 2 large beakers of same size
- Hot water
- Cold water
- 2 different colors of food coloring
- Projector and Speakers

Evaluate

- Project Organizer Handout

6th Grade Science Unit 2: Extreme Living

Task 4: Thermal Energy Transfer

Instructions**Engage**

1. Introduce Task 4: So far in the unit, you have been thinking about why the regions you chose have such extreme climate conditions. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
 - Before you pass out the student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.
2. Transition to Task 4: Your job for the culminating project is to design a product that makes it possible to live in one of these regions, even with such extreme temperatures. Before we design this product, we first need to understand how temperature actually works!
 - Now pass out their Task 4 student guide.
3. Introduce the following scenario to students: You are boiling a pot of water while cooking pasta. You place a cool metal spoon into the pot to stir the mixture. You have to leave the stove for a minute and when you come back, you grab the metal spoon...ouch! It's now boiling hot!
 - Optional - Show the first 20 seconds of the following video to help set this context: <https://www.youtube.com/watch?v=wV7gzckKegdU>. DO NOT SHOW THE WHOLE VIDEO. They will return to the rest of this video in the *Elaborate*.
4. This activity asks students to call upon any prior experiences they have and make a hypothesis to the following question in pairs: Why is the handle of the spoon hot even though the handle is not submerged in the boiling water?
5. Share out ideas as a class.
 - Students will likely be able to convey the general idea of thermal energy transfer without the scientific terminology. For example, many students will discuss how the boiling water heats up the bottom of the spoon, so the whole spoon gets hot. This experiential understanding sets the stage for students to consider how exactly heat is transferred later in this task.
 - We encourage using equity sticks to foster more equitable participation in class-wide discussions like these (See "How To Use This Curriculum" for more details).

Explore

1. Students know based on experiences like the one above that the temperature of objects can change. But the questions remain: How is temperature able to change? And what factors affect changes in an object's temperature? In this activity, students plan and conduct their own investigations to try to answer these questions.
 - This activity gives students practice at the SEP of **Planning and Carrying Out Investigations** as students engage in all the relevant tasks associated with planning an investigation (i.e., writing an experimental question, identifying variables, writing a procedure, and collecting data).

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- Due to the content of these investigations, students will also emphasize the CCC of **Scale, Proportion, and Quantity** as students gather data to identify proportional relationships among different types of quantities, such as mass and temperature.
2. Review the material options you will provide to students (See Materials List above) and assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Facilitator, Materials Manager, Harmonizer, and Recorder.
 - Ask the Facilitator to read the directions and to make sure everyone understands the task.
 - Ask the Materials Manager to gather the materials needed to complete the task.
 - Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone's voice is heard.
 - Ask the Recorder to make sure the group is recording all parts of their experiment in their Student Guides
 3. Keep in mind that this activity will likely require a lot of teacher facilitation. When students plan their own investigations, they can often take paths away from the content you would like them to focus on. Here are some facilitation strategies to help students stay on track:
 - Review the DCIs in the alignment table above so you are clear about what you want students to get out of their investigations.
 - Student investigations should focus on the relationships between mass and temperature change or the type of matter and temperature change.
 - i. Walk around and check in with students throughout the planning process. Ask student groups probing questions as they plan their experiments to ensure they are addressing one of the above objectives.
 - ii. We also recommend establishing checkpoint safter the planning process. For example, first have each group share their experimental design with another group. Then, they must clear their experimental design with you before they can conduct their experiment. This allows you to see if they are on the right track before they go through the entire experimental procedure.
 4. Here is a sample of a potential experiment a student group might plan.

Experimental Design

1. Write your experimental question: Based on the materials available, what would you like to test?
How does the mass of an object affect its temperature when heated?
2. Identify the Dependent Variable: What are you trying to measure or observe at the end of the experiment?
The change in temperature of the object
3. Identify the Independent Variable: What will you need to manipulate (change) in order to measure this?
Mass of the object

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4. Identify the Controlled Variables: What should you keep the same so that you only measure what you want to?

