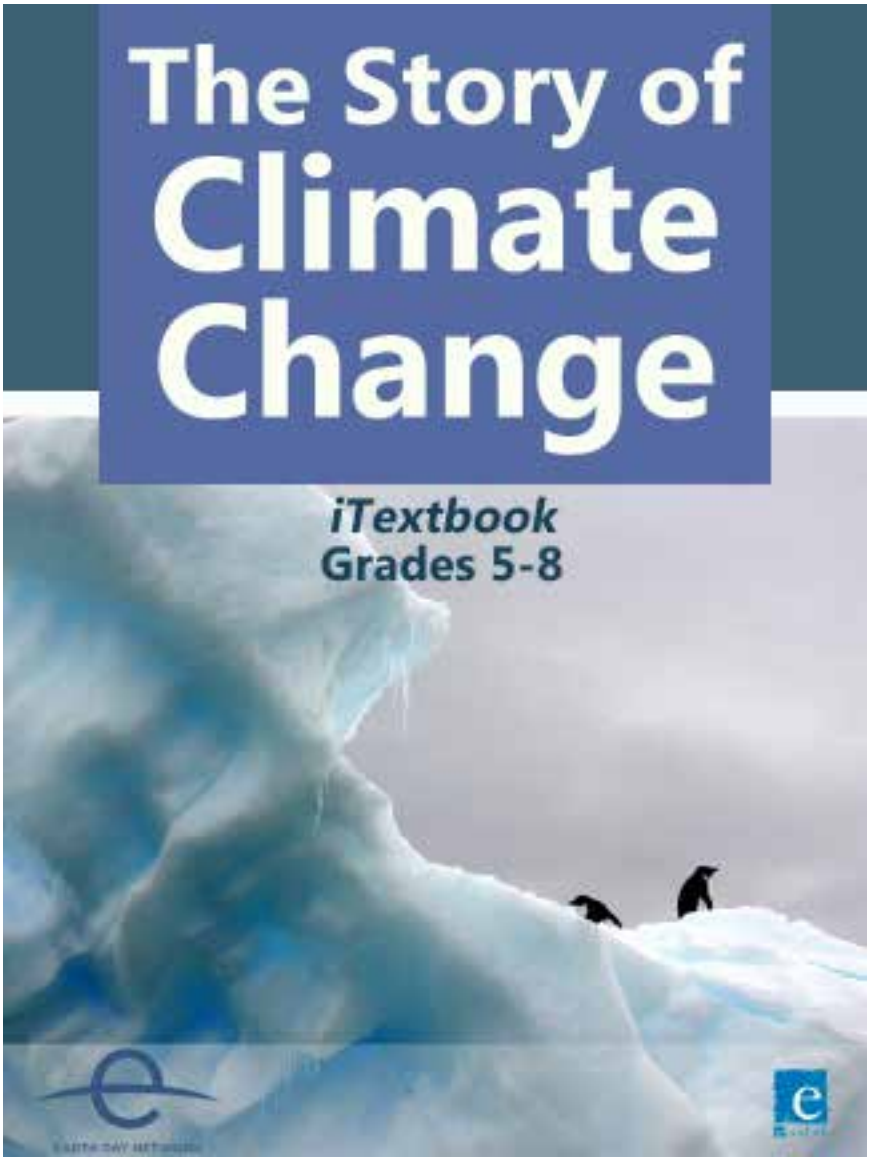
Earth Day Network

TEACHER'S GUIDE

THE STORY OF CLIMATE CHANGE



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Why Teach Climate Change?

Climate change is the biggest issue facing our world today. It pervades every part of our lives, and is an increasingly important factor affecting scientific, political, and social research and planning. It is imperative that we prepare students with the knowledge and critical-thinking tools they will needto handle this inevitable hurdle.

What we know about climate change today far exceeds what we knew ten or even just five years ago. It is a constantly developing and highly interdisciplinary field of study, relevant to modern living as well as students' future prospects. Climate education is not only important for students, but also academically stimulating. Thinking about the future of the environment requires students to find connections between global and local events, combine knowledge from various subjects, consider costs and consequences, and think about the big picture.

Providing our students with the latest climate science is the first step we can take to combat climate change in the coming years. The lessons that we teach today will ensure that future decisionmakers understand the context and impacts of climate change, and will help them make more informed decisions. By ensuring that each student has a solid foundation, we can preserve our community and environment far into the future.

Content

The Story of Climate Change consists of six chapters aimed at giving students a well-rounded and engaging foundation in climate change issues and solutions.

- Chapter 1: What Is Climate Change?
- Chapter 2: The Carbon Cycle
- Chapter 3: What Is Melting and Why Does It Matter?
- Chapter 4: The Impact of Climate Change
- Chapter 5: The People and Places of Climate Change
- Chapter 6: What Can You Do?

