Climate Change: Connections and Solutions

An Interdisciplinary Curriculum

Recommended for Grades 9-12

2-Week Curriculum Unit

Facing THE Future™

CLIMATE CHANGE: Connections and Solutions
High School

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Connections and Solutions

Two-Week Unit for High School
(Grades 9-12)

Facing THE Future™

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from the Hewlett-Packard Company

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Climate Change: Connections and Solutions

Climate change is a complex, interconnected global issue that cuts across many disciplines. This curriculum is aligned with national science and social studies standards and may be used in other classes as well. Appropriate disciplines are suggested for each lesson.

The 2-week unit begins with an introduction to climate change. During the first week, the foundation is laid for understanding some of the forces behind climate change. Students learn basic scientific phenomena related to climate change, beginning with the carbon cycle and the greenhouse effect and concluding with an analysis of different fuel types.

The second week widens and deepens students' understanding of climate change and its connections to various social, economic, and environmental factors. By the end of this 2-week unit, students will understand and be able to communicate complex and interconnected issues related to climate change.

Each week of the curriculum is a stand-alone unit that can be taught independently of the other week.

Grade Level: 9-12

Unit Length: 2 weeks

Subject Areas Included:

- Science
- Social Studies
- Mathematics
- Communications
- Technology
- Language Arts
- Health
- Business/Finance

Key Concepts Covered:

- Carbon dioxide trends
- Carbon footprint
- Climate change policy
- Ecosystems
- Emissions trading
- Energy use and conservation
- Environmental justice
- Environmental regulations
- Equity, poverty, and scarcity
- Global connections
- Greenhouse effect
- Greenhouse gases
- Personal and structural solutions
- Regional climate impacts
- Renewable and nonrenewable energy sources
- Temperature trends

Student Objectives:

- Explain the science behind the greenhouse effect and rising global temperatures
- Investigate current and historic carbon dioxide trends
- Understand the impacts of climate change on living communities
- Assess personal carbon emissions

- Analyze the benefits and consequences of using various fuel sources
- Understand the impacts of climate change on societies and environments in different parts of the world
- Explore environmental justice issues related to climate change
- Describe some economic solutions to climate change
- Debate climate change policy from multiple viewpoints
- Brainstorm and discuss personal and structural solutions to climate change

Student Skills Developed:

- Collaboration
- Critical thinking
- Graphing
- Inquiry
- Problem-solving
- Systems thinking
- Written and oral communication

National Science Education Standards (NSES) Addressed:

- Standard A: Science as Inquiry
- Standard B: Physical Science
- Standard C: Life Science
- Standard D: Earth and Space Science
- Standard E: Science and Technology
- Standard F: Science in Personal and Social Perspectives

National Council for the Social Studies (NCSS) Standards Addressed:

- Strand 3: People, Places, and Environments
- Strand 6: Power, Authority, and Governance
- Strand 7: Production, Distribution, and Consumption
- Strand 8: Science, Technology, and Society
- Strand 9: Global Connections
- Strand 10: Civic Ideals and Practices

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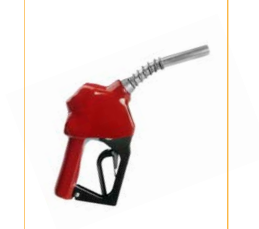
Greenhouse Gas Investigations	Carbon Dioxide Trends	Effects of Climate Change on Living Things	It All Adds Up!	Energy Exploration	
					
Student Reading **1** **What Is Climate and How Is It Changing?**		Compile information for Lesson 4: **It All Adds Up!**	Student Reading **2** **What Size Is Your Footprint?**	Student Reading **3** **Save Your Energy!**	**suggested homework**

Day 6	Day 7	Day 8	Day 9	Day 10	
Changes All Around	How Much Does Carbon Cost?	Shopping Heats Up	Energy Policies for a Cool Future	Energy Policies for a Cool Future	
					
		Student Reading **4** **Climate Justice**	Student Reading **5** **What's Happening Out There?**		**suggested homework**

1 Greenhouse Gas Investigations

Through an experiment, students explore Earth's greenhouse effect. Students graph results of 3 scenarios to draw conclusions about how greenhouse gases affect air temperature.



Inquiry/Critical Thinking Questions

- What is the greenhouse effect?
- What are some greenhouse gases, and what activities produce them?

Objectives

Students will:

- Review examples of greenhouse gases and how they are produced
- Investigate how greenhouse gases affect air temperature
- Explore effects of different greenhouse gases
- Discuss connections between human activities and greenhouse gases

Time Required

50 minutes (Allow extra time if an extensive review of the included introductory material is required.)

Key Concepts

- Greenhouse effect
- Greenhouse gases
- Scientific inquiry

Subject Areas

- Science (Earth, Environmental, Physical)
- Mathematics

National Standards Alignment

National Science Education Standards (NSES)

- Standard A: Science as Inquiry
- Standard B: Physical Science
- Standard D: Earth and Space Science
- Standard F: Science in Personal and Social Perspectives

Vocabulary

- **greenhouse effect—**process by which certain gases in Earth's atmosphere trap energy from the sun (as infrared radiation, or heat) that has been reflected off Earth's surface; this process warms the earth's surface
- **greenhouse gas—**any gas in the atmosphere capable of absorbing infrared radiation (heat) reflected from the earth's surface

Materials/Preparation

- Thermometers, 3 per group of 4-5 students
- Glass containers (e.g., jars, beakers, tumblers), 3 identical containers per student group
- (Optional) Plastic cling wrap, 2 small pieces per student group
- Paper towels, 1 per student group
- Handout: Data Table, 1 per student group
- Graph paper, 1 sheet per student group
- Warm water to wet paper towels
- Sunny location or heat lamp

Activity

Introduction

1. Ask students if they have ever seen or been inside a greenhouse. If no one has, ask if they have been inside a car that has been parked in the sun all day. Why do they think the air inside a greenhouse or a car is so much warmer than the outside air? (Heat energy from the sun passes through the glass and is retained within the greenhouse. Because the energy stays inside the greenhouse, the inside air is much warmer than the air outside.)
2. Tell them that they will do an experiment that simulates the "greenhouse effect." Greenhouse gases act somewhat like windows in a greenhouse, trapping the sun's energy near Earth's surface.

   Note: The process by which air warms in a greenhouse is not identical to the greenhouse effect. While greenhouse gases absorb and reemit heat radiating from Earth's surface, the glass in a greenhouse traps the heated air.

3. Ask them to share what they know about the greenhouse effect. What is it? Is it a bad thing? Could we live without it? (No, Earth would be too cold for many organisms to survive without the greenhouse effect.)

   Note: This sharing activity could take the form of a KWL chart (What I Know. What I Want to Know. What I Learned.).

4. Ask students if they can name any greenhouse gases. What are some sources of these gases?

   Note: You may want to write gases and sources on the board as students name them. Or, write the following greenhouse gases and their sources on the board as an introduction to some of the major greenhouse gases:

   a. Water vapor—evaporation (from Earth's natural water cycle)
   b. Carbon dioxide (CO_2)—burning fossil fuels and plant matter, deforestation, volcanic eruptions
   c. Methane (CH_4)—decomposition/decay, livestock waste, decomposing waste in landfills
   d. Nitrous oxide (N_2O)—fertilizer production, burning fossil fuels and wood, agricultural soil processes (nitrification and denitrification)
   e. Synthetic gases (e.g., fluorinated gases, CFCs)— industrial processes, manufacturing

Steps

1. Divide the class into groups of 4-5. Each group should have 3 thermometers, 3 identical glass containers, 2 small pieces of plastic cling wrap (optional), 1 paper towel, and 1 piece of graph paper.
2. Make sure all thermometers read the same temperature. Within each group, 3 people are responsible for taking temperature readings on the 3 thermometers every minute. A fourth student is responsible for writing down the data.
3. Directions for each group: Either in a sunny spot (a window sill receiving direct sunlight, an open sidewalk, etc.) or under a heat lamp, place 1 thermometer in an uncovered glass container. Place 1 thermometer in a second glass container and cover the top of the container with plastic wrap (if you are using a jar or drinking glass, you can dispense with the plastic wrap by simply turning the glass upside down). Place 1 thermometer in a third glass container with a damp paper towel that has been held under warm water. Cover the top of the container with plastic wrap (or turn it upside down, if you did this for the other container).

   Note: This last scenario with the damp paper towel has been shown to have the most variability in the classroom. To demonstrate the ability of water vapor to retain heat most effectively, warmer temperatures are required.

4. Ask students to predict which environment will be the warmest after 20 minutes.
5. Instruct students to take initial readings from all 3 thermometers and record this information in the data table.
6. Students continue collecting and recording temperatures every minute for 20 minutes, recording temperatures in the data table. (The covered/damp container should become the warmest, and the uncovered container should remain the coolest.)
7. Next, tell students to move the thermometers away from the heat source, keeping the covered thermometers covered. Ask students to observe which environment retains the most heat and which temperature drops the fastest. (The covered containers should retain more heat. The uncovered container should lose heat fastest.)
8. Instruct students to graph all 3 scenarios (uncovered, covered/dry, and covered/damp) on a single graph. Students can use 3 different colored pens to graph, or use symbols on each line to differentiate between the 3 treatments. Alternately, students can use a computer graphing program.
9. After groups have completed graphing the experimental data, begin a class discussion using the following reflection questions.

Reflection

1. What factors were "controlled" (identical for all 3 treatments) in this experiment? Why would we be unable to trust the results of the experiment if these variables were not controlled?
2. If the thermometers in the covered glass containers did NOT indicate higher temperatures than the uncovered thermometer, what factors could have produced your results? Explain any possible sources of error or things you would do differently if you tried the experiment again.
3. Gases in Earth's atmosphere, such as carbon dioxide, act much like the glass did in this experiment. Why did temperatures increase in the covered/dry container more than in the uncovered container? How do you think increasing amounts of carbon dioxide will affect temperatures on Earth?
4. Water vapor is a natural greenhouse gas. How does water vapor affect air temperature? How do you think temperature would be affected by adding other greenhouse gases?

5. Many greenhouse gases, including some that occur naturally, are produced as a result of human activities. Predict what will happen to temperatures on Earth if we continue to add more greenhouse gases to Earth's atmosphere.
6. How can we lessen our impacts on Earth's climate?

Writing Extension

Have students write a brief research paper to explain how different activities are linked to various greenhouse gas emissions. Tell them to be specific when explaining how activities generate greenhouse gas emissions. For example, why does burning a forest result in carbon dioxide emissions? How does raising livestock contribute to methane emissions?

Action Project

In small groups, have students create an experiment or activity to help young children understand the greenhouse effect. Have students test and improve upon their ideas. Partner with younger student buddies or a local elementary school so that the students can see these activities in action.

Additional Resources

Websites

- **http://www.climateclassroom.org—** The National Wildlife Federation (NWF) has put together an online Climate Classroom. Here, you can download their excellent slideshow, "What's Up with Global Warming?"
- **http://lwf.ncdc.noaa.gov/oa/climate/gases.html**—The National Climatic Data Center, a division of the National Atmospheric and Oceanic Administration (NOAA), provides basic information about specific greenhouse gases, sources, and trends.
- **http://www.epa.gov/climatechange/emissions/index.html**—The U.S. Environmental Protection Agency (EPA) climate change website gives an overview of greenhouse gases, greenhouse gas inventories, and emission trends and projections.
- **http://gaw.kishou.go.jp/wdcgg/gas.html**—The World Data Centre for Greenhouse Gases, a website maintained by the Japan Meteorological Agency, provides basic information on numerous greenhouse gases.
- **http://www.greenhouse.gov.au/education/factsheets/what.html**—The Australian Greenhouse Office is a government initiative that provides information for students on the greenhouse effect and different greenhouse gases. Short student "fact sheets" are included.

Data Table

GROUP MEMBERS ______________________________

Hypothesis

Predict which one of the three environments will be the warmest after 20 minutes, and explain why you expect this.

____

____

____

Procedures

1. Make sure that all 3 thermometers read the same temperature.
2. Near a heat source, place one thermometer in an uncovered glass container.
3. Next to the uncovered glass container, place one thermometer in a second glass container. Cover the top of the container with plastic wrap.
4. Next to the second glass container, place one thermometer in a third glass container with a damp paper towel that has been held under warm water. Cover the top of the container with plastic wrap.
5. Make sure that all thermometers are equidistant from the heat source so that they receive the same amount of heat energy.
6. Record the temperature of all three thermometers every 60 seconds for 20 minutes. Record data below.
7. After 20 minutes, move the three containers away from the heat source and observe what happens to the temperature in each container.

Data Table

Time (minutes)	Temperature (ºCelsius)		
	Uncovered	Covered/Dry	Covered/Damp
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Results

Which environment warmed the most?

After you removed the containers from the heat source, which one retained the most heat?

2

Carbon Dioxide Trends

Students graph data to examine seasonal and long-term atmospheric carbon dioxide trends over the past 45 years. They will predict future carbon dioxide emissions based on the graph. Students also examine graphs of historical temperature and carbon dioxide data. The activity closes with a discussion of ways to reduce carbon dioxide emissions.

Inquiry/Critical Thinking Questions

- What are some activities that emit carbon dioxide into Earth's atmosphere?
- What have been the major trends in atmospheric carbon dioxide levels?
- How is carbon dioxide related to temperatures on Earth?
- How can we reduce future carbon dioxide emissions?

Objectives

Students will:

- Identify processes that contribute to carbon dioxide emissions
- Graph carbon dioxide emissions
- Predict future carbon dioxide trends
- Assess the relationship between atmospheric carbon dioxide and global surface temperatures
- Brainstorm ways to reduce carbon dioxide emissions

Time Required

50 minutes

Key Concepts

- Carbon dioxide emissions
- Greenhouse effect

Subject Areas

- Science (Life, Environmental, Physical, Earth)
- Mathematics

National Standards Alignment

National Science Education Standards (NSES)

- Standard A: Science as Inquiry
- Standard C: Life Science
- Standard D: Earth and Space Science
- Standard F: Science in Personal and Social Perspectives

Materials/Preparation

- Graph paper, 1 sheet per student pair (alternately, use a graphing program such as Microsoft Excel)
- Handout: CO_2 Dataset, 1 per student pair
- Overhead: long-term carbon dioxide and temperature trends

Activity

Introduction

1. Ask students to recall which gases are involved in the greenhouse effect. (water vapor, carbon dioxide, methane, and nitrous oxide, along with man-made gases) Tell students that today they'll be exploring historical trends in carbon dioxide emissions. Explain that carbon dioxide (CO_2) is an important greenhouse gas that has been linked to many human activities.
2. Ask students if they can name some activities, human or otherwise, that might add CO_2 to our atmosphere. (burning fossil fuels, cutting trees, burning wood, and cellular respiration all release CO_2)

Steps

1. Divide the class into pairs.
2. Give each pair 1 sheet of graph paper and 1 CO_2 dataset.

   Note: This dataset from Mauna Loa is the most complete and accurate CO_2 dataset in the world. CO_2 is measured in parts per million; 316 parts per million means that for every 1 million particles in the atmosphere, 316 of those are carbon dioxide molecules.