Type of object, amount of time heated, heat source, vessel to hold object, intervals for measuring temperature

Materials:

- Bin
- Hot water (50-60°C, anything hotter and burns may occur quickly)
- Foil
- Plastic Knife
- Butter

Procedure:

1. Using a plastic knife, cut a piece of butter into two uneven pieces: one large piece and one small piece.
2. Create a small foil boat that will safely hold the piece of butter.
3. Place the large piece of butter into the foil boat and carefully set the foil boat into the tub so it floats on top of hot water.
4. Watch carefully for 2 minutes. Record observations and draw a labeled diagram of what they observe in the notebook data table.
5. Repeat this process with the small piece of butter.

Data Collection Table

Object	Observations	Diagram	Observed Change in Temperature (Hotter or Colder)
Large Piece of Butter			
Small Piece of Butter			

5. Once students have conducted their experiments, have each group share out their experiment and findings so other groups can use it in their conclusions during the *Explain*. If possible, use a document camera so students can show their experimental set-ups and their data collection as they explain their experiments.
- We recommend students take notes on other experiments that were different from theirs so they can use this information in the *Explain*.
 - We also recommend creating a public record of the class data. Record findings as they are shared, so they can be displayed to the class as students do the *Explain*. The public display makes it easier to look for patterns in the data across everyone’s findings. This emphasizes the supplementary CCC of **Patterns** as they look across data to identify cause and effect relationships.

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Task 4: Thermal Energy Transfer

6. Optional: If you feel students still need more exposure to these concepts, select a few groups' experiments that were well-designed for the objectives. Demonstrate these experiments as a whole class and have students discuss the relationships they see.

Explain

1. Students now have the data to draw conclusions about the different relationships they observed. However, it is very difficult to discuss these investigations without the proper terminology, especially since these terms are so closely related, they are often accidentally used interchangeably.
2. To learn about these differences between temperature, thermal energy, and heat, students first individually read and annotate the article provided in their Student Guides.
 - We recommend using whichever annotation strategy students are familiar with in your classroom, but an option is also provided in the "How to Use This Curriculum" document, if needed.
 - After reading, have students share with a partner to practice describing these terms in their own words.
3. Armed with these new terms, students are ready to draw conclusions about their investigations. We recommend this be done in groups because it is often difficult for students to analyze student-designed investigations without support.
 - These conclusions emphasize the CCCs of **Scale, Proportion, and Quantity** and **Patterns**. Students are using patterns across class data to identify and describe proportional relationships, using appropriate scientific terminology.
4. For student groups who are struggling to identify relationships, pose some facilitating questions to jumpstart their thinking.
 - For example, if we consider the sample experiment in the *Explore* section, you might ask: "What happened to both pieces of butter when you placed the foil boats in the hot water? Why do you think the temperature of these objects changed? How did the results differ amongst the pieces of butter? What do you think caused these differences?"
 - Other general questions could be: "Your experiment measured one factor affecting temperature change...what were other experiments that measured other factors? Based on the experiments, how and why does temperature change? What information from the article can you use to support this idea?"
5. We recommend debriefing these questions in a class discussion for a quick formative assessment to see where students are in their understanding. This gives you an opportunity to address any gaps in understanding before the *Elaborate*.

Elaborate

1. So far in this task, students have seen how thermal energy is transferred between objects and how this causes changes in temperature. But what is actually happening at the particle level? Why does thermal energy transfer between objects and why does the temperature change?
 - This activity gives students an opportunity to extend their understanding a step further by thinking about the microscopic mechanism that makes everything they saw in the *Explore*

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Task 4: Thermal Energy Transfer