Each chapter utilizes photos, videos, and animations to enhance the information taught. The included videos are concise, relevant, and informative.

Some of the interactive content may require an Internet connection; however, the primary text, static images, and review sections found in the iTextbook can be accessed freely with or without an Internet connection. Throughout the book, important or new terms are marked and linked to the glossary so that students can quickly access needed definitions.

The review section found at the end of each chapter provides students with discussion questions and multiple-choice questions written to reinforce concepts and facts found within the chapter. Activities are also provided throughout the iTextbook, which may be used to help students link abstract or global concepts to their personal experiences or local observations.

Interactive Resources

The Story of Climate Change utilizes interactive widgets throughout each chapter to enhance the content and concepts of each topic. There are various types of interactive resources, all of which are labeled as interactive. These can all be activated by tapping or dragging various components.

Glossary

Important terms and vocabulary that students may be unfamiliar with are marked in the glossary. Within the iTextbook, all terms with glossary entries are bolded. Glossary definitions can be accessed by tapping on the word within the text, which will pull a small popup with the glossary text. Students can also access the glossary to see where the terms are used within the iTextbook.

Highlighting and Notes

Students can also highlight or take digital notes within the iTextbook. This function can be used by selecting the text that you want to highlight or take notes on, double tapping it, and choosing the highlight or notes options.

Videos

Videos are used in the iTextbook to supplement or expand on concepts or examples, and can all be accessed offline. These videos are integral to connecting the ideas of the chapters, and students will find them extremely helpful and clarifying. Videos can be played by tapping on the play button on the video, and can be paused by tapping on the video again. Videos do require sound, and are on average two to five minutes long. The videos have been handpicked to enhance the students' grasp on the text and are integral to user experience and education.

Interactives

Interactives are primarily embedded into the the iTextbook; however, some widgets require Internet in order to work. These widgets may run slower or require longer loading times depending on the speed of the Internet connection.

Activities

In this teacher's guide, you will find one activity associated with each *Story of Climate Change* chapter in order to reinforce important concepts and expand learning. The activities range from classroom experiments to short research projects. Some activities may require setup time.

Discussion and Review Questions

At the end of every chapter you will find a review section that includes discussion and review questions. The purpose of these questions is to check that students are following the content of the chapter and encourage them to think about the ideas for that unit.

Discussion questions are open-ended, and can be used to guide dialogue in large or small groups. These questions focus on helping students understand or use the ideas found in the chapter, and emphasize broad concepts rather than chapter facts and details.

Review questions are provided in a multiple-choice format and are written to ensure students recall and absorb important facts from the text. Review questions require students to read the text thoroughly and understand the significance of facts within the context of unit themes.

Standards Alignment

In an effort to help educators integrate this resource into lesson planning, we have inlcuded some of the Next Generation Science Standards, Common Core Standards, and Climate Literacy: Essential Principles of Climate Science that each chapter addresses. The lists are not meant to be all-inclusive, as other standards may be identified.

Standards alignment has been identified for both the general chapter as well as the chapter's associated activity.

Chapter 1: Overview

Chapter 1 is a brief introduction to the definition of climate change.

Students will learn about the impacts of human activity, beginning with the Industrial Revolution, on our planet. The focus of this chapter is the importance of the correlation between increasing global temperatures and increasing concentrations of carbon dioxide in the atmosphere. Students are introduced to the concept of environmental indicators with a brief discussion of melting glaciers.

NGSS Standards

Standard Addressed	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.	Developing and Using Models	**ESS2.A** Earth's Materials and Systems	Stability and Change
MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	Constructing Explanations and Designing Solutions	**ESS2.A** Earth's Materials and Systems	Scale and Proportion Quality
MS-ESS3-3. Apply scientific principles for monitoring and minimizing a human impact on the environment.	Constructing Explanations and Designing Solutions	**ESS2.C** Human Impacts on Earth Systems	Cause and Effect
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.	Engaging in Argument from Evidence	**ESS3.C** Human Impacts on Earth Systems	Cause and Effect
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.	Asking Questions and Defining Problems	**ESS3.D** Global Climate Change	Stability and Change

Chapter 1: Discussion

Teacher's Guidance for Discussion Questions

Can you think of any environmental indicators besides glaciers? What might they tell us about the health of an ecosystem?
Students may provide any of the following answers based on their reading of Chapter 1: change in concentration of carbon dioxide, change in global temperature, or rising sea levels. They may suggest other answers based on what they have read in the news or learned in previous courses.

If students propose any of the following indicators, you can mention that these topics will be discussed in Chapters 4 and 5: intensity of hurricanes, unpredictable and extreme weather, extinction of species, migration of species to different habitats.