3. Have students graph the data. (Year should be on the x-axis and CO_2 emissions on the y-axis. The scale should be appropriate for the data.) Students can use a computer graphing program as an alternative to graphing by hand.

   Lesson Variation: To shorten this activity, have students only graph the numbers for May.

4. Ask students to predict an average carbon dioxide concentration for the year 2020 and put a star on their graph to represent that number on their graph.
5. Reconvene the class to view and discuss the graphs from the Woods Hole Research Center on historical temperature and CO_2 trends. Ask students to explain what they see in these graphs. Where is the Mauna Loa data shown in these graphs? When does the most recent warming trend begin?
6. Bring the class together for a discussion using the following reflection questions.

Reflection

1. What might account for differences in the CO_2 concentrations measured in May and October of each year? (Lower values represent increased CO_2 uptake during the summer when plants are photosynthesizing more; high values represent decreased photosynthesis during the winter.)
2. How could we take advantage of those natural periods of increased CO_2

uptake to reduce overall CO_2 in our atmosphere?

3. Based on the data shown on your graph, what do you think the carbon dioxide concentration will be in the year 2020?
4. Why do you think carbon dioxide levels have continued to rise during the past 45 years?
5. What types of activities might raise carbon dioxide levels even faster?
6. How do you think this will affect Earth's climate? Predict how your life will be different if this climate change occurs.
7. What types of actions can we take to lower our carbon dioxide emissions?

History Extension

For the years 1880-2000, assign students to a particular 10-20 year period (e.g., 1900-1910). Have students, either individually or in small groups, research trends in industry, technology, and politics during their assigned time period to examine what specific activities might have contributed to climate change.

Additional Resources

Video

- *Climate Connections*, a partnership between National Public Radio (NPR) and National Geographic, features Robert Krulwich's 5-part cartoon series, Global Warming: It's All About Carbon. These 5 short films explain in simple yet humorous ways the role of carbon in climate change. **http://www.npr.org/news/specials/climate/video/**
- *"The One Degree Factor," Episode 2 of the Strange Days on Planet Earth series*, National Geographic, 2005, http://www.pbs.org/strangedays. This 60-minute episode narrated by Edward Norton explores the impact that climate change has on our lives and what we can do to slow rising temperatures.

Websites

- **http://www.climatehotmap.org**—Global Warming: Early Warning Signs is a world map showing regional effects of climate change. Information was compiled by the Union of Concerned Scientists. Impacts shown are based on the latest scientific findings.
- **http://www.whrc.org/resources/online_publications/warming_earth/index.htm**—The Warming of the Earth: A Beginner's Guide to Understanding the Issue of Global Warming is an online publication by the Woods Hole Research Center that explains the greenhouse effect, scientific evidence, causes, and potential outcomes.

CO_2 Dataset

YEAR	May CO_2 (parts per million)	October CO_2 (parts per million)
1958	317.5	---
1959	318.3	313.3
1960	320.0	313.8
1961	320.6	315.3
1962	321.0	315.4
1963	322.2	316.0
1964	322.2	316.9
1965	322.2	317.3
1966	324.1	318.1
1967	325.0	319.4
1968	325.6	320.3
1969	327.4	321.8
1970	328.1	323.1
1971	328.9	323.6
1972	330.1	325.2
1973	332.5	327.2
1974	333.1	327.4
1975	334.0	328.3
1976	334.9	328.9
1977	336.7	331.2
1978	338.0	332.5
1979	339.5	333.9
1980	341.5	336.0
1981	342.9	336.9
1982	344.1	337.9
1983	345.8	340.0
1984	347.4	341.4
1985	348.9	342.8
1986	350.2	344.2
1987	351.8	346.4
1988	354.2	348.9
1989	355.7	350.0
1990	357.2	351.2
1991	359.3	352.2
1992	359.7	353.3
1993	360.3	354.0
1994	361.7	356.0
1995	363.8	357.8
1996	365.4	359.6
1997	366.8	360.8
1998	369.3	364.2
1999	371.0	365.1
2000	371.8	366.7
2001	374.0	368.1
2002	375.6	370.2
2003	378.4	373.0
2004	380.6	374.2

From: Keeling, C. D. and T. P. Whorf. 2005. Atmospheric CO_2 records from sites in the S10 air sampling network. In Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy. http://cdiac.ornl.gov/trends/co2/sio-mlo.htm

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1965	322.2	317.3
1966	324.1	318.1
1967	325.0	319.4
1968	325.6	320.3
1969	327.4	321.8
1970	328.1	323.1
1971	328.9	323.6
1972	330.1	325.2
1973	332.5	327.2
1974	333.1	327.4
1975	334.0	328.3
1976	334.9	328.9
1977	336.7	331.2
1978	338.0	332.5
1979	339.5	333.9
1980	341.5	336.0
1981	342.9	336.9
1982	344.1	337.9
1983	345.8	340.0
1984	347.4	341.4
1985	348.9	342.8
1986	350.2	344.2
1987	351.8	346.4
1988	354.2	348.9
1989	355.7	350.0
1990	357.2	351.2
1991	359.3	352.2
1992	359.7	353.3
1993	360.3	354.0
1994	361.7	356.0
1995	363.8	357.8
1996	365.4	359.6
1997	366.8	360.8
1998	369.3	364.2
1999	371.0	365.1
2000	371.8	366.7
2001	374.0	368.1
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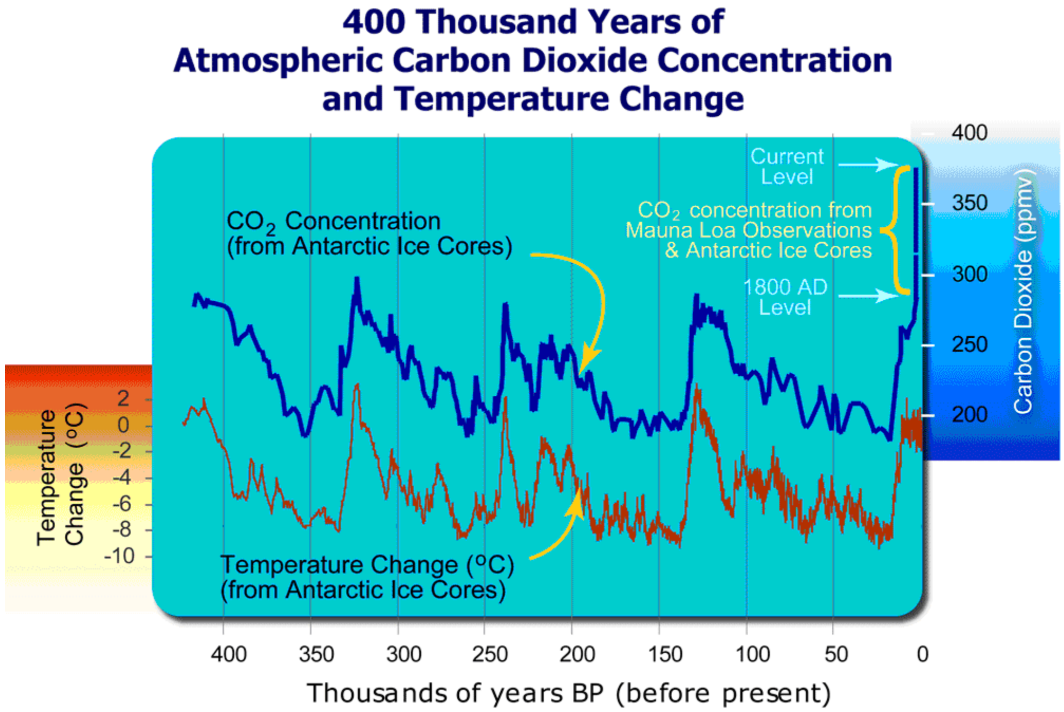
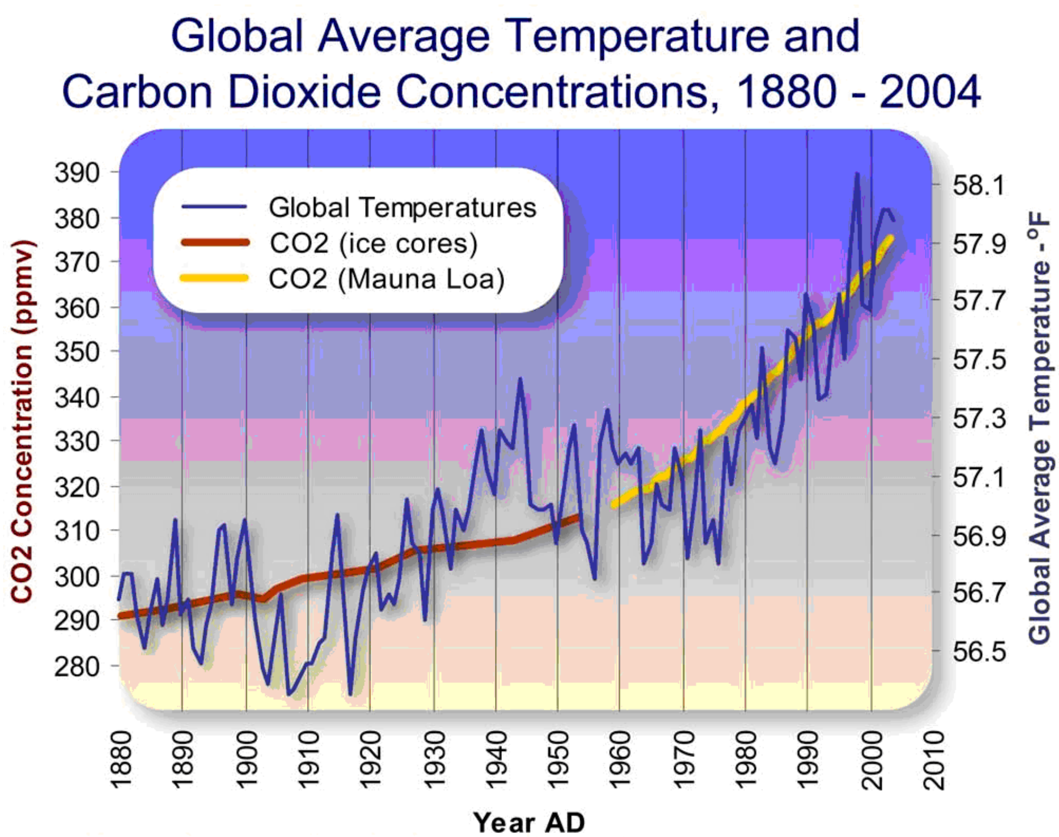


Data Source CO2: ftp://cdiac.ornl.gov/pub/trends/co2/vostok.icecore.co2
Data Source Temp: http://cdiac.esd.ornl.gov/ftp/trends/temp/vostok/vostok.1999.temp.dat

Graphic: Michael Ernst, The Woods Hole Research Center

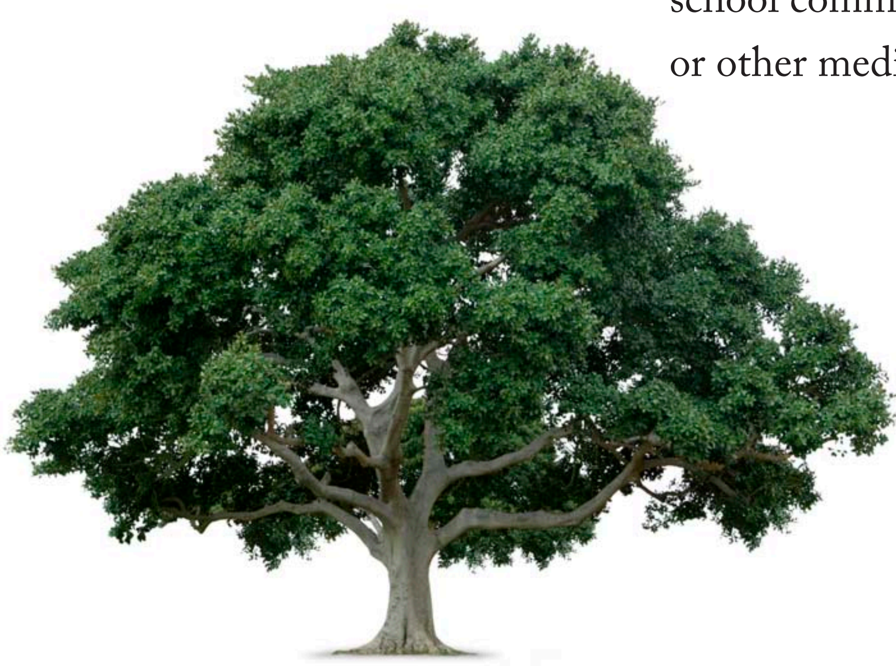


Data Source Temperature: ftp://ftp.ncdc.noaa.gov/pub/data/anomalies/annual_land.and.ocean.ts
Data Source CO2 (Siple Ice Cores): http://cdiac.esd.ornl.gov/ftp/trends/co2/siple2.013
Data Source CO2 (Mauna Loa): http://cdiac.esd.ornl.gov/ftp/trends/co2/maunaloa.co2

Graphic Design: Michael Ernst, The Woods Hole Research Center

3 Effects of Climate Change on Living Things

In small groups, students learn about potential impacts of climate change on living things in a variety of ecosystems. Students communicate these impacts to their school community through informative posters or other media.



Adapted from "Communities of Living Things" by Elizabeth K. Andre, Will Steger Foundation

Inquiry/Critical Thinking Questions

- What are potential positive and negative impacts of climate change on organisms in various ecosystems?
- How might some populations adapt to climate change?

Objectives

Students will:

- Explain how a changing climate can increase uncertainty for living things
- Identify ways in which particular organisms will be affected by climate change
- Communicate the effects of climate change on living things to the class

Time Required

50 minutes (Extra time may be required, depending on time allowed for research and presentation preparation.)