- possible. It also provides a meaningful transition to the next task as students begin to think about a product that minimizes or maximizes thermal energy transfer.
- Here students are again emphasizing the supplementary CCC of **Patterns** as they use patterns in what they observe to explain the cause-and-effect relationship both at the macroscopic level and the microscopic level.
2. Do a demonstration of food coloring mixing at two different temperatures. Set up two large beakers: one with very cold water and one with very hot water. At the same time, drop 2-3 drops of food coloring into each of the beakers and ask students to observe.
 - You may want to ask students to share out some of their observations as a class before writing down their hypotheses about why this happens individually.
 - Students should share hypotheses first with a partner and then a few as a whole group. Emphasize to students that there is no right answer at this point!
 - This might be a good time to also ask students to predict what it would like when you drop food coloring into room temperature water based on what they've seen. Then, demonstrate this scenario and students can make observations again.
 - Again, we encourage using equity sticks to foster more equitable participation in class-wide discussions like these (See “How To Use This Curriculum” for more details).
 3. Show the rest of the video from the *Engage* to give students a visual of what is happening at the molecular level during thermal energy transfer: <https://www.youtube.com/watch?v=wV7gzckKegdU>.
 - Then show the following simulation to highlight the transfer of energy through conduction between solids with different energy. This allows students to actually see the energy being transferred, with one particle losing energy and the corresponding particle gaining energy during the collision: <http://lab.concord.org/embeddable.html#interactives/external-projects/CREATE/solid-heat-transfer.json>.
 - Give students an opportunity to discuss what they learned from the video and simulation in partners.
 4. Students now have the information to explain the food coloring demonstration on their own.
 - Students should be able to explain that the food coloring mixes more quickly in the hot beaker because the molecules are moving faster at the higher temperature. The molecules in the cold beaker are moving much slower, so the food coloring mixes more slowly.
 - Question 3A gives students the opportunity to explicitly connect this idea to their *Explore* investigations. For example, students might say that this gradual transfer of particle motion explains why objects with more mass need more thermal energy transfer to increase temperature.
 - This section of the task provides a great opportunity for formative assessment. Collect student work to assess their ability to explain thermal energy transfer within a new context. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

6th Grade Science Unit 2: Extreme Living**Task 4: Thermal Energy Transfer**

5. Return to the whole-class concept map from the Lift-Off Task.
 - In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See “How To Use This Curriculum” for more details).
 - Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
 - Draw circles around each question and boxes around each concept.
 - Write connector words to describe connections between the concept boxes.
 - For this task, students may begin to connect some of their previous question circles to concept boxes about the following: the definition of temperature, what factors affect temperature change, and thermal energy transfer.
 - Have students analyze the additions to the class concept map for as many examples of this task’s crosscutting concept as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
 - **Scale, Proportion, and Quantity:** These could be phrases such as, “is proportional to”, “compared to”, “has a ratio of”, “is bigger/smaller than”, “is longer/shorter than”, etc.
 - Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

Evaluate: Connecting to the Culminating Project

1. Students independently complete the Task 4 section of the Unit 2 Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.
2. Students have been asked to design a product that makes it more comfortable for people to live in a region with an extreme climate. Their prompt is as follows: Think about the climate in the region you selected.
 - ✓ Will your product need to help people stay warm or cool down?
 - ✓ Would this require increasing the kinetic energy of the particles or decreasing the kinetic energy of the particles? Explain.
 - ✓ Based on your explorations, how might you be able to make this possible? What factors should your product consider?

Reflection

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:

6th Grade Science Unit 2: Extreme Living**Task 4: Thermal Energy Transfer**

- At the beginning of this task, you were asked make a hypothesis to the following question: Why is the handle of the spoon hot even though the handle is not submerged in the boiling water? Look back at your hypothesis. After everything you have learned through this task, what would you change or add to your response? Record this below:
 - In this task, we focused on the crosscutting concept of **Scale, Proportion, and Quantity**: Proportional relationships among different quantities tell us about the magnitude of processes. Where did you see examples of **Scale, Proportion, and Quantity** in this task?
 - Now that you have learned more about temperature for the design of your product, what questions do you still have?
2. There are no right answers, but encourage students to look back at their student guides and their class concept map. They should not change their initial responses, but rather use this reflection space to add to their ideas and questions based on what they have learned through this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and gathering knowledge and skills for their final projects.