What did the Industrial Revolution give us? What did it cost us?
Students may recognize that the Industrial Revolution gave us advances in technology that, in many ways, improved the quality of human life by making it possible to do certain jobs more quickly.

They may also recognize that the quest for making our lives easier has driven the demand for fossil fuels, which harm the environment when burned.

Encourage your students to figure out ways to maintain our standard of living while minimizing our negative impacts on the environment. Ideas may include buying products that are grown or manufactured locally, changing our habits of transportation and climate control, and exploring the use of alternate sources of energy, among others.

The U.S. has substantially higher greenhouse gas emissions than South America? Why is that?
Students may realize that people in the United States rely on machinery and automated processes much more extensively than people in South America. Americans drive more, fly more, process more food in factories, and transport more products across the country than the people who live in South America do. All of these processes require fossil fuels.

Students may think that there are more people in the United States than South America. Ask them to research the populations. They will find that, while the population of the U.S. is comparable to the entire population of South America, it is actually smaller (about 18 percent smaller in 2015). Therefore, the differences in fuel consumption are due entirely to lifestyle habits.

Chapter 1: Activity

How It's Made: A Discussion of the Carbon Footprint in Everyday Items

Lesson Goals

Students will be able to:

- Understand that most products we use every day have an environmental impact
- Learn about how various products cause carbon emissions
- Understand their personal carbon footprint

Lesson Objective

Having applied concepts learned from Chapter 1, students will be able to explain the carbon emissions associated with different products and how their choices impact Earth.

Standards

NGSS

MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Common Core

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

MP.2 Reason abstractly and quantitatively.

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.

Materials Needed

- Small bag
- Several items commonly found in a home or classroom
- Computers or tablets with Internet access
- Poster board or paper
- Markers or colored pencis

Process: 30 minutes

Teacher Preparation

Gather several everyday objects for students to choose out of a bag at random.

Procedure

1. Explain the activity: Students will work in groups determined by the teacher to create posters about how their chosen item affects their environment, from its creation to its appearance in the classroom. Refer to Interactive 1.1: "A Pencil's Carbon Footprint" on page 7 for ideas on how an everyday item can have an effect on carbon emissions.

2. Ask for groups to volunteer to present their poster and to discuss the carbon footprint and various environmental impacts of their items.

3. Ask for other groups to comment on the presentations.

4. Have students use a carbon footprint calculator to find their own carbon footprint. http://www.earthday.org/footprint-calculator

5. Facilitate discussion on other items that the students use that significantly affect the environment.

Group Discussion Questions

1. Which object required the most steps, from beginning to end?

2. Which object probably required the most energy, from beginning to end?

3. Which object probably generated the most CO_2 from beginning to end?

4. Is there any part of the process you could do differently to reduce the amount of energy required or the amount of CO_2 produced in order to get a certain object? (For example, buy only local tomatoes, buy products manufactured nearby, and so on)

Chapter 2: Overview

Chapter 2 provides students with the foundation to understand the role of carbon in climate change.

Students learn about the natural processes that cycle carbon around our planet. The focus of this chapter shows how humans are converting fossil fuels to carbon dioxide at a rate that is too rapid for the natural processes of the carbon cycle to handle.

NGSS Standards

Standard Addressed	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.	Developing and Using Models	**PS1.A** Structures and Properties of Matter	Scale Proportion and Quantity
MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.	Obtaining, Evaluating, and Communicating Information	**PS1.A** Structures and Properties of Matter **PS1.B** Chemical Reactions	Structure and Function
MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.	Constructing Explanations and Designing Solutions	**LS1.C** Organization for Matter and Energy Flow in Organisms **PS3.D** Energy in Chemical Processes and Everyday Life	Interdependence of Science, Engineering, and Technology
MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	Developing and Using Models	**LS2.B** Cycle of Matter and Energy Transfer in Ecosystems	Influence of Science, Engineering, and Technology on Society and the Natural World
MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.	Develop and Using Models	**ESS2.A** Earth Materials and Systems	Energy and Matter

Standard Addressed	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	Constructing Explanations and Designing Solutions	**ESS2.A** Earth Materials and Systems **ESS2.C** The Roles of Water in Earth's Surface Processes	Scale, Proportion, and Quantity
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.	Asking Questions and Defining Problems	**ESS3.D** Global Climate Change	Stability and Change
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.	Engaging in Argument from Evidence	**ESS3.C** Human Impacts on Earth Systems	Cause and Effect

Chapter 2: Discussion

Teacher's Guidance for Discussion Questions

We have seen that CO_2 and temperature change together over long periods of time. What would make them change over shorter periods of time? How do the seasons change the amount of CO_2 in the air?
A sharp increase in atmospheric CO_2 would lead to a dramatic increase in temperature. As we overwhelm the capacity of the carbon cycle to use CO_2, we increase the possibility that positive feedback loops will begin to increase temperatures at a faster rate than we have previously observed—like the glaciers and albedo effect.