Key Concepts

- Variability
- Adaptation
- Ecosystems

Subject Areas

- Science (Life, Environmental, Physical)
- Social Studies (Geography, World Cultures, World History)

National Standards Alignment

National Science Education Standards (NSES)

- Standard C: Life Science
- Standard F: Science in Personal and Social Perspectives

National Council for the Social Studies (NCSS)

- Strand 3: People, Places, and Environments
- Strand 7: Production, Distribution, and Consumption
- Strand 9: Global Connections

Vocabulary

- **community**—all of the various species that live in the same geographic region
- **ecosystem**—a community of organisms, together with their environment, functioning as a unit
- **population**—a group of organisms of the same species living in the same geographic region

Materials/Preparation

- Role Cards, 1 per group
- Materials for creating posters (paper and marking pens) or other presentation

Wind and precipitation patterns have changed in many regions during the past century, resulting in increased rainfall in some places and droughts in others.

Student Reading 01, page 99

Activity

Introduction

1. Ask students to define an ecosystem. An ecosystem includes all of the populations of different species that live together in the same area (a community), as well as the nonliving components of their environment.
2. Ask for examples of ecosystems that students have seen or heard about (e.g., coral reefs, hardwood forests, Arctic tundra). What are the characteristics of the ecosystem they live in? Tell them that they will be exploring how climate change can affect living things in ecosystems around the world. They will create and present informative posters to educate others about ways in which particular organisms are sensitive to climate change.

Steps

1. Divide students into 6 groups. Give each group a Role Card.

   Lesson Variation: Students may conduct their own research into climate change impacts rather than using the Role Cards. Websites for research are provided at the bottom of each card.

2. Ask groups to state whether the Role Card they received represents a population or a community.
3. Have students take turns reading aloud sections of their passage from the Role Card to the rest of their group.
4. Have each group discuss the impacts described in their passages, and then create a poster illustrating and

summarizing the information from their Role Card.

Lesson Variation: Alternately, student groups can communicate the information through pamphlets, Power Point presentations, videos, podcasts, or skits.

5. Reconvene the entire class. Allow groups to present their posters one at a time, explaining the impacts shown. Display completed posters around the classroom or in school hallways.

Reflection

1. Explain how climate change may cause "uncertainty" for populations, communities, and ecosystems.
2. What areas of Earth do you think are most vulnerable to climate change? Why are these areas more sensitive to climate change than other regions?
3. In what ways might some people benefit from climate change?
4. Which effects of climate change that you learned about today will have the greatest impact on Earth's ecosystems? Give reasoning to support your answer.
5. What are some other living organisms that may be affected by changes in the ecosystem that your group studied? In what ways might they be affected?
6. How might the ecosystem that you live in change if average global temperatures and sea levels continue to rise? How do you think the human community will adapt?

Action Project

Have students write their own ecosystem impact cards. They can research particular populations or communities in the ecosystem where they live, or ecosystems elsewhere in the world. Students can publish their information about impacts of climate change on various ecosystems as a school newspaper article, a podcast, or an online news article.

Additional Resources

Film

Silent Sentinels, directed by Richard Smith, produced by the Australian Broadcasting Corporation, 1999, 57 minutes, **http://www.bullfrogfilms.com/catalog/sil.html**. This documentary film takes a broad look at coral reefs and how the coral organism has coped with climate change over time.

Websites

- **http://www.ipcc-wg2.org/**—The Working Group II Report from the Intergovernmental Panel on Climate Change (IPCC) provides an in-depth assessment of specific impacts of climate change on populations around the world.
- **http://amap.no/acia/**—The scientific report, Impacts of a Warming Arctic, can be downloaded from the Arctic Climate Impact Assessment website. This report details impacts of a warming climate on Arctic ecosystems.

Ecosystem Role Cards

Humans in Northern Europe

Impact: Increased agricultural yields

A longer growing season due to increased temperatures will increase growth of plants. Northern European crops such as wheat and sugar beets will benefit from a longer growing season. Farmers will also be able to grow crops such as sunflowers and soybeans formerly grown only in warmer regions. Because plants need carbon dioxide for photosynthesis, increased carbon dioxide in the atmosphere will help plants to thrive.

Impact: Tourism boom

Warmer temperatures will make northern Europe a more inviting tourist destination. Tourists may prefer to visit cooler mountainous regions, rather than travel to hotter tropical destinations.

Impact: Shifting navigation

Melting sea ice will open up navigation channels in Arctic regions. Materials, including food and fuel supplies, will be able to be shipped from northern Europe through the Northern Sea Route, requiring less time and fuel for transport.

Other means of travel may be negative impacted by climate change. Extreme weather events, including rain and wind, may damage land-based transportation systems. Flooding can destroy roads and railways. Extreme winds make any mode of transportation more dangerous; windy conditions are hazardous to boats, airplanes, and automobiles.

Impact: Improvements and threats to human health

Warmer temperatures will result in fewer deaths related to cold temperatures. However, heat-related deaths will increase as temperatures rise. Susceptibility to tick-borne diseases like Lyme disease and mosquito-borne diseases like malaria will increase. Children and elderly persons are most susceptible to these diseases. Increased water pollution from bacterial growth, and air pollution due to smog, also pose threats to human health.

Reference:

Alcamo, J., J. M. Moreno, B. Nováky, M. Bindi, et al. 2007. Europe. In Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, ed. M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson, 541-580. Cambridge, UK: Cambridge University Press. http://www.ipcc-wg2.org/.

Ecosystem Role Cards

Polar Bears (*Ursus maritimus*)

Impact: Difficulty getting food

Polar bears hunt seals that live in water underneath floating sea ice. The bears walk on the ice, waiting for a 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 become unstable or break up earlier in the spring, 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.

Underweight females have fewer and smaller cubs that are less likely to survive. When the polar bear mother and cubs leave 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.

Impact: Loss of shelter

Climate change can affect weather patterns around the world. Increasing numbers and strength of spring rainstorms can cause bear dens to collapse.

Impact: Competition from newly arrived species

As the climate warms, grizzly bears travel farther 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

Many of the air pollutants from the northern hemisphere reach the Arctic through the circulation of air in 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 increased precipitation and water flow carries more chemical contaminants. Plants and animals that are low on the food chain absorb these pollutants from the water. Larger animals like seals and polar bears absorb the pollutants from their food in even greater amounts. The concentration of pollutants increases as the pollutants are transferred from prey to predators (bioaccumulation). This pollution negatively affects the health of polar bears and their food.

Reference: Hassol, S. J., R. Correll, P. Prestrud, G. Weller, P. A. Anderson, S. Baldursson, et al. 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge, UK: Cambridge University Press. http://www.amap.no/acia/.

For more information: Roach, John. 2006. Polar Bears Proposed for U.S. Endangered Species List. National Geographic News, December 27. http://news.nationalgeographic.com/news/2006/12/061227-polar-bears.html.

Ecosystem Role Cards

Australian Sea Turtles

Impact: Nest incubation threatened

Marine turtles in Australia require nest temperatures of 25-32^{o}C (77-90^{o}F) for egg incubation. Turtles from eggs in nests cooler or warmer than this range will not hatch. Increased temperatures may result in decreased numbers of hatchlings and migration to new habitats with nesting sites of an appropriate temperature.

Impact: Shifting sex ratios

Like many reptile species, the sex of these sea turtles is determined by nest temperature. Warmer nests will produce more female hatchlings, while cooler temperatures result in more males.

Impact: Nest sites at low elevations susceptible to flooding

Sea level rise will have a large impact on low-lying areas, including beaches where turtles lay their eggs. Nesting sites may be destroyed by rising waters and erosion. Turtles may seek new beaches with higher elevation nesting grounds.

Impact: Reduced food availability

Increased temperatures result in damage and sometimes death to coral reefs, an important resource for sea turtles. Sea turtles depend on coral reefs for habitat and eat plants and animals found in reef ecosystems. Warmer waters can result in coral bleaching—a whitening of coral caused by loss of algae. Coral bleaching can destroy reef ecosystems.

Higher temperatures also negatively affect sea grasses that turtles feed on. Severe storms such as cyclones and hurricanes, brought about by global climate change, also damage coral reefs and sea grasses.

Reference:
Limpus, C. J. 2006. Impacts of Climate Change on Marine Turtles: A Case Study. In Migratory Species and Climate Change: Impacts of a Changing Environment on Wild Animals, United Nations Environment Programme (UNEP)/Convention on Migratory Species (CMS), 34-9. Bonn, Germany: United Nations Environment Programme (UNEP) and the Secretariat of the Convention on the Conservation of Migratory Species of Wild Animals (CMS). http://www.cms.int/publications/pdf/CMS_CimateChange.pdf.

Ecosystem Role Cards

Humans in the Arctic

Impact: Diminishing food supplies and cultural resources

The Inuit people (Native people of the Arctic, formerly known as Eskimos) hunt caribou (deer relatives), which provide them with an affordable food source and help them survive the cold seasons. Caribou numbers have decreased, perhaps due to an inability to travel over melting snow and ice to reach food.

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

Impact: Difficulty traveling

Many Inuit villages are accessible only by dogsled, snowmobile, or sometimes on roads over permafrost (permanently frozen ground). As snow- and ice-free periods get longer, travel by dogsled or snowmobile becomes difficult or even impossible. The permafrost is melting earlier in the spring, turning the roads into mud pits.

Impact: Erosion of coastal lands

Warmer ocean water and air can melt the permafrost that stabilizes coastal land and shorelines. This melting, combined with rising sea levels and shrinking shore and sea ice that once buffered the shore from stormy wave action, 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 was previously locked in ice, and therefore impassible to most ships, can now be navigated. For example, a cruise ship recently arrived and unloaded its passengers in Pangnirtung, a remote Inuit village on the southern tip of Baffin Island in the Canadian Arctic that before was accessible only by air or dogsled.

Reference:
Hassol, S. J., R. Correll, P. Prestrud, G. Weller, P. A. Anderson, S. Baldursson, et al. 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge, UK: Cambridge University Press. http://www.amap.no/acia/.
For more information:
David Willis. 2004. Sea Engulfing Alaskan Village. BBC News, July 30, http://news.bbc.co.uk/2/hi/europe/3940399.stm.

Ecosystem Role Cards

Arctic Plants

Impact: Thawing permafrost and soil instability

The ice in the permafrost (permanently frozen ground) helps maintain the structure of the soil. Permafrost supports the weight of buildings and roads. When it melts, trees can begin to fall over and sinkholes can develop, which then can fill with water and drown the trees standing there.

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 storms where most of it runs off to the rivers quickly. Also, as temperatures get warmer, more water will evaporate and plants will lose more water during transpiration. These processes send water back into the atmosphere. It is therefore possible that certain areas could dry out and become polar deserts.

Impact: Thriving pests

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. However, warmer winters mean that more bark beetles will survive each year, and these beetles can kill spruce trees.

Healthy spruce trees have natural defenses against bark beetle attacks. When a beetle tries to bore into the tree to lay her eggs, the tree can push sap out against the beetle to keep her from moving far enough into the tree to lay eggs. When trees are stressed from dry conditions and warmer than normal temperatures, however, they do not have enough sap to fight the beetles.

Impact: Competition from foreign species

As temperatures warm, plant species begin to migrate and survive farther north, invading areas previously inhabited by Arctic species only. 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°F (16°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 grow at all.

Reference: Hassol, S. J., R. Correll, P. Prestrud, G. Weller, P. A. Anderson, S. Baldursson, et al. 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge, UK: Cambridge University Press. http://www.amap.no/acia/.

For more information: “Most of Arctic's Near-Surface Permafrost to Thaw by 2100.” Science Daily, December 20, 2005. http://www.sciencedaily.com/releases/2005/12/051220085054.htm

Ecosystem Role Cards

Humans on Small Pacific Islands

Solomon Islands, Papua New Guinea, American Samoa

Impact: Coastal erosion

Many of these small islands are less than 4 meters (about 13 feet) above sea level. Sea levels (from glacial melting and thermal expansion) have risen continually in the past century. Higher sea levels encroach on coastal habitat, which affects not only human settlements but natural coastal ecosystems as well. Increased sea levels and saltwater intrusion cause declines in mangrove tree populations. Mangrove roots protect coastlines from erosion, but as sea levels rise over time, mangroves migrate toward the land. If they eventually reach a sea wall or other barrier, they may be reduced to a narrow strip of trees or may disappear altogether.

Impact: Reduced tourism

Algae living on coral reefs are sensitive to warmer water temperatures. If the water is too warm, they die, causing coral to appear white (this is called "coral bleaching"). Tourism from diving will be reduced if coral reefs are damaged.

Impact: Reduced freshwater quality

Low-lying islands depend on rainfall and natural filters such as mangroves to maintain a clean supply of freshwater. Rising sea levels cause salt water to move farther inland, often contaminating drinking water sources. Mangroves act as natural filters, preventing sediment and toxins from reaching island water sources. Reduction of mangrove habitat from rising sea levels would allow more sediments and pollutants to move inland, polluting fresh water sources.

Impact: Lack of food resources

Loss of mangrove and coral reef habitats signals dwindling food resources for islanders. Mangroves provide habitat for many types of seafood, including crabs, clams, and fish. Coral reefs likewise provide habitat for many fish.

References:

Gilman, E., H. Van Lavieren, J. Ellison, V. Jungblut, et al. 2006. Pacific Island Mangroves in a Changing Climate and Rising Sea: UNEP Regional Seas Reports and Studies No. 179. Nairobi, Kenya: United Nations Environment Programme (UNEP). http://www.unep.org/PDF/mangrove-report.pdf.

Mimura, N., L. Nurse, R. F. McLean, J. Agard, et al. 2007. Small Islands. In Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, ed. M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson, 687-716. Cambridge, UK: Cambridge University Press. http://www.ipcc-wg2.org/.

4

It All Adds Up!

Students gather information about their personal energy use to calculate their carbon footprint, using an online carbon calculator. Their results are compared to the carbon footprint of an average person in the United States. Students discover ways to decrease their carbon emissions.

Inquiry/Critical Thinking Questions

- How do our lifestyles affect climate change?
- What is a carbon footprint, and how is it measured?
- What changes in our daily lives would result in lower carbon emissions?

