OUR CHANGING CLIMATE

Grades 6-12

CLIMATE GENERATION
A WILL STEGER LEGACY

Dear Educator:

Climate change is a reality. It threatens both our society and life as we know it on earth. The overwhelming consensus of the scientific community for the past decade has been that the planetary warming we are now experiencing, and the resulting climate change, is largely a human induced phenomenon. This is brought on mainly by the release of carbon dioxide through the burning of fossil fuels, which blankets our atmosphere raising the earth's surface temperature.

Environmentally, we see dramatic signs of climate change in our polar regions. Yet, because these regions are remote and go unseen by most people, it's easy to ignore the potent warnings. Climate Generation's founder, Will Steger has been to both poles and seen the catastrophic consequences of the effects of climate change. He crossed both the Ward Hunt Ice Shelf in the Arctic and Larsen A and B Ice Shelves on Antarctica, which have since collapsed into the sea in the last two decades as a result of climate change. He experienced firsthand the melting of the sea ice on the Arctic Ocean, and in the spring of 2008 traveled through the ruins of the Arctic Ocean's melt from the previous summer. That same year on the Greenland ice cap, he was confronted with rivers of water at 7,000 feet during the summer; unprecedented at that elevation!

If we educate ourselves and re-connect with our community, we can reduce our fossil fuel consumption and eventually chart a different course for the Arctic and the rest of the globe. We need discussion, engagement, but also the desire to live a bit differently than we have until now. Your efforts are critical to our success.

Action begins with education and climate literacy and climate change must be an essential topic in the educational agenda. This agenda begins with a sound educational curriculum based on best practices in educational research and pedagogy and continues with teacher education and professional development. Because we are dealing with an immediate threat and opportunity, we must launch a public education campaign to educate everyone. I invite you to be a part of this effort by incorporating climate change concepts into your teaching which have been included in this guide and are available free for download at www.climategen.org. Let's begin the process of changing the way we live so that we can mobilize and act to make a difference.

Thank you for your dedication to climate literacy,

From the team at Climate Generation: A Will Steger Legacy

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Students will explain why carbon dioxide and other heat-trapping gases are necessary for life as we know it.

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Students will be able to explain how increased atmospheric concentrations of heat-trapping gases warm the atmosphere.

Students will be able to predict what will happen to global temperatures if atmospheric concentration of heat-trapping gases increase.

Students will be able to identify sources of heat-trapping emissions.

Students will calculate their carbon footprint.

Students will identify ways they can reduce their carbon footprint.

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Students will brainstorm ideas of how to respond to climate change.

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About Climate Generation

Climate Generation: A Will Steger Legacy

Climate Generation: A Will Steger Legacy is a nationally connected and trusted nonprofit dedicated to climate literacy, climate change education, youth leadership and citizen engagement for innovative climate change solutions.

Climate Generation: formerly known as Will Steger Foundation, has a unique story that stems from our founder, Will Steger, a recognized authority on the Polar Regions and an eyewitness to the effects of climate change. Will has spent more than 50 years traveling through the Polar Regions, advocating for the Earth's preservation and advising on permanent solutions to climate change. His compelling eyewitness account of the consequences of a warming world in the Arctic and Antarctic has engaged thousands of people in the issue and solutions. It is Will's historical achievements as an explorer, educator and advocate that has shaped the core programming of Climate Generation. Climate Generation: A Will Steger Legacy was established in 2006 with the mission of educating and empowering people to engage in solutions to climate change.

We recognize educators are critical messengers of climate and energy literacy, and schools and nonformal learning centers provide powerful examples of sustainability in communities. We also recognize that youth will inherit the unparalleled impacts of climate change and are among our most powerful advocates. With these factors guiding our approach, Climate Generation is having a tangible impact through climate literacy, youth leadership, and citizen engagement on climate change solutions.

Education Program History and Mission

When Climate Generation was founded in 2006 the education program was centered on adventure learning and expeditions by raising awareness of climate change in the Polar Regions. Although the education program has evolved, we still stay committed to the idea of eyewitness accounts and the metaphor of the expedition.

To reflect the evolution of our education program, and to stay current with the field of climate change education, our strategic goal was revised in 2011:

> *"to support educators, students and the public with science-based interdisciplinary educational resources on climate change, its implications and solutions to achieve climate literacy."*

We accomplish this through curriculum development, professional development, online resources and education partnerships.

Curricula Resources

Climate Generation offers a suite of Grades 3-12 curriculum resources. Aligned with national and Minnesota state standards, the Next Generation Science Standards (July 2014) and the climate and energy literacy principles, the curricula has been reviewed by scientists, professional educators, and organizations. All lessons have online connections in the form of videos, articles and other content and can be downloaded for free from *http://climategen.org/curriculaextras/*

***Our Changing Climate* for Grades 3-6**
These five lesson plans are interdisciplinary in nature, standards-based, help students master the requisite background information on global climate change processes, and teach how to communicate about the issue using communication strategies.

***Our Changing Climate* for Grades 6-12**
These six interdisciplinary lesson plans help students master the requisite background information on global climate change processes, the importance of the Arctic to global climate, the potential effects of climate change in the Arctic, and to consider what could/should be done in response.

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About Climate Generation (cont.)

Minnesota's Changing Climate for Grades 3-8. 9-12
This set of lesson plans explores Minnesota's unique biomes and what a changing climate will mean for the state. It is considered a model for place-based climate change education.

Experience Energy for Grades 3-8
These lessons introduce students to energy basics, emphasizes the connection between our energy use and consumption, the resulting impact on our climate, and energy solutions that mitigate its impact.

Citizen Climate for Grades 9-12
Citizen Climate is for high school students and focuses on global climate solutions. It emphasizes civic engagement and helps teachers and students understand the critical and complex climate solutions being discussed on the national and international stage.

Online Curriculum

Arctic Community
This curriculum features the Arctic community as seen by animals, native peoples, explorers and scientists; all with diverse perspectives and ways of knowing, and all contributing to knowledge and action to slow climate change. The focus is on solutions and positive messages of hope and action.

Minnesota's Changing Climate
This online classroom was developed in conjunction with the Minnesota's Changing Climate lessons. Through the classroom students have the opportunity to learn about Minnesota's unique biomes and the impacts of climate change.

Professional Development Opportunities

Summer Institute for Climate Change and Energy Education
Climate Generation has provided professional development to teachers for six years through annual Summer Institutes. The institutes provide teachers with tools to communicate climate change in the classroom. Past keynote speakers have included Bill McKibben, Dr. James Hansen, Andrew Revkin, Dr. Genie Scott and Dr. Naomi Oreskes.

Webinar Series
Climate Generation offers frequent climate and energy literacy webinars featuring climate change and energy experts and education resources. Webinars are archived and can be accessed via the website.

Custom Workshops
Climate Generation staff would love to work with your school, nature center, district or other educational setting to design a workshop focused on a variety of topics related to climate change and energy.

Online Resources

Climate Lessons Blog for Educators
Climate Generation maintains a blog dedicated to providing tools and references for educators and communicators of climate change.

Video Gallery
Climate Generation's video gallery contains 100's of videos featuring past expedition footage in polar regions, as well as presentations by leading climate scientists and other climate educators.

Academic Standards Aligned to Our Changing Climate, Grades 6-12

Climate Literacy Principles

Developed through a cooperative effort of numerous US federal agency scientists, formal and informal educators, interested individuals and representatives from non-governmental organizations and other institutions involved in climate research, education, and outreach the Essential Principles of Climate Science summarizes the most important principles and concepts of climate science. It presents important information for individuals and communities to understand Earth's climate, impacts of climate change, and approaches for adapting and mitigating change. Principles can serve as discussion starters or launching points for scientific inquiry. They can also serve educators who teach climate science as part of their science curricula.

More information can be found at: *http://cleanet.org/cln/climateliteracy.html*

A climate literate person:

-understands the essential principles of Earth's climate system

-knows how to assess scientifically credible information about climate

-communicates about climate and climate change in a meaningful way

-is able to make informed and responsible decisions with regard to actions that may affect climate

The Guiding Principle for Informed Climate Decisions		Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
Principle	Supporting Concepts						
Humans can take actions to reduce climate change and its impacts.							
	A. Climate information can be used to reduce vulnerabilities or enhance the resilience of communities and ecosystems affected by climate change. Continuing to improve scientific understanding of the climate system and the quality of reports to policy and decision-makers is crucial.					•	
	B. Reducing human vulnerability to the impacts of climate change depends not only upon our ability to understand climate science, but also upon our ability to integrate that knowledge into human society. Decisions that involve Earth's climate must be made with an understanding of the complex interconnections among the physical and biological components of the Earth system as well as the consequences of such decisions on social, economic, and cultural systems.						
	C. The impacts of climate change may affect the security of nations. Reduced availability of water, food, and land can lead to competition and conflict among humans, potentially resulting in large groups of climate refugees.					•	
	D. Humans may be able to mitigate climate change or lessen its severity by reducing greenhouse gas concentrations through processes that move carbon out of the atmosphere or reduce greenhouse gas emissions.						
	E. A combination of strategies is needed to reduce greenhouse gas emissions. The most immediate strategy is conservation of oil, gas, and coal, which we rely on as fuels for most of our transportation, heating, cooling, agriculture, and electricity. Short-term strategies involve switching from carbon-intensive to renewable energy sources, which also requires building new infrastructure for alternative energy sources. Long-term strategies involve innovative research and a fundamental change in the way humans use energy.						
	F. Humans can adapt to climate change by reducing their vulnerability to its impacts. Actions such as moving to higher ground to avoid rising sea levels, planting new crops that will thrive under new climate conditions, or using new building technologies represent adaptation strategies. Adaptation often requires financial investment in new or enhanced research, technology, and infrastructure.					•	
	G. Actions taken by individuals, communities, states, and countries all influence climate. Practices and policies followed in homes, schools, businesses, and governments can affect climate. Climate-related decisions made by one generation can provide opportunities as well as limit the range of possibilities open to the next generation. Steps toward reducing the impact of climate change may influence the present generation by providing other benefits such as improved public health infrastructure and sustainable built environments.						•

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Climate Literacy Principles (cont.)

The Essential Principles of Climate Science		Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
Principle	Supporting Concepts						
The sun is the primary source of energy for Earth's climate system.							
	Sunlight reaching the Earth can heat the land, ocean, and atmosphere. Some of that sunlight is reflected back to space by the surface, clouds, or ice. Much of the sunlight that reaches Earth is absorbed and warms the planet.	•	•				
	When Earth emits the same amount of energy as it absorbs, its energy budget is in balance, and its average temperature remains stable.						
	The tilt of Earth's axis relative to its orbit around the Sun results in predictable changes in the duration of daylight and the amount of sunlight received at any latitude throughout a year. These changes cause the annual cycle of seasons and associated temperature changes.						
	Gradual changes in Earth's rotation and orbit around the Sun change the intensity of sunlight received in our planet's polar and equatorial regions. For at least the last 1 million years, these changes occurred in 100,000-year cycles that produced ice ages and the shorter warm periods between them.						
	A significant increase or decrease in the Sun's energy output would cause Earth to warm or cool. Satellite measurements taken over the past 30 years show that the Sun's energy output has changed only slightly and in both directions. These changes in the Sun's energy are thought to be too small to be the cause of the recent warming observed on Earth.						
Climate is regulated by complex interactions among components of the Earth system.							
	Earth's climate is influenced by interactions involving the Sun, ocean, atmosphere, clouds, ice, land, and life. Climate varies by region as a result of local differences in these interactions.						
	Covering 70% of Earth's surface, the ocean exerts a major control on climate by dominating Earth's energy and water cycles. It has the capacity to absorb large amounts of solar energy. Heat and water vapor are redistributed globally through density-driven ocean currents and atmospheric circulation. Changes in ocean circulation caused by tectonic movements or large influxes of fresh water from melting polar ice can lead to significant and even abrupt changes in climate, both locally and on global scales.				•		
	The amount of solar energy absorbed or radiated by Earth is modulated by the atmosphere and depends on its composition. Greenhouse gases—such as water vapor, carbon dioxide, and methane—occur naturally in small amounts and absorb and release heat energy more efficiently than abundant atmospheric gases like nitrogen and oxygen. Small increases in carbon dioxide concentration have a large effect on the climate system.	•	•				
	The abundance of greenhouse gases in the atmosphere is controlled by biogeochemical cycles that continually move these components between their ocean, land, life, and atmosphere reservoirs. The abundance of carbon in the atmosphere is reduced through seafloor accumulation of marine sediments and accumulation of plant biomass and is increased through deforestation and the burning of fossil fuels as well as through other processes.						
	Airborne particulates, called "aerosols," have a complex effect on Earth's energy balance: they can cause both cooling, by reflecting incoming sunlight back out to space, and warming, by absorbing and releasing heat energy in the atmosphere. Small solid and liquid particles can be lofted into the atmosphere through a variety of natural and manmade processes, including volcanic eruptions, sea spray, forest fires, and emissions generated through human activities.						

Climate Literacy Principles (cont.)

The Essential Principles of Climate Science		Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
Principle	**Supporting Concepts**						
	The interconnectedness of Earth's systems means that a significant change in any one component of the climate system can influence the equilibrium of the entire Earth system. Positive feedback loops can amplify these effects and trigger abrupt changes in the climate system. These complex interactions may result in climate change that is more rapid and on a larger scale than projected by current climate models.				•		
Life on Earth depends on, is shaped by, and affects climate.							
	Individual organisms survive within specific ranges of temperature, precipitation, humidity, and sunlight. Organisms exposed to climate conditions outside their normal range must adapt or migrate, or they will perish.			•			
	The presence of small amounts of heat-trapping greenhouse gases in the atmosphere warms Earth's surface, resulting in a planet that sustains liquid water and life.		•				
	Changes in climate conditions can affect the health and function of ecosystems and the survival of entire species. The distribution patterns of fossils show evidence of gradual as well as abrupt extinctions related to climate change in the past.						
	A range of natural records shows that the last 10,000 years have been an unusually stable period in Earth's climate history. Modern human societies developed during this time. The agricultural, economic, and transportation systems we rely upon are vulnerable if the climate changes significantly.		•				
	Life—including microbes, plants, and animals and humans—is a major driver of the global carbon cycle and can influence global climate by modifying the chemical makeup of the atmosphere. The geologic record shows that life has significantly altered the atmosphere during Earth's history.						
Climate varies over space and time through both natural and man-made processes.							
	Climate is determined by the long-term pattern of temperature and precipitation averages and extremes at a location. Climate descriptions can refer to areas that are local, regional, or global in extent. Climate can be described for different time intervals, such as decades, years, seasons, months, or specific dates of the year.						
	Climate is not the same thing as weather. Weather is the minute-by-minute variable condition of the atmosphere on a local scale. Climate is a conceptual description of an area's average weather conditions and the extent to which those conditions vary over long time intervals.						
	Climate change is a significant and persistent change in an area's average climate conditions or their extremes. Seasonal variations and multi-year cycles (for example, the El Niño Southern Oscillation) that produce warm, cool, wet, or dry periods across different regions are a natural part of climate variability. They do not represent climate change.						
	Scientific observations indicate that global climate has changed in the past, is changing now, and will change in the future. The magnitude and direction of this change is not the same at all locations on Earth.				•		
	Based on evidence from tree rings, other natural records, and scientific observations made around the world, Earth's average temperature is now warmer than it has been for at least the past 1,300 years. Average temperatures have increased markedly in the past 50 years, especially in the North Polar Region.		•				
	Natural processes driving Earth's long-term climate variability do not explain the rapid climate change observed in recent decades. The only explanation that is consistent with all available evidence is that human impacts are playing an increasing role in climate change. Future changes in climate may be rapid compared to historical changes.		•				
	Natural processes that remove carbon dioxide from the atmosphere operate slowly when compared to the processes that are now adding it to the atmosphere. Thus, carbon dioxide introduced into the atmosphere today may remain there for a century or more. Other greenhouse gases, including some created by humans, may remain in the atmosphere for thousands of years.						

Climate Literacy Principles (cont.)

The Essential Principles of Climate Science		Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
Principle	**Supporting Concepts**						
Our understanding of the climate system is improved through observations, theoretical studies, and modeling.							
	The components and processes of Earth's climate system are subject to the same physical laws as the rest of the Universe. Therefore, the behavior of the climate system can be understood and predicted through careful, systematic study.						
	Environmental observations are the foundation for understanding the climate system. From the bottom of the ocean to the surface of the Sun, instruments on weather stations, buoys, satellites, and other platforms collect climate data. To learn about past climates, scientists use natural records, such as tree rings, ice cores, and sedimentary layers. Historical observations, such as native knowledge and personal journals, also document past climate change.						
	Observations, experiments, and theory are used to construct and refine computer models that represent the climate system and make predictions about its future behavior. Results from these models lead to better understanding of the linkages between the atmosphere-ocean system and climate conditions and inspire more observations and experiments. Over time, this iterative process will result in more reliable projections of future climate conditions.						
	Our understanding of climate differs in important ways from our understanding of weather. Climate scientists' ability to predict climate patterns months, years, or decades into the future is constrained by different limitations than those faced by meteorologists in forecasting weather days to weeks into the future.						
	Scientists have conducted extensive research on the fundamental characteristics of the climate system and their understanding will continue to improve. Current climate change projections are reliable enough to help humans evaluate potential decisions and actions in response to climate change.					•	
Human activities are impacting the climate system.							
	The overwhelming consensus of scientific studies on climate indicates that most of the observed increase in global average temperatures since the latter part of the 20th century is very likely due to human activities, primarily from increases in greenhouse gas concentrations resulting from the burning of fossil fuels.		•				
	Emissions from the widespread burning of fossil fuels since the start of the Industrial Revolution have increased the concentration of greenhouse gases in the atmosphere. Because these gases can remain in the atmosphere for hundreds of years before being removed by natural processes, their warming influence is projected to persist into the next century.		•				
	Human activities have affected the land, oceans, and atmosphere, and these changes have altered global climate patterns. Burning fossil fuels, releasing chemicals into the atmosphere, reducing the amount of forest cover, and rapid expansion of farming, development, and industrial activities are releasing carbon dioxide into the atmosphere and changing the balance of the climate system.		•				
	Growing evidence shows that changes in many physical and biological systems are linked to human-caused climate change. Some changes resulting from human activities have decreased the capacity of the environment to support various species and have substantially reduced ecosystem biodiversity and ecological resilience.			•			
	Scientists and economists predict that there will be both positive and negative impacts from global climate change. If warming exceeds 2 to 3°C (3.6 to 5.4°F) over the next century, the consequences of the negative impacts are likely to be much greater than the consequences of the positive impacts.						