Some smaller, seasonal changes in atmospheric CO_2 concentration can be traced to biological activity. In the winter, CO_2 concentrations are higher because there are fewer plants to take in the carbon. In the spring, plants begin to flourish and take up more CO_2. By the summertime, CO_2 levels drop to a seasonal low due to the biological activity of plants.

If we didn't have greenhouse gases, what do you think our planet would be like?
This question allows students to discover that the greenhouse effect itself is not a bad thing. In fact, it is necessary to sustain life on Earth as we know it. Without greenhouse gases, our planet would be more like Mars than the Earth we know. Temperatures would vary greatly depending almost solely on the presence or absence of sunlight. Such an environment would pose incredible difficulties to us and to all organisms who have adapted to the relatively stable changes in temperature on Earth.

Students may realize that if Earth had never had greenhouse gases, life would have evolved very differently than how it has, if at all!

What do you think will happen if we keep adding CO_2 to the atmosphere? What are some ways we can slow down our use of fossil fuels or even stop using them?
Students may realize that the addition of CO_2 to the atmosphere will cause temperatures to climb higher at a faster rate, with disastrous effects. They may realize that the carbon cycle cannot handle the rate at which we are adding CO_2 to the atmosphere and that our only hope is to change our habits of transportation, manufacturing, and climate control to reduce our demand for processes that burn fossil fuels. They may also propose that we invest in alternative sources of energy, such as solar or wind energy, to lower the demand for fossil fuels.

Chapter 2: Activity

Greenhouse Gas in a Jar

Lesson Goals

Students will be able to:

- Define the greenhouse effect and how it work as a physical phenomenon
- Define how a physical effect is intensified by changing the components
- Describe how their observations apply to the Earth's atmosphere

Lesson Objective

Students will synthesize carbon dioxide through a simple chemical reaction and measure the effect of the gas on air temperature. They will relate their findings to the effect greenhouse gases have on our atmosphere as a whole.

Standards

NGSS

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Common Core

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

MP.2 Reason abstractly and quantitatively.

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Materials Needed

- Three small thermometers
- Beaker or container small enough to fit in the soda bottle
- Baking soda
- White vinegar
- Two two-liter (0.5 g) plastic soda bottles, labels removed, tops evenly cut off so each bottle sits flat when turned upside down
- Clock or watch
- Sunlamp or access to a sunny area

Process: 80-100 minutes

Background Information

The atmosphere is important to maintaining heat on the surface of the Earth. Without the atmosphere, our average temperature would be about -18º C (0º F) instead of the 15º C (60º F) it is now. CO_2, water vapor, and methane are greenhouse gases that make Earth habitable.

Greenhouse gases are made up of at least two atoms. Bonds between the atoms absorb heat that radiates from Earth's surface and would otherwise be lost in space. Greenhouse gases reflect that long-wave radiation back to Earth's surface and make it hotter.

Procedure

1. Group the students and ask students to predict how the temperatures might differ between the greenhouse gas bottle, the normal air bottle, and the air. Record their predictions.

2. Distribute materials. Each group should place its thermometers several inches (a few inches) apart under the sunlamp or in direct sunlight.

3. Wait about 3 minutes and then have the students record the time and the temperature readings on all three thermometers.

4. In the small beaker or container, place 30 grams (1 oz) baking soda. Carefully add 60 millileters (2 oz) vinegar.

5. As soon as the mixture foams up (creating carbon dioxide), place one thermometer near the beaker and cover the beaker and thermometer with one upside-down soda bottle.

6. Each group should now place a soda bottle upside down over the second thermometer. For the next 10 minutes at 2 minute intervals, the students should record the readings of both thermometers. Afterward, read the temperatures every 5 minutes for a total of 30 minutes of recorded temperatures.

7. Compare students' observations to their predictions. Discuss how the carbon dioxide affected the temperature inside the bottle. Discuss how this phenomenon relates to our environment.

Explanation

The air over the uncovered thermometer is constantly changing, Because the air in the bottles cannot circulate to the rest of the room, it stays in the sunlight and gets warmer and warmer. The bottle with carbon dioxide traps even more heat and warms even faster than room air, which contains only a trace amount of carbon dioxide. A similar trapping of heat happens in Earth's atmosphere. Sunlight passes through the atmosphere and warms Earth's surface. The heat radiating out from the surface is trapped by greenhouse gases. Both the atmosphere and the bottles allow light to enter and trap that energy when it is converted to heat. They work differently, however, because the bottles keep in the heated air, while greenhouse gases absorb radiative heat.