Objectives

Students will:

- Use an online carbon calculator to determine impacts of daily choices on carbon emissions
- Explore ways to reduce their carbon footprint

Time Required

50 minutes

Key Concepts

- Carbon footprint
- Personal solutions

Subject Areas

- Science (Environmental, Life, Earth, Physical)
- Social Studies (U.S. History, Geography)
- Mathematics
- Technology

National Standards Alignment

National Science Education Standards (NSES)

- Standard A: Science as Inquiry
- Standard C: Life Science
- Standard D: Earth and Space Science
- Standard F: Science in Personal and Social Perspectives

National Council for the Social Studies (NCSS)

- Strand 3: People, Places, and Environments
- Strand 7: Production, Distribution, and Consumption

Materials/Preparation

- Access to computers, 1 per student
- Students should come to class prepared to answer the questions for the online carbon calculator (read questions at **http://www.epa.gov/climatechange/wycd/calculator/ind_calculator.html**), or have students bring a copy of their home electricity, gas, and heating oil bills, plus the number of miles they or a parent drives in a week
- Handout: Carbon Footprint Results, 1 per student

Activity

Introduction

1. Ask students to brainstorm all of the things they use in a day that require power (or energy). Ask how the use of energy is related to climate change.
2. Ask students to recall what carbon is and how it can affect Earth's climate. Ask them if they think they produce much carbon dioxide during their daily activities. Tell them that they're about to find out how their carbon emissions (also called a "carbon footprint") compare to those of an average person living in the United States.

Steps

1. Give each student a Carbon Footprint Results handout.
2. Have students go to the U.S. Environmental Protection Agency's personal emissions calculator at **http://www.epa.gov/climatechange/wycd/calculator/ind_calculator.html** and enter their responses.

   Note: An Excel spreadsheet version is available that explains calculations and assumptions (see link at the bottom of the EPA page). Students may calculate their carbon footprint and read more about the calculations on this page.

3. After students have entered their information (under "Your Current Household Emissions") to calculate

their total carbon emissions, have them record their total emissions on the handout, Carbon Footprint Results.

4. Now have students experiment with making positive changes (under "What You Can Do to Reduce Emissions" on the EPA carbon calculator site) to see how much less carbon dioxide (CO_2) they can emit, completing the Carbon Footprint Results handout as they go.
5. After students have completed the handout, begin a discussion using the following reflection questions.

Reflection

1. How does waste disposal affect climate change? What items are recyclable in your community? What are some other ways you could reduce waste (other than recycling)?
2. Name some energy uses that were NOT included in the carbon calculator (for example, the energy required to manufacture, process, and transport material goods and food items).
3. What are additional benefits, other than reduced CO_2 emissions, of reducing energy use?
4. How might reducing CO_2 emissions improve your quality of life?
5. Carbon footprints can be calculated not only for individuals, but for countries and regions as well. What factors are likely to increase a country's carbon footprint?

"Two major components of your footprint are electricity and transportation.

Student Reading 02, page 101

Science Extension

Have students calculate the volume of 1 pound of carbon dioxide. To put it in terms they can easily identify with, ask students to report how many 2-liter soda bottles would be required to contain 1 pound of carbon dioxide.

Writing Extension

Have students write an essay or journal entry describing a day in the life of 3 people with 3 distinct carbon footprints (small, medium, and large). How do these 3 people spend their time? Where do they live? What kinds of things do they use? How do they travel?

Action Project

Perform an in-depth energy audit of your school's campus using the Climate Change Emission Calculator Kit (**http://www.epa.gov/climatechange/wycd/school.html**). Detailed information about your school's energy use, waste, and land management is used to calculate greenhouse gas emissions.

Additional Resources

Book

You Can Prevent Global Warming (and Save Money!): 51 Easy Ways, Jeffrey Langholz and Kelly Turner, Andrews McMeel Publishing, 2003. Practical tips are provided for reducing energy use and CO_2 emissions. Savings are calculated in dollars and in pounds of CO_2 not emitted.

Websites

- **http://hes.lbl.gov**—The Home Energy Saver website offers specific tips for making your home more energy-efficient.
- **http://www.americanforests.org/resources/ccc/**—The nonprofit conservation organization, American Forests, provides a climate change calculator that translates energy use and other activities to CO_2 emissions, and the number of trees it takes to offset those emissions.
- **http://www.nature.org/initiatives/climatechange/calculator**—The Nature Conservancy has a carbon calculator that starts with an average carbon footprint and subtracts CO_2 emissions for actions that reduce emissions.

Carbon Footprint Results*

NAME ______________________________

1. What is your carbon footprint (total CO_2 emissions per year)? ________ pounds CO_2
2. How do your household emissions compare to the average emissions for a two-person household in the United States? ____________

3. How many pounds of CO_2 per year can you avoid by increasing your family car's mileage by one more mile per gallon? ____________
4. What are two things you can do to increase a car's gas mileage? (See EPA's website for tips on how you can reduce greenhouse gas emissions on the road: http://www.epa.gov/climatechange/wycd/road.html.)

5. How many pounds of CO_2 per year would you avoid by driving seven miles less per week? (That's just one less mile per day.) ____
6. How could you or others in your household drive less each week but still get where you want to go?

7. How many pounds of CO_2 per year can be avoided by turning down the thermostat by one degree Fahrenheit in the winter? ________

8. Do you think you would feel a one-degree change? ____________
9. What are things you could do to keep warm without turning up the heat?

10. How many pounds of CO_2 per year can be avoided by turning up the thermostat by one degree Fahrenheit in the summer? ________
11. What could you do to keep cool without cranking up the air conditioner?

12. How many pounds of CO_2 per year can be avoided by recycling magazines? ________
13. What things can be recycled in your community?

14. If you do not already recycle, identify the obstacles that prevent you from recycling.

15. What are two simple things that you can do to reduce your carbon dioxide emissions?

*From the Environmental Protection Agency's Personal Emissions Calculator: http://www.epa.gov/climatechange/wycd/calculator/ind_calculator.html

5 Energy Exploration

In small groups, students read about various sources of energy used for electricity production. Students identify the pros and cons of these energy sources and take a position, either encouraging or discouraging the class to use particular energy sources.

Inquiry/Critical Thinking Questions

- What are some social, economic, and environmental benefits and consequences of using various fuel sources?
- How do different energy sources contribute to climate change?

Objectives

Students will:

- Learn about renewable and nonrenewable energy sources
- Determine benefits and consequences of different energy sources
- Take a position on whether or not a particular energy source should be used in the future
- Communicate their findings and recommendations to the class

Time Required

50 minutes (plus another 50 minutes for research, optional)

Key Concepts

- Renewable and nonrenewable energy sources
- Electricity generation
- Impacts of energy use

Subject Areas

- Science (Earth, Physical, Environmental)
- Social Studies (Geography)
- Communications

National Standards Alignment

National Science Education Standards (NSES)

- Standard B: Physical Science
- Standard D: Earth and Space Science
- Standard F: Science in Personal and Social Perspectives

National Council for the Social Studies (NCSS)

- Strand 3: People, Places, and Environments
- Strand 7: Production, Distribution, and Consumption
- Strand 8: Science, Technology, and Society

Activity
Introduction

1. Ask students to recall some things that we do or use everyday that contribute to greenhouse gas emissions. If no one identifies energy (for transportation, home electricity, etc.), remind them that the largest source of our emissions is from energy use.
2. Tell them that they will be researching different sources of energy and reporting back to the class, with a recommendation on which sources are best to use.

Vocabulary

- **renewable energy**—a source of usable power that can be replaced as it is consumed; examples: wind, water, sunlight, firewood
- **nonrenewable energy**—a source of usable power that cannot be replaced within a human lifetime; examples: coal, natural gas, petroleum
- **fossil fuel**—a source of energy produced by the decomposition of prehistoric plants and animals

Materials/Preparation

- Handout: Energy Source worksheets, 1 per group

> Did you know that 5% or more of your home's electricity is "leaked" from appliances and other electronics that are turned off but still plugged in?
>
> Student Reading 03, page 108

Steps

1. Split the class into 7 groups. Give each group a different Energy Source worksheet.

   Lesson Variation: Cut along the dotted line on each worksheet and give student groups the bottom part of the worksheet with the questions. Have student groups complete their own research to answer the questions.

2. For each group, assign 1 person to be the group writer, who will write the group's answers to the questions on the worksheet. Assign a second student to present the group's findings and position to the class. The remaining students will take turns reading the given information aloud to the group.

3. Give groups 15 minutes to read through and complete the worksheet.
4. Allow each group 3-5 minutes to present information about their assigned energy source to the class. Ask each group to share their position on whether the energy source should be used, in light of economic, social, and environmental concerns. Tell students to take notes as each group is speaking about the pros and cons of each energy source.
5. Encourage other groups to ask questions after each group presents. Students should be allowed to respectfully challenge conclusions reached by each group. Encourage an atmosphere of friendly debate, while monitoring the debate to ensure that all student voices are heard and respected.
6. After all groups have presented, begin a discussion of overall findings and conclusions using the following reflection questions.

Reflection

1. Which energy source appears to be the best choice, when taking into account social, environmental, and economic factors? What types of resources does that energy source use? Are they renewable? Does the use of that energy source benefit some people at the expense of others?
2. Why do you think energy sources that are strongly linked to climate change are used all over the world?
3. If we know about technology and conservation techniques that can limit greenhouse gas emissions, why don't we use them in all instances?
4. Do you think that all people know which energy source is used to generate the electricity they use? What energy sources are used to provide electricity in your community?
5. Are there places where certain technologies couldn't be used? Why couldn't all technologies be used in all places?
6. How could conservation (using less energy) play a part in deciding which energy sources to use?

Mathematics Extension

To investigate the availability of nonrenewable resources, students can research the total known quantities of natural gas, petroleum, and coal in the world. Where are these fossil fuels found? How much of each is used in a year? (This information is provided by the World Resources Institute. Visit **http://earthtrends.wri.org**, click on Energy and Resources, then Searchable Database.) Have students calculate the number of years that we can continue to use each fossil fuel at current rates of use.

Science Extension

Have students research alternative transportation fuels, such as biodiesel, hydrogen fuel cells, and hybrid cars. Ask them to make a recommendation on which fuel type is best, in light of environmental, social, and economic factors.

Action Project

Have students research which fuel sources are used to generate electricity for their community. Why are these fuels used (cost, convenience, natural resource availability)? Are alternative fuels available? Have each student write a letter to local or national politicians, encouraging them to provide funding for research and promotion of fuels that will reduce contributions to climate change. Make sure they include reasoning in their letter, explaining how their fuel choice will reduce climate change.

Additional Resources

Websites

- **http://www.princeton.edu/~cmi/resources/stabwedge.htm**—In the Stabilization Wedge Game, a resource developed by the Carbon Mitigation Initiative, students work to stabilize carbon dioxide emissions at current levels by using existing technologies, increasing energy efficiency, and conserving natural resources.
- **http://www.ases.org/climatechange/climate_change.pdf**—The American Solar Energy Society report, "Tackling Climate Change in the U.S.," explains how energy efficiency and use of various renewable energy sources can greatly reduce carbon emissions.

Energy Source: Natural Gas

GROUP MEMBERS ____

NATURAL GAS IS A COLORLESS, odorless gas. The main ingredient in natural gas is methane, a greenhouse gas that warms Earth's surface. Natural gas is considered a fossil fuel because it is composed of ancient organic material. It takes millions of years to turn organic material into fossil fuels.

Natural gas can be drilled from below Earth's surface either on land or in the ocean. Pipelines are used to bring the gas up to Earth's surface, where it is stored or transported elsewhere to create electricity.

Burning natural gas to create electricity produces carbon dioxide and nitrous oxide emissions. Natural gas burns "cleaner" than coal and oil because it produces fewer greenhouse gas emissions and other air pollution emissions. However, it provides less energy than coal.

Concerns about natural gas center around human and environmental safety. Natural gas is very flammable and can cause explosions if it leaks from pipes or storage containers. Drilling below Earth's surface for natural gas can cause erosion, landslides, and decreased land productivity after drilling.

Description of natural gas:

Benefits of using natural gas for electricity:

Negative consequences of using natural gas:

Does natural gas used for electricity contribute to climate change? Explain your answer.

Should natural gas be a major source for future electricity production? Why or why not?

Energy Source: Coal

GROUP MEMBERS

COAL IS A BLACK ROCK formed by decomposing organic material over millions of years. It is considered a fossil fuel because of the long time required to create it. Coal contains more energy than other fossil fuels.

Some coal is buried near Earth's surface, but often coal is located hundreds of feet below the surface. Underground mining is required to extract coal buried far below Earth's surface. Mine shafts and elevators allow people to remove deeply buried coal. Coal nearer to the surface can be removed through surface mining. This is cheaper than underground mining. One common type of surface mining is strip mining, which involves removing plants, soil, and rocks to reach the coal below the surface. Another method of surface mining is called mountaintop removal, whereby entire mountain tops are removed to access coal.

Safety concerns about mining include lung damage to workers and collapse of mine shafts. Environmental concerns include damage to land, water, and air. Burning coal releases many air pollutants and creates solid waste called ash. Water is removed from surrounding environments and used to remove impurities from coal, as well as for cooling water at coal-fired power plants.

Using coal for electricity production releases more carbon dioxide than other fossil fuels and fossil fuel alternatives. Transporting coal from mines to power plants also relies heavily on fossil fuels to power trains, barges, and trucks. Although transporting coal is expensive, coal is generally affordable for consumers.

Description of coal:

Benefits of using coal for electricity:

Negative consequences of using coal:

Does coal used for electricity contribute to climate change? Explain your answer.

Should coal be a major source for future electricity production? Why or why not?

Energy Source: Solar Energy

GROUP MEMBERS ____________________

SOLAR ENERGY IS THE ENERGY FROM the sun that can be converted into electrical energy. Photovoltaic (PV) cells, which are made of metals and silicon, are often used to convert solar energy into electricity. Solar-thermal technologies, such as mirrors, can also be used to concentrate the sun's energy.

Although the sun's light contains much energy, it is difficult to use all of this energy because the sun's energy is not concentrated into a single beam. Currently, PV cells are not very efficient. They lose over 70% of energy collected when they convert light into electrical power.

The silicon used to make PV cells is often found in sand. Energy is required to remove the silicon from the sand. This process releases greenhouse gases. The solar cell itself doesn't release greenhouse gases after it is made.

PV cells are initially costly for energy consumers. However, because the sun's energy is free and people who get energy from PV cells don't have to pay an electricity company for solar energy, solar power can be cost-effective long-term.

Solar energy is used to provide electricity in many different places for many different purposes. For example, space shuttles, watches, and homes and office buildings all use PV cells.

Description of solar energy:

Benefits of using solar energy for electricity:

Negative consequences of using solar energy:

Does solar energy used for electricity contribute to climate change? Explain your answer.

Should solar energy be a major source for future electricity production? Why or why not?

Energy Source: Hydropower

GROUP MEMBERS ______________________________

HYDROPOWER IS THE ENERGY GENERATED by moving water. Fast-flowing water and water that falls a great distance contain much energy. Often a dam is built to harness flowing water and create electricity as needed.