Climate Literacy Principles (cont.)

The Essential Principles of Climate Science		Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
Principle	Supporting Concepts						
Climate change will have consequences for the Earth system and human lives.							
	Melting of ice sheets and glaciers, combined with the thermal expansion of seawater as the oceans warm, is causing sea level to rise. Seawater is beginning to move onto low-lying land and to contaminate coastal fresh water sources and beginning to submerge coastal facilities and barrier islands. Sea-level rise increases the risk of damage to homes and buildings from storm surges such as those that accompany hurricanes.				•	•	
	Climate plays an important role in the global distribution of freshwater resources. Changing precipitation patterns and temperature conditions will alter the distribution and availability of freshwater resources, reducing reliable access to water for many people and their crops. Winter snowpack and mountain glaciers that provide water for human use are declining as a result of climate change.					•	
	Incidents of extreme weather are projected to increase as a result of climate change. Many locations will see a substantial increase in the number of heat waves they experience per year and a likely decrease in episodes of severe cold. Precipitation events are expected to become less frequent but more intense in many areas, and droughts will be more frequent and severe in areas where average precipitation is projected to decrease.					•	
	The chemistry of ocean water is changed by absorption of carbon dioxide from the atmosphere. Increasing carbon dioxide levels in the atmosphere is causing ocean water to become more acidic, threatening the survival of shell-building marine species and the entire food web of which they are a part.						
	Ecosystems on land and in the ocean have been and will continue to be disturbed by climate change. Animals, plants, bacteria, and viruses will migrate to new areas with favorable climate conditions. Infectious diseases and certain species will be able to invade areas that they did not previously inhabit.			•			
	Human health and mortality rates will be affected to different degrees in specific regions of the world as a result of climate change. Although cold-related deaths are predicted to decrease, other risks are predicted to rise. The incidence and geographical range of climate-sensitive infectious diseases—such as malaria, dengue fever, and tick-borne diseases—will increase. Drought-reduced crop yields, degraded air and water quality, and increased hazards in coastal and low-lying areas will contribute to unhealthy conditions, particularly for the most vulnerable populations.					•	

Academic Standards Aligned to Our Changing Climate, Grades 6-12
The Next Generation Science Standards (NGSS)

In 2013, the NGSS were released as the most current, research- based way of educating students in STEM and preparing them for STEM careers. The NGSS establishes high standards for delivering effective STEM education. They challenge us to provide the instructional support in our curriculum resources and to make NGSS accessible to educators in the classroom. Hands on learning, effective communication, making connections across all domains of science and other disciplines, an emphasis on including "all voices," and the importance of developing a learning progression are not only integral to the NGSS, but have always guided Climate Generation's development of educational resources.

NGSS performance expectations represent the final assessment of learning and therefore cannot fully develop a student's full mastery. Additionally, true NGSS instruction and learning is three dimensional- including not only core ideas (CI), but cross cutting concepts (CCC) and scientific and engineering practices (SEP) as well. Lesson plans that best support NGSS performance expectations, CI, CC and SEP are listed below.

Performance Expectations	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
ESS3 Earth and Human Activity						
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century		•				
MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.						•
LS2 Ecosystems: Interactions, Energy and Dynamics						
HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.						•
LS4 Biological Evolution: Unity and Diversity						
HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.			•			
ESS2 Earth's Systems						
HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.		•	•	•		
HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.	•	•		•		
ESS3 Earth and Human Activity						
HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.			•	•		•
HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*						•
HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.					•	
ETS1 Engineering Design						
HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.						•
HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.						•
HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.						•
Life Science Disciplinary Core Ideas						
LS2A - Relationships in Ecosystems			•			
LS2B - Cycles in Ecosystems			•			
LS2C - Ecosystem Dynamics			•			
LS4D - Biodiversity & Humans			•	•	•	
Earth & Space Science Disciplinary Core Ideas						
ESS2A - Earth Materials & Systems	•	•		•		
ESS2C - Role of Water on Earth			•	•	•	
ESS2D - Weather & Climate	•	•	•	•	•	
ESS2E - Biogeology			•			
ESS3A - Natural Resources		•			•	

The Next Generation Science Standards (cont.)

Earth & Space Science Disciplinary Core Ideas (cont.)	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
ESS3C - Human Impacts on Earth Systems		•	•	•	•	
ESS3D - Global Climate Change	•	•	•	•	•	
Engineering, Technology & Applications of Science Disciplinary Core Ideas						
ETS1B - Developing Possible Solutions						•
ETS2A - Interdependence of Science, Engineering & Technology						•
ETS2B - Influence of Science, Engineering & Technology on Society & the Natural World						•
Cross Cutting Concepts						
1. Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.	•	•	•	•	•	
2. Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.	•	•	•	•	•	
3. Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.	•	•	•	•	•	
4. Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.	•	•		•	•	
5. Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.	•			•		
7. Stability and change. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.		•	•	•	•	
Scientific and Engineering Practices						
1. Asking questions (for science) and defining problems (for engineering)	•	•	•	•	•	
2. Developing and using models			•			
4. Analyzing and interpreting data	•	•			•	
6. Constructing explanations (for science) and designing solutions (for engineering)		•	•	•	•	•
7. Engaging in argument from evidence	•			•	•	•
8. Obtaining, evaluating, and communicating information	•	•	•	•	•	•

Academic Standards Aligned to Our Changing Climate, Grades 6-12

Minnesota Science Standards

Grade	Strand	Substrand	Standard "Understand that ...	Code	Benchmark	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
6	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	1. Designed and natural systems exist in the world. These systems consist of components that act within the system and interact with other systems.	6.1.3.1.1	Describe a system in terms of its subsystems and parts, as well as its inputs, processes and outputs.	•	•				
6	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment.	6.2.3.2.3	Describe how heat energy is transferred in conduction, convection and radiation.	•	•				
7	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.	7.1.1.1.1	Understand that prior expectations can create bias when conducting scientific investigations. For example: Students often continue to think that air is not matter, even though they have contrary evidence from investigations.		•				
7	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry uses multiple interrelated processes to investigate questions and propose explanations about the natural world.	7.1.1.2.3	Generate a scientific conclusion from an investigation, clearly distinguishing between results (evidence) and conclusions (explanation).		•				
7	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	3. Current and emerging technologies have enabled humans to develop and use models to understand and communicate how natural and designed systems work and interact.	7.1.3.4.2	Determine and use appropriate safety procedures, tools, measurements, graphs and mathematical analyses to describe and investigate natural and designed systems in a life science context.		•				
7	4. Life Science	2. Interdepen-dence Among Living Systems	1. Natural systems include a variety of organisms that interact with one another in several ways.	7.4.2.1.1	Identify a variety of populations and communities in an ecosystem and describe the relationships among the populations and communities in a stable ecosystem.			•			
7	4. Life Science	4. Human Interactions with Living Systems	1. Human ativity can change living organisms and ecosystems.	7.4.4.1.2	Describe ways that human activities can change the populations and communities in an ecosystem.			•			
8	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural and engineered world and investigate phenomena.	8.1.1.2.1	Use logical reasoning and imagination to develop descriptions, explanations, predictions and models based on evidence.		•	•			
8	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	3. Science and engineering operate in the context of society and both influence and are influenced by this context.	8.1.3.3.3	Provide examples of how advances in technology have impacted how people live, work and interact.		•				
8	3. Earth Science	2. Interdepen-dence Within the Earth system	1. The sun is the principal external energy source for the Earth.	8.3.2.1.2	Recognize that oceans have a major effect on global climate because water in the oceans holds a large amount of heat.				•		

CLIMATE GENERATION
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Minnesota Science Standards (cont.)

Grade	Strand	Substrand	Standard "Understand that ...	Code	Benchmark	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
8	3. Earth Science	2. Interdepen-dence Within the Earth system	1. The sun is the principal external energy source for the Earth.	8.3.2.1.3	Explain how heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and hydrosphere producing winds, ocean currents and the water cycle, as well as influencing global climate.	•					
8	3. Earth Science	2. Interdepen-dence Within the Earth system	2. Patterns of atmospheric movement influence global climate and local weather.	8.3.2.2.1	Describe how the composition and structure of the Earth's atmosphere affects energy absorption, climate, and the distribution of particulates and gases. For example: Certain gases contribute to the greenhouse effect.	•					
8	3. Earth Science	4. Human Interactions with Earth Systems	1. In order to maintain and improve their existence humans interact with and influence Earth systems.	8.3.4.1.2	Recognize that land and water use practices affect natural processes and that natural processes interfere and interact with human systems. For example: Levees change the natural flooding process of a river. Another example: Agricultural runoff influences natural systems far from the source.			•	•	•	•
9 thru 12	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by emperical criteria, logical argument and skeptical review.	9.1.1.1.2	Understand that scientists conduct investigations for a variety of reasons, including: to discover new aspects of the natural world, to explain observed phenomena, to test the conclusions of prior investigations, or to test the predictions of current theories.		•	•		•	
9 thru 12	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by emperical criteria, logical argument and skeptical review.	9.1.1.1.3	Explain how the traditions and norms of science define the bounds of professional scientific practice and reveal instances of scientific error or misconduct. For example: The use of peer review, publications and presentations.						
9 thru 12	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by emperical criteria, logical argument and skeptical review.	9.1.1.1.6	Describe how changes in scientific knowledge generally occur in incremental steps that include and build on earlier knowledge.		•				
9 thru 12	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world that is characterized by emperical criteria, logical argument and skeptical review.	9.1.1.1.7	Explain how scientific and technological innovations-as well as new evidence-can challenge portions of, or entire accepted theories and models including, but not limited to: cell theory, atomic theory, theory of evolution, plate tectonic theory, germ theory of disease, and the big bang theory.		•				

Minnesota Science Standards (cont.)

Grade	Strand	Substrand	Standard "Understand that ...	Code	Benchmark	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
9 thru 12	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.	9.1.1.2.2	Evaluate the explanations proposed by others by examining and comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the scientifically acceptable evidence, and suggesting alternative scientific explanations.						•
9 thru 12	1. The Nature of Science and Engineering	2. The Practice of Engineering	1. Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.	9.1.2.1.2	Recognize that risk analysis is used to determine the potential positive and negative consequences of using a new technology or design, including the evaluation of causes and effects of failures. For example: Risks and benefits associated with using lithium batteries.					•	
9 thru 12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	1. Natural and designed systems are made up of components that act within a system and interact with other systems.	9.1.3.1.1	Describe a system, including specifications of boundaries and subsystems, relationships to other systems, and identification of inputs and expected outputs. For example: A power plant or ecosystem.			•	•		
9 thru 12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	1. Natural and designed systems are made up of components that act within a system and interact with other systems.	9.1.3.1.2	Identify properties of a system that are different from those of its parts but appear because of the interaction of those parts.	•		•		•	
9 thru 12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	1. Natural and designed systems are made up of components that act within a system and interact with other systems.	9.1.3.1.3	Describe how positive and/or negative feedback occur in systems. For example: The greenhouse effect				•		
9 thru 12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	2. Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry.	9.1.3.2.1	Provide examples of how diverse cultures, including natives from all of the Americas, have contributed scientific and mathematical ideas and technological inventions. For example: Native American understanding of ecology; Lisa Meitner's contribution to understanding radioactivity; Tesla's ideas and inventions relating to electricity; Watson, Crick and Franklin's discovery of the structure of DNA; or how George Washington Carver's ideas changed land use.			•			
9 thru 12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	3. Science and engineering operate in the context of society and both influence and are influenced by this context.	9.1.3.3.1	Describe how values and constraints affect science and engineering. For example: Economic, environmental, social, political, ethical, health, safety, and sustainability issues.						•

Minnesota Science Standards (cont.)

Grade	Strand	Substrand	Standard "Understand that ...	Code	Benchmark	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
9 thru 12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	3. Science and engineering operate in the context of society and both influence and are influenced by this context.	9.1.3.3.3	Describe how scientific investigations and engineering processes require multi-disciplinary contributions and efforts. For example: Nanotechnology, climate change, agriculture, or biotechnology.		•	•		•	
9 thru 12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	4. Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.	9.1.3.4.1	Describe how technological problems and advances often create a demand for new scientific knowledge, improved mathematics, and new technologies.					•	
9 thru 12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	4. Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.	9.1.3.4.3	Select and use appropriate numeric, symbolic, pictorial, or graphical representation to communicate scientific ideas, procedures and experimental results.			•			
9 thru 12	2. Physical Science	4. Human Interactions with Physical Systems	1. There are benefits, costs and risks to different means of generating and using energy.	9.2.4.1.1	Compare local and global environmental and economic advantages and disadvantages of generating electricity using various sources or energy. For example: Fossil fuels, nuclear fission, wind, sun or tidal energy.						•
9 thru 12	2. Physical Science	4. Human Interactions with Physical Systems	1. There are benefits, costs and risks to different means of generating and using energy.	9.2.4.1.2	Describe the trade-offs involved when technological developments impact the way we use energy, natural resources, or synthetic materials. For example: Fluorescent light bulbs use less energy than incandescent lights, but contain toxic mercury.						•
9 thru 12	3. Earth and Space Science	2. Interdepen-dence Within the Earth System	2. Global climate is determined by distribution of energy from the sun at the Earth's surface.	9.3.2.2.1	Explain how Earth's rotation, ocean currents, configuration of mountain ranges, and composition of the atmosphere influence the absorption and distribution of energy, which contributes to global climatic patterns.	•	•		•	•	
9 thru 12	3. Earth and Space Science	2. Interdepen-dence Within the Earth System	2. Global climate is determined by distribution of energy from the sun at the Earth's surface.	9.3.2.2.2.	Explain how evidence from the geologic record, including ice core samples, indicates that climate changes have occurred at varying rates over geologic time and continue to occur today.			•			
9 thru 12	3. Earth and Space Science	2. Interdepen-dence Within the Earth System	3. The cycling of materials through different reservoirs of the Earth's system is powered by the Earth's sources of energy.	9.3.2.3.1	Trace the cyclical movement of carbon, oxygen and nitrogen through the lithosphere, hydrosphere, atmosphere and biosphere. For example: The burning of fossil fuels contributes to the greenhouse effect.		•				

Academic Standards Aligned to Our Changing Climate, Grades 6-12

Minnesota Science Standards (cont.)

Grade	Strand	Substrand	Standard "Understand that ...	Code	Benchmark	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
9 thru 12	3. Earth and Space Science	4. Human Interactions with the Earth Systems	1. People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.	9.3.4.1.1	Analyze the benefits, costs, risks and tradeoffs associated with natural hazards, including the selection of land use and engineering mitigation. For example: Determining land use in floodplains and areas prone to landslides.			•	•	•	
9 thru 12	3. Earth and Space Science	4. Human Interactions with the Earth Systems	1. People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.	9.3.4.1.2	Explain how human activity and natural processes are altering the hydrosphere, biosphere, lithosphere and atmosphere, including pollution, topography and climate. For example: Active volcanoes and the burning of fossil fuels contribute to the greenhouse effect.		•	•	•	•	•
9 thru 12	4. Life Science	2. Interdependence Among Living Systems	1. The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.	9.4.2.1.1	Describe factors that affect the carrying capacity of an ecosystem and relate these to population growth.			•		•	
9 thru 12	4. Life Science	2. Interdependence Among Living Systems	2. Matter cycles and energy flows through different levels of organization of living systems and the physical environment, as chemical elements are combined in different ways.	9.4.2.2.2	Explain how matter and energy is transformed and transferred among organisms in an ecosystem, and how energy is dissipated as heat into the environment.				•		
9 thru 12	4. Life Science	4. Human Interactions with Living Systems	1. Human activity has consequences on living organisms and ecosystems.	9.4.4.1.2	Describe the social, economic and ecological risks and benefits of changing a natural ecosystem as a result of human activity. For example: Changing the temperature or composition of water, air or soil; altering the populations and communities, developing artificial ecosystems; or changing the use of land or water.		•	•	•	•	
9 thru 12	4. Life Science	4. Human Interactions with Living Systems	1. Human activity has consequences on living organisms and ecosystems.	9.4.4.1.3	Describe contributions from diverse cultures, including Minnesota American Indian tribes and communities, to the understanding of interactions among humans and living systems. For example: American Indian understanding of sustainable land use practices.			•			
9 thru 12	4. Life Science	4. Human Interactions with Living Systems	2. Personal and community health can be affected by the environment, body functions and human behavior.	9.4.4.2.4	Explain how environmental factors and personal decisions, such as water quality, air quality and smoking affect personal and community health.			•		•	
Chemistry	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	3. Developments in chemistry affect society and societal concerns affect the field of chemistry.	9C.1.3.3.1	Explain the political, societal, economic and environmental impact of chemical products and technologies. For example: Pollution effects, atmospheric changes, petroleum products, material use or waste disposal.		•	•			

CLIMATE GENERATION
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Academic Standards Aligned to Our Changing Climate, Grades 6-12
Minnesota Social Studies Standards

Grade	Strand	Sub-Strand	Standard	Code	Benchmark	For Example.	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
8	1. Citizenship and Government	1. Civic Skills	1. Democratic government depends on informed and engaged citizens who exhibit civic skills and values, practice civic discourse, vote and participate in elections, apply inquiry and analysis skills and take action to solve problems and shape public policy.	8.1.1.1.1	Exhibit civic skills, including participating in civic discussion on issues in the contemporary world, demonstrating respect for the opinions of people or groups who have different perspectives, and reaching consensus.	For example: Civic discourse skills—speaking, listening, respecting diverse viewpoints, evaluating arguments. Issues in the contemporary world might include participation in international treaty organizations, positive discrimination/affirmative action, environmental issues.		•			•	•
8	3. Geography	1. Geospatial Skills	2. Geographic inquiry is a process in which people ask geographic questions and gather, organize and analyze information to solve problems and plan for the future.	8.3.1.2.1	Formulate questions about topics in geography; pose possible answers; use geospatial technology to analyze problems and make decisions within a spatial context.	For example: Questions about geographic issues might relate to urban development, environmental concerns, transportation issues, flood control. Geospatial technology—Geographic Information Systems (GIS), online atlases and databases, Google Earth or similar programs.			•	•	•	
8	3. Geography	3. Human Systems	6. Geographic factors influence the distribution, functions, growth and patterns of cities and human settlements.	8.3.3.6.1	Describe how the physical and environmental features of the United States and Canada affect human activity and settlement.	For example: Physical and environmental features—Climate, landforms, distribution of resources, waterways, ecosystems.					•	
8	3. Geography	3. Human Systems	6. Geographic factors influence the distribution, functions, growth and patterns of cities and human settlements.	8.3.3.6.2	Describe how the physical and environmental features of Latin America affect human activity and settlement.						•	
8	3. Geography	3. Human Systems	6. Geographic factors influence the distribution, functions, growth and patterns of cities and human settlements.	8.3.3.6.3	Describe how the physical and environmental features of Europe and Russia affect human activity and settlement.						•	
8	3. Geography	3. Human Systems	6. Geographic factors influence the distribution, functions, growth and patterns of cities and human settlements.	8.3.3.6.4	Describe how the physical and environmental features of Southwest Asia and North Africa affect human activity and settlement.						•	

Minnesota Social Studies Standards (cont.)