Adapted from:
http://forces.si.edu/atmosphere/pdf/Atmo-Activity-7.pdf

Chapter 3: Overview

Chapter 3 is an in-depth exploration of glaciers, not only as environmental indicators, but also as sources of data critical to the study of climate change.

Students will learn how scientists gather data from ice cores that tell us how the climate has changed over the past 700,000 years. They will also see data about the melting of glaciers and ice sheets due to global warming, setting the stage for predictions about rising sea levels in Chapter 4. Finally students will be introduced to the albedo effect and the positive feedback loop associated with melting glaciers.

NGSS Standards

Standard Addressed	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.	Developing and Using Models	**PS1.A** Structure and Properties of Matter **PS3.A** Definitions of Energy	Cause and Effect
MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.	Develop and Using Models	**ESS2.A** Earth Materials and Systems	Stability and Change
MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	Constructing Explanations and Designing Solutions	**ESS2.A** Earth Materials and Systems **ESS2.C** The Roles of Water in Earth's Surface Processes	Scale, Proportion, and Quantity
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.	Asking Questions and Defining Problems	**ESS3.D** Global Climate Change	Stability and Change

Chapter 3: Discussion

Teacher's Guidance for Discussion Questions

Why is it important to analyze air bubbles trapped in glaciers?
Analyzing these air bubbles allows us to understand what the concentration of CO_2 was like hundreds of thousands of years ago. The data allow us to look at how global temperatures and atmospheric CO_2 concentrations have changed together over a very long period of time. This understanding helps us see the impact our CO_2 emissions are having on global climate change.

What are the five most populated cities in the U.S. How many of them are coastal cities? Assuming all coastal cities would be affected by global sea level rise, what is the total number of people who would be affected?
The top five biggest cities, according to the 2010 Census, are:

City	Population
New York Los Angeles	8,175,133 3,792,621
Chicago Houston	2,695,598 2,099,451
Philadelphia	1,526,006

All of these cities are coastal cities, with the exception of Chicago, so their total populations would be affected by rising sea levels. It is interesting to note, however, that melting glaciers and thermal expansion could result in levels rising in the Great Lakes, which would affect Chicago as well. Potentially, all five of the most populated cities in the United States could be affected by this phenomenon!

What is a positive feedback loop? How does glacial melting lead to further glacial melting? Can you think of another example of a positive feedback loop?
According to NOAA, a positive feedback loop is a process by which an initial change will bring about an additional change in the same direction. As glaciers melt, they expose more land. Unlike glaciers, which reflect much of the sun's energy, land absorbs energy from the sun and warms up the atmosphere, resulting in more ice melting. Thus, the process continues.

Students may find it easier to propose non-environmental examples of positive feedback loops at first. This is a good way to solidify the concept, so accept these answers before encouraging them to find environmental examples. They may have learned about interest calculations in math, so they will understand that as more money is in the account, it will earn more interest, which results in more money in the account.

Chapter 3: Activity

ACTIVITY

Canned Heat: Demonstration of the Albedo Effect

Lesson Goals

Students will be able to:

- Set up a simple experiment, controlling for different variables
- Draw conclusions from their data
- Show that light and dark colored objects absorb the sun's radiation at different rates
- Understand how the albedo feedback loop speeds up Arctic melting

Lesson Objective

The demonstration will show that water in a dark colored can will have a higher temperature after exposure to the sun than water in a shiny can.

Standards

NGSS

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

Common Core

6.SP.B.5. Summarize numerical data sets in relation to their context.

MP.2. Reason abstractly and quantitatively.

RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Materials Needed

- Two large coffee cans, empty
- No-Gloss / Matte spray paint
- Thermometer

Process: 120 minutes

Teacher Preparation

One coffee can needs to have a shiny metallic surface inside and out. The other can should be painted matte inside and out.

Procedure

1. Fill the two cans with about 5 centimerters (2 in) of water.

2. Measure the temperature of the water in each can. (The readings should be the same.)

3. Remove the thermometer and place the cans in a sunny location where they will not be disturbed and receive 2 hours of sunlight.

4. After 2 hours, measure the temperature of the water in each can.

Group Discussion Questions:

1. What is the definition of albedo?

2. What effect do you think snow and ice have on surface temperatures? (Remember that snow and ice are light colored and reflective.)

3. What effect do you think dark soil has on surface temperatures?

4. Why is albedo related to Arctic melting and higher sea levels?

Adapted from:
http://www.srh.noaa.gov/jetstream/atmos/ll_cannedheat.htm

Chapter 4: Overview

In Chapter 4, we turn our attention to the effects of climate change around the world.

The problems of sea level rise and extreme and unpredictable weather are discussed as global problems. The focus shifts to the biological impacts of climate change: changing habitats, invasive species, the spread of diseases, and destruction of coral reefs are all discussed. The chapter ends with a discussion of the impacts of climate change on culture, which is the focus of Chapter 5.