Hydropower is a renewable energy source. Water is renewed naturally through Earth's water cycle. Hydropower is considered a clean energy source because it does not result in any carbon dioxide emissions, air pollution, or water pollution.

Water is a cheap energy source. The cost of hydropower lies in building and maintaining dams and channels. Dams have big impacts on environments. Sediments (soil, sand, leaves) can build up in reservoirs—the bodies of water held by dams. That sediment reduces water quality for organisms that live in the water and can choke out the sun's light. Migrating fish may have trouble swimming around dams. Changing the path of a stream affects any organisms dependent on that stream. It may also cause erosion along riverbanks.

Building dams can also affect human communities. Often, people must be relocated from their homes if they live in an area where a dam and reservoir are to be constructed. People displaced by dams are often poor. One benefit of creating reservoirs is the opportunity for recreation, such as swimming and fishing.

Description of hydropower:

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Benefits of using hydropower for electricity:

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Negative consequences of using hydropower:

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Does hydropower used for electricity contribute to climate change? Explain your answer.

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Should hydropower be a major source for future electricity production? Why or why not?

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Energy Source: Wind Energy

GROUP MEMBERS ______________________________

WIND ENERGY IS ACTUALLY A form of solar energy. The sun heats different parts of the earth at different rates. Also, different surfaces absorb or reflect sunlight in different amounts. This causes the atmosphere to warm unevenly, creating wind. Average annual wind speeds of at least 9-13 miles per hour are required to have successful electrical production from wind.

Wind-generated electricity requires wind turbines (sometimes called windmills). These are made primarily of steel. Steel is made of iron and other metals, and mining and processing these metals produces greenhouse gases. However, once the turbine is made, using wind energy to create electricity produces no land, water, or air pollution. Wind turbines can be installed on land or offshore.

Costs of wind power have decreased steadily. Building and maintaining wind turbines are the major costs. Some farmers and ranchers have installed wind turbines on their land to make extra money.

Some people don't like wind turbines because they can harm birds and bats that might get caught in the blades. Others don't like the way they look or the noise that large wind farms can create.

Description of wind energy:

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Benefits of using wind energy for electricity:

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Negative consequences of using wind energy:

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Does wind used for electricity contribute to climate change? Explain your answer.

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Should wind energy be a major source for future electricity production? Why or why not?

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Energy Source: Nuclear Energy

GROUP MEMBERS ______________________________

NUCLEAR ENERGY IS ENERGY OBTAINED from splitting apart atoms in a process called fission. Uranium, a nonrenewable metal found in rocks, is used as a fuel for nuclear fission. Neutrons hit uranium atoms, causing the uranium atoms to split apart. Energy is released as heat when atoms break apart.

Nuclear energy doesn't result in any greenhouse gas emissions, other than those produced by mining and transporting uranium to nuclear plants. Water is required for various steps in electricity production from nuclear energy.

Uranium is radioactive. It can harm living organisms if it is released into the environment. Radioactivity can cause illnesses such as cancer and even death. Radioactive wastes are dangerous for a long time. Currently there is no known way to dispose of nuclear waste safely; it must be contained in special storage areas.

There are other safety concerns associated with nuclear energy. Uranium used for nuclear fuel can also be used to create nuclear weapons. Also, the extreme heat created by fission makes reactors susceptible to fires or explosions if safety measures malfunction.

Description of nuclear energy:

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Benefits of using nuclear energy for electricity:

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Negative consequences of using nuclear energy:

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Does nuclear energy used for electricity contribute to climate change? Explain your answer.

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Should nuclear energy be a major source for future electricity production? Why or why not?

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Energy Source: Geothermal Energy

GROUP MEMBERS ______________________________

GEOTHERMAL ENERGY IS HEAT THAT originates within the earth. Extremely high temperatures are continuously produced inside the earth by the slow decay of radioactive particles, a process that happens in rocks.

Reservoirs of hot water, steam, and hot dry rocks can be used to generate electricity. Pipes are often drilled 1-2 miles below Earth's surface to reach these reservoirs of thermal energy. Geothermal reservoirs are difficult to access in places where they are not close to Earth's surface.

Geothermal energy is not as renewable as solar or wind energy because a specific location can cool over time. However, it is constantly available and is unaffected by weather.

Construction of geothermal power plants can affect land stability in the surrounding region. However, after a power plant has been constructed, geothermal energy is inexpensive and clean. Geothermal power plants release less than 5% of the CO_2 emissions of a fossil fuel plant.

The shallow ground of the earth provides another form of geothermal energy that can be accessed almost anywhere to heat or cool buildings. For most areas in the world, temperatures in the upper 10 feet of Earth's crust are usually warmer than the air in the winter and cooler than the air in the summer, kind of like a cave. Geothermal heat pumps transfer heat from the ground into buildings in the winter and reverse the process in the summer, transferring heat from the air into the cooler ground.

Description of geothermal energy:

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Benefits of using geothermal energy for electricity:

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Negative consequences of using geothermal energy:

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Does geothermal energy used for electricity contribute to climate change? Explain your answer.

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Should geothermal energy be a major source for future electricity production? Why or why not?

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6

Changes All Around

In small groups, students examine the climate of countries in different environments. Students then predict what might happen to the climate of a particular country as the earth continues to warm.

Adapted from "Regional Effects of Global Warming"
by Elizabeth K. Andre, Will Steger Foundation

Inquiry/Critical Thinking Questions

- How does climate differ in regions around the world?
- What are some common impacts of climate change?
- How might the climate in a particular country change as the earth warms?
- What are some ways that we can reverse, limit, and/or prevent damaging impacts of climate change on different environments?

Objectives

Students will:

- Examine the climate of countries in different world regions
- Consider the common manifestations of climate change
- Predict how a rise in average global temperature might impact countries in particular regions
- Explore how humans will be impacted by changes in their own environment and by changes in foreign environments
- Identify ways to prevent or mitigate the effects of climate change on different environment

Time Required

50 minutes (plus another 50 minutes for research, optional)

Key Concepts

- Regional climate features and variations
- Global impacts of climate change
- Climate predictions
- Interconnections

Subject Areas

- Social Studies (Geography, Global Studies, Contemporary World Problems)
- Science (Earth, Environmental, Life, Physical)

National Standards Alignment

National Science Education Standards (NSES)

- Standard A: Science as Inquiry
- Standard C: Life Science
- Standard D: Earth and Space Science
- Standard F: Science in Personal and Social Perspectives

National Council for the Social Studies (NCSS)

- Strand 3: People, Places, and Environments
- Strand 7: Production, Distribution, and Consumption
- Strand 9: Global Connections

Materials/Preparation

- Climate Impact Projections, 1 set per group of 2-4 students
- Regional Climate Summary, 1 per student group
- Climate Prediction Sheet, 1 per student group

Activity

Introduction

1. Ask students if they think climate change is different than global warming. Have them explain why or why not.
2. Have students review/brainstorm some common elements of climate change worldwide (e.g., changes in precipitation, rising sea levels).
3. Tell students that they are going to be making more specific predictions about climate change impacts for countries in different environments.

Steps

1. Divide students into groups of 2-4.
2. Hand out 1 Regional Climate Summary to each group. If students do not know the location of the region on their card, help them find it on a world map.

   Lesson Variation: Instead of using the Regional Climate Summaries, have students research information about specific countries using the CIA World Factbook (**http://www.cia.gov/cia/publications/factbook/index.html**), the United Nations Statistics Division (**http://unstats.un.org/unsd/cdb/cdb_list_countries.asp**), and World Climate (**http://www.worldclimate.com**). Students can find information about population, GDP, economic sectors, geographic features, climate trends, and signs of climate change, to help them predict climate impacts for their assigned country.

3. Give each group a Climate Impact Projections handout.
4. Give the groups 10-20 minutes to predict how the climate in their assigned region may change as the earth continues to warm. Have the group members read each of the Climate Impact Projections and then discuss how the general trend described might affect their region, using information from the Regional Climate Summary.
5. Have each group write their predictions on the Climate Prediction Sheet, and tell them to be prepared to share their predictions with the rest of the class.
6. Ask each group to give the class a short description of their region and its climate, as well as the group's predictions and how they reached these predictions.
7. When listening to the other groups, encourage students to think about how the impacts other students are predicting might affect the climate in their assigned environment.
8. Continue with the following reflection questions.

Reflection

1. Was it difficult to make predictions, even with the information and knowledge you had? Why or why not? What additional information or tools would be helpful in making more accurate climate change predictions?
2. How important do you think it is to make accurate projections about climate change in order to take steps to reverse, mitigate, or prevent climate change?
3. What kinds of connections did you discover between climate change impacts in your country and other countries? How might humans in your environment be impacted by climate change in other environments?
4. Are any environments impacted more (i.e., more sensitive or vulnerable to climate change) than others? What characteristics of these environments make them especially sensitive to climate change?
5. What are some variables that are likely to affect the rate of future climate change? (E.g., population growth, economic development, global equity, type, and efficiency of energy use.)
6. What actions do we take that contribute to the impacts of climate change on other environments? What can we do to mitigate the impacts of climate change on other environments?

Technology Extension

Have students examine computerized climate models from the Hadley Centre for Climate Prediction and Research: **http://www.metoffice.gov.uk/research/hadleycentre/models/modeldata.html**. One of the animated models shows predicted global temperature changes from 1870-2100. The other shows predicted sea ice coverage for the same time period.

Based on what they have learned about climate change predictions in this lesson, ask students to identify some of the uncertain variables that must have gone into these models (population growth, economic growth, measures to reduce greenhouse gas emissions, etc.). Have students imagine how these models would be altered by a change in these variables. Students can create drawings of these new "models" for specific time periods.

Action Project

Interview a climate witness. Collect oral histories from older relatives or community members. Ask them to explain how climate (temperatures, rainfall, long-term weather patterns) has changed during their lifetime. Document climate change in your community by combining these oral histories in a book to share with other community members. For more information, including a sample interview form, see the World Wildlife Fund's Climate Witness project, available at http://www.panda.org/climatewitness.

Additional Resources

Film

Rising Waters: Global Warming and the Fate of the Pacific Islands, directed by Andrea Torrice, 2000, 57 minutes, http://www.bullfrogfilms.com/catalog/rw.html. Through personal stories of Pacific Islanders in Kiribati, the Samoas, Hawaii, and the atolls of Micronesia, as well as researchers in the continental United States, this documentary film puts a human face on the international climate change debate.

Websites

- **http://www.panda.org/climatewitness**—Climate Witness is a World Wildlife Fund (WWF) initiative to document the direct experiences of people who are witnessing the impacts of climate change on their local environment. WWF works with scientists around the world who provide scientific background information to the climate witness testimonies.

- **http://www.npr.org/news/specials/climate/interactiv**e—On the Climate Connections: A Global Journey website, students can click on an interactive world map to read and hear stories from National Public Radio (NPR) related to climate change around the world.
- **http://green.nationalgeographic.com/environment/global-warming/gw-impacts-interactive.html**—National Geographic provides an interactive map with expected impacts of climate change in various regions. Students can click on specific locations on the map to learn about these impacts.

"Just as climate change does not affect all places in the same way, it does not affect all people in the same way, either.

Student Reading 04, page 110

Climate Impact Projections

Increasing temperatures

THE GLOBAL AVERAGE TEMPERATURE IS projected to rise between 2.5 and 10.4ºF (1.4 and 5.8ºC) over the period 1990-2100. Temperatures will not rise equally everywhere, however. The centers of continents will warm more rapidly than land near the oceans. Landmasses in higher latitudes are also predicted to warm more than in lower latitudes (tropics). For example, the Arctic is projected to warm an additional 7.2-12.6ºF (4 to 7ºC), while tropical areas are projected to warm much less.

Consequences of higher temperatures may include the following:

- more heat-related deaths, especially in urban areas and among poor people
- fewer cold-related deaths in cooler climates
- decreased use of energy for heat (in cooler climates) and increased use of energy for air conditioning
- melting glaciers and permafrost (permanently frozen ground)
- later frosts, earlier spring plantings, and longer growing seasons in cooler climates
- reduced growing season and increased heat damage to crops in warmer and drier climates
- changes in ecosystems due to poleward shift of plant and animal species
- earlier spring migrations of birds and fish
- increased heat stress to wildlife and livestock
- increased risk of drought and forest wildfires
- increased susceptibility of trees and crops to pests
- shifts in tourist destinations

Changes in precipitation

WARMER TEMPERATURES ARE EXPECTED TO lead to changes in the water cycle, and global mean precipitation is expected to increase. However, it is difficult to predict how much the amount of precipitation will change in any given area. Certain regions will get more precipitation and others less. In general, areas in higher latitudes (closer to the poles) and closer to oceans may get more precipitation, while areas in lower latitudes (closer to the equator) and farther inland may get less. Areas in which there are already water shortages may have even less available water. While the frequency of precipitation may not increase, the intensity of precipitation (or amount of precipitation per event) is expected to increase. As a result, precipitation in many areas may come in extreme events, causing flooding and erosion.

Consequences of changes in precipitation may include increased stress on flood insurance systems and government disaster relief systems, increased damage to plants and crops, increased risk of forest fires, and recharged floodplain aquifers (natural underground water storage areas).

Increasing evaporation

EVEN THOUGH CLIMATE CHANGE MAY increase the total amount of precipitation that an area receives, increased heat will cause increased evaporation. If the rain comes during the winter or wet season and the heat comes in the summer or dry season, the land may dry out.

This may cause increased desertification and drying-up of lakes and rivers, decreased crop yields, decreased water resource quantity and quality, and increased risk of forest fires.

Warmer oceans

GLOBAL OCEAN HEAT CONTENT IS expected to continue to increase. Most of the increase will happen near the surface of the ocean.

The temperature differences between the oceans, the atmosphere, and land creates winds and atmospheric circulation patterns such as the jet stream. Because oceans do not warm up as quickly as air and land (due to the capacity of water to absorb heat), the difference in temperature between sea and land is expected to increase, causing a higher likelihood of strong winds, storms, and unpredictable weather events. 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 intense.

Warming oceans are likely to cause bleaching of coral reefs, as a result of the algae living in the reef dying. Coastal communities that rely on fish and other marine animals living around these coral reefs will be affected. Communities that rely on aquaculture (the raising of fish in enclosures floating in the ocean) may have difficulty if waters become too warm for the type of fish they are raising, or if the warmer water makes diseases and toxic algal blooms more common. The warming of the oceans is also a major cause of rising sea levels.