Grade	Strand	Sub-Strand	Standard	Code	Benchmark	For Example.	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
8	3. Geography	3. Human Systems	6. Geographic factors influence the distribution, functions, growth and patterns of cities and human settlements.	8.3.3.6.6	Describe how the physical and environmental features of South Asia and Central Asia affect human activity and settlement.						•	
9 thru 12	1. Citizenship and Government	1. Civic Skills	1. Democratic government depends on informed and engaged citizens who exhibit civic skills and values, practice civic discourse, vote and participate in elections, apply inquiry and analysis skills and take action to solve problems and shape public policy.	9.1.1.1.1	Demonstrate skills that enable people to monitor and influence state, local and national affairs.	For example: Working with others; conducting civil conversations; articulating ideas and interests; negotiating differences and managing conflict with people or groups who have different perspectives; using parliamentary procedures; building consensus.						•
9 thru 12	2. Economics	3. Fundamental Concepts	3. Because of scarcity, individuals, organizations and governments must evaluate trade-offs, make choices and incur costs.	9.2.3.3.1	Identify the incentives and trade-offs related to a choice made by an individual, household, organization or government; describe the opportunity cost of a choice; and analyze the consequences of a choice (both intended and unintended).	For example: An opportunity cost of choosing to spend more than your income, be it an individual or government, is less financial security and ability to spend later.						•
9 thru 12	3. Geography	2. Places and Regions	3. Places have physical characteristics (such as climate, topography and vegetation) and human characteristics (such as culture, population, political and economic systems).	9.3.2.3.1	Make inferences and draw conclusions about the physical and human characteristics of places based on a comparison of maps and other geographic representations and geospatial technologies.	For example: Physical characteristics— landforms (Rocky Mountains), ecosystems (forest), bodies of water (Mississippi River, Hudson Bay), vegetation, weather and climate. Human characteristics— bridges (Golden Gate Bridge), Erie Canal, cities, political boundaries, population distribution, settlement patterns, language, ethnicity, nationality, religious beliefs.					•	
9 thru 12	3. Geography	3. Human Systems	5. The characteristics, distribution and migration of human populations on the Earth's surface influence human systems (cultural, economic and political systems).	9.3.3.5.5	Describe the factors influencing the growth and spatial distribution of large cities in the contemporary world.	For example: Economic development, migration, population growth.			•		•	
9 thru 12	3. Geography	4. Human environment Insteraction	9. The environment influences human actions; and humans both adapt to and change, the environment.	9.3.4.9.1	Analyze the interconnectedness of the environment and human activities (including the use of technology), and the impact of one upon the other.				•		•	

CLIMATE GENERATION
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Minnesota Language Arts Standards

Level	Strand/ Sub-strand	Anchor Standard	Benchmark	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
6	5. READING Informational Text	1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.	1. Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.			•	•	•	
6	5. READING Informational Text	2. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.	2. Determine a central idea of a text and how it is conveyed through particular details; provide a summary of the text distinct from personal opinions or judgments.	•		•	•	•	•
6	1. 5. READING Informational Text	3. Analyze how and why individuals, events, and ideas develop and interact over the course of a text.	3. Analyze in detail how a key individual, event, or idea is introduced, illustrated, and elaborated in a text (e.g., through examples or anecdotes).	•		•	•	•	
6	5. READING Informational Text	7. Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.	7. Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.	•	•	•	•		•
6	7. WRITING	1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.	1. Write arguments to support claims with clear reasons and relevant evidence a. Introduce claim(s) and organize the reasons and evidence clearly. b. Support claim(s) with clear reasons and relevant evidence, using credible sources and demonstrating an understanding of the topic or text. c. Use words, phrases, and clauses to clarify the relationships among claim(s) and reasons. d. Establish and maintain a formal style. e. Provide a concluding statement or section that follows from the argument presented.						•
6	7. WRITING	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)	•	•	•	•	•	•
6	7. WRITING	10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.	10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. a. Independently select writing topics and formats for personal enjoyment, interest, and academic tasks.	•	•	•	•	•	•
6	9. SPEAKING, VIEWING, LISTENING, AND MEDIA LITERACY	1. Prepare for and participate effectively in a range of conversations and collaboration with diverse partners, building on others' ideas and expressing their own clearly and persuasively.	1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. a. Come to discussions prepared having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. b. Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed. c. Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion. d. Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing. e. Cooperate, mediate, and problem solve to make decisions as appropriate for productive group discussion.	•	•		•	•	•
6	9. SPEAKING, VIEWING, LISTENING, AND MEDIA LITERACY	2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.	2. Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.	•	•	•	•	•	

Minnesota Language Arts Standards (cont.)

Level	Strand/ Sub-strand	Anchor Standard	Benchmark	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
6	9. SPEAKING, VIEWING, LISTENING, AND MEDIA LITERACY	4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.	4. Present claims and findings, respect intellectual properties, sequence ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.		•	•	•		•
6	11. LANGUAGE	5. Demonstrate understanding of figurative language, word relationships and nuances in word meanings.	5. Demonstrate understanding of figurative language, word relationships, and nuances in word meanings to extend word consciousness. a. Interpret figures of speech (e.g., personification) in context. b. Use the relationship between particular words (e.g., cause/effect, part/whole, item/category) to better understand each of the words. c. Distinguish among the connotations (associations) of words with similar denotations (definitions) (e.g., stingy, scrimping, economical, unwasteful, thrifty).	•					
7	5. READING Informational Text	1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.	1. Cite several pieces of textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.			•	•	•	
7	5. READING Informational Text	2. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.	2. Determine two or more central ideas in a text and analyze their development over the course of the text; provide an objective summary of the text.			•	•	•	•
7	5. READING Informational Text	3. Analyze how and why individuals, events, and ideas develop and interact over the course of a text.	3. Analyze the interactions between individuals, events, and ideas in a text (e.g., how ideas influence individuals or events, or how individuals influence ideas or events).			•	•	•	
7	7. WRITING	1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.	1. Write arguments to support claims with clear reasons and relevant evidence. a. Introduce claim(s), acknowledge alternate or opposing claims, and organize the reasons and evidence logically. b. Support claim(s) with logical reasoning and relevant evidence, using accurate, credible sources and demonstrating an understanding of the topic or text. c. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), reasons, and evidence. d. Establish and maintain a formal style. e. Provide a concluding statement or section that follows from and supports the argument presented.						•
7	7. WRITING	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)		•	•	•	•	•
7	7. WRITING	10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.	10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. a. Independently select writing topics and formats for personal enjoyment, interest, and academic tasks.		•	•	•	•	•

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Minnesota Language Arts Standards (cont.)

Level	Strand/ Sub-strand	Anchor Standard	Benchmark	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
7	9. SPEAKING, VIEWING, LISTENING, AND MEDIA LITERACY	1. Prepare for and participate effectively in a range of conversations and collaboration with diverse partners, building on others' ideas and expressing their own clearly and persuasively.	1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly. a. Come to discussions prepared having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. b. Follow rules for collegial discussions, track progress toward specific goals and deadlines, and define individual roles as needed. c. Pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed. d. Acknowledge new information expressed by others and, when warranted, modify their own views. e. Cooperate, mediate, and problem solve to make decisions as appropriate for productive group discussion.		•	•	•		•
7	9. SPEAKING, VIEWING, LISTENING, AND MEDIA LITERACY	2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.	2. Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue under study.		•	•	•	•	
7	9. SPEAKING, VIEWING, LISTENING, AND MEDIA LITERACY	4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.	4. Present claims and findings, respect intellectual properties, emphasize salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.		•	•	•		•
7	11. LANGUAGE	5. Demonstrate understanding of figurative language, word relationships and nuances in word meanings.	5. Demonstrate understanding of figurative language, word relationships, and nuances in word meanings to extend word consciousness. a. Interpret figures of speech (e.g. literary, biblical, and mythological allusions) in context. b. Use the relationship between particular words (e.g., synonym/antonym, analogy) to better understand each of the words. c. Distinguish among the connotations (associations) of words with similar denotations (definitions) (e.g., refined, respectful, polite, diplomatic, condescending).	•					
8	5. READING Informational Text	1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.	1. Cite the textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text.			•	•	•	
8	5. READING Informational Text	2. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.	2. Determine a central idea of a text and analyze its development over the course of the text, including its relationship to supporting ideas; provide an objective summary of the text.			•	•	•	•
8	5. READING Informational Text	3. Analyze how and why individuals, events, and ideas develop and interact over the course of a text.	3. Analyze how a text makes connections among and distinctions between individuals, ideas, or events (e.g., through comparisons, analogies, or categories).			•	•	•	

Minnesota Language Arts Standards (cont.)

Level	Strand/ Sub-strand	Anchor Standard	Benchmark	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
8	7. WRITING	1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.	1. Write arguments to support claims with clear reasons and relevant evidence. a. Introduce claim(s), acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically. b. Support claim(s) with logical reasoning and relevant evidence, using accurate, credible sources and demonstrating an understanding of the topic or text. c. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence. d. Establish and maintain a formal style. e. Provide a concluding statement or section that follows from and supports the argument presented.						•
8	7. WRITING	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)		•	•	•	•	•
8	7. WRITING	10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.	10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. a. Independently select writing topics and formats for personal enjoyment, interest, and academic tasks.		•	•	•	•	•
8	9. SPEAKING, VIEWING, LISTENING, AND MEDIA LITERACY	1. Prepare for and participate effectively in a range of conversations and collaboration with diverse partners, building on others' ideas and expressing their own clearly and persuasively.	1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. a. Come to discussions prepared having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. b. Follow rules for collegial discussions and decision-making, track progress toward specific goals and deadlines, and define individual roles as needed. c. Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas. d. Acknowledge new information expressed by others, and, when warranted, qualify or justify their own views in light of the evidence presented e. Cooperate, mediate, and problem solve to make decisions or build consensus as appropriate for productive group discussion.			•	•		•
8	9. SPEAKING, VIEWING, LISTENING, AND MEDIA LITERACY	2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.	2. Analyze the purpose of information presented in diverse media and formats (e.g., visually, quantitatively, orally) and evaluate the motives (e.g., social, commercial, political) behind its presentation.					•	
8	9. SPEAKING, VIEWING, LISTENING, AND MEDIA LITERACY	4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.	4. Present claims and findings, respect intellectual properties, emphasize salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.			•	•		•
8	11. LANGUAGE	5. Demonstrate understanding of figurative language, word relationships and nuances in word meanings.	5. Demonstrate understanding of figurative language, word relationships, and nuances in word meanings to extend word consciousness. a. Interpret figures of speech (e.g. verbal irony, puns) in context. b. Use the relationship between particular words to better understand each of the words. c. Distinguish among the connotations (associations) of words with similar denotations (definitions) (e.g., bullheaded, willful, firm, persistent, resolute).	•					
9	5. READING Informational Text	1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.	1. Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.			•	•	•	

Minnesota Language Arts Standards (cont.)

Level	Strand/ Sub-strand	Anchor Standard	Benchmark	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
9	5. READING Informational Text	2. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.	2. Determine a central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text.			•	•	•	•
9	5. READING Informational Text	3. Analyze how and why individuals, events, and ideas develop and interact over the course of a text.	3. Analyze how the author unfolds an analysis or series of ideas or events, including the order in which the points are made, how they are introduced and developed, and the connections that are drawn between them.			•	•	•	
9	7. WRITING	1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.	1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. a. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly, supplying evidence for each while pointing out the strengths and limitations of both in a manner that anticipates the audience's knowledge level and concerns. c. Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from and supports the argument presented.						•
9	7. WRITING	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)		•	•	•	•	•
9	7. WRITING	10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.	10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences. a. Independently select writing topics and formats for personal enjoyment, interest, and academic tasks.		•	•	•	•	•
9	9. SPEAKING, VIEWING, LISTENING, AND MEDIA LITERACY	1. Prepare for and participate effectively in a range of conversations and collaboration with diverse partners, building on others' ideas and expressing their own clearly and persuasively.	1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, including those by and about Minnesota American Indians, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to set rules for collegial discussions and decision-making (e.g., informal consensus, taking votes on key issues, presentation of alternate views), clear goals and deadlines, and individual roles as needed. Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions. c. Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.			•	•		
9	9. SPEAKING, VIEWING, LISTENING, AND MEDIA LITERACY	4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.	4. While respecting intellectual property, present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task (e.g., persuasion, argumentation, debate).			•	•		•
11	5. READING Informational Text	1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.	1. Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.			•	•	•	

Minnesota Language Arts Standards (cont.)

Level	Strand/ Sub-strand	Anchor Standard	Benchmark	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
11	5. READING Informational Text	2. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.	2. Determine two or more central ideas of a text and analyze their development over the course of the text, including how they interact and build on one another to provide a complex analysis; provide an objective summary of the text.			•	•	•	•
11	5. READING Informational Text	3. Analyze how and why individuals, events, and ideas develop and interact over the course of a text.	3. Analyze a complex set of ideas or sequence of events and explain how specific individuals, ideas, or events interact and develop over the course of the text.			•	•	•	
11	7. WRITING	1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.	1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant evidence for each while pointing out the strengths and limitations of both in a manner that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from and supports the argument presented.						•
11	7. WRITING	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)			•	•	•	•
11	7. WRITING	10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.	10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences. a. Independently select writing topics and formats for personal enjoyment, interest, and academic tasks.			•	•	•	•
11	9. SPEAKING, VIEWING, LISTENING, AND MEDIA LITERACY	1. Prepare for and participate effectively in a range of conversations and collaboration with diverse partners, building on others' ideas and expressing their own clearly and persuasively.	1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 11–12 topics, texts, and issues, including those by and about Minnesota American Indians, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed. c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task.			•	•		
11	9. SPEAKING, VIEWING, LISTENING, AND MEDIA LITERACY	4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.	4. While respecting intellectual property, present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks (e.g., persuasion, argumentation, debate).			•	•		•

Our Changing Climate 6–12 Lesson Organizer

Lesson/Objectives	Lesson Materials
LESSON 1: OUR UNIQUE ATMOSPHERE 40 minutes • Explain how heat-trapping gases work in the atmosphere • Explain why carbon dioxide and other heat-trapping gases are necessary for life as we know it	Reading 1: The Structure of the Atmosphere Reading 2: Heat-Trapping Gases in the Atmosphere Reading 3: The Greenhouse Effect
LESSON 2: EMISSIONS OF HEAT TRAPPING GASES 40 minutes • Explain how increased atmospheric concentrations of heat-trapping gases warm the atmosphere • Predict what will happen to global temperatures if atmospheric concentrations of heat-trapping gases increase • Identify sources of heat-trapping emissions • Calculate a carbon footprint • Identify ways they can reduce their carbon footprint	Handout 1: Energy Use in Your Home Image 1:Greenhouse – Green Planet Image 2: 1000 Years of Changes Image 3: Carbon Dioxide in the Atmosphere Handout 2: 20 Simple Steps to Reduce Climate change
LESSON 3: COMMUNITIES OF LIVING THINGS 40 minutes • Explain how changing weather patterns, a changing balance of competitors and changes in the availability of food and shelter can increase uncertainty for communities of living things • Give examples of these uncertainties and disruptions from the Arctic communities • Predict how continued warming may affect communities of living things with which they are familiar	Reading 1: Polar Bears Reading 2: Ice-edge Dwellers Reading 3: Land-Dwellers Reading 4: Plant Communities Reading 5: Human Communities
LESSON 4: IMPLICATIONS OF WARMING IN THE ARCTIC 40 minutes • Explain feedbacks including surface reflectivity (albedo), ocean circulation, melting permafrost releasing heat-trapping gases and melting ice contributing to rising sea levels • Explain how warming in the Arctic affects the rest of the world	Feedback 1: Surface Reflectivity Feedback 2: Ocean Circulation Feedback 3: Melting Permafrost
LESSON 5: REGIONAL EFFECTS OF CLIMATE CHANGE 40 minutes • Explain how climate change will cause droughts and floods from changing precipitation patterns combined with increased evaporation, more intense hurricanes fueled by warmer oceans, insect and disease outbreaks and other possible effects • Predict what might happen in a specific region	Region 1: Maldives Region 2: Norway Region 3: Iowa Region 4: Republic of Chad Region 5: Amazon basin Region 6: Southern California Impacts of Climate change
LESSON 6: WHAT NOW? 40 minutes • Brainstorm ideas of how to respond to climate change • Think critically about the trade-offs between different possible courses of actions	None

Lesson 1: Our Unique Atmosphere

How does our atmosphere keep the Earth warm?