NGSS Standards

Standard Addressed	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.	Constructing Arguments and Designing Solutions	**LS2-4.A** Independent Relationships in Ecosystems	Cause and Effect
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	Constructing Explanations and Designing Solutions	**ESS3.C** Human impacts on Earth systems	Cause and Effect
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.	Asking Questions and Defining Problems	**ESS3.D** Global Climate Change	Stability and Change

Chapter 4: Discussion

Teacher's Guidance for Discussion Questions

Imagine that you are in charge of preparing a coastal town for rising sea levels. What are some things you might do?
Accept any reasonable answer the students propose. The point is for them to realize how disruptive and expensive, if not dangerous, rising sea levels are.

Imagine that you live in Oklahoma. How will sea level rise impact you? Imagine you live in California. How will the loss of corn crops in the Midwest impact you?
Students may realize that rising sea levels in California will affect industries, like shipping, which could impact consumers all over the country, including Oklahoma. They may also realize that the loss of crops in the Midwest will impact the prices and availability of products for people all over the country, including California.

Can you think of any ways in which your culture is changing as a result of climate change?
Accept any reasonable answers. These will vary widely according to where you are in the world.

Chapter 4: Activity

ACTIVITY
Changes Close to Home

Lesson Goals

Students will be able to:
- Demonstrate their ability to gather, analyze, and interpret data
- Communicate results of their investigations
- Use a climate database
- Explain the difference between weather and climate

Lesson Objective

After reading about the different effects of climate change in Chapter 4, students will look for signs of climate change in their hometown. They will investigate how temperature and precipitation have changed over the past 30 years and also conduct interviews with long-time residents.

Standards

NGSS
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Common Core
SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

MP.2 Reason abstractly and quantitatively.

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research

Materials Needed

- Internet access

Process: 90 minutes

Part 1

Discuss with Students

1. Ask the students how the weather has been this week. Do they think that it is an accurate representation of their town's climate? Why or why not? What is the difference between weather and climate?

2. How does climate affect them? (Do rainy days stop your soccer games? Has heavy snow closed school?)

3. Have they seen any changes in their town's climate over their lifetime? What about older people in the community?

Part 2
Interpret Your State's Historical Weather Data

1. Using NOAA's Climate at a Glance, students will look up their state's annual temperature and annual precipitation for the past 30 years and input it into the graph widget. They can also take a look at the graph generated from the website.

2. Once they have input the data into the graph widget, they should calculate the average annual precipitation for the first 10 years as well as for the last 10 years. Then calculate the difference between the two averages to see how temperature and precipitation have changed.

Part 3
Interview longtime residents of the community to get firsthand accounts of how they have felt the climate change.

1. Students will interview a longtime community residents—their interviewees should have lived in the community for at least two decades. Discuss why it is important to talk to residents who have lived in the community for a long time (climate is a long term look at weather patterns).

2. Write up a list of survey questions to ask the community member. The survey should include questions such as these:

a. How long have you lived here?
b. Do you spend a lot of time outdoors?
c. Do you feel like the climate has changed over your lifetime?
d. Compared with the past, how have winters changed?
e. Compared with the past, how have summers changed?
f. Are there fewer or more storms and unpredictable weather; such as droughts, wildfires, tornados, hurricanes, or flooding?
g. Do you still see the same animals and birds around?

3. After the students have conducted the interviews, facilitate a discussion of the survey results and the historical weather records of their state.

a. What were the results of the survey? Do the responses vary between the community members?
b. What did the historical weather records show about climate change? Is this reflected the same way in the results of the survey?

4. Relate students' research back to the different effects of climate change in Chapter 4.

a. Has climate change affected the culture of your town?
b. What type of changes do you think we will see in the future?

Group Discussion Questions:

1. Looking at the average temperatures for the most recent ten years of your "CIlmate at a Glance" table, do you notice any trends? If so, why do you think the trends are present?

2. Do you think these changes have been large enough for people to notice?

Chapter 5: Overview

In Chapter 5, students will learn how the inhabitants of three different places are affected by global climate change, and how they adapt.

Students will first learn about New York City, which experienced record storm surges during Hurricane Sandy. Next, they learn about Greencastle, Indiana, a farming community hit by extreme drought in 2012. Finally students are introduced to Tuvalu, an island nation that is projected to be submerged in the near future due to rising sea levels.