Assessment

1. Collect students' Task 4 Student Versions and assess the *Explore* using the 3-Dimensional Task 4 Rubric below. To maintain the authenticity of the Culminating Project, the SEP of MS-PS3-4 will be assessed through this task rather than within the Culminating Project.
2. You may collect students' Project Organizer and assess using:
 - *Criteria of your choice*. We recommend using the 3-Dimensional Assessment matrix at the beginning of this document to inform your criteria.
 - This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching as necessary.
3. You may also give students time to make revisions with one of the two options:
 - Students may make changes to their Project Organizer according to your comments OR
 - Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.

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Task 4: Thermal Energy Transfer

Task 4 Rubric: Student plans an investigation to determine the relationship between change in temperature and mass OR change in temperature and type of matter.

- Use to assess student responses in the *Explore*.
- Dimensions Assessed: SEP – Planning and Carrying Out Investigations; DCI – PS3.A: Definitions of Energy or PS3.B: Conservation of Energy and Energy Transfer

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
<p>Student plans an irrelevant investigation that does not determine the relationship between temperature and mass OR temperature and type of matter.</p>	<p>Student plans a relevant investigation with major errors to determine the relationship between temperature and mass OR temperature and type of matter.</p>	<p>Student plans a relevant investigation with minor errors to determine the relationship between temperature and mass OR temperature and type of matter.</p>	<p>Student plans a relevant and thorough investigation to determine the relationship between temperature and mass OR temperature and type of matter.</p>
<p>Look Fors:</p> <ul style="list-style-type: none"> • Student plans an irrelevant experiment that does not investigate the relationship between change in temperature and mass (i.e., IV – mass of an object) or the relationship between change in temperature and type of matter (i.e., IV – type of material). For example, student describes an experiment to see whether hot objects float and cold objects sink in a water bath. 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student plans a relevant experiment to investigate the relationship between change in temperature and mass (i.e., IV – mass of an object) or the relationship between change in temperature and type of matter (i.e., IV – type of material). • Some parts of the experimental plan are accurate, but there are major errors or many missing components (See <i>Advanced Look-Fors</i> for list of requirements). 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student plans a relevant experiment to investigate the relationship between change in temperature and mass (i.e., IV – mass of an object) or the relationship between change in temperature and type of matter (i.e., IV – type of material). • Most parts of the experimental plan are accurate, but with some minor errors or missing components (See <i>Advanced Look-Fors</i> for list of requirements). 	<p>Look Fors:</p> <ul style="list-style-type: none"> • Student plans a relevant experiment to investigate the relationship between change in temperature and mass (i.e., IV – mass of an object) or the relationship between change in temperature and type of matter (i.e., IV – type of material). • All parts of the experimental plan are accurate and complete, including: experimental question, dependent variable, independent variable, controlled variables, material list, experimental set-up, procedure, and data collection table.

6th Grade Science Unit 2: Extreme Living

Task 5: Extreme Living Solutions

Unit Essential Question: *How do people use technology to survive in regions with different climates?*

Introduction

In the last task, students planned and conducted investigations to figure out what is happening at the molecular level during thermal energy transfer and what factors affect temperature change. By the end of the last task, they had begun to envision types of product for their culminating project and the factors they should consider. In this task, they move on to the actual design process! Throughout this task, students engage with a series of guided steps to help them brainstorm, design, build, test, and revise a prototype for a product that makes it possible to live in a region with extreme temperatures. By the end, students will have a solid idea of the product they want to present in their culminating project, including an understanding of the science behind how it works and the engineering process it took to get them to their final product.