Question	How does our atmosphere keep the earth warm?
Objective	Students will be able to explain how heat-trapping gases work in the atmosphere. Students will explain why carbon dioxide and other heat-trapping gases are necessary for life as we know it.
Time Needed	40 minutes
Materials	Reading 1: The Structure of the Atmosphere Reading 2: Heat-Trapping Gases in the Atmosphere Reading 3: The Greenhouse Effect

Directions:

WARM UP ACTIVITY

Have students count off from one to three. Each student must then find another student who has the same number. In these pairs, have the students cooperatively read the passage that corresponds to their number:

Reading 1: The Structure of the Atmosphere
Reading 2: Heat-Trapping Gases in the Atmosphere
Reading 3: The Greenhouse Effect

LESSON

1. Each pair then plans a way to teach their topic to other students. Their lesson will need to include an explanation of the major concepts in the passage and an explanation of the visuals that accompany the passage. Students will also need to include in their lesson an original analogy and an original visual that help explain the concepts in their passage.
2. Make sure students understand that an analogy is a comparison based on a similarity between two things that are otherwise dissimilar. For example, students who read the passage about the layers of the atmosphere could compare the layers of the atmosphere to the different colored layers on a Gobstopper candy or an onion or a layer cake. They would then draw a visual that helps clarify their analogy.
3. These pairs then split and each student finds another student who also has the same number. For example, a student with the number one will find a different student who is also a number one. These new pairs then share with each other the lesson they prepared with their first partner, including the analogy and original visual. These new partners give each other feedback on aspects of their lesson that were especially good. Each can then decide to incorporate certain aspects of the partner's lesson into his/her lesson to strengthen it.
4. Next, students find new groups that comprise a student with each number. For example, a student with the number one would find a student with the number two and also a student with the number three. Starting with the student with the number one, the students teach their lessons to the other two students in their group.
5. The teacher then picks one student from each group to share his or her analogy and visual with the class.

Notes to Teachers:

As the students are cooperatively reading, planning and practicing their lessons and presenting their lessons to each other, circulate between the groups and listen at each group for a few moments to gauge the progress of the groups and to make certain that students are focusing their efforts on the task.

Before dividing the students into groups, explain the entire activity to them and let them know how much time they will have for each section of the activity.

Explain to the students that you will be circulating between the groups during this activity and that you may ask any student at any time to explain any aspect of the passages. Let them know that it is the responsibility of each group to make sure that each group member understands all the concepts and would be ready to explain any of the topics.

Photo Credit: NASA

Reading 1: The Structure of the Atmosphere

The atmosphere is about 372 miles (600 kilometers) thick. While this may seem like a lot, when compared to the size of the Earth, the atmosphere is a relatively thin layer of gases. In the photo on the left, you can see how relatively thin the atmosphere is.

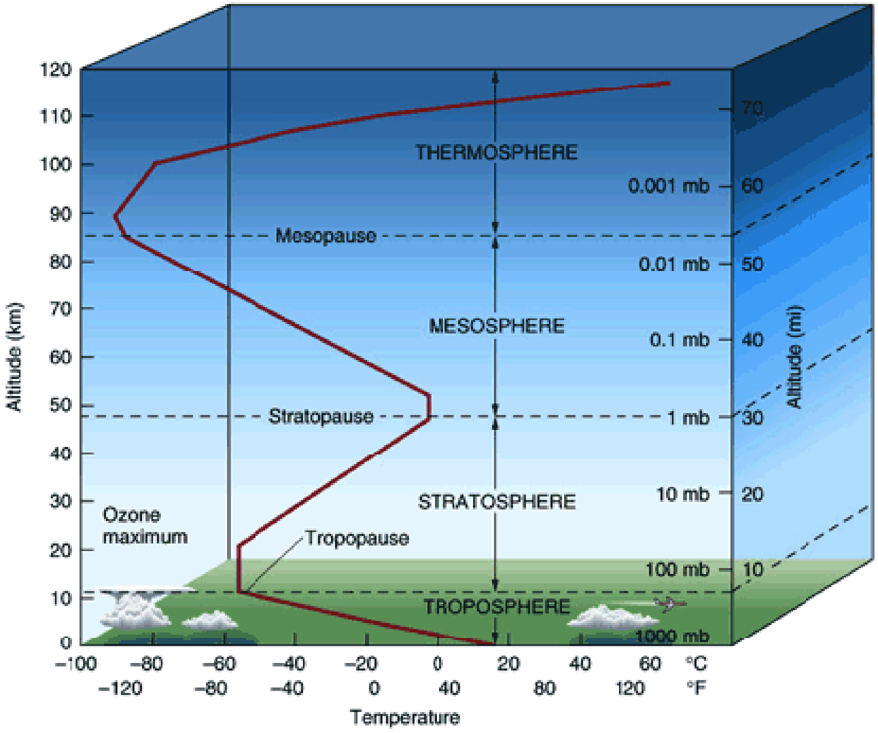
Based on temperature, the atmosphere is divided into four layers. The layer closest to Earth's surface is the troposphere. The troposphere is thickest in the tropics (about 9 miles/14.5 kilometers thick) and thinnest at the poles (about 5 miles/8 kilometers thick). Most weather happens in the troposphere. The troposphere is the densest of all the layers of the atmosphere and it contains about 80% of the mass of the atmosphere and almost all of the water in the atmosphere. The average temperature in the troposphere is highest at ground level and decreases to about negative 57 degrees F (-52 degrees C) in the uppermost parts of the troposphere.

At the very top of the troposphere is the tropopause. This layer is very stable and separates the troposphere from the next layer, the stratosphere. Have you ever seen a thunderhead (cumulonimbus cloud) with a flat top? Sometimes this flat top is caused by winds, but sometimes it is caused by the top of the cloud reaching the tropopause and not being able to go up any further.

Together, the troposphere and the tropopause are known as the lower atmosphere. It is in the lower atmosphere that heat-trapping gases (some people refer to these as greenhouse gases) accumulate. Above the tropopause is the stratosphere and the mesosphere. Together they are known as the middle atmosphere. Chemicals in the middle atmosphere absorb and scatter the ultraviolet radiation coming in from the sun.

Above the middle atmosphere is the thermosphere or upper atmosphere. Temperatures increase the higher you go in the thermosphere because of the incoming energy from the sun. Temperatures can reach over 3140 degrees F (1700 degrees C).

Study the graph on the left. The red line represents the average temperature.



Reading 2: Heat-Trapping Gases In the Atmosphere

Heat-trapping gases collect in the troposphere and include carbon dioxide (CO_2), nitrous oxide (N_20), methane (CH_4), water vapor (H_20), ozone (O_3) and chlorofluorocarbons (CFCs). These gases act like a blanket in the atmosphere trapping heat and warming the planet. Some scientists have also called these gases "greenhouse" gases, because akin to an actual greenhouse made of glass and used to grow plants when it would be too cold outside, these gases trap heat and help regulate the temperature on Earth.

Air is made up of different gases, and gases are made up of molecules (which are, in turn, made up of atoms). These molecules are so small that they cannot be seen with the naked eye and there is a lot of space between individual molecules; that is why air is transparent.

Based on the structure of the molecules, some gases are more effective at trapping heat than others and stay in the atmosphere longer than others. The better a gas is at trapping heat and the longer it stays in the atmosphere, the more potential it has for aiding climate change (we will learn more about how this works in the next lesson).

We use the climate change potential of carbon dioxide (CO_2) as a standard against which we can compare other trace gases. To make comparisons easily, we label carbon dioxide (CO_2) as having a Climate change Potential (GWP) of 1. We can compare this to other greenhouse gases. Methane (CH_4) has a GWP of 23 (measured over a 100 year period). Other gases have much longer atmospheric residence times, like sulfur hexafluoride which has a GWP of 22,000 over 100 years. We don't hear much about hexafluoride, however, because it has very low concentrations in the atmosphere.

One heat-trapping gas that has a low GWP because its atmospheric residence time is only a few days is water vapor (H_2O). Even though it has a low GWP, there is a lot of it in the atmosphere at any given time. Water vapor is the most common heat-trapping gas.

As we learn more about the greenhouse effect and climate change, we will be hearing a lot more about carbon dioxide and methane. Both of these gases have a big impact on how much heat is trapped in the lower atmosphere.

The concentration of gases in the atmosphere is measured in parts per million (ppm), parts per billion (ppb) or parts per trillion (ppt). For reference, concentrations of carbon dioxide are currently about 388 ppm and concentrations of methane are about 1800 ppb.

Reading 3: The Greenhouse Effect

Everyone experiences the greenhouse effect everyday. It keeps the Earth relatively warm. It's natural and was here long before humans.

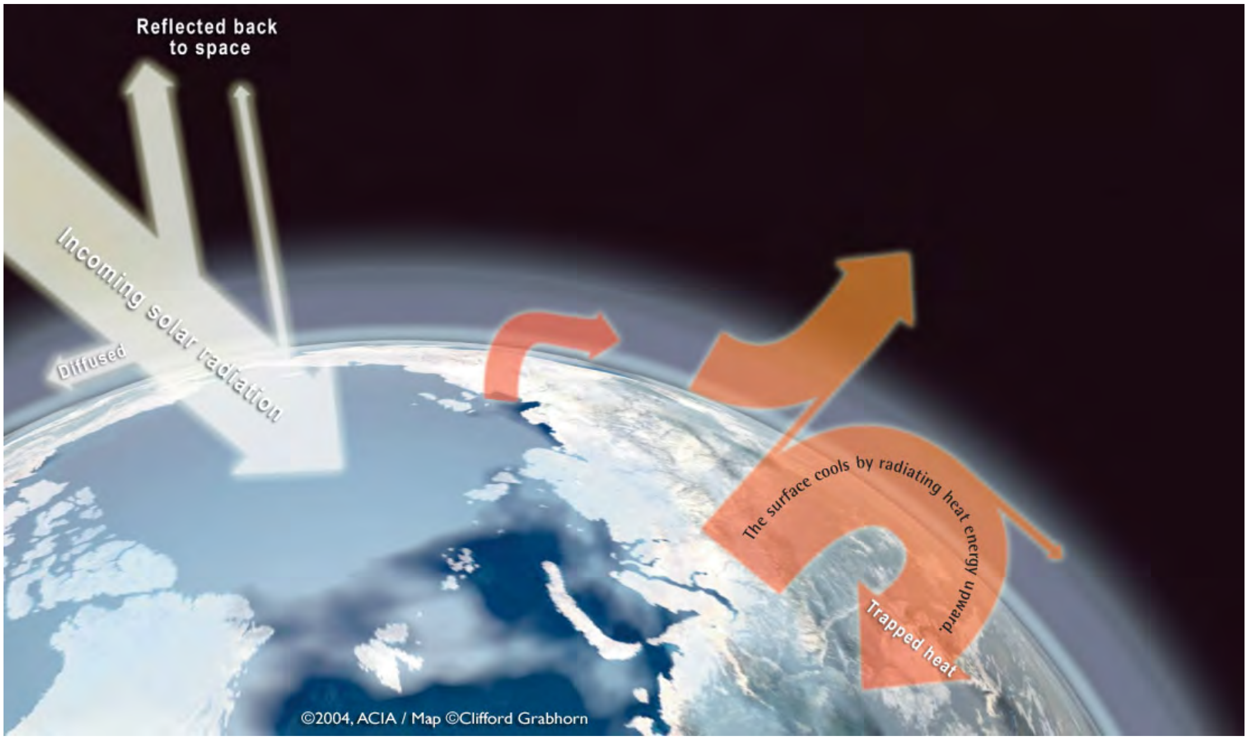
The Earth has a greenhouse effect that keeps the temperature warmer than the temperature in space. The Earth has a layer of gases that, although it is not a perfect analogy, act like the layer of glass on a greenhouse or in your car and trap heat that would otherwise be lost to space. The way it works is that energy, in the form of light and heat, comes from the sun. That energy is either reflected by the Earth or absorbed and then re-radiated back towards space. When this out-going energy hits the layer of heat-trapping gases, some of it passes through back out into space, but some of it gets trapped and re-reflected back to Earth.

The atmosphere and this heat-trapping effect makes life as we know it possible on Earth. Without the heat-trapping gases in our atmosphere, temperatures on Earth would average around 0 degrees F (-18 degrees C) and the surface of the Earth would be frozen.

Without an atmosphere, the temperatures on the Earth would be more like the Moon. Because the Moon doesn't have the same atmosphere and greenhouse gases, temperatures vary dramatically between the side of the Moon that faces the sun and the dark side that faces away. In fact, on the side of the Moon that faces the sun, the temperatures can reach 260 degrees F (water boils at 212 degrees F). On the dark side of the Moon, it can get as cold as -280 degrees F.

On the Earth there is a difference in temperature between the day and the night (this is called diurnal variation), but it is nowhere near the difference in temperatures experienced on the Moon between the light side and the dark side. This is because of our atmosphere and our heat-trapping gases.

If a planet has a lot more heat-trapping gases, the temperature would be much hotter. For example, Venus has a much higher concentration of heat-trapping gases and temperatures on the surface of Venus are above 350 degrees F (177 C). That is hot enough to melt lead!



Lesson 2: Emissions of Heat-Trapping Gases

How do heat-trapping gases affect our atmosphere?

Question	How do heat-trapping gases affect our atmosphere?
Objective	Students will be able to explain how increased atmospheric concentrations of heat-trapping gases warm the atmosphere. Students will be able to predict what will happen to global temperatures if atmospheric concentrations of heat-trapping gases increase. Students will be able to identify sources of heat-trapping emissions. Students will calculate their carbon footprint. Students will identify ways they can reduce their carbon footprint.
Time Needed	40 minutes
Materials	Image 1: Greenhouse – Green Planet Image 2: 1000 Years of Changes Image 3: Carbon Dioxide in the Atmosphere Handout 1: Energy Use in Your Home Handout 2: 20 Simple Steps to Reduce Climate Change Readings available as worksheets at: http://www.climategen.org/what-we-do/education/climate-change-and-energy-cirricula/curriculum-guides/our-changing-climate-for-grades-6-12/worksheets/

Preparation:

Several days before you plan to teach this lesson, give students the question slips from Handout 1 so that they can find out the following information about their home and family energy use:

- How do you heat your house: electric, natural gas or heating oil?
- On average, how many miles a week do you ride in or drive a car?
- What is the average gas mileage of the cars you drive or in which you ride?
- On average, how much does your family spend on electricity each month?
- On average, how much does your family spend on natural gas each month?
- On average, how much does your family spend on heating oil each month?
- What percentage of recyclables does your family currently recycle?

Directions:

Ask students to recall from Lesson One how the Earth's atmosphere is structured, which atmospheric gases trap heat and how climate change works. Answers should cover the following information:

- When compared with the size of the Earth, the atmosphere is a relatively thin layer of gases.
- Based on temperature, the atmosphere is divided into four layers: the troposphere, stratosphere, mesosphere and thermosphere.
- Heat-trapping gases accumulate in the troposphere and include carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), water vapor (H_20) and chlorofluorocarbons (CFCs).
- The Earth absorbs energy from the sun and then re-emits that energy back towards space. Some of that energy is absorbed by heat-trapping gases and re-emitted back towards Earth. This is what some scientists refer to as the greenhouse effect.
- Heat-trapping gases make life as we know it possible on our planet. Without them, Earth would be a frozen wasteland with an average temperature of 0 degrees F (-18 degrees C). ***(5 min)***

Notes to Teachers:

Some students may have heard that climate change is "junk science" or that there is a big debate over whether or not it is really happening. You can let them know that there is no debate about whether or not increased levels of heat-trapping gases in the atmosphere will warm the planet. This is atmospheric physics. The only uncertainty lies in how much and how quickly the planet will warm.

Notes to Teachers:

The reason there is a range of projections for both atmospheric CO_2 concentrations and temperature is 1) to account for different scenarios of human response to a changing climate and 2) to account for uncertainty in climate models.

Notes to Teachers:

If your students do not have internet access in class, make this a homework activity and give them several days advance notice to complete it. If you have internet access in class as a teacher, but the students do not have access in class, have one student volunteer to share his or her information on home and family energy use. Enter his or her information into the EPA calculator and share the process and results with the rest of the class.

For easy access to the links and graphics that are used in this lesson plan, visit: ***http://www.climategen.org/what-we-do/education/climate-change-and-energy-cirricula/curriculum-guides/our-changing-climate-for-grades-6-12/worksheets/***

Ask students to predict, based on their understanding of the atmosphere and heat-trapping gases, what would happen with increasing levels of heat-trapping gases in the atmosphere. Students should be able to guess that more heat-trapping gases would hold more heat in the atmosphere and prevent it from radiating back into space. If they are having trouble guessing this, you could ask them what happens when they add more blankets to their bed.

After students guess that increased levels of heat-trapping gases will warm the planet, let them know that is correct. Show them Image 1, Greenhouse – Green Planet, and ask a student to summarize what is being illustrated. Note: Carbon dioxide (CO_2) is not the only heat-trapping gas. ***(5 min)***

Then share with the students Image 2 and 3 that show carbon dioxide (CO_2) levels and temperature change over the past 1000 years and past 160,000 years ***(Source: Hassol, S. J., Correll, R., Prestrud, P., Weller, G., Anderson, P.A., Baldursson, S., et al. (2004). Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, England.).***

Give the students several minutes to study the two graphs. Ask them to try to figure out on their own what the graphs are illustrating (you can let them know that ppm is an abbreviation for "parts per million" and *Gt C* is an abbreviation for "giga-tons of carbon"). ***(5 min)***

Then ask the students to partner with the person sitting next to them. The pairs of students should discuss the graphs together and make sure that their partner understands what the graphs are representing. Let the students know that if they and their partner cannot understand the graph they can ask the pair sitting next to them. Let the students know that you are going to call on one student to explain the graphs to the class and that it is each person's responsibility to make sure that his or her partner understands the graphs. ***(5 min)***

Ask a student to explain the graph to the class. Student responses should cover these points:

- As CO_2 concentrations increase, global average temperature increases.
- CO_2 concentrations are now higher than they have been at any time in the past 160,000 years.
- There is a range of projected future levels of both CO_2 and temperature.
- Human-caused emissions of carbon come from both the burning of fossil fuels and from land-use changes such as deforestation and land-clearing.
- The majority of human-caused carbon emissions today comes from the burning of fossil fuels. ***(5 min)***

Now that students understand that increased atmospheric concentrations of heat-trapping gases will warm the planet and what the sources are of human-caused emissions, they will calculate the amount of heat-trapping emissions for which they are directly responsible and learn ways they could reduce their emissions.