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 would enable more insect pests to survive. This could threaten local communities of living things. Also, less snowpack that melts earlier means that less water might be available in the spring and summer, when plants need it most. Areas with winter tourism would also suffer from reduced ice and snowpack.

Spreading disease vectors

AS THE CLIMATE WARMS, DISEASE vectors (things that carry disease) like mosquitoes and ticks will be able to extend their ranges. At the same time, climate change may increase waterborne pathogens (microorganisms that cause disease), decrease water and air quality, and decrease the amount and quality of available food in some regions. These effects will be most severe in developing countries and among the poor.

Rising sea levels

SEA LEVEL WILL CONTINUE TO rise as a result of global warming. 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 icecaps. 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 how much glaciers will melt, how much sea water will expand, and how ocean circulation patterns will change. Projections for sea level rise by the year 2100 range from 4 inches (10 centimeters) 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 evacuated.

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Regional Climate Summaries

Region #1: Maldives

THIS ISLAND NATION, LOCATED IN the Indian Ocean about 435 miles (700 kilometers) southwest of Sri Lanka, is smaller than one-tenth of the U.S. state of Rhode Island and is home to almost 300,000 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 twenty-six 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 December 2004 Tsunami almost completely flooded the Maldives with waves of up to 5 feet (1.5 meters) 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 maps of the country had to be redrawn.

The two major industries of the Maldives are tourism and fisheries. Each year, around half a million tourists visit the Maldives. Fisheries employ about one-third of the country's citizens. Other industries such as shipping, banking, and manufacturing are growing.

The Maldives has the highest per capita GDP (gross domestic product, which is one way that economists measure wealth) of all the nations in South Asia. The Maldives GDP is about US$4000 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 4.6 million people. Norway is a long and thin country with a very long coastline bordering five bodies of water (North Atlantic Ocean, Barents Sea, Arctic Ocean, North Sea, and Norwegian Sea). The northern part of Norway is north of the Arctic Circle. More than two-thirds of Norway is covered in rugged mountains. Several major glaciers occupy the central mountain plateau.

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 Fahrenheit (16.4 degrees Celsius) in the summer and 24 degrees Fahrenheit (-4.3 degrees Celsius) in the winter. The climate farther inland and to the north can be more severe.

In recent decades, however, Norway has been experiencing warmer temperatures. The average temperature in Norway over the last fifteen years has been 1.8-4.5 degrees Fahrenheit (1-2.5 degrees Celsius) warmer in January and 0.9-1.8 degrees Fahrenheit (0.5-1 degree Celsius) warmer in July.

The economy of Norway is based on petroleum and natural gas exports, forestry, fishing, mining, and hydroelectric power. Less than 3% of the land in Norway is arable (able to be cultivated with crops).

Region #3: Iowa

THE U.S. STATE OF IOWA is located in the upper Midwest and home to almost 3 million people. The upper Midwest has a continental climate, which means that it is far away from the temperature-moderating influence of the oceans. Winters are cold, with daytime temperatures as low as 0 degrees Fahrenheit (-18 degrees Celsius). Summers can get very hot, with daytime temperatures over 100 degrees Fahrenheit (38 degrees Celsius).

Iowa's main industries are agriculture, manufacturing, and insurance. About 90% of the land area in Iowa is used for farming. Iowa leads the nation in the production of pork, corn, soybeans, and eggs. Iowa is also the country's largest producer of corn-derived ethanol (a fuel). Iowa also produces beef, dairy, sheep, and honey.

Iowa receives an average of about 33 inches (84 centimeters) of precipitation per 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 some 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 United States history.

Region #4: Southern California

THE SOUTHERN QUARTER OF THE U.S. state of California is home to around 24 million people and includes 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.

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 centimeters) of rain per year and the San Joaquin Valley averages less than six inches (15.2 centimeters) of rain per 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.

Securing and distributing enough water to the large human population in southern California is a challenge for this region.

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 frequent winds fueling the flames, wildfires in southern California can be intense. Wildfires can destroy the vegetation that previously prevented erosion. When intense rains come after wildfires, they can sometimes trigger landslides and flash floods.

Region #5: The Republic of Chad

CHAD IS A LAND-LOCKED nation in Central Africa and larger than the U.S. states of Texas and California combined. It is home to about 9.7 million people, 80% of whom rely on subsistence farming and raising livestock. Chad's main exports have, until recently, been cotton, cattle, and chewing gum. Beginning in 2003, Chad began to export petroleum, and its petroleum exports have been growing rapidly since then, doubling the country's GDP (gross domestic product, one way that economists measure wealth) to about US$1000 per person per year. Chad is one of the poorer countries in the world.

Chad is far from the ocean and gets little precipitation. Only 3% of the land in Chad is arable (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 shrunk by 90%. 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 enough rainfall during the rainy season to allow agriculture without irrigation. Daytime temperatures in this region range from around 80 degrees Fahrenheit (27 degrees Celsius) to around 104 degrees Fahrenheit (40 degrees Celsius).

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 Fahrenheit (32 degrees Celsius) in the coolest months to around 113 degrees Fahrenheit (45 degrees Celsius) in the hottest months.

Region #6: The Amazon River Basin

THE AMAZON RIVER BASIN COVERS about 2.7 million square miles (7 million square kilometers) in eight different South American countries. The climate is warm and humid with an average daily temperature of almost 80 degrees Fahrenheit (26.6 degrees Celsius) and an average annual rainfall of around 80 inches (203 centimeters). 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 navigable by large steamers as far as 900 miles (1450 kilometers) upstream of its mouth. This river is an important means of transportation for people along its length.

Beginning in 2005 and continuing through 2006, however, the Amazon experienced an extreme drought. The river dried to a trickle in many places, stranding boats and stressing ecosystems.

Climate Prediction Sheet

GROUP MEMBERS ____________________

COUNTRY NAME ____________________

INSTRUCTIONS: Based on the information you have about the climate in your country and the Climate Impact Projections reading, answer the questions below to predict how global climate change might affect your country.

Remember that these are just your predictions, and not right/wrong answers!

1. At what time of year might precipitation come? In what form? How much?

2. Might part of your region be affected by droughts? Floods?

3. Might the area be affected by storms? What kinds of storms, and where?

4. Would shorter and milder winters affect the area? If so, how?

5. Might the area be affected by rising sea levels? If so, how?

6. How would the production of food or other crops be affected?

7. What concerns might the area have related to diseases? Agricultural pests?

7

How Much Does Carbon Cost?

Students begin with a simulation to understand limits imposed by environmental regulations. They compare 2 structural solutions to regulate carbon emissions, then play a cap and trade game that explores ways to reduce emissions in the most cost-effective manner.

Adapted from "The Cap and Trade Game" by Ava Erickson, Seattle Girls School

Inquiry/Critical Thinking Questions

- What are some examples of ways that businesses and industries are regulated to reduce carbon emissions?
- How does a cap and trade system work?
- What are the benefits and drawbacks of different types of environmental regulations?

Objectives

Students will:

- Calculate the economic efficiency of 2 systems designed to regulate carbon emissions
- Participate in a cap and trade game
- Determine which regulatory system reduces CO_2 emissions most effectively

Time Required

50 minutes

Key Concepts

- Structural solutions
- Cap and trade system
- Environmental regulations

Subject Areas

- Social Studies (Economics, World History, Civics, Contemporary World Problems)
- Science (Environmental)
- Mathematics
- Business/Finance

National Standards Alignment

National Science Education Standards (NSES)

- Standard F: Science in Personal and Social Perspectives

National Council for the Social Studies (NCSS)

- Strand 6: Power, Authority, and Governance
- Strand 7: Production, Distribution, and Consumption
- Strand 8: Science, Technology, and Society
- Strand 9: Global Connections

Vocabulary

- **cap and trade**—rather than placing a cap (maximum allowable amount) on each individual CO_2 emitter (power plant, factory, or other business), this system places a cap on industry overall; each emitter is given a certain number of CO_2 allowances per year, and can trade with other emitters to acquire more allowances or sell off excess allowances
- **environmental regulation**—a law passed that is intended to protect or enhance the environment; often people or businesses are required to follow certain rules to limit their environmental impact
- **structural solution**—a way in which a component of a system can be changed in order to alleviate a problem (vs. a personal solution, which is a way in which an individual can act to alleviate a problem)

Materials/Preparation

- Handout: Costs of Environmental Regulations, 1 per student
- (Optional) Teacher Master: Costs of Environmental Regulations
- Handout: Cap and Trade Balance Sheet, 1 per group of 3-4 students
- Dice, 1 per group of 3-4 students
- (Optional) Play money, $1000 per student group

“Many companies are taking steps to reduce their carbon footprints, often by using renewable energy or energy-efficient technology.

Student Reading 05, page 116

Activity

Introduction

1. Begin this activity by asking students how their lives would be affected if they could only make 5 phone calls each week. If they make fewer than 5 phone calls, they can sell their extra phone calls to classmates; or, they may buy phone calls from classmates if they need to make more than 5 calls. Ask students how they would respond to this new limit placed on their phone calls.
2. Now explain that one way to fight climate change is to set limits. A government or other entity may limit, or regulate, emissions produced by companies. Students will soon play a game to explore 1 climate change regulatory mechanism.
3. In order to prepare for the game, first work through the handout, Costs of Environmental Regulations. Have students work either individually or in pairs, and then discuss results as a class.
4. After finishing the worksheet, ask students which option (Individual Limit or Cap and Trade) seems to be best for each company. If you were AllStuff and you knew the government was going to impose regulations, would you prefer Individual Limit or Cap and Trade? Why?

Steps

1. Divide the class into groups of 3-4. Give each group a Cap and Trade Balance Sheet and a die.
2. (Optional) Give each group $1000 in play money so that they can actually gain or lose dollars during each transaction.
3. First, students will create their company name. What does the company do? What is it called?
4. Instruct all groups to roll their die twice and add up the numbers, then multiply by 10. This is their CO_2 emissions in tons per year. Have them write that number on their balance sheet.
5. Now have them roll the die once and multiply by 10. This is the cost to their company to reduce emissions by 1 ton of CO_2. Have them write that number on their balance sheet.
6. Depending on their total emissions, students may have extra allowances, or they may need to reduce their emissions. To reduce emissions, companies may pay to reduce emissions themselves (through conservation, improved efficiency, or new technology). They may also buy allowances from companies with extra allowances; this may be cheaper and faster.

7. Tell students to circulate in the class to meet other companies. If a company has extra allowances, it will want to sell them for the most money it can get. If a company needs to reduce its emissions, it needs to do so for the least amount of money. Each company will have to decide if it is cheaper to make the reductions themselves or buy allowances from another company.
8. Have students record each transaction, making sure not to exceed the total amount of money they started with. Continue the game for 10-15 minutes, or until everyone has had a chance to make at least 2 transactions. For an extra challenge, introduce a second year of trading with fewer allowances.
9. At the end of the game, poll the class to see who was able to sell extra allowances for the most money. Also, who purchased allowances for the least money? Conclude with the following reflection questions.

Reflection

1. Did anyone reduce emissions on their own rather than buy allowances? If so, why?
2. How do you think businesses whose emissions exceed the maximum number of allowances would feel about a cap and trade system? Why?
3. How do you think businesses whose emissions are below the maximum number of allowances would feel about a cap and trade system? Why?
4. Do you think a cap and trade system is a good way to reduce overall CO_2 emissions? Is this a good climate change solution? Are there other solutions that you think would work better to reduce the impact businesses have on climate change? (Other environmental regulations include performance standards, mandating use of best available technology, and pollution taxes.)
5. How might businesses be persuaded to reduce CO_2 emissions without regulations? How could businesses benefit by saving energy?
6. How do you think the impact of these types of structural solutions (environmental regulations) compares with personal solutions (e.g., reducing energy use, using "cleaner" technology)?

Additional Resources

Websites

- **http://www.worldwatch.org/node/3949**—In this question and answer site maintained by the Worldwatch Institute, ideas are offered for how businesses and governments can work toward climate change solutions.
- **http://www.theclimategroup.org**—The Climate Group is a nonprofit organization dedicated to advancing business and government leadership on climate change. Click on Low Carbon Solutions to learn about ways that businesses and governments can lower their CO_2 emissions.

Costs of Environmental Regulations

WE WILL USE OUR MATH skills to learn more about 2 types of environmental regulations: Individual Limit and Cap and Trade.

Let's suppose there are only 2 carbon dioxide (CO_2) emitters in the world: the ElectroGen power plant and the AllStuff factory. Each company can reduce its emissions by improving efficiency or installing new technologies. Following are the emissions and costs for reducing CO_2 for both companies.

COMPANY	CO_2 EMISSIONS PER YEAR	COST TO REDUCE CO_2
ElectroGen	120 tons	$20 per ton
AllStuff	90 tons	$15 per ton

Individual Limit

THE GOVERNMENT TELLS ELECTROGEN AND AllStuff that each emitter (power plant or factory) is allowed to emit only 100 tons of CO_2 per year.

1. By how many tons will ElectroGen have to reduce their emissions?

2. By how many tons will AllStuff have to reduce their emissions?

3. ElectroGen calculates that it will cost $20 to reduce their emissions by 1 ton of CO_2 per year. How much will it cost ElectroGen each year to reduce its total emissions to 100 tons of CO_2?

4. It costs AllStuff only $15 to reduce its emissions by 1 ton of CO_2. How much will it cost AllStuff to reduce its total emissions to 100 tons of CO_2?

5. Imagine that you are the President of ElectroGen, and the government announces that you cannot emit more than 100 tons of CO_2 per year. How would you respond?

6. Now imagine that you are the President of AllStuff, and the government announces that you cannot emit more than 100 tons of CO_2 per year. How would you respond?

Cap and Trade

THE GOVERNMENT DECIDES THAT TOTAL emissions for ElectroGen and AllStuff combined must be capped (limited) at 200 tons of CO_2 per year. Each company is given 100 allowances. (An allowance is the right to emit 1 ton of CO_2.) They can make the reductions themselves, or they can trade allowances with each other.

7. By how many tons will ElectroGen and AllStuff combined have to reduce their emissions?
8. How many additional allowances does ElectroGen need?
9. How many extra allowances does AllStuff have?
10. ElectroGen is emitting more CO_2 than it has allowances for. It wants to meet the regulations in the cheapest way possible. In a cap and trade system, companies can buy allowances from each other. ElectroGen decides to buy AllStuff's extra allowances. What is the most that ElectroGen would pay for them?