Alignment Table

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]</p>	<p>Designing Solutions</p> <ul style="list-style-type: none"> Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system. 	<p>PS3.A: Definitions of Energy</p> <ul style="list-style-type: none"> Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. <p>PS3.B: Conservation of Energy and Energy Transfer</p> <p>Energy is spontaneously transferred out of hotter regions or objects and into colder ones.</p>	<p>Energy and Matter</p> <ul style="list-style-type: none"> The transfer of energy can be tracked as energy flows through a designed or natural system.
<p>MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best</p>	<p>Analyzing and Interpreting Data</p> <ul style="list-style-type: none"> Analyze and interpret data to determine similarities and 	<p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> There are systematic processes for evaluating solutions 	<p>No CCC listed</p>

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Task 5: Extreme Living Solutions



<p>characteristics of each that can be combined into a new solution to better meet the criteria for success.</p>	<p>differences in findings.</p>	<p>with respect to how well they meet the criteria and constraints of a problem.</p> <ul style="list-style-type: none"> • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. <p>ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. 	
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<p>Supplementary Science and Engineering Practices</p> <ul style="list-style-type: none"> • Asking Questions and Defining Problems <ul style="list-style-type: none"> ○ Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. • Developing and Using Models <ul style="list-style-type: none"> ○ Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales. • Planning and Carrying Out Investigations <ul style="list-style-type: none"> ○ Collect data about the performance of a proposed object, tool, process or system under a range of conditions.
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<p>Equity and Groupwork</p> <ul style="list-style-type: none"> • Come to consensus on a design idea by considering and combining ideas from all group members.
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- Participate in group roles to design, build, and test a product through a guided design process.
- Participate in group roles to make a poster.
- Share data with other groups and learn from others' data.
- Use ideas and data from other groups to inform a redesign of a product.

Language

- Cite experimental data to support ideas.
- Gather and read external research to inspire ideas.
- Use sequence language to describe a procedure.
- Represent scientific terminology in visual models.

Learning Goals

This learning task asks students to design, construct, test, and revise a device that either minimizes or maximizes thermal energy transfer. More specifically, the purpose is to:

- Engage prior knowledge of heat-regulation devices to brainstorm potential ideas for a product.
- Explore the design process to design, build, and test a prototype of their product.
- Explain products and compare test data to other groups so that all groups can learn from each other's tests.
- Analyze and interpret data from various tests to improve the design of their final product.
- Draw a labeled diagram of their final product, explaining the science of how it works and the design process used.

Content Background for Teachers

In the last task, students learned about thermal energy transfer, temperature, and heat as they relate to the kinetic energy in particles. For more information on these specific terms, please reference the article in the Task 4 *Explain* section of the Student Guide. Students also investigated that the amount of thermal energy transfer needed to change the temperature of a sample is highly dependent on the types, states, and amounts of matter present. By the end of the task, students were able to explain that thermal energy is transferred when particles collide and the kinetic energy of high-energy particles transfer to low-energy particles.

In this task, students build off these ideas to design a product that minimizes or maximizes thermal energy transfer. This could be a range of different products relating to clothing, housing, heating devices, cooling devices, etc. In the design of this product, students will use the idea that thermal energy moves from regions of higher temperature to regions of lower temperature, and not the other way around. Thermal energy is stored in molecules as vibrations or movement. The more that particles in solids are vibrating, the more thermal energy that solid has. During the transfer of thermal energy between contacting substances, the kinetic energy of one substance decreases, while it increases in the other.

After deciding on a type of product, students will use their investigations from Task 4 and any additional research they gather to build and test a product. In their research, you may want to guide them toward sources about materials that are insulators and materials that are conductors.

For some materials, for example, transferring thermal energy is easy: one high-energy molecule makes a neighboring molecule start to vibrate. That new molecule then makes its neighbors vibrate. Pretty soon, all the

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molecules are vibrating. Eventually, the whole object may increase in temperature. This type of material is a conductor. Metals are particularly good conductors because there are virtually no spaces between molecules in metals, meaning that particle collisions occur very rapidly, and energy is transferred quickly. Liquids can be good conductors because the molecules also tend to be close together, but not as close as with metals. Some solids (such as wood or plastic), though they have molecules which are close together, also contain empty spaces which reduce the number of possible molecule collisions, thus reducing the substances effectiveness as a conductor.