If students have access to the internet in class, ask them to enter the answers they researched about their home and family energy use into the U.S. Environmental Protection Agency's greenhouse gas calculator at: *http://www.epa.gov/climatechange/students/calc/index.html* (5 min). If you're looking for some other carbon calculator resources, check out our review of popular carbon calculators: *http://www.climategen.org/climate-lessons-blog/item/1175-carbon-calculators-reviewed.* ***(5 min)***

Give each student Handout 2: Fight Climate change, a list of twenty ways they can reduce their personal emissions of heat-trapping gases.

Have each student identify actions from the list that he or she could conceivably take. Each student should then calculate the total amount of heat-trapping emissions that he or she would save by taking these actions. *(10 min)*

Each student should then convert these numbers to more-easily conceptualized quantities at the U.S. EPA website at *http://www.epa.gov/climatechange/students/calc/index.html*. You can also access all links used in this lesson plan through *http://www.climategen.org/what-we-do/education/climate-change-and-energy-cirricula/curriculum-guides/our-changing-climate-for-grades-6-12/online-connections/*

Note:

If there is no Internet access in your classroom, consider visiting this site in advance and calculating some of your figures to share with the class. For example, you might decide to wash your clothes in cold or warm water instead of hot. This would amount to an annual savings of 350 pounds of carbon dioxide (CO_2). At the U.S. EPA website, you could convert this number to the more easily conceptualized 18 gallons of gasoline or the amount of carbon four tree saplings would take up in ten years of growing.

Homework:

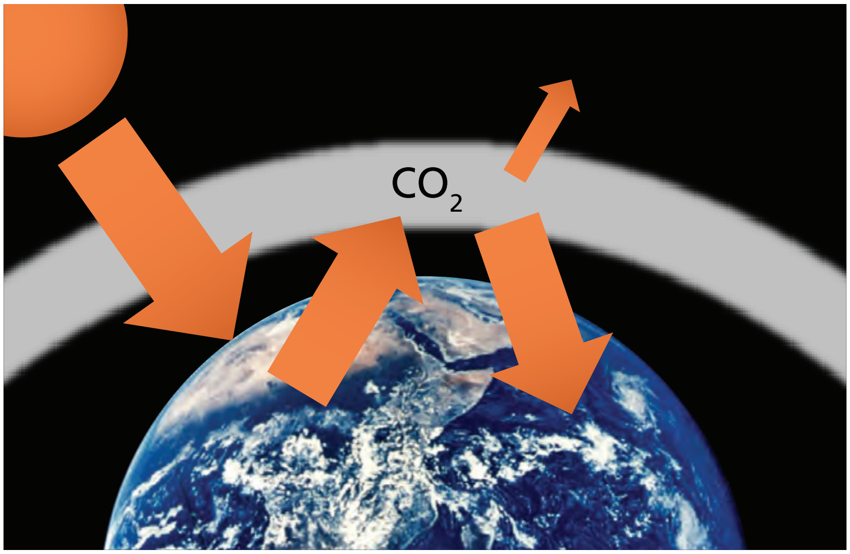
Each student then writes his or her thoughts and ideas about heat-trapping emissions. Suggested topics for student writing could include: actions they will take to reduce heat-trapping emissions, why they chose those actions, their predictions of how much effort it will take to make these changes, factors that may inhibit them from taking some of the actions, factors they see keeping other people from taking action, etc.

For more information on energy use, emissions of heat trapping gases and other topics presented in this lesson, as well as expedition resources linked to this lesson plan, visit: ***http://www.climategen.org/what-we-do/education/climate-change-and-energy-cirricula/curriculum-guides/our-changing-climate-for-grades-6-12/online-connections/***

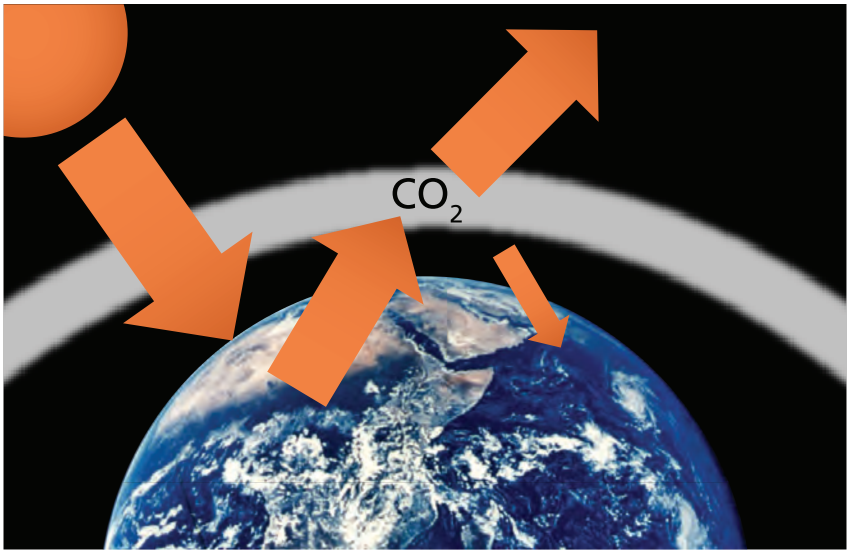
Notes to Teachers:

- There is a large amount of misinformation in the general public about climate change. Students may have heard that humans are not causing climate change—that the Earth goes through natural cycles of warming and cooling and that the warming that we've experienced over the last two-hundred years is caused by something other than human activity. Let your students know it is true that the Earth does go through periods of warming as well as periods of cooling and has done this several times in the history of the planet. The intense and rapid warming that we have experienced over the past hundred years, however, can be explained only when human impacts are factored in. There is broad international scientific consensus that the majority of warming over the past several decades is caused by human activity.
- One of the most common misconceptions is that human-caused emissions of heat-trapping gases are insignificant because the majority of heat-trapping gas in the atmosphere is water vapor that is naturally occurring. It is true that on a sunny day water vapor is responsible for as much as 70% of the greenhouse effect as compared with 25% for carbon dioxide. The difference, however, is that water vapor stays in the atmosphere for only a short time (days) before it falls as precipitation. Heat-trapping emissions from human sources (burning fuels or deforestation), by contrast, can have a very long life in the atmosphere, so they keep accumulating. For example, the atmospheric lifetime of CO_2 is estimated at 200 to 450 years (unless an individual CO_2 molecules is taken up by plants or absorbed by the ocean) and the heat-trapping gas tetraflouromethane has an atmospheric lifetime of 50,000 years. Also, the more the atmosphere warms, the more water vapor it can hold, which in turn causes the atmosphere to warm more until it reaches equilibrium.
- Another common misconception is that because a warmer atmosphere can hold more water, more clouds will cool the planet enough to offset the warming from the increased concentrations of heat-trapping gases. It is true that clouds can have a regional cooling effect, but their long-term effect is an area of active research among scientists.

Reference:
Albritton, D. L., Meira Fiho, L. G., Cubasch, U., Dai, X., Ding, Y., Griggs, D.J., et al. (2001). Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, England.



Less heat escapes



More heat escapes

Image 1: Greenhouse - Green Planet

Source: NOVA Greenhouse—Green Planet
http://www.pbs.org/wgbh/nova/ice/greenhouse.html

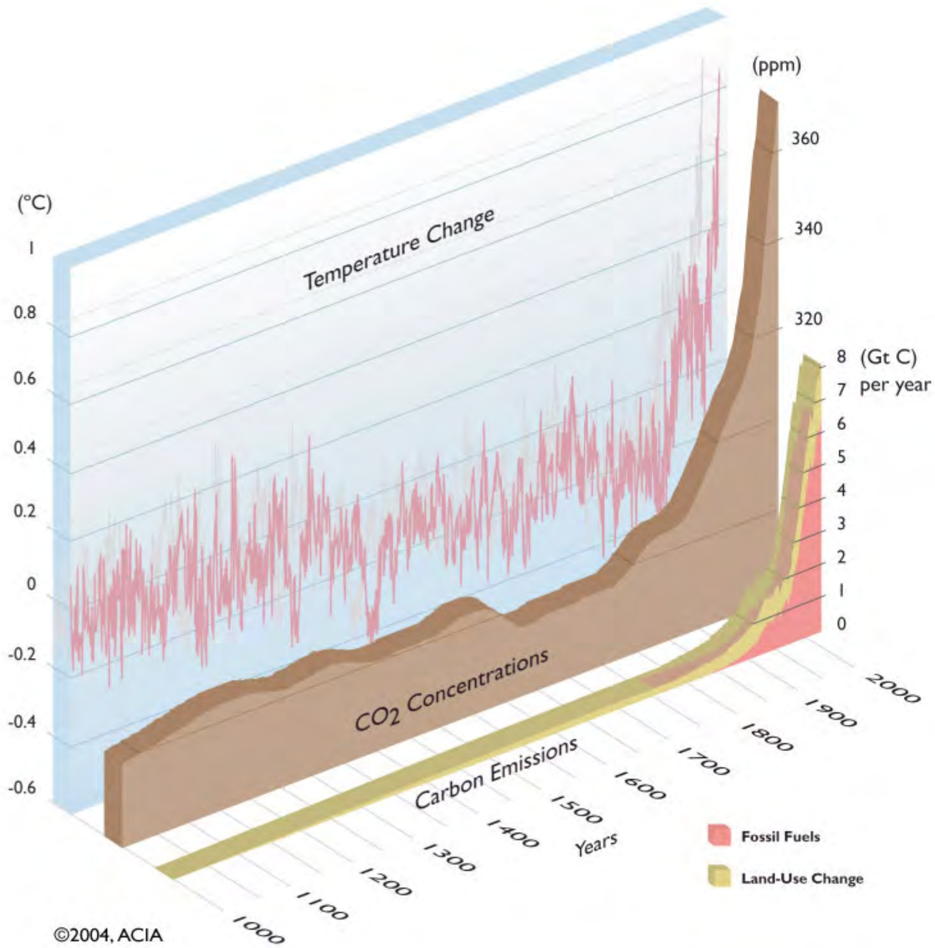


Image 2: Heat-Trapping Gases In the Atmosphere

Source: Arctic Climate Impact Assessment. Impacts of a Warming Arctic. New York, NY: Cambridge UP, 2004.

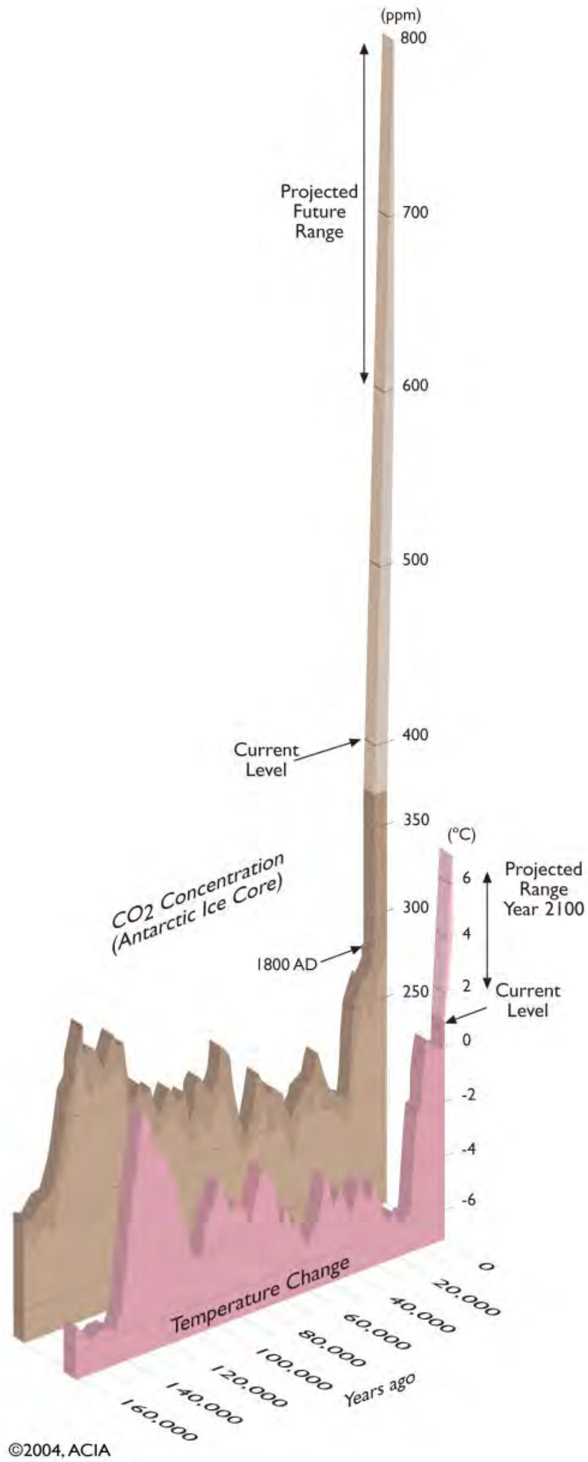


Image 3: Greenhouse - Green Planet

Source: Arctic Climate Impact Assessment. Impacts of a Warming Arctic. New York, NY: Cambridge UP, 2004.

Handout 1: Energy Use in Your Home

Directions: Answer the following questions about energy use in your home.

- How do you heat your house: electric, natural gas or heating oil?
- On average, how many miles a week do you ride in or drive a car?
- What is the average gas mileage of the cars you drive or in which you ride?
- On average, how much does your family spend on electricity each month?
- On average, how much does your family spend on natural gas each month?
- On average, how much does your family spend on heating oil each month?
- What percentage of recyclables does your family currently recycle?

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- On average, how much does your family spend on natural gas each month?
- On average, how much does your family spend on heating oil each month?
- What percentage of recyclables does your family currently recycle?

20 Simple Steps to Reduce Climate Change

Whenever you save energy--or use it more efficiently--you reduce the demand for gasoline, oil, coal and natural gas. Less burning of these fossil fuels means lower emissions of carbon dioxide, the major contributor to climate change. Right now the U.S. releases about 40,000 pounds of carbon dioxide per person each year. If we can reduce energy use enough to lower greenhouse gas emissions by about 2% a year, in ten years we will "lose" about 7000 pounds of carbon dioxide emissions per person.

Here are 20 simple steps that can help cut your annual emissions of carbon dioxide by thousands of pounds. The carbon dioxide reduction shown for each action is an average saving.

HOME APPLIANCES

1. Run your dishwasher only with a full load. Use the energy-saving setting to dry the dishes. Don't use heat when drying. Carbon dioxide reduction: 200 pounds a year.
2. Wash clothes in warm or cold water, not hot.
   Carbon dioxide reduction (for two loads a week): up to 500 pounds a year.
3. Turn down your water heater thermostat; 120 degrees is usually hot enough.
   Carbon dioxide reduction (for each 10- degree adjustment): 500 pounds a year.

HOME HEATING AND COOLING

4. Don't overheat or overcool rooms. Adjust your thermostat (lower in winter, higher in summer).
   Carbon dioxide reduction (for each 2-degree adjustment): about 500 pounds a year.
5. Clean or replace air filters as recommended. Cleaning a dirty air conditioner filter can save 5% of the energy used.
   Carbon dioxide reduction: About 175 pounds a year.

SMALL INVESTMENTS THAT PAY OFF

6. Buy energy-efficient compact fluorescent bulbs for your most-used lights.
   Carbon dioxide reduction (by replacing one frequently used bulb): about 500 pounds a year
7. Wrap your water heater in an insulating jacket.
   Carbon dioxide reduction: Up to 1000 pounds a year.
8. Install low-flow shower heads to use less hot water.
   Carbon dioxide reduction: Up to 300 pounds a year.
9. Caulk and weatherstrip around doors and windows to plug air leaks.
   Carbon dioxide reduction: Up to 1000 pounds a year.
10. Ask your utility company for a home energy audit to find out where your home is poorly insulated or energy-inefficient. Carbon dioxide reduction: Potentially, thousands of pounds a year.

GETTING AROUND

11. Whenever possible, walk, bike, carpool or use mass transit.
    Carbon dioxide reduction (for every gallon of gasoline you save): 20 pounds.
12. When you buy a car, choose one that gets good gas mileage.
    Carbon dioxide reduction (if your new car gets 10 mpg more than your old one): about 2500 pounds a year.

REDUCE, REUSE, RECYCLE

13. Reduce waste: Buy minimally packaged goods; choose reusable products over disposable ones; recycle. Carbon dioxide reduction (if you cut down your garbage by 25%): 1000 pounds a year.
14. If your car has an air conditioner, make sure its coolant is recycled whenever you have it serviced. Equivalent carbon dioxide reduction: Thousands of pounds.

HOME IMPROVEMENTS

15. Insulate your walls and ceilings; this can save about 25% of home heating bills. Carbon dioxide reduction: Up to 2000 pounds a year.
16. If you need to replace your windows, install the best energy-saving models. Carbon dioxide reduction: Up to 10,000 pounds a year.
17. Plant trees next to your home and paint your home a light color if you live in a warm climate, or a dark color in a cold climate. Carbon dioxide reduction: About 5000 pounds a year.
18. As you replace home appliances, select the most energy-efficient models. Carbon dioxide reduction (if you replace your old refrigerator with an efficient model): 3000 pounds a year.

SCHOOLS, BUSINESS, AND COMMUNITIES

19. Reduce waste and promote energy-efficient measures at your school or workplace. Work in your community to set up recycling programs. Carbon dioxide reduction (for every pound of office paper recycled): 4 pounds.
20. Be informed about environmental issues. Keep track of candidates' voting records and write or call to express concerns. Carbon dioxide reduction (if we vote to raise U.S. auto fuel efficiency): Billions of pounds.

Lesson 3: Communities of Living Things

How are different communities affected by climate change?