NGSS Standards

Standard Addressed	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.	Constructing Arguments and Designing Solutions	**LS2-4.A** Independent Relationships in Ecosystems	Cause and Effect
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	Constructing Explanations and Designing Solutions	**ESS3.C** Human Impacts on Earth systems	Cause and Effect
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.	Engaging in Argument from Evidence	**ESS3.C** Human Impacts on Earth Systems	Cause and Effect
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.	Asking Questions and Defining Problems	**ESS3.D** Global Climate Change	Stability and Change

Chapter 5: Discussion

Teacher's Guidance for Discussion Questions

How do you see climate change impacting your neighborhood?
Accept any reasonable answers. These will vary widely according to where you are in the world. Encourage the students to look at the examples of New York, Indiana and Tuvalu for ideas.

What kinds of environmental challenges do you see in your community?
Answers will vary widely. Encourage students to start by thinking of problems caused in their community recently by extreme weather. Think of the predominant industry in your area and how that industry has been affected.

How could you solve some of the environmental challenges you see in your community?
Based on their answers to the previous questions, encourage students to be creative in their problem solving. Some solutions center around repairing damage, while other solutions focus more on prevention of future problems. Encourage the students to look at the examples in the chapter of how the people of Tuvalu, New York, and Indiana adapted to their problems.

Imagine that you are in charge of explaining climate change, and the way the changing climate impacts people all around the world, to another group of students. What kinds of examples would you use? What kinds of evidence would you use?
This question could be a great summative assessment for your students. At this point they should be able to link all kinds of environmental impacts to global warming, which they can in turn link to the rise of CO_2 concentration. Any examples and evidence that follow this pattern are acceptable.

Chapter 5: Activity

Cooking with Solar Ovens
Harnessing Solar Energy

Lesson Goals

Students will be able to:

- Explain how solar energy can be used for cooking
- Explain the principles of solar cooking (dark colored objects absorb sunlight; double glazing traps and helps retain heat, creating a greenhouse effect; light colored objects and shiny surfaces reflect sunlight; insulation slows heat energy transfer)
- Construct a solar oven
- Use the sun to obtain maximum heating (setting the reflector to reflect sunlight into the oven and positioning the oven to face the sun throughout the cooking time)

Lesson Objective

In this activity, students will learn about using the sun's energy to meet our needs. They will be introduced to concepts related to solar energy and cooling (using dark colors to absorb sunlight and heat; light colors to reflect sunlight; materials that insulate; greenhouse effect for personal advantage). Using this science knowledge, they will then construct and use a solar oven.

Standards

NGSS

MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

Common Core

6.SP.B.5 Summarize numerical data sets in relation to their context.

MP.2 Reason abstractly and quantitatively.

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Materials Needed

- Pizza box
- Craft knife
- Aluminum foil
- Tape
- Sheets of clear plastic or cling film (if cling film, try to keep it as smooth as possible)
- Black paper
- Newspaper
- Chocolate, marshmallows, and graham crackers (or other easily heated treat)
-Thermometer

Process: 90 minutes

Procedure

1. Draw a square on top of the lid about 5 centimeters (2 in) in from the outer edges, and then use a craft knife to cut along the front and 2 sides. Fold the flap back.

2. Cover the inner part of the flap with aluminium foil, and tape the foil in place. The flap will be use to reflect light to the box.

3. Seal the square cut into the lid by taping plastic or cling wrap over the hole. Tape on two layers of see-through material, one inside the lid and the other outside the lid. This will allow sunlight in but trap heat.

4. Line the bottom of the box with black paper.

5. Tuck rolled up newspaper around the inside edges to help insulate the box.

6. Place your chocolate s'more or other snacks in the box, along with the thermometer. Close the lid.

7. Keep the aluminum flap open by propping it up with a stick or ruler.

8. Place the oven in a sunny spot. The aluminium foil should face the sun and reflect light into the box.

9. During cooking, keep checking the oven to make sure it is still facing the sun. Note any changes in themperature.

10. Have students answer the discussion questions and compare data with classmates.

Group Discussion Questions:

1. What is the purpose of the aluminum foil?

2. What is the purpose of the black paper?

3. What is the purpose of the newspaper?

4. Was your oven hot enough to heat your food? What was the maximum temperature you recorded in your oven?

5. What does this activity teach us about renewable energy?

Chapter 6: Overview

At this point, students will want to know what they can do to help minimize the devastation of climate change around the world. In this final chapter, they are introduced to kids just like them who have made a difference in their communities and in the world.

We provide students with ideas for action projects they can initiate in their own communities as well as resources to accomplish their goals. Armed with their understanding of the science of climate change, students are empowered to change the world!