Insulators are materials that reduce thermal energy transfer because they reduce the amount of possible molecular collisions. The best insulator is a vacuum, or completely empty space devoid of molecules. If there are no molecules, there can be no molecular collisions. A good insulator that is available to students is air. Air does not transfer heat very well because the molecules are so far apart from each other that they do not often bump into other air molecules to transfer the thermal energy. In essence, air is a good insulator because the molecules are too far apart for it to be a good conductor. This is why double-paned glass is used for windows in well-insulated homes. Below are some other good examples of insulators:

- A bunch of air-filled plastic bubbles arranged in a honeycomb pattern
- Foam, a frothy plastic material containing gas within non-connected tiny cells
- Dry wood, which has a great deal of empty space inside it
- Fiberglass, a mat of fine glass strands in a suitable containing wrap.
- Styrofoam

Some fiberglass insulation comes wrapped in an aluminized (reflective) material to also inhibit thermal radiation. Often, reflective surfaces are used as insulators because thermal radiation bounces off the surface rather than being absorbed. For example, in a thermos, the shiny-mirrored surface reflects the heat back toward the source, keeping the fluid hot. Cold substances in the thermos stay cool because the heat from the outside is reflected away from the contents. Though students may research and use these types of technologies in their design, the main elements of their design will need to focus on minimizing or maximizing thermal energy transfer.

Academic Vocabulary

- Design
- Product
- Prototype
- Minimize
- Maximize
- Criteria
- Constraints

Time Needed (Based on 45-Minute Periods)

6 Days

- Engage: 0.5 period
- Explore: 2 periods
- Explain: 1 period
- Elaborate: 1.5 periods
- Evaluate and Reflection: 1 period

6th Grade Science Unit 2: Extreme Living**Task 5: Extreme Living Solutions****Materials**

- Unit 2, Task 5 Student Version

Engage

- Post-its (at least 3 per student)
- Poster Paper (per group)

Explore (Per Group)

- Computers or tablets for research
- Options of materials to build and test prototypes
 - Heat Sources
 - Heating Pads
 - Hot Water in Containers
 - Thermometers
 - Timers
 - Tape
 - Aluminum Foil
 - Newspaper
 - Cardboard
 - Plastic Bags
 - Different kinds of Cloth
 - Bubble Wrap
 - Foam
 - Any additional materials you or students may want to bring from home

Explain

- Computers or tablets to re-watch conduction video if necessary
- Posters
- Markers

Elaborate

- Optional: materials to test new designs of products

Evaluate

- Project Organizer Handout

Instructions**Engage**

1. Introduce Task 5: Your job for your culminating project is to design a product to make it possible to live in a region with extreme temperatures. In the last task, you investigated what temperature is and different factors that affect temperature changes in objects. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
 - Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.

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2. Transition to Task 5: Today, you'll be able to use what you learned in your investigations to actually design, build, and test your product!
 - Now pass out the Task 5 student guide.
3. We recommend first giving students individual think-time to picture the region they selected for their culminating project and use the following questions to begin their thought process: What kinds of products might make the temperature conditions more comfortable for the people living there? Which of these products uses the science concepts you investigated in Task 4?
4. In this *Engage*, students will be creating a design board. This involves each student adding post-its of their own ideas to a poster and then clustering these post-its to come to consensus on a design idea for their product.
 - Distribute 3-5 post-its to each student and give them time without speaking to brainstorm and record their own ideas. Because we want product designs to align to the DCIs by relating to thermal energy transfer, ask students to draw a star next to ideas that use concepts they learned in Task 4.
 - Students place their post-its on their group poster.
 - As a group, students review the ideas on the poster, put them into clusters of similar ideas, and revise and combine ideas as necessary.
 - In the end, they will decide on the best idea to move forward with in the next sections of this task. However, save these posters in case students need to return to some of their other ideas for their culminating project.
5. Coming to consensus is challenging for students. We recommend assigning roles to each group. You may use whatever roles you prefer. We recommend the use of the Facilitator, Materials Manager, Harmonizer, and Reporter.
 - Ask the Facilitator to read the directions and to make sure everyone understands the task.
 - Ask the Materials Manager to gather the materials needed to complete the task.
 - Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone's voice is heard.
 - Ask the Reporter to make sure any revisions are reported on the poster.