Question	How are different communities affected by climate change?
Objective	Students will be able to explain how changing weather patterns, a changing balance of competitors and changes in the availability of food and shelter can increase uncertainty for communities of living things. Students will be able to give examples of these uncertainties and disruptions from the Arctic communities. Students will predict how continued warming may affect communities of living things with which they are familiar.
Time Needed	40 minutes
Materials	Reading 1: Polar Bears Reading 2: Ice-edge Dwellers Reading 3: Land-Dwellers Reading 4: Plant Communities Reading 5: Human Communities

Directions:

Divide students into as many as five group with two-three students in each group depending on the number of students in the class. Give each group one of the readings about impacts of climate change on communities of living things (use scrap paper to print these if possible). If you have fewer than five groups, consider giving more than one set of passages to a group. ***(5 min)***

Reading 1: Polar Bears
Reading 2: Ice-edge Dwellers
Reading 3: Land-Dwellers
Reading 4: Plant Communities
Reading 5: Human Communities

Reource: Hassol, S. J., Correll, R., Prestrud, P., Weller, G., Anderson, P.A., Baldursson, S., et al. (2004). Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, England.

Have students take turns reading aloud sections of their passage to the rest of their group. ***(5 min)***

Next have each group discuss the impacts described in their passages and then plan a skit to illustrate these impacts. Skits should be a maximum of three minutes long. Groups will have very little time to plan their skits, so let them know in advance that skits do not need to be "polished." They should be impromptu, quickly moving and fun. ***(5 min)***

Have the entire class reconvene and have each group take turns presenting their skit. After each group's skit, one member of the group explains to the entire class the impact they were illustrating, including Arctic-specific examples from the passage. To allow for transition time between groups and for each group to explain the concepts in their skit, plan for five minutes for each group. ***(25 min)***

Homework:

Each student should write about a way in which continued climate change could affect a community of living things with which he or she is familiar.

Notes to Teachers:

- Before dividing the students into groups, explain the entire activity to them and let them know how much time they will have for each section of the activity.
- Circulate between the groups as the students are reading the passages to each other and planning and practicing their skits. Circulate between the groups and listen at each group to gauge their progress and to make certain that students are focusing their efforts on the task.
- Clearly set the expectation that skits should respect other members of the class and respect the living beings portrayed in the skits. Let students know that no inappropriate language, harassing or discriminatory content or explicitly sexual or violent portrayals will be tolerated.
- Monitor the time closely to ensure that all groups have time to present their skit. Give groups a two- and one-minute warming. Groups will have very little time to plan their skits, so let them know in advance that skits do not need to be "polished." They should be impromptu, quickly moving and fun.

Reading One: Polar Bears

IMPACT: DIFFICULTY GETTING FOOD

Polar bears hunt ice-living seals. The polar bears walk quietly on the ice to the edge of a seal's breathing hole in the ice. The bear then waits for the seal to surface for air. This hunting technique takes much less energy for the bear than chasing a seal while swimming. If warmer conditions cause the ice to form later in the fall and break up earlier in the spring, become unstable, or retreat too far from shore, polar bears will have difficulty getting enough food. In fact, if the ice retreats too far from the shore, bears can drown trying to swim out to the ice.

If a female bear doesn't get enough food, she will have less fat stored to help her have cubs. Underweight females have fewer and smaller cubs that are less likely to survive. When the polar bear mother and cubs emerge from their den in the spring, it will have been between five and seven months since the mother has eaten. She will need to be successful hunting for her family to survive. She needs ice on which to hunt.

IMPACT: LOSS OF SHELTER

In addition to making it more difficult for polar bears to get food, climate change can also directly cause bear deaths. For example, increased number and strength of spring rainstorms can cause bear dens to collapse.

IMPACT: BARRIERS TO TRAVEL

Earlier break-up of sea ice can separate traditional den sites from feeding areas and young cubs would not be able to swim to the feeding areas.

IMPACT: COMPETITION FROM NEWLY ARRIVED SPECIES

As the climate warms, grizzly bears extend their range to the north. Grizzly bears are more aggressive than polar bears and can out-compete them. They can also interbreed with polar bears, thereby reducing the numbers of non-hybrid polar bears.

IMPACT: INCREASED POLLUTION DUE TO CLIMATE CHANGE

Many of the air pollutants from the industrialized parts of the northern hemisphere reach the Arctic through the circulation of the atmosphere and the flow of water. Climate change is predicted to bring more precipitation (snow and rain) and higher river flows to the Arctic. This will bring more chemical contaminants. Plants and animals that are low on the food chain will absorb these pollutants and then seals will eat them and absorb those pollutants at higher concentrations. Polar bears, at the top of the food chain, will eat seals and absorb the pollutants at even higher concentrations. Pollution stored in polar bears can affect their health, especially when they are already weak from not getting enough food.

Photo Credit: Howard Ruby

Reading Two: Ice-edge Dwellers

IMPACT: HABITAT DISINTEGRATING

Ice-dependent seals like the ringed seal, ribbon seal and bearded seal give birth and nurse their pups on the ice. They make their lairs out of snow on top of the ice. If there is not enough snow cover, they will have difficulty rearing their young. If the ice breaks up too early, pups can be separated from their mothers and drown. The seals also use the ice to rest.

IMPACT: DIFFICULTY GETTING FOOD

Walrus depend on the sea ice to find food. The edge of the ice is an area rich in plant and animal life. The most productive areas are over the shallow water nearest to the coasts. Walrus can use the ice to rest and then dive down to the bottom to eat clams and other shellfish that grow there. When the ice edge retreats away from the shallow areas, there will be fewer clams nearby for the walrus to eat.

Some sea birds like ivory gulls and little auks also depend on the ice to find food. The ivory gull nests on rocky cliffs near the ocean and then flies to the nearby sea ice to fish through cracks in the ice and scavenge for food left on top. If the sea ice retreats too far from the coast, the birds have difficulty getting enough food.

IMPACT: COMPETITION FROM NEWLY ARRIVED SPECIES

Inuit people report seeing new animals they have never seen before. These animals are expanding northward as the climate warms and now compete with native Arctic species for food and habitat.

Photo Credit: Howard Ruby

Reading Three: Land Dwellers

IMPACT: DIFFICULTY GETTING FOOD

Climate change has affected the winter temperature and precipitation in the Arctic. Precipitation that once fell as snow now increasingly falls as freezing rain. This freezing rain as well as increasingly-common freeze-thaw events (when the changing temperature rises above freezing and snow begins to melt and then falls below freezing and the water turns to ice), can cover plants in a layer of ice. Even if the plants can survive being covered in ice, animals have difficulty reaching the plants and can starve. Lemmings, musk ox and reindeer/caribou have all had large die-offs due to ice crusting making their food inaccessible.

IMPACT: DISINTEGRATION OF SHELTER

Even though snow may seem cold to you, it provides much-needed insulation for small animals like lemmings and voles who live and find food in the space between the frozen ground and the snow. For them, the snow is a shelter from the cold winds and very cold air temperatures. Mild and wet winter weather can reduce the ability of the snow to provide insulation and can even make the under-snow spaces collapse. Some animals such as snowy owls, skuas, weasels and ermines hunt lemmings and voles and almost nothing else. If numbers of lemmings and voles decline due to disintegration of their shelter, numbers of their predators will decline as well.

Reading Four: Plant Communities

IMPACT: THAWING PERMAFROST DESTABILIZES THE SOIL

The ice in the permafrost (permanently frozen ground) helps maintain the structure of the soil. When it melts, trees can start to fall over or sink-holes can develop which then seasonally fill with water and kill trees living there.

IMPACT: THAWING PERMAFROST DRAINS WETLANDS AND PONDS

In some Arctic wetlands, ponds and lakes, the water is perched on top of a layer of permafrost. The permafrost acts like the countertop in your kitchen and the wetlands are like a sponge that is completely full of water sitting on top of the counter. If the permafrost melts, then the water can drain out of the wetlands and ponds just like the water would drip out the bottom of the sponge if there were no countertop. When wetlands and ponds drain, not only are the plants that live there affected, but also the fish and other animals that rely on the water.

IMPACT: POTENTIAL DESERTIFICATION

Even though the total amount of precipitation is projected to increase in the Arctic, precipitation may come at times of the year when plants do not need it, or it may come in extreme events where most of it runs off to the rivers quickly. Also, as the temperatures get warmer, more water will evaporate and plants will transpire more water. Both processes acting together, known as evapotranspiration, send water back into the atmosphere. It is possible that in certain areas the increased precipitation may not be able to keep up with the increased evapotranspiration. If this happens, areas can dry out and become polar deserts.

IMPACT: INSECT PESTS THRIVE WITH WARMER TEMPERATURES.

When winters are long and very cold and when summers are short, as they traditionally have been in the Arctic, numbers of pests like the spruce bark beetle are kept in check. Spruce bark beetles can kill spruce trees. Warmer winters mean that more bark beetles survive each year. Also, the bark beetle usually needs two years to complete its life cycle. When the summers are unusually warm and long, however, bark beetle lifecycles can be accelerated and take only one year. This means that there will be many more beetles. Also, healthy spruce trees have natural defenses against bark beetle attacks. When the beetles try to bore into the tree to lay eggs, the tree can push pitch (sap) out against the beetle and keep them from being able to get into the tree far enough to lay eggs. When trees are stressed from drought and warmer than normal temperatures, however, they do not have enough pitch to fight the beetles.

Similarly, spruce bud worms, another pest that can kill spruce trees, lay more eggs when it is warmer. Also, warmer temperatures make spruce bud worms change the time of their reproduction. When this happens, the natural predators of the spruce bud worm are not available or ready to eat them, so bud worm numbers increase.

IMPACT: COMPETITION FROM INVADING SPECIES

As temperatures warm, plant species begin to shift their ranges northward, invading areas previously inhabited by Arctic species. Many of the adaptations that allow Arctic species to survive in such cold conditions also limit their ability to compete with invading species. For example, when the temperature gets above about 60 degrees F (16 degrees C), black and white spruce trees are not able to grow as well. If temperatures get too hot, the black and white spruce will not be able to grow at all.

IMPACT: INCREASED FOREST FIRES.

As climate warms and forests dry, forest fires increase. The average area of North American Boreal (northern) forests that burns each year has more than doubled since 1970.

Reading Five: Human Communities

IMPACT: DIMINISHING FOOD SUPPLIES

For thousands of years, groups of Inuit people (Native peoples of the Arctic, formerly known as Eskimos) have relied on hunting caribou to have enough food to survive through the cold seasons. Today the Inuit have access to food that is shipped into stores. For many Inuit families, however, store-bought food is too expensive to be their sole source of food. For this reason as well as for cultural reasons, Inuit rely on the caribou hunt for much of their food source. As numbers of caribou decline due to climate change-related impacts, the Inuit can face hardships.

The Inuit also hunt seals, walrus, polar bears, whales, moose, musk ox, ducks, geese, ptarmigan and fish. As the number and location of these animals are impacted by climate change, the Inuit will also face changes to their diet.

IMPACT: DECLINE IN CULTURAL RESOURCES

In addition to using caribou for food, Inuit people also value caribou as an important part of their mythology, spirituality and cultural identity.

IMPACT: INABILITY TO REACH HUNTING GROUNDS

Climate-related changes can make it difficult for Inuit hunters to reach the places where they hunt. For example, unusually deep snow, late freeze-up and early break-up of river and sea ice can make travel treacherous or impossible.

IMPACT: DIFFICULTY TRAVELING AND NAVIGATING

Many Inuit villages are accessible only by dogsled, snowmobile, or sometimes on roads over permafrost (permanently frozen ground). As the snow and ice-free period of the year gets longer, travel by dogsled or snowmobile becomes difficult or even impossible. As the permafrost melts earlier and to a greater depth, the roads become impassible mud-pits. Also, some Inuit people use the prevailing wind direction to navigate over frozen tundra and sea ice. For many generations these winds have always blown in the same direction. As weather patterns change, the wind can change direction and Inuit may get lost trying to find important cultural sites.

IMPACT: EROSION OF COASTAL COMMUNITIES

Warmer ocean water and air can melt the permafrost that stabilizes coastal land and shorelines. This, combined with rising sea levels and a reduction in the shore ice and sea ice that once buffered the wave action from storms, can make coastal buildings, pipelines and roads fall into the ocean and flood low-lying areas, contaminating them with salt.

IMPACT: INCREASED ACCESSIBILITY TO SHIPS

As the sea ice diminishes, ocean that previously was locked in ice and therefore inaccessible to most ships can now be navigated. For example, in Pangnirtung, a remote Inuit Village on the southern tip of Baffin Island in the Canadian Arctic, a cruise ship recently arrived and unloaded its passengers into a village that before was accessible only by air or dogsled.

IMPACT: INCREASED POLLUTION DUE TO CLIMATE CHANGE.

Many of the air pollutants from the industrialized parts of the northern hemisphere reach the Arctic through the circulation of the atmosphere and the flow of water. Climate change is predicted to bring more precipitation (snow and rain) and higher river flows to the Arctic. This will bring more chemical contaminants. Plants and animals that are low on the food chain will absorb these pollutants and then humans will eat them and absorb those pollutants at higher concentrations. Inuit women have such high levels of PCB pollutants in their breast milk that they are asked to not breast feed their babies.

Lesson 4: Implications of Warming in the Arctic

Why should we learn about climate change in the Arctic?

Question	Besides being a "canary in the coal mine," why should we learn about climate change in the Arctic?
Objective	Students will be able to explain feedback loops including surface reflectivity (albedo), ocean circulation, melting permafrost releasing heat-trapping gases and melting ice contributing to rising sea levels. Students will be able to explain how warming in the Arctic affects the rest of the world.
Time Needed	40 minutes
Materials	Feedback #1: Surface Reflectivity (Albedo) Feedback #2: Ocean Circulation (Thermohaline circulation) Feedback #3: Melting permafrost

Directions:

Explain to your students that the Arctic responds more quickly and more dramatically than the rest of the world to the early effects of climate change. In the past few decades, Arctic average temperature has risen almost twice as quickly as the average temperature in the rest of the world. This makes study of the Arctic interesting and important for several reasons including:

- Effects of climate change in the Arctic are easily recognizable and often dramatic.
- The Arctic supplies oil, gas and fish to the rest of the world and these supplies will be affected by climate change.
- Studying the Arctic can give us an early indication of the environmental and societal significance of climate change.
- Warming in the Arctic can impact the global climate and have other worldwide implications including sea-level rise.

Explain that one of the ways that Arctic warming can impact the global climate is through **feedback loops**. A positive feedback loop is a process that creates conditions that make that process quicken or intensify. A negative feedback loop is a process that creates conditions that make that process slow or diminish. Let students know that they are about to learn about three positive feedback loops in the Arctic that can affect the global climate. ***(5 min)***

Have students count off from one to three. Each student must then find another student who has the same number. In these pairs, the students cooperatively read the following passages:

Feedback #1: Surface Reflectivity (Albedo)
Feedback #2: Ocean Circulation (Thermohaline circulation)
Feedback #3: Melting permafrost
(5 min)

Then have each pair plan a way to teach their topic to other students. Their lesson will need to include an explanation of the major concepts in the passage and an explanation of the visuals that accompany the passage. ***(5 min)***

If you are interested in seeing animation of a positive feedback, visit: ***http://www.climategen.org/what-we-do/education/climate-change-and-energy-cirricula/curriculum-guides/our-changing-climate-for-grades-6-12/online-connections/***

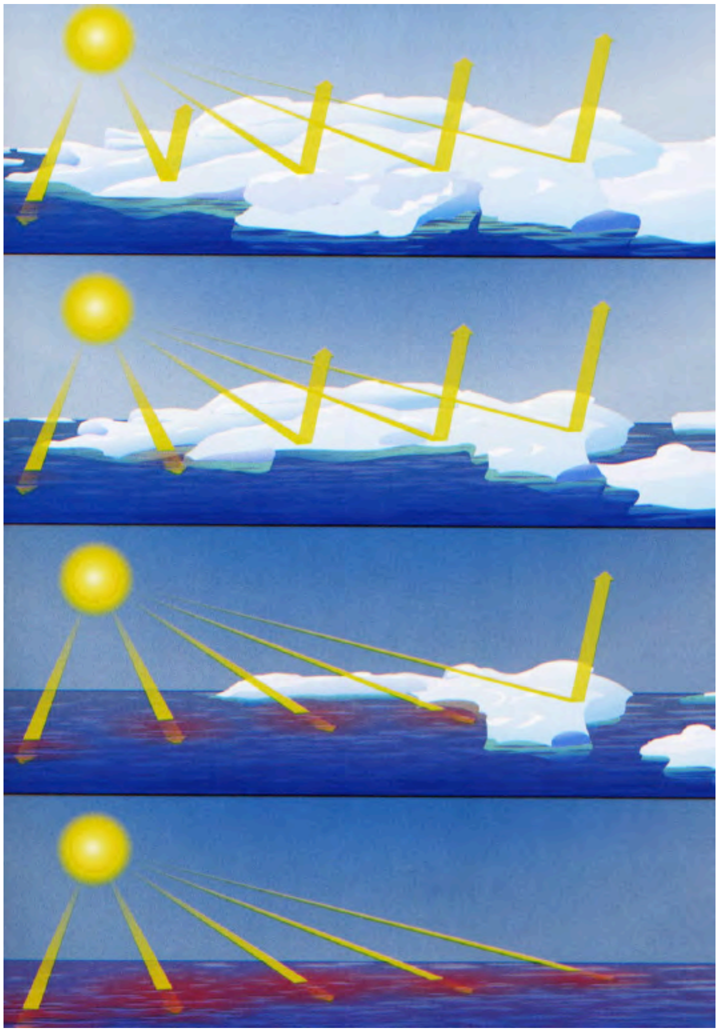
These pairs will then split and each student will find another student who also has the same number. For example, a student with the number one will find a different student who is also a number one. These new pairs will then share with each other the lesson they prepared with their first partner, including the analogy and original visual. These new partners give each other feedback on aspects of their lesson that were especially good. Students can then decide to incorporate certain aspects of their partner's lesson into their lesson to strengthen it. ***(5 min)***

Next, students find new groups that comprise a student with each number. For example, a student with the number one would find a student with the number two and also a student with the number three. Starting with the student with the number one, the students teach their lessons to the other two students in their group. ***(5 min)***

The teacher will then ask students to explain and summarize feedback loops including **surface reflectivity** (albedo), **ocean circulation** (thermohaline circulation) and **melting permafrost.** ***(5 min)***

Ask the students what another global effect will be of melting glaciers. If they do not mention sea-level rise, ask them to imagine a glass of water that is 4/5 full. Imagine what would happen if you kept adding more and more ice cubes (the water would spill over the rim of the glass). This is the analogy for icebergs calving off land-based glaciers directly into the sea and raising sea level. Also ask your students to imagine a bathroom sink full of water with a rim that slopes to drain excess water down into the basin. Imagine placing ice cubes next to the faucet handles. When the ice cubes melted, the water would run into the sink basin and raise the water level in the sink. This is the analogy for melting land-based mountain glaciers with streams that eventually flow into the ocean.