NGSS Standards

Standard Addressed	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	Constructing Explanations and Designing Solutions	**ESS3.C** Human Impacts on Earth systems	Cause and Effect
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.	Engaging in Argument from Evidence	**ESS3.C** Human Impacts on Earth Systems	Cause and Effect
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.	Asking Questions and Defining Problems	**ESS3.D** Global Climate Change	Stability and Change
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	Asking Questions and Defining Problems	**ETS1. A** Defining and Delimiting Engineering Problems	Cause and Effect

Standard Addressed	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	Engaging in Argument from Evidence	**ETS1. B** Developing Possible Solutions	Influence of Science, Engineering, and Technology on Society and the Natural World

Chapter 6: Discussion

Teacher's Guidance for Discussion Questions

If you were the leader of your country, what would you do about climate change? What kinds of things might be hard to achieve, even as leader?
Accept all reasonable answers. The point is to realize how disruptive climate change is and how far reaching its impacts are. It would be impossible for one person, even the leader of your country, to change it all alone.

What are some of the things your community is currently doing about climate change? What else could be done?
Accept all reasonable answers. It may be useful to turn this question into a current events exercise. Students can find news articles that answer the question and share them with the class.

What are you willing to do in your own life to tackle climate change?
This is an excellent chance for the students to internalize what they have learned in this unit and reflect on what they can do personally. Accept all reasonable answers.

How can you help your parents make a difference?
Students may realize that some of the decisions with the greatest impact ultimately lie with the adults in their lives. Empower them by telling them they have the knowledge to share good strategies with their parents and inform them of the science behind those strategies.

Action Plan: Energy Auditing

Student Action Plan

Introduction

Would you like to help save the planet and save your school money, too?
One of the simplest ways to accomplish both of these goals is by conducting an energy audit at your school. An energy audit is the first step toward assessing how much energy your school uses and the measures you can take to make your school more energy efficient.

Background

An energy audit is a way to evaluate where your school uses energy and to identify opportunities to reduce the amount of energy used. The three major categories of energy consumption are lighting, electronics, and heating and cooling. There are tons of easy, helpful ways to reduce energy usage in the classroom, from turning off the lights to unplugging electronics that you're not using. By doing an energy audit, you'll be able to figure out where your school is using the most energy and the best ways to save that energy.

Not only does saving energy reduce the amount of natural resources that we use, it also reduces the amount of greenhouse gases and pollution that we generate. By being environmentally conscious, we are also cleaning up the air we breathe and cutting electricity costs. The energy audit is the first step to improving efficacy and efficiency in your school!

Action Plan: School Bus Idling

Student Action Plan

Introduction

When riding a school bus, have you ever noticed the bus running while it's sitting idle? School bus idling, or leaving the engine running while the bus is parked or not in use, has large environmental and health effects.

Background

Bus Idling

School buses run on diesel fuel instead of gasoline. Diesel fuel produces fumes that the U.S. Environmental Protection Agency has ruled potentially harmful.

You have probably seen (and smelled) the black smoke billowing out from bus exhaust. This exhaust contains particulate matter, tiny pieces of dust and soot that can become lodged in the throat and lungs. Idling buses release this particulate matter along with greenhouse gases into the air, polluting the air in and around the bus. The exhaust can also enter school buildings through ventilation, doors, and windows. Studies have shown that exposure to bus exhaust over a long period of time can aggravate respiratory problems such as asthma and potentially cause cancer.

Bus idling is also extremely wasteful. A typical school bus burns half a gallon of fuel per hour just by idling. Extended idling can cause the engine to wear out quickly—one hour of idling adds the equivalent of 20,30 kilometers (1,260 mi) of wear to the engine!

Car Idling

Many parents drive their own cars to pick up their children in the afternoon, some of them arriving 10 to 15 minutes before school gets out. Traffic at bigger high schools can get backed up when school lets out. These drivers often let their engines idle while parked.

Action Plan: Recycling & Waste Reduction

Student Action Plan

Introduction

In 2012, Americans consumed 71,821 metric tons of paper—that's a lot of paper! The good news is that 56.1 percent of that paper (54.3 million tons) was recycled. When you recycle old notebooks and newspapers, they are used to make new items, rather than simply sitting in a landfill. Paper isn't the only resource that can be recycled either. Plastic, aluminum, steel, and glass can be reused too. Schools are a great source of recyclable materials. Just think about the amount of paper that students and teachers use on a daily basis.

Background

Reasons for a Recycling Program

Recycling helps preserve and protect the limited resources that we have on Earth. It also helps us produce less trash, reduces the need for raw materials like wood, and results in less pollution and greenhouse gas emission. Not only does a recycling program help Earth and the local environment, it also makes the school a cleaner place to be!

For every ton of paper recycled, 2.2 cubic meters (3.3 cu yd) of space is saved in landfills. Think of all the paper that you and your classmates might use during the year. Just by recycling that paper, you can significantly reduce landfill waste.

In 2006, Americans generated about 251 million tons of trash. This means the average American generates 2.1 kilograms (4.6 lb) of waste per day, but only recycles 1 kilogram (1.5 lb) pounds of it! It's time for students to step up and pave way for recycling in their schools!