Explore

1. Now that groups have an idea of the product they want to design, they are ready to begin the design process, which involves: re-defining the problem in terms of criteria and constraints, gathering inspiration from existing data and external research, drawing a prototype, building a prototype, and testing a prototype.
 - This activity gives students practice at the SEP of **Designing Solutions** as students apply scientific ideas to design, construct, and test a product that maximizes or minimizes thermal energy transfer.
 - In the guided steps of the design process, students are also practicing the supplementary SEPs of **Asking Questions and Defining Problems**, **Developing and Using Models**, and **Planning and Carrying Out Investigations** as they re-define criteria and constraints, draw a model of their prototype, and plan and conduct an investigation to test their prototype.

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2. Introduce the task to students by reading the text on their Student Guide aloud: Now that you have an idea for a potential product to minimize or maximize thermal energy transfer, you can design, build, and test it to create the best possible final product. As a group, use the questions below to guide you through this design process.
 - If students are not familiar with the terms minimize, maximize, or prototype, use this time to explicitly define them for students, using examples.
 - Also present them with the material options they have to design their prototype to help them focus their research. They may also bring in materials from home, but remind students they can't bring in devices that have already been built for insulation or conduction (ie. a thermos).
3. You will notice that most of the activities in this task are done as a group. This is because students are designing their product for the culminating project and collaboration is essential for a well-designed product. Assign roles to each group, but mix up the role assignments from the *Engage*. We recommend the use of the Facilitator, Materials Manager, Harmonizer, and Recorder.
 - Ask the Facilitator to read the directions and to make sure everyone understands the task.
 - Ask the Materials Manager to gather the materials needed to complete the task.
 - Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone's voice is heard.
 - Ask the Recorder to make sure the group is recording all parts of their design process in their Student Guides.
4. Students first return to the Lift-Off section of their Project Organizer to clarify the criteria and constraints of the problem in their region. This allows them to clearly recall the problem they are solving before they dive into their design.
5. Next students gather more inspiration for their product design.
 - Students should cite specific data from Task 4 that they are using to inform their design.
 - They will also likely want to do some additional outside research for their product design. Provide students with computers, tablets, or your own curated resources. It may be helpful to point them toward resources about materials that function as insulators and conductors.
6. Now that students have done some research, they can begin to design their prototype. Encourage students to consider structure, material, size, mechanism, etc. in their design. Students draw a diagram of their prototype, using labels to explain how the product will work.
 - This diagram asks students to emphasize the CCC of **Energy and Matter** as they must show how energy flows through their designed system as thermal energy transfer is either maximized or minimized.
 - We recommend establishing a checkpoint after this step. For example, student groups must clear their design with you first before they can test the prototype. This allows you to see if their design actually uses scientific concepts to minimize or maximize thermal energy transfer.
 - Students may come up with a variety of different designs:
 - i. For extreme cold: houses with double-paned windows, concrete walls inside of houses with large windows to absorb and retain heat from the sun, building insulation in walls,

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insulated gloves, hot water bottles, quilts or clothing with pattern of insulation pockets, thick curtains, thermos, radiator foil, solar ovens, etc.

- ii. For extreme heat: houses with double-paned windows, wind towers, white washed houses, cooling domes, water trenches beneath huts for evaporative cooling, small windows, dugouts, reflective clothing, loose-fitting clothing, water-wicking clothing, ice chest, etc.

7. Lastly, students build and test their prototype. Because students are not being explicitly assessed on the planning of these investigations, the guiding prompts are looser in structure. However, you may use the same questions in the Task 4 *Explore* if you wish to follow a more rigid structure for planning their experiments.
 - This data will be used to evaluate how successful their product will be and what improvements they should make.