Explain to your students that as melt-water accumulates on top of ice sheets like the Greenland Ice sheet or the Western Antarctic Ice sheet, water can tunnel down through the ice in rivers called **moulins** that lubricate the bottom of the ice sheet where it rests on the rock. This water can make the ice sheet unstable and it can slide into the ocean. Recent studies have shown when ice sheets begin to disintegrate, sea level can rise as quickly as a few meters per century (Hansen, 2005). ***(5 min)***



Albedo effect in the Arctic

Lesson 4: Implications of Warming in the Arctic

Why should we learn about climate change in the Arctic?

Let your students know that although the Earth will continue to warm for centuries due to heat-trapping gases already in the atmosphere, it is not too late for us to act to help slow that warming and prevent some of the most extreme effects.

Ask your students to recall actions from Lesson Three that they can take as individuals to help reduce heat-trapping emissions. ***(5 min)***

Homework:

Ask your students to write a journal entry about some aspect of this topic that interests them. Suggested topics include how global emissions of heat-trapping gases affect the Arctic and how changes in the Arctic in turn affect the global climate, thoughts about what our society's response should be to these changes, how the student can respond to this issue on a personal level, etc.

For more information on positive feedback loops and other topics presented in this lesson, as well as relevant expedition resources, visit: ***http://www.climategen.org/what-we-do/education/climate-change-and-energy-cirricula/curriculum-guides/our-changing-climate-for-grades-6-12/online-connections/***

Notes to Teachers:

- Before dividing the students into groups, explain the entire activity to them and let them know how much time they will have for each section of the activity.
- As the students are cooperatively reading, planning and practicing their lessons and presenting their lessons to each other, circulate between the groups and listen at each group for a few moments to gauge the progress of the groups and to make certain that students are focusing their efforts on the task.
- Inform students that you will circulate between the groups during this activity and that you may ask any student at any time to explain any aspect of the passages. Let them know that it is the responsibility of each group to make sure that each member understands all the concepts and would be ready to explain any of the topics.
- Students may ask why the Arctic warms more quickly than the rest of the world. In addition to the effect of albedo explained in this lesson, there are three additional factors. First, in the tropics much of the extra energy from the heat trapped at the surface goes into evaporation. By contrast, in the Arctic, a much higher percentage of that extra heat goes directly into warming the atmosphere. Second, in the Arctic the layer of the atmosphere that has to warm in order to warm the surface is much thinner than that same layer in the tropics (~5 miles in the Arctic versus ~9 miles in the tropics). Third, alterations in the circulation patterns of the atmosphere and oceans can bring more heat to the Arctic.
- This lesson did not illustrate any negative climate feedback loops. Cloud cover is an example of a negative feedback loop. As the atmosphere warms and as more water vapor evaporates, there will be more clouds. Clouds have a cooling effect and thus slow climate change. As discussed earlier, clouds (water vapor) are short lived in the atmosphere. Scientists are actively studying clouds to assess their net effects during the warming of the planet.
- One additional negative climate feedback loop is increased plant growth. Plants use carbon dioxide to photosynthesize and higher concentrations of CO_2 can make plants increase production, thereby incorporating more carbon from the atmosphere and temporarily storing it in plant tissue. Some have hoped that this increased carbon-storing capacity of plants will remove enough carbon dioxide from the atmosphere to solve the problem of climate change. Recent studies, however, show that plants will not be able to increase production enough to compensate for human-caused emissions. This is due to a number of factors including limited available nitrogen, land use changes and other plant stressors.
- Scientists have found no negative-feedback loops that would be significant enough to compensate for increasing atmospheric concentrations of heat-trapping gases.

References:

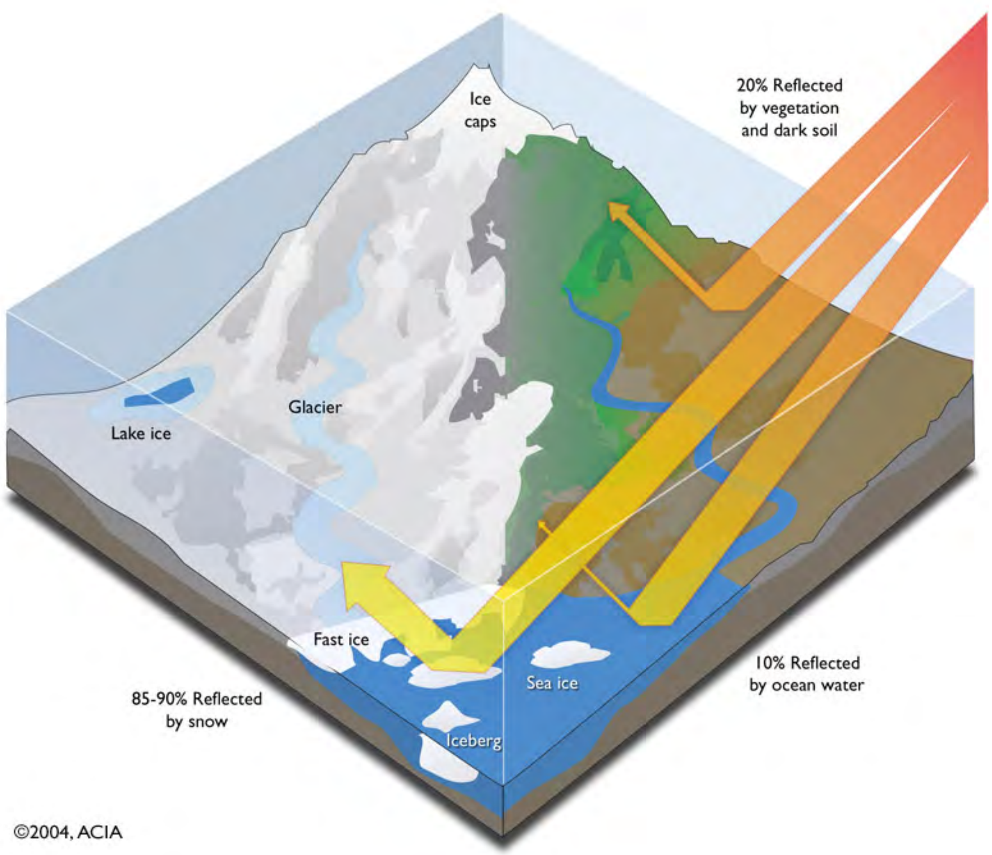
Hansen, J. E. (2005). Is There Still Time to Avoid 'Dangerous Anthropogenic Interference' with Global Climate? Presentation on December 6, 2005 at the American Geophysical Union, San Francisco, California.

Hassol, S. J., Correll, R., Prestrud, P., Weller, G., Anderson, P.A., Baldursson, S., et al. (2004). Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, England.

Feedback #1: Surface Reflectivity (Albedo)

One amplification cycle or "feedback loop" in the Arctic that will have an impact on global climate is surface reflectivity (also called albedo). Light-colored objects reflect more heat than dark-colored objects. This is why wearing black clothes on a sunny day feels so much warmer than wearing white clothes.

Snow and ice covers much of the Arctic land and ocean. Because snow and ice is bright white, as much as 90% of the solar energy that hits them reflects back into space. When warmer temperatures melt the snow and ice, the darker-colored vegetation or ocean water below absorbs up to 90% of the incoming solar radiation. When this extra energy is absorbed instead of being reflected, it further heats the oceans, land and surrounding air which in turn causes more melting. Thus, it is a positive feedback loop because the process of melting snow and ice creates conditions that melt even more snow and ice. The graphic below illustrates the surface reflectivity/albedo feedback loop. This feedback loop is one of the reasons that the Arctic is warming more quickly than the rest of the world. The effects are not limited to just the Arctic, however, because Arctic warming increases warming on a global scale.



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Feedback #2: Ocean Circulation (Thermohaline circulation)

Ocean circulation is a feedback loop through which changes in the Arctic can make larger changes in the rest of the world. Global ocean currents are like giant conveyor belts that move warm water from the tropics up to the higher latitudes and cold water from the polar areas down towards the tropics. This process helps cool the warm parts of the world and warm the cold parts of the world. For example, in western Europe, countries like England and France are as far north as Newfoundland and Labrador off the east coast of Canada. In that section of Canada, the climate is very cool and winters are long and cold. By contrast, in the United Kingdom and France, the climate is mild in the winter. Tropical plants can grow in England and there is hardly ever any snow at lower elevations. Part of what keeps the climate in western Europe so mild in the winter are the ocean currents called the Gulf Stream and the North Atlantic Drift that bring warm water north from the tropics. Look at the graphic below. The red lines represent warm water on the surface and the blue lines represent cold, deeper water. See how a red line goes north past western Europe and a blue line comes down past the east coast of Canada? These currents are largely responsible for that part of Canada being cold and western Europe, at the same latitude, being mild.

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These ocean current "conveyor belts" are driven by two factors: temperature and salinity (saltiness). The entire system is called thermohaline circulation. *Thermo* means "temperature" and *haline* means "salt." Warm water is less dense than cold water. Fresh water is also less dense than salt water. Warm, salty water travels from the tropics towards the poles on the surface. When it gets to the polar regions it cools and becomes more salty as some of the water turns to ice and rejects its salt which then goes into the water around it, making that water more salty. This colder and saltier water sinks and then travels along the bottom back towards the tropics. Along the way it gets warmer and fresher (less salty) from the discharge of rivers along the way.

As the Arctic warms, so does the water there, making it less dense. It is also becoming less dense because ice is melting and river discharge is increasing, pumping more fresh water into the Arctic ocean and ultimately the North Atlantic Ocean. These two factors slow the global thermohaline circulation. This affects the global climate.

Besides affecting global climate, ocean circulation also carries carbon dioxide (CO_2) into the deep ocean. Carbon dioxide can be incorporated into colder ocean surface waters at a greater rate than into warm surface waters. As the ocean continues to warm, its ability to uptake carbon dioxide from the atmosphere will decrease. Also as the ocean circulation slows, less carbon is stored in the ocean, letting more of it build up more quickly in the atmosphere, hence increasing climate change.

Feedback #3: Melting Permafrost

Melting permafrost is a feedback loop through which warming in the Arctic can have an affect on global climate. One third of the carbon stored in the soil of the Earth is stored in the Arctic, much of it frozen in permafrost. The reason there is so much carbon in the Arctic is that for much of the year, the temperature is so cold that when plants and animals die, they do not readily decompose. Consequently, the carbon (which is the building blocks of life forms) stays frozen in the soil. Over years as living things continue to die, more and more carbon accumulates in the frozen ground.

As the soil warms, the dead material begins to decompose (rot). Decomposition releases both methane (CH_4) and carbon dioxide (CO_2) into the atmosphere. Both methane and carbon dioxide are heat-trapping gases, meaning they trap energy in the atmosphere and keep it from radiating back into space.

These emissions of methane (a gas which lingers in the atmosphere for about 12 years) and carbon dioxide (which lingers in the atmosphere for over a century) further contribute to climate change. This is a positive feedback loop because melting permafrost releases heat-trapping gases, which make conditions that melt even more permafrost and release even more heat-trapping gases.

Lesson 5: Regional Effects of Climate Change

Though most dramatic in the Arctic, how is climate change affecting the rest of the world?

Question	Although we may see the effects of climate change most dramatically in the Arctic, what effects might we see in the rest of the world?
Objective	Students will be able to explain how climate change could cause droughts and floods from changing precipitation patterns combined with increased evaporation, more intense hurricanes fueled by warmer oceans, insect and disease outbreaks and other possible effects. Students will be able to predict what might happen in their region.
Time Needed	40 minutes
Materials	Region #1: Maldives Region #2: Norway Region #3: Iowa Region #4: The Republic of Chad Region #5: Amazon basin Region #6: Southern California Impacts of Climate Change

Directions:

Explain to students that climate change does not simply make the temperature a few degrees warmer all over the world. Climate change disrupts the climate, which includes precipitation, weather patterns and storms. This in turn affects plant, animal and insect communities, crops and the spread of disease.

Let students know that they are about to learn about potential regional effects of climate change. In groups they will read a description of the current climate and geographic location of a particular region of the world. They will have general information about how climate change can affect particular aspects of climate. They will then have to predict what might happen to the climate of that region as the Earth continues to warm. ***(5 min)***

Divide students into groups of three. Each group will get a reading that has a description of the climate and geographic location of ONE of the following regions:

Region #1: Maldives
Region #2: Norway
Region #3: Iowa
Region #4: The Republic of Chad
Region #5: Amazon basin
Region #6: Southern California

Reference:

Central Intelligence Agency (2006). The World Fact Book. Retrieved on August 7, 2006 from https://www.cia.gov/cia/publications/factbook/index.html.

Each group will also get IMPACTS of Climate change. This set of readings should be cut into seven slips of paper, each with one of the following passages topics related to climate change:

- Increasing temperatures
- Increasing evaporation
- Changing precipitation
- Warmer oceans
- Shorter and milder winters
- Disease vectors
- Rising sea levels

References:

Albritton, D. L., Meira Fiho, L. G., Cubasch, U., Dai, X., Ding, Y., Griggs, D.J., et al. (2001). Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, England.

Hansen, J. E. (2005). Is There Still Time to Avoid 'Dangerous Anthropogenic Interference' with Global Climate? Presentation on December 6, 2005 at the American Geophysical Union, San Francisco, California.

The groups should divide the seven passages among the members of the group. Each student will read his or her slips of paper to the rest of the group. The group will then use the information they have on their assigned region to predict what might happen to the climate of that region as the Earth continues to warm. One student from each group should write the group's predictions. ***(10 min)***

Predictions should include:

- When might precipitation come? In what form? How much?
- Might the area be affected by droughts? Floods?
- Might the area be affected by storms?
- Would shorter and milder winters affect the area? If so, how?
- Might the area be affected by rising sea levels? If so, how?
- Would the production of food or other crops be affected?
- What concerns might the area have related to disease? Pests?

Ask several groups to report to the rest of the class about the region for which they made predictions. Student reports should include a short description of the region and its current climate, the group's predictions and how they reached those predictions. ***(10 min)***

Now ask the students to make predictions for their home region. As students make predictions, write them on the white-board. ***(10 min)***

Remind your students that although the Earth will continue to warm for centuries due to the heat-trapping gases already in the atmosphere, it is not too late for us to act to help slow that warming and prevent some of the most extreme effects.

Ask your students to recall actions from Lesson Three that they can take as individuals to help reduce heat-trapping emissions. ***(5 min)***

Homework:

Ask the students to journal on the following questions. Now that you understand a bit more about climate change, what is your opinion of the term "climate change"? Do you feel that it adequately describes the issue? How do you think that the term "climate change" contributes to the general public's perception of the issue? If not, what term would you propose instead? Some people use the terms "global warming," "climate crisis," or "climate disruption." Do you think that one of these terms would be as productive and helpful as the other options? What are ways we can help more people understand the impacts of climate change?

Notes to Teachers:

- As the students are cooperatively reading, planning and practicing their lessons and presenting their lessons to each other, circulate between the groups and listen at each group for a few moments to gauge the progress of the groups and to make certain that students are focusing their efforts on the task.
- Before dividing the students into groups, explain the entire activity to them and let them know how much time they will have for each section of the activity.
- Inform students that you will be circulating between the groups during this activity and that you may ask any student at any time to explain any aspect of the passages. Let them know that it is the responsibility of each group to make sure that each member understands all the concepts and would be ready to explain any of the topics.

For more information on the effects of climate change around the globe, as well as well as expedition resources linked to this lesson plan, visit: ***http://www.climategen.org/what-we-do/education/climate-change-and-energy-cirricula/curriculum-guides/our-changing-climate-for-grades-6-12/online-connections/***

Region #1: Maldives

This island nation located in the Indian Ocean about 435 miles (700 km) southwest of Sri Lanka is seven and a half percent the size of the U.S. State of Rhode Island and is home to almost 393,500 people. The Maldives holds the record for being the flattest and lowest nation. Its highest natural elevation is 7.5 feet (2.3 meters) above sea-level, although in certain areas, the land has been constructed to be somewhat higher. The Maldives is composed of 26 atolls which are low-lying coral islands and 1,192 islets (200 of which are inhabited by people). Islets are mounds of broken coral and other reef detritus (waste) that stick out of the water in shallow lagoons.

The Tsunami of December 26, 2004 almost completely flooded the Maldives with waves of up to five feet high. The tsunami killed at least seventy-five people and the devastation from the waves left many people homeless. After the tsunami, the shape of the islands had changed and now the maps of the country are having to be redrawn.

The two major industries of the Maldives are tourism and fisheries. Around half a million tourists each year visit resorts in the Maldives. Fisheries employ about a third of the citizens of the Maldives. Other industries such as shipping, banking and manufacturing are growing.

The Maldives has the highest per-capita GDP (gross domestic production, which is one way economists measure wealth) of all the nations in South Asia. The Maldives GDP is around 8,730 U.S. Dollars per person per year.

Region #2: Norway

The Scandinavian nation of Norway is approximately the size of the U.S. State of New Mexico and is home to 5,136,700 people. Norway is a long and thin country with a very long coastline on the North Atlantic, Barents Sea, Arctic Ocean, North Sea and Norwegian Sea. The northern part of Norway is north of the Arctic Circle.

The moderating influence of the oceans and the Gulf Stream make the climate in coastal Norway quite temperate, considering how far north it is. Temperatures in the capital, Oslo, average 61 degrees F (16.4 degrees C) in the summer and 24 degrees F (-4.3 degrees C) in the winter. The climate further inland and further to the north can be more severe and in the far north, it is sub-arctic.