11. If ElectroGen buys all of AllStuff's allowances, how many more will ElectroGen need?

12. To reduce its remaining 10 tons of CO_2, ElectroGen could install new technology that will cost $20 per ton to reduce emissions. But that's pretty expensive. It's cheaper for AllStuff to reduce its emissions ($15 per ton), so ElectroGen and AllStuff strike a deal.

    a. AllStuff decides to reduce its emissions by 10 tons, so that it is only emitting 80 tons of CO_2 per year. What is the total cost to AllStuff for that reduction?
    b. How many extra allowances does AllStuff have now?
    c. ElectroGen offers to buy the allowances from AllStuff. What is the least amount of money per allowance that AllStuff will accept?
    d. What is the most amount of money ElectroGen will pay AllStuff for extra allowances?
    e. Suppose they compromise in the middle. How much will ElectroGen pay per allowance?
    f. How does this benefit both companies?

13. Suppose you are the President of ElectroGen. How would you respond if the government was to impose this cap and trade limit of CO_2 emissions to 100 tons per year?

14. Suppose you are the President of AllStuff. How would you respond if the government was to impose this cap and trade limit of CO_2 emissions to 100 tons per year?

Costs of Environmental Regulations

Teacher Master

1. 20
2. 0 (they are below the limit)
3. $400 ($20 x 20 tons)
4. $0 (they do not need to reduce emissions)
5.
6.
7. 10 (120 + 90 = 210)
8. 20
9. 10
10. $20/ton ($400 for 20 tons)
11. 10
12.
    a. $150 ($15 x 10 tons)
    b. 20
    c. $15
    d. $20
    e. $17.50
    f. AllStuff makes money on each allowance sold to ElectroGen.
    ElectroGen can save money by paying AllStuff to reduce CO_2 emissions.
13.
14.

Cap and Trade Balance Sheet

TEAM MEMBERS ______________________________

COMPANY NAME ______________________________

DESCRIPTION OF COMPANY (What product or service to you provide?)

____

Starting Information:

Starting Money	Allowances (tons of CO_2 you can emit)	CO_2 Emissions per Year (roll die twice; add the numbers and multiply by 10)	Cost to Reduce Emissions by 1 Ton (roll die once and multiply by 10)	How many extra allowances do you have?	How many extra allowances do you need?
$1000	65				

IF YOU NEED TO REDUCE YOUR EMISSIONS, find a company willing to sell you allowances for LESS than it would cost you to reduce CO_2 emissions by 1 ton.

IF YOU HAVE EXTRA ALLOWANCES TO SELL, try to make as much money as you can by selling the allowances. In some cases, it may be best to pay to reduce your CO_2 emissions even more and then sell the allowances gained for MORE than you paid.

Balance Sheet:

Transaction (buy, sell, or reduce your own emissions)	Other Company Involved in Transaction	Number of Allowances Bought/Sold	Amount Per Allowance	Total for Allowances Bought/Sold (multiply number of allowances by amount per allowance)	Money You Have Now (subtract money if you paid for allowances; add money if you sold allowances)	Total CO_2 Emissions You Have Now
Example: Buy	*FunnyCo*	*10 bought*	*$30*	*$300*	*$1000 – $300 = $700*	

8

Shopping Heats Up

In this simulation, students experience how resources are distributed and used by different people based on access to wealth, paying attention to the environmental and social impacts of resource consumption. Students discuss the impacts of their consumption on climate change.

Inquiry/Critical Thinking Questions

- What choices are available to people with relatively little access to wealth/income compared to people with relatively high access?
- What are some environmental and social impacts of each of those choices and decisions?
- What personal choices can we make to help reduce the negative impacts from our consumption?

Objectives

Students will:

- Make and explain purchasing/consumption choices
- Compare different purchasing/consumption choices and their social and environmental impacts
- Describe how relative affluence and high consumption levels relate to climate change
- Discuss how socioeconomic status can limit choices
- Discuss personal choices to reduce the negative environmental and social impacts of consumption

Time Required

50 minutes

Key Concepts

- Equity, poverty, and scarcity
- Consumption patterns
- Environmental impacts

Subject Areas

- Social Studies (Geography, Economics, Global Studies, Contemporary World Problems)
- Science (Environmental, Life)
- Mathematics
- Health/Nutrition

National Standards Alignment

National Science Education Standards (NSES)

- Standard C: Life Sciences
- Standard F: Science in Personal and Social Perspectives

National Council for the Social Studies (NCSS)

- Strand 3: People, Places, and Environments
- Strand 7: Production, Distribution, and Consumption
- Strand 9: Global Connections

Materials/Preparation

- Handout: Global Mall Dollars, 1 card per student (there are 6 cards per sheet)
- Handout: Global Mall Items, 1 sheet per student
- (Optional) Teacher master: Global Mall Impacts, 1 copy as teacher reference
- Handout: Choices and Impacts, 1 per group
- Make enough copies of the Global Mall Dollars sheets so that there is 1 card for each student. (Each sheet has 3 $200 cards, 2 $1500 cards, and 1 $5000 card to reflect income distribution around the world. Therefore, more students will end up with $200 cards and $1500 cards than $5000 cards.) Cut the sheets along the dotted lines and fold each card so the amount is not visible.

Activity

Introduction

1. Have the class brainstorm human needs (shelter, food, water, energy, etc.).
2. Ask students to think about ways that meeting these needs might contribute to climate change. Are there ways of meeting these needs while improving the environment?
3. Tell students that today they will have a chance to shop for some of their needs at the "Global Mall." The Global Mall sells resources that humans depend on to live, as well as some "nonessential" items.

Steps

1. Pass out the handout, Global Mall Items, which lists the items available. Tell students they can select items from the list to purchase with their Global Mall Dollars, but they must first meet basic needs for themselves and their families by selecting items from the categories of food, heat/fuel, and shelter. Only after these needs are met can they buy any of the other items.
2. Pass around a basket with the Global Mall Dollars and instruct each student to take 1 card and not show it to anyone.
3. Instruct students to write the items they purchase on the lines on their card (or on the back), along with the cost of each item (be sure they do this part of the activity individually).

4. While students are making their purchasing choices, keep the pressure on to instill a sense of urgency. Ask, "Who's done shopping?" Say, "The mall is closing soon!" Students with $200 Global Mall Dollars will likely finish much sooner than those with $1500 and $5000.
5. When students finish their shopping, have them break into 3 groups, putting students with the same dollar amounts ($200, $1500, $5000) together. (There will be more students with $200; if necessary, subdivide groups so you have 3-5 students per group.)
6. In their groups, have students complete the handout, Choices and Impacts. Ask them to discuss anything they could not afford to purchase and how not having those items might affect their lives.
7. Circulate among the groups and suggest impacts they might not have considered. Use the handout, Global Resource Mall Impacts as a teacher reference.
8. Have each group report to the class on the decisions they made and the impact these decisions would have on their lives and on the environment.
9. Answers to the questions on the Choices and Impacts handout are good starting points for more in-depth discussion. This lesson is also a good introduction for a discussion of who contributes most to climate change (often wealthier nations) and who is most greatly affected by climate change (often poorer people living on marginalized land), as well as a discussion of how poor people can meet their basic needs and improve quality of life in a sustainable manner.

Lesson Extension

Assign each group a family from the book, *Material World*, by Peter Menzel. Have the students analyze what that family owns and brainstorm the relative impact those items might have on climate change. Have them examine and compare the carbon dioxide emissions from each family's country.

Math Connection

Have students research cost-effective ways of reducing greenhouse gas emissions (e.g., compact fluorescent light bulbs, sealing cracks around windows and doors, unplugging appliances when not in use). Some high-tech solutions are too costly for many people to use; finding cost-effective measures is essential to involve more people in climate change solutions. Give students a "budget" of $50 and challenge them to find the most effective ways to reduce CO_2 emissions within that budget. How many pounds of CO_2 can their $50 prevent from entering Earth's atmosphere? Encourage them to share their findings with parents and teachers.

Additional Resources

Books

- *Plan B: Rescuing a Planet Under Stress and a Civilization in Trouble*, Lester R. Brown, W.W. Norton & Company, New York, 2003. Brown calls for a worldwide mobilization to stabilize population and climate before they spiral out of control. It provides a plan for sustaining economic progress worldwide.
- *You Can Prevent Global Warming (and Save Money!)*, Jeffrey Langholz and Kelly Turner, Andrews McMeel Publishing, Kansas City, 2003. 51 tips are provided for reducing greenhouse gas emissions at home while saving money. Potential impacts are reported in dollars saved and pounds of carbon dioxide not emitted.

Websites

- **http://www.undp.org**—The United Nations Development Programme (UNDP) is the UN's global development network – an organization advocating for change and connecting countries to knowledge, experience, and resources to help people build a better life.
- **http://ibuydifferent.org**—The Center for a New American Dream encourages people to consume responsibly in order to protect the environment, enhance quality of life, and promote social justice. Their "I Buy Different" website provides ideas on how to have a positive impact on the world through consumption choices.

Global Mall Dollars

$200

ITEM	COST

$200

ITEM	COST

$200

ITEM	COST

$1,500

ITEM	COST

$1,500

ITEM	COST

$5,000

ITEM	COST

Global Mall Items

Food	Rice and beans once or twice a day. All of this food is locally grown. **$100**	Beans, vegetables, and rice daily, plus meat/dairy about once a month. Most of this food is locally grown. **$300**	A variety of fast foods 2-3 times a day, such as a hamburger, chicken sandwich, tacos, French fries, soda, and ice cream. Most of this food is highly processed. **$600**	High quality food 3 times a day, including eggs, meat, fish, fresh vegetables, fresh imported fruit, bread, milk, imported cheese, and chocolate. Much of this food is organically grown using few chemicals. **$900**
Heat/ Fuel	Firewood cut from a local forest, sometimes hours away. Most of this work is done by children and women. **No cost**	Coal purchased in the market and used for cooking and heating. **$250**	Oil used for cooking and heating. **$600**	Solar panels using the sun's energy to heat home and water; natural gas for cooking. **$1500**
Transportation	One bicycle shared by your family; walk when distance is less than 10 miles. **$75**	Community bus with 4 scheduled pick-up times in your community daily. **$125**	Older car for driving short distance; gets poor gas mileage. For long distances you have to take a bus or train. **$700**	Car large enough to carry a family of 5 people comfortably; includes air conditioning and a radio. **$1200**
Home	Small home made from sticks and mud. This home is in a rural area with no electricity. **No cost**	1-bedroom apartment in a large apartment building in a large city. **$500**	Suburban 2-bedroom house with a small front yard. **$1000**	Large 3-bedroom house with a pool in the backyard. This home is 15 miles away from where you work. **$2000**
Luxury Item	Radio running on batteries. **$50**	Small color television in your house. **$150**	Refrigerator in your house and air conditioning. **$500**	Hawaii surf vacation, including airline ticket, hotel, and souvenirs. **$800**

Global Mall Impacts

Teacher Master

Food	Rice and beans Environmental: no/less agricultural chemicals; little tilling of the soil Social: lack of essential vitamins results in more malnutrition	**Beans, veggies, meat** Environmental: tilling soil releases CO_2; livestock release methane and require much food and water Social: good nutritional value	**Fast foods** Environmental: water/ feed for beef production, deforestation for cattle grazing (releases CO_2); livestock release methane; making fertilizers releases nitrous oxide Social: convenient but unhealthy, some fats linked to heart disease	**High quality food** Environmental: deforestation for cattle grazing; greenhouse gas emissions from transportation of imports; agricultural chemicals; air and water pollution Social: healthy but cash crops take away from staple food crops
Heat/ Fuel	**Firewood** Environmental: deforestation; desertification; fewer trees for carbon storage; air pollution Social: poverty (time away from school, work, food production); smoke linked to lung disease	**Coal** Environmental: CO_2 emissions; air pollution; water pollution from mining Social: easier to use than firewood, but may result in lung disease if cooking area is not ventilated; miners susceptible to lung disease and mining-related injuries	**Oil/Gas** Environmental: oil drilling, spills, pipeline impacts; CO_2 emissions; air pollution; loss of habitat Social: convenient, but results in dependency on oil/gas supplies, often from foreign regions	**Solar panels** Environmental: clean, renewable source of energy; no CO_2 emissions (except to manufacture and transport panels) Social: convenient; sunlight is free; expensive to install but saves money in the long run; no health risks
Transportation	**Bicycle and walk** Environmental: no greenhouse gas emissions, except from manufacturing the bike Social: good for physical health; often takes longer to bike or walk than to use motor transportation	**Bus** Environmental: relies on fossil fuels and causes air pollution, but less than if each rider drove a single automobile Social: less air pollution (better for lung health); time spent waiting for bus	**Older car/Bus/Train** Environmental: burns fossil fuels; exhaust pollutes air; train and bus pollute less per passenger Social: freedom to go to nearby places at any time	**Newer car** Environmental: air pollution and greenhouse gas emissions; environmental resources to make car (e.g., metal from mining, plastic from petroleum) Social: freedom to drive anywhere and carry large items
Home	**Hut** Environmental: removing sticks from forest leads to erosion and reduction of soil nutrients Social: continual maintenance required; difficult to keep out heat/cold and flies	**Small apartment** Environmental: living in dense housing uses fewer environmental resources and requires less heating Social: close community; no yard; less privacy than a single-family home	**Two-bedroom house** Environmental: suburban neighborhoods have many dead-end streets, requiring extra driving; water used to maintain yard Social: yard for recreation; potential stress of driving into city (traffic, accidents, etc.); gas expense	**Large house with pool** Environmental: energy required to heat and cool large house; water and chemicals for pool; CO_2 from driving Social: economically exclusive neighborhood is often less culturally diverse; time and gas spent driving to/ from work
Luxury Item	**Radio** Environmental: energy required to manufacture and use; batteries toxic to soil Social: access to information; entertainment	**Color TV** Environmental: resources to manufacture and use; pollution from improper disposal or recycling Social: access to information; entertainment	**Refrigerator** Environmental: CO_2 and chlorofluorocarbon (CFC) emissions; resources to manufacture Social: convenient access to fresh food	**Surf vacation** Environmental: burning jet fuel releases CO_2; resources to make airplane; land used for airport and runways Social: lower stress; enjoyable; expensive

Choices and Impacts

GROUP MEMBERS ______________________________

Amount of money each group member started with ______________

INSTRUCTIONS: Select and list 4 items that members of your group purchased. Consider environmental (including climate change connections) and social impacts, whether positive or negative, for each item. Then discuss and write answers to the questions below.

ITEMS PURCHASED	ENVIRONMENTAL IMPACTS	SOCIAL IMPACTS

1. How would the choices you made affect Earth's climate? Would they contribute to or lessen the effects of climate change, or would they have a neutral effect?

2. How did your economic status affect your purchasing choices, including whether you were able to consider environmental and social impacts?

3. In what ways could you reduce the negative impacts of one of the items you purchased?

4. In what ways will climate change impact someone of your group's economic status?

5. Do you think people with more or less money will be affected by climate change to a greater degree? Explain your answer.

6. How can poor people improve their quality of life in ways that don't contribute greatly to climate change?

9

Energy Policies for a Cool Future

Students compare energy use and CO_2 emissions by country and per capita in developing countries (China and Bolivia) and developed countries (Germany and United States). They discuss energy impacts and suggest policies for addressing global climate change related to energy use at a "World Climate Change Summit."

Inquiry/Critical Thinking Questions

- How does total energy use compare between developing and developed countries, and between different sectors in these countries?
- How does per capita energy use compare between developing and developed countries?
- How is energy use connected to climate change?
- What can be done to conserve energy resources and reduce CO_2 emissions?

Objectives

Students will:

- Calculate and compare the percentage of energy use and emissions by country to world average energy use and emissions
- Brainstorm impacts of energy use and sustainable energy solutions
- Develop a policy addressing global climate change
- Present their policy at a mock "World Climate Change Summit"

Time Required

Two 50-minute class periods

Key Concepts

- Energy use
- Renewable and nonrenewable energy resources
- Climate change policy
- Energy conservation

Subject Areas

- Social Studies (World History, Geography, Civics/Government, Global Studies, Contemporary World Problems)
- Science (Earth, Environmental, Physical)
- Mathematics
- Language Arts

National Standards Alignment

National Science Education Standards (NSES)

- Standard C: Life Science
- Standard D: Earth and Space Science
- Standard E: Science and Technology
- Standard F: Science in Personal and Social Perspectives

National Council for the Social Studies (NCSS)

- Strand 3: People, Places, and Environments

- Strand 6: Power, Authority, and Governance
- Strand 7: Production, Distribution, and Consumption
- Strand 8: Science, Technology, and Society
- Strand 9: Global Connections
- Strand 10: Civic Ideals and Practices

Vocabulary

- **developed country**—a nation with high average per capita (or per person) income; includes countries such as Japan, Canada, U.S., Australia, New Zealand, and countries in western Europe
- **developing country**—a nation with low average per capita income; includes all countries except developed countries and those in the former Soviet Union and eastern Europe
- **policy**—a plan of action for tackling issues; often initiated by a political party in government
- **sustainability**—meeting current needs without limiting the ability of future generations to meet their needs

Materials/Preparation

- Handout: Total Energy Use and CO_2 Emissions by Countries, 1 per 2-3 students
- Handout: Assessing Energy Possibilities, 1 per group
- Calculators, 1 per group

"Learn more about the issues and contact government representatives with your concerns and ideas for solutions

Student Reading 05, page 118

Activity—Day 1

Introduction

1. Write on the board or overhead these 3 energy sectors: transportation, residential, and industrial/commercial.
2. Have students brainstorm different uses of energy (e.g., cars, home heating and cooling, lights, food production) and list them below the appropriate sector. Some items or activities may fall under more than one category. For example, driving a car would be "transportation," but manufacturing the car would be "industrial." This can be a good starting point for discussing the various energy uses required to produce a given item.
3. Tell the class they are going to do an activity that examines and compares the type and amount of energy use and emissions in some developing and developed countries.

Steps

1. Divide the class into 12 groups of 2-3 students. Assign groups to a sector and a country; each group represents 1 of the 3 energy-use sectors (transportation, residential, and industrial/commercial) for each of the 4 countries. For example, 1 group will be the transportation sector for India.
2. Give each group a copy of Total Energy Use and CO_2 Emissions by Countries.
3. Give groups about 10 minutes to complete the table for their country. Each group will need a calculator to figure out the percentages.
4. Have a representative from each country report to the class on the percentages in the first table and have students fill in their tables based on the reported data from the other groups. Make sure that groups representing different sectors from the same country have the same results as those reported to the class.
5. Now instruct groups to answer questions from the handout, Assessing Energy Possibilities.

   (**Optional**) Have students research how energy is being used in their sector and country by visiting the World Resources Institute website: http://earthtrends.wri.org. This will provide them with additional background information for answering the questions on the handout.

6. Bring the class back together for the following discussion prompts and questions. After the discussion, have students either hold onto their completed worksheets or collect the worksheets and pass them out again on Day 2 of the activity. Tell the class that the next day they are going to participate in a "World Climate Change Summit."

Activity—Day 2

Introduction

1. Welcome the class to the "World Climate Change Summit." Tell students they will work together in sector groups to develop an international policy addressing energy consumption, conservation, and emission reductions.
2. Review the term "policy" with students. A policy is a plan of action for tackling issues, often initiated by a political party in government. For example, the Kyoto Protocol is an international policy for addressing climate change.

Reflection

1. Discuss the difference in percentages between developed and developing countries' energy use and emissions.
2. Which country has the highest per capita energy use? What does per capita energy use tell you about how an "average" person lives in each country?
3. Which sector uses the most energy?
4. Which country uses the most total energy? Do you think that is due primarily to per capita energy use, population, or other factors?
5. Who do you think bears a greater responsibility for reducing energy use and emissions: businesses or individuals, or both? Do you think some countries have a greater responsibility to reduce their energy use and emissions than others? If so, why?
6. Why should we care about energy use and emissions? What impacts does it have on people and our planet? How does energy use relate to climate change?
7. Have students share and discuss possible sustainable energy solutions. What might be some unintended consequences of reducing energy use and/or CO_2 emissions?

Steps

1. Arrange the class so that each sector joins the same sector from the other countries. There will be 3 large groups, comprised of a transportation sector, a residential sector, and an industrial/commercial sector. In each group, students will work to develop a policy to reduce energy use and CO_2 emissions for their sector in all countries. Students should take on the roles of their countries during this activity.
2. Have the groups assign roles: facilitator, timekeeper, note taker, and reporter.
3. Give students the following instructions: On a blank sheet of paper, outline your group's international policy. Make sure to address the following questions in your policy:

- Which countries should be required to reduce their energy use and/or CO_2 emissions?
- How much should each country reduce their energy use and/or CO_2 emissions?
- What are your recommendations and ideas for reducing energy use worldwide for your sector? Give specific suggestions for conservation and/or best technologies.
- Aside from reducing energy use, do you have other ideas for reducing CO_2 emissions worldwide for your sector? Explain why different strategies might be needed for different countries.
- Who should be responsible for enforcing this policy?

4. Give the groups about 20 minutes to discuss and decide on a policy to address energy consumption, conservation, and emission reductions. They may need to refer to the Assessing Energy Possibilities worksheet from the first day. The reporter from each sector will present their group's policy to the class.
5. Hold a "World Climate Change Summit" in which each group has 3-5 minutes to present their proposed policy to the class.
6. Each student should take notes on the policies that are presented so they can discuss and vote on the policies they want to adopt.
7. After all groups present, facilitate a discussion on the pros and cons of each proposed policy.
8. Have students vote for 1 solution from each sector that they think will be most effective in reducing energy use and CO_2 emissions. When voting, students should keep in mind the particular situation of their assigned country and sector.
9. Conclude with the following reflection questions.

Reflection

1. What are some of the difficulties involved in creating an international agreement? Were all countries within your sector in agreement? If not, what were the sources of conflict?
2. Why are all solutions not appropriate for people in all places?
3. How do the energy needs of Bolivia compare to a more rapidly developing nation like China? Do you think Bolivia and China should have different emissions targets based on their rates of economic growth? Why or why not?

4. Sustainability means meeting current needs without compromising the ability of future generations to meet their needs. How can developing countries meet their growing energy needs and develop in a sustainable manner? (Discuss the concept of "leapfrog technology" in which modern, sustainable technologies are transferred to developing countries, avoiding the unsustainable stage of industrial development that developed countries experienced.)

Writing Extension

Have students research 1 of their favorite strategies proposed at the mock World Climate Change Summit. For example, they will want find out if any countries (or energy sectors) have adopted a similar strategy, and if this strategy is part of any international agreements. Have students write a letter to a local or national government official, urging him or her to adopt the strategy. In the letter, students should provide support for their positions with evidence from their research.

Technology Extension

Have students experiment with the World Resources Institute's Climate Analysis Indicators Tool (CAIT): **http://cait.wri.org**. This tool allows them to research and create a multitude of charts and graphs on global climate change and energy use by sector and country.

Action Projects

- Have students write an essay explaining what they would do if they were unable to use any oil- or gasoline-powered vehicles once a week. Then have them plan and implement "fossil fuel-free" activity days for their family and neighborhood.
- Create a more energy-efficient learning environment. Many local energy companies or city utility agencies are teaming up with students to save schools and districts energy and money, and to beautify learning environments. By providing energy audits, technical assistance with retrofit plans, information about financing methods, staff training, and educational programs, these companies and agencies can help schools identify many ways to save energy and money. Have students investigate local energy and utility companies to identify the resources and opportunities available to address energy consumption in their school or district. Your students can play a critical role in educating their peers and community on the many benefits of creating a more energy-efficient learning environment.

Additional Resources

Books

- *Stormy Weather: 101 Solutions to Global Climate Change*, Guy Dauncey with Patrick Mazza, New Society Publishers, 2001. This book provides a comprehensive overview of energy issues and practical solutions.
- *Material World: A Global Family Portrait*, Peter Menzel, Sierra Club Books, 1994. Families are pictured around the world in front of their homes with all of their material possessions. Information on energy use and emissions for each country is included in the back.

Websites

- **http://www.earthtrends.wri.org**—World Resources Institute's "Earth Trends" is a comprehensive on-line database that focuses on environmental, economic, and social trends. "Country Profiles" present environmental information about key variables for several topic areas. View charts and graphs to find statistics for over 220 countries.
- **http://cait.wri.org**—The Climate Analysis Indicators Tool (CAIT) is an information and analysis tool on global climate change developed by the World Resources Institute.
- h**ttp://unfccc.int/2860.php**—The United Nations Framework Convention on Climate Change (UNFCC) provides information about measures taken by countries in response to climate change. Links to the Kyoto Protocol and background information are provided.
- **http://www.princeton.edu/~cmi/resources/stabwedge.htm**—The Carbon Mitigation Initiative at Princeton University provides information on stabilization wedges. Information on how current technologies can stabilize carbon emissions is provided, as well as a stabilization wedge game for students.

Total Energy Use and CO_2 Emissions by Country

	Population	Total Energy Use/Year*	Percent of World Energy Use[1]	Per Capita Energy Use/Year[2]	Total CO_2 Emissions/Year**	Per Capita CO_2 Emissions/Year[3]
World	6,211,082,000	9,702,786,000	100	1.56	24,215,376,000	3.90
Bolivia	8,705,000	4,572,000			12,071,000	
China	1,294,377,000	1,088,349,000			3,316,760,000	
Germany	81,990,000	337,196,000			825,162,000	
United States	288,530,000	2,269,985,000			5,447,640,000	

Source: World Resources Institute. 2007. "EarthTrends: Environmental Information," http://earthtrends.wri.org. Population data is from 2002. Energy and emissions data are from 1999 and 2000.

* Energy use reported in metric tons of oil equivalent. One ton of oil equivalent = 10^7 kilocalories, 41.868 gigajoules, or 11,628 GWh.

** CO_2 emissions reported in metric tons of CO_2.

*** Industrial/Commercial sector includes energy use from industry, commercial and public services, and agriculture.

1 To determine percent of world energy use for each country, divide total world energy use by energy use for that country and multiply by 100.

2 To determine per capita (per-person) energy use, divide total energy use by population for each country.

3 To determine per capita CO_2 emissions, divide total CO_2 emissions by population for each country.

Total Energy Use and CO_2 Emissions by Sector

	Industrial/Commercial***		Transportation		Residential	
	Energy Use/ Year	CO_2 Emissions/ Year	Energy Use/ Year	CO_2 Emissions/ Year	Energy Use/ Year	CO_2 Emissions/ Year
World	2,818,316,000	14,235,000,000	1,755,505,000	5,505,000,000	1,845,475,000	1,802,000,000
Bolivia	869,000	4,000,000	1,214,000	4,000,000	986,000	1,000,000
China	363,523,000	2,399,000,000	69,176,000	221,000,000	289,489,000	211,000,000
Germany	96,261,000	470,000,000	68,286,000	178,000,000	63,515,000	119,000,000
United States	554,076,000	3,225,000,000	601,275,000	1,693,000,000	254,209,000	352,000,000

Source: World Resources Institute. 2007. "EarthTrends: Environmental Information," http://earthtrends.wri.org. Population data is from 2002. Energy and emissions data are from 1999 and 2000.

* Energy use reported in metric tons of oil equivalent. One ton of oil equivalent = 10^7 kilocalories, 41.868 gigajoules, or 11,628 GWh.

** CO_2 emissions reported in metric tons of CO_2.

*** Industrial/Commercial sector includes energy use from industry, commercial and public services, and agriculture.

1 To determine percent of world energy use for each country, divide total world energy use by energy use for that country and multiply by 100.

2 To determine per capita (per-person) energy use, divide total energy use by population for each country.

3 To determine per capita CO_2 emissions, divide total CO_2 emissions by population for each country.

Assessing Energy Possibilities

GROUP MEMBERS ______________________________

COUNTRY ______________ ENERGY SECTOR ______________

Your sector's energy use per year ________ CO_2 emissions per year ________

1. Look at the number for per capita energy use in your country. Does this number mean that every person in your country uses this amount of energy?

2. What types of activities or items use energy in your sector?

3. Do you think people in your sector can have an important impact on reducing energy use in your country? Why or why not?

4. What are some ideas for reducing the amount of **energy used** in this sector in your country?

5. What are some ideas for reducing the level of **CO_2 emissions** for your sector and country? Are there ways to use energy that would produce lower CO_2 emissions?

6. What might be some obstacles to making these changes in your sector and country, and what are some ideas for overcoming these obstacles?

What Is Climate and How Is It Changing?

Photo by Jesse Stanley

Student Reading 1

You have probably seen or heard the term **climate change** in numerous places, from magazines to movies, at school, and at home. Everyone is talking about it. But what exactly is climate change, and how does it relate to our lives?

Climate change refers to any change in climate over time, whether due to natural factors (such as

Exit Glacier in Alaska has receded significantly in the last century. *Photo by Jesse Stanley*

> Eating foods that are grown closer to home can reduce greenhouse gas emissions from transporting food long distances.