Explain

1. Students now have data to serve as evidence for how well their design works. In this *Explain*, students use scientific concepts from Task 4 to analyze why they got these results and distill all this information into a poster they can share with the rest of the class.
 - This encourages a sharing of data that can lead all groups to improve their designs.
2. Provide students with materials to make a poster. You may also want to provide a tablet and/or computer so students can revisit the *Conduction* video and simulation from Task 4, if necessary: <https://www.youtube.com/watch?v=wV7gzcKegdU> and <http://lab.concord.org/embeddable.html#interactives/external-projects/CREATE/solid-heat-transfer.json>. Again, assign group roles, but mix up the role assignments.
3. On the poster, students should include a diagram showing how their product works, the data from the test of their prototype, and an explanation for why they think they got those results.
 - This last explanation emphasizes the CCC of **Energy and Matter** as students track the energy transfer in their designed system.
4. These posters can be presented as whole class presentations or in a gallery walk. Regardless of the presentation format, encourage students to take notes on not only the features of the designs they liked but also the data that justifies that these designs work well. Emphasize that this data will be essential to include in their individual culminating project so they will want to have good notes.
 - We recommend leaving up the posters for the rest of this task, so students can walk up to them and refer to the data as they make revisions to their product in the *Elaborate*.

Elaborate

1. Equipped with their own data as well as other groups' data, students can return to their original design and consider how they might modify it so it better meets the criteria and constraints of the problem.
 - This activity emphasizes the SEP of **Analyzing and Interpreting Data** as students analyze the similarities and differences in test data to identify best characteristics of the designs they have seen.

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2. As a group, students analyze data from different designs and re-design their product to combine best characteristics from these designs.
 - Optional: If time and materials allow, give students an opportunity to test their new design to see how it works.
3. Return to the whole-class concept map from the Lift-Off Task.
 - In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See “How To Use This Curriculum” for more details).
 - Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
 - Draw circles around each question and boxes around each concept.
 - Write connector words to describe connections between the concept boxes.
 - For this task, students may begin to connect some of their previous question circles to concept boxes about the following: products that minimize or maximize thermal energy transfer, the engineering and design process.
 - Have students analyze the additions to the class concept map for as many examples of this task’s crosscutting concept as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
 - **Energy and Matter:** These could be phrases such as, “energy is transferred/flows,” “is conserved,” “is important for,” “is needed,” etc.
 - Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

Evaluate: Connecting to the Culminating Project

1. Students independently complete the Task 5 section of the Unit 2 Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.
2. Students have been asked to design a product that makes it more comfortable for people to live in a region with an extreme climate. Their prompt is as follows: You now have a revised prototype of that product!
 - ✓ Draw a labeled diagram of your final product.
 - Show how thermal energy transfer is either minimized or maximized.
 - ✓ Explain how it works.
 - ✓ Describe how you combined best characteristics from different designs to create a product that

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best meets your criteria and constraints.

- Cite the data that supported your decisions
3. This prompt again emphasizes the CCC of **Energy and Matter** as students draw a diagram that shows how energy flows through their designed system as thermal energy transfer is either maximized or minimized.

Reflection

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:
 - At the beginning of this task, you brainstormed a variety of different ideas. After seeing all the tests of the different prototypes, are there any other ideas from your poster that you would still want to try?
 - In this task, we focused on the crosscutting concept of **Energy and Matter**: The transfer of energy drives the motion or cycling of matter, and it can be tracked as it flows through a system. Where did you see examples of **Energy and Matter** in this task?
 - Now that you have tested a design for your product, what questions do you still have?
2. There are no right answers, but encourage students to look back at their student guides and their class concept map. They should not change their initial responses, but rather use this reflection space to add to their ideas and questions based on what they have learned through this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and gathering knowledge and skills for their final projects.

Assessment

1. You may collect students' Project Organizer and assess using:
 - *Criteria of your choice*. We recommend using the 3-Dimensional Assessment matrix at the beginning of this document to inform your criteria.
 - This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching as necessary.
2. You may also give students time to make revisions with one of the two options:
 - Students may make changes to their Project Organizer according to your comments OR
 - Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.