In recent years, however, Norway has been experiencing warmer temperatures. The average temperature in Norway over the last fifteen-years has been 1.8 to 4.5 degrees F (1 to 2.5 degrees C) warmer in January and .9 to 1.8 degrees F (.5 to 1 degree C) warmer in July.

More than two-thirds of Norway is covered in rugged mountains. Several major glaciers occupy the central mountain plateau.

The economy of Norway is based on petroleum and natural gas exports, forestry, fishing, mining and hydroelectric power. Less than three percent of the land in Norway is arable (able to be farmed).

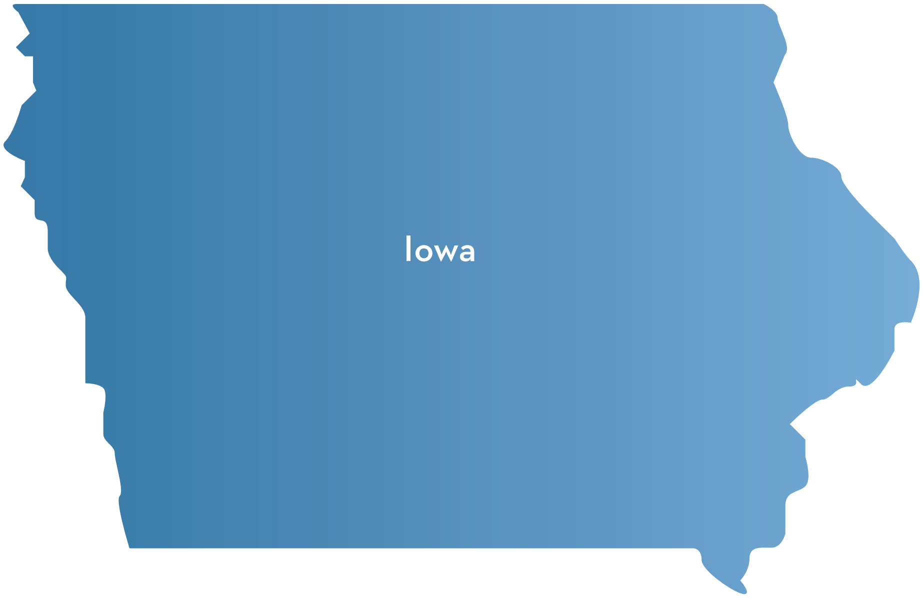
Region #3: Iowa

The U.S. state of Iowa is home to almost three million people. It is located in the upper Midwest. The upper Midwest has a continental climate, which means that it is far away from the temperature-moderating influence of the oceans. This means that winters can get cold, with days as cold as 0 degrees F (-18 degrees C). This also means that summers can get very hot, with days over 100 degrees F (38 degrees C).

Iowa's main industries are agriculture, manufacturing and insurance. About ninety percent of the land area in Iowa is used for farming. Iowa leads the nation in the production of pork, corn, soybeans and eggs. Iowa also leads the nation in the amount of corn-derived ethanol (a fuel) produced. Iowa also produces beef, dairy, sheep and honey.

Iowa receives an average of 34 inches of precipitation each year. The months of April through October receive the most rain. This relatively regular rainfall, especially during the growing season, means that it has traditionally been possible to grow crops in Iowa without irrigation, although certain farmers do irrigate.

The Mississippi River forms the eastern border of Iowa and the Missouri River forms the western border. From May through September of 1993, heavy rains caused record flooding on the Mississippi, Missouri and numerous other major rivers in the upper Midwest. The flood caused billions of dollars in damages in what was one of the worst natural disasters in the United States' history. In contrast, in the winter of 2012-2013, the Mississippi River experienced the worst drought in 50 years. The lack of precipitation reduced water levels and threatened to halt shipping on the river which would have massive economic consequences.



Region #4: The Republic of Chad

Chad is a landlocked nation in Central Africa, larger than the states of Texas and California combined. It is home to about 10,330,000 people, 80% of whom rely on subsistence farming and livestock raising for their livelihood. Chad's main exports have been, until recently, cotton, cattle and chewing gum. Beginning on 2003, however, Chad began to export petroleum at a rate that has quickly grown. Chad is considered a lesser-developed country (LDC) and is one of the more poor countries in the world with annual per capita GDP at $1,865.

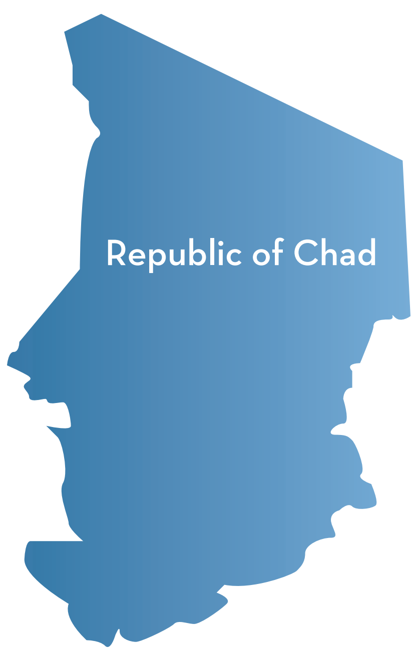
Chad is distant from the ocean and gets little precipitation. Only three percent of the land in Chad is arable, meaning able to be cultivated with crops. Chad has frequent droughts, persistent hot and dry winds and frequent locust plagues (insects that destroy crops).

Lake Chad, which is on the border of Chad and neighboring Cameroon, was once the second-largest lake in Africa. In the past several decades, however, Lake Chad has been shrinking and is now less than ten percent of its former size. Lake Chad doubles in size during the rainy season.

The only two important rivers in Chad are in the southwest of the country and flow into Lake Chad. The low-lying plains in the Lake Chad Basin get frequent enough rainfall during the rainy season to allow agriculture without irrigation. Daytime temperatures in this region range from around 80 degrees F (27 degrees C) in the coolest months to around 104 degrees F (40 degrees C).

The center of the country is arid plains inhabited by mostly nomadic people (people who, instead of living in permanent housing, move frequently to follow livestock or desirable weather conditions).

The northern part of Chad is desert and receives only trace amounts of rain. Daytime temperatures in the northern desert range from around 90 degrees F (32 degrees C) in the coolest months to around 113 degrees F (45 degrees C) in the hottest months.



CLIMATE GENERATION
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Region #5: The Amazon River Basin

The Amazon River basin covers about 2.7 million square miles in eight different South American countries. The climate is warm and humid with an average daily temperature of almost 80 degrees F (26.6 degrees C) and an average annual rainfall of around 80 inches (203 cm). There is little seasonal temperature variation in the Amazon basin.

There is typically no dry season in the Amazon River Basin. The basin often floods between June and October. This wet climate supports the Amazon rainforest, the largest rainforest in the world.

The main channel of the Amazon River is usually between one and six miles wide and is usually navigable by large steamers as far as 900 miles upstream of its mouth. This river is an important means of transportation for people along its length.

In recent years, however, the Amazon has experienced extreme drought, at times being reduced to a trickle, stranding boats and stressing ecosystems.

Region #6: Southern California

The southern quarter of the U.S. State of California is home to around 24 million people and contains the second largest metropolitan area in the United States (encompassing Los Angeles, San Diego and neighboring cities) as well as the surrounding desert. Coastal areas in southern California are home to unique ecosystems as well as to human communities.

Southern California has a diversified economy that includes the service industry, entertainment, tourism, technology, construction, manufacturing, finance, insurance, real estate and trade as well as agriculture and fishing. Southern California leads the nation in production of fruit and vegetables such as broccoli, carrots, onions, tomatoes, lettuce, almonds, strawberries, oranges and flowers. These crops depend on irrigation (the agricultural Imperial Valley averages less than 3 inches [7.6 cm] of rain a year and the San Joaquin Valley averages less than six inches [15.2 cm] of rain a year, making them both deserts). With irrigation, however, the land can produce two crops a year and is a major source of the nation's fresh produce during the winter.

The large human population in Southern California needs water as well, and securing and distributing enough water for everyone's needs is continually an issue in this area.

Parts of Southern California are moist enough to allow trees to grow, but are still dry enough that forest fires are a common occurrence. With the frequent winds fueling the flames, wildfires in southern California can be intense. Wildfires can destroy the vegetation that previously prevented erosion and when intense rains come after wildfires, they can sometimes trigger landslides, ash flows and flash floods.

IMPACTS of Climate Change

(Cut the paper so each impact is on a separate piece. Give one complete set of readings to each group.)

Increasing temperatures.

The global average temperature is projected to rise between 2.5 and 10.4 degrees F (1.4 and 5.8 degrees C) over the period from 1990 to 2100. The temperature will not rise equally everywhere, however. The centers of continents will warm more rapidly than land near the oceans. The higher latitudes are also predicted to warm more than the lower latitudes (tropics). This could mean that certain areas could experience rises in average temperature that are much more than what is projected for the world as a whole. For example, the Arctic is projected to warm an additional 7.2 to 12.6 degrees F (4 to 7 degrees C), while tropical areas are projected to warm much less. Higher temperatures may cause heat-related deaths especially in urban areas and among poor people, stress to wildlife and livestock, shifts in tourist destinations, increased risk of damage to some crops and possible increase in electricity demands as people run air conditioners (and related increase in heat-trapping emissions from increased energy use).

Changes in precipitation.

Certain areas will get more precipitation and other areas will get less. It is very difficult to predict how much the amount of precipitation will change in any given area. In general, areas in higher latitudes (closer to the poles) and closer to oceans may get more precipitation and areas in lower latitudes (closer to the equator) and further inland may get less. Areas in which there are already water shortages may have even less available water as the climate warms.

The precipitation in many areas may come in extreme events. These extreme rain events will cause flooding and erosion, stress flood insurance systems and deplete government disaster relief systems. On the other hand, increased precipitation and extreme rain events may help to recharge flood-plane aquifers (natural underground water storage areas).

The precipitation associated with the Asian monsoon season may become more variable. This may cause certain areas in temperate and tropical Asia to have droughts while other areas may experience floods.

Increasing evaporation.

Even though climate change may increase the total amount of precipitation that any area receives, increased heat will cause increased evaporation. If the rain comes during the winter and the heat comes in the summer, during the summer the land may dry out. This is most likely to happen in the interior of continents. This may cause decreased crop yields, decreased water resource quantity and quality and increased risk of forest fire.

Warmer oceans

Hurricanes get their energy from energy stored in the ocean in the form of heat. As more energy in the form of heat accumulates in the oceans, hurricanes can get more and more intense.

Coastal communities that rely on aquaculture (the raising of fish in enclosures floating in the ocean) may have difficulty with warmer waters if it gets too warm for the type of fish they are raising or if the warm water makes diseases and toxic algal blooms more common.

Shorter and milder winters

In areas with traditionally cold winters, the hard frosts kill off insect pests and the accumulated snow melts slowly during the spring to recharge groundwater and feed streams. Often these areas rely on snow and ice to draw winter tourists for activities like skiing, snowmobiling, dogsledding, and ice climbing.

Warmer winters will mean that more insect pests may survive. This could threaten local communities of living things. Also, less snow-pack that melts earlier would mean that water may be less available in the spring and summer when plants need it. Areas with winter tourism would also suffer from reduced ice and snow-pack.

Disease vectors and human health

As the climate warms, disease vectors (things that carry disease) like mosquitoes and ticks will be able to extend their ranges. Also climate change can increase waterborne pathogens (microorganisms that cause disease), decrease water and air quality and decrease the amount and quality of available food. These effects will be the most severe in developing countries and among the poor.

Rising sea levels

Scientists know that the sea level will continue to rise as a result of climate change. Part of this rise is due to thermal expansion of the oceans (as water gets warmer, it becomes less dense and takes up more space) and part is due to melting glaciers and ice caps. Scientists have so far been unable to predict precisely how much and how quickly the oceans will rise because there are so many variables, including which choices we make regarding our energy sources. Projections for sea-level rise by the year 2100 range from 4 inches (10 cm) to as high as several yards/meters (if ice sheets begin to disintegrate). Rising sea levels will make low-lying coastal areas, deltas and small islands at risk for flooding and erosion. Some very low-lying islands and other areas may need to be evacuate.

Lesson 6: What Now?

How can/should we as humans respond to climate change?

Question	How can/should we as humans respond to climate change?
Objective	Students will brainstorm ideas of how to respond to climate change. Students will think critically about the trade-offs between different possible courses of actions.
Time Needed	40 minutes
Materials	Internet access (for student preparation)

Preparation:

Several days in advance of teaching this lesson, ask your students to research (on the internet, in newspapers or magazines, through word-of-mouth or interviews) three different ways that people are working to solve or mitigate climate change-related issues. These examples can be personal, local, regional, national or international. Students should bring newspaper clippings, printed pages from the internet or a short written description of the action. Examples could be groups installing solar panels or wind turbines, groups coordinating carpools and bike commutes, groups planting trees, individuals installing compact fluorescent light bulbs or other energy-efficient measures, cities pledging to reduce emissions, regional or state targets for emission reduction, ideas for new laws being considered in Congress, international carbon-trading markets, etc.)

Directions:

Ask students to summarize what climate change is, what causes it and what some effects of it might be. Student answers should include:

- Our atmosphere has a natural ability to trap heat that would otherwise escape back into space. Without heat-trapping gases, temperatures would average around 0 degrees F and life as we know it would be impossible.
- Increasing concentrations of heat-trapping emissions are making the Earth increasingly warm. Human-caused sources of these emissions include land use change and burning of fossil fuels.
- As the Earth warms, sea levels will rise, there will be more droughts, floods, severe storms, disruptions to communities of living things and possible spread of disease. ***(5 min)***

Explain to your students that scientific evidence suggests that if atmospheric concentrations of heat-trapping gases stabilize at or below 544 parts per million (ppm CO2 equivalent), we have a good chance of holding global average temperature increases below 3.6 degrees fahrenheit (1.98 degrees celsius) from 1990 levels. This would avert the most severe impacts of climate change. Staying under the 544 ppm threshold would require cutting global emissions roughly in half from today's levels by mid-century. Given that the United States leads the world in both absolute and per capita emissions, we must achieve even deeper reductions here at home. Across the country, many U.S. states have already adopted 75-85 percent long-term reduction goals. To meet these aggressive emission reduction goals, we can draw on solution options that range from changing our personal actions, to local, state and national policies. Businesses can also play an important role through emission reduction commitments and investments in clean energy technologies.

Notes to Teachers:

- As the students are brainstorming and critiquing their ideas, circulate between the groups and listen at each group for a few moments to gauge the progress of the groups and to make certain that students are focusing their efforts on the task.
- Before dividing the students into groups, explain the entire activity to them and let them know how much time they will have for each section of the activity.
- Explain to the students that you will be circulating between the groups during this activity and that you may ask any student at any time to explain any of their ideas.
- The goal of the homework letter writing activity is to help students develop citizenship skills. The goal is not to force students to take an action in which they do not believe.

Now divide students into groups of three. Ask each group to brainstorm and make a list of possible courses of action for human beings to take. Let the students know that during a brainstorming session, all ideas are good ideas. Students should feel free to suggest ideas such as doing nothing, moving everyone who lives within a few meters of sea-level to higher ground, searching for another planet on which to live, etc.

Next ask students to read through their list as a group and write benefits and pitfalls for each idea. They should discuss how difficult the idea would be to implement and how much of an impact it would make. The group should then choose their favorite one or two (depending on time) ideas to share with the class. ***(15 min)***

Ask each group to share one or two of their ideas with the class. Students should mention any benefits or pitfalls they see for each idea. ***(10 min)***

Now ask several students to share examples they found during their research of actions already being taken in response to climate change. ***(10 min)***

Finish the class by summarizing for your students that although the Earth will continue to warm for centuries due to the greenhouse gases already in the atmosphere, it is not too late for us to act to help slow that warming and prevent some of the most extreme effects. Introduce the idea that the buildings and power plants we build today will have a lifetime of many years. For that reason, decisions we make today about what types of buildings and power plants to build will affect our levels of emissions in the future.

Homework:

Local, state, regional, national, international and corporate leaders are currently debating different courses of action in response to global climate change. Citizen input is important in these processes. Based on what they've learned, students may have different feelings about the urgency of the issue and what actions, if any, should be taken. Have students write a letter to a decision maker (for example their member of Congress, Governor or Mayor) that expresses their opinion on what response should be taken to climate change. Students should feel free to write whatever they believe. For example, they could write that they don't believe any action should be taken, call for more research, ask for mandatory emission reductions, or urge the United States to reenter international negotiations, etc.

Please visit ***http://www.climategen.org/what-we-do/education/climate-change-and-energy-cirricula/curriculum-guides/our-changing-climate-for-grades-6-12/online-connections/curriculaextras*** to find additional resources

Appendix

Grades 6–12 Lessons	Recommended Expedition Dispatches/Videos *Go to http://www.climategen.org/what-we-do/education/climate-change-and-energy-cirricula/curriculum-guides/our-changing-climate-for-grades-6-12/online-connections/* to access recommended dispatches/videos.
Our Unique Atmosphere	**Baffin Island:** Sunburns
Emissions of Heat-Trapping Gases	**Baffin Island:** Jessieloosie **Ellesmere Island:** Adam Ayles **Larsen Ice Shelf:** Glacier Melt (audio)
Communities of Living Things	**Baffin Island:** A conversation with Theo Qujannanmiik (Thank You) Qikiqtarjuag Polar Bears and Arctic Hares Lemmings Earth Day (video) **Ellesmere Island:** Polar Bears! **Larsen Ice Shelf:** Krill Glacier Melt (audio)
Implications of Warming in the Arctic	**Baffin Island:** Glacier Loss (video) Earth Day (video) **Ellesmere Island:** Expedition Travels Through Arctic Ocean Ruins **Larsen Ice Shelf:** Antarctic Ocean January 7th, 2008 (audio) January 10th, 2008 (audio) Global Tourism (audio)
Regional Effects of Climate change	**Larsen Ice Shelf:** Iceberg, Glacier Melt (audio), January 7th, 2008 (audio), January 10th, 2008 (audio), Global Tourism (audio)
What Now?	**Baffin Island:** Pondering our Legacy Reflecting on the Expedition Earth Day (video) **Ellesmere Island:** Homebound Electricity from the Sun Heading South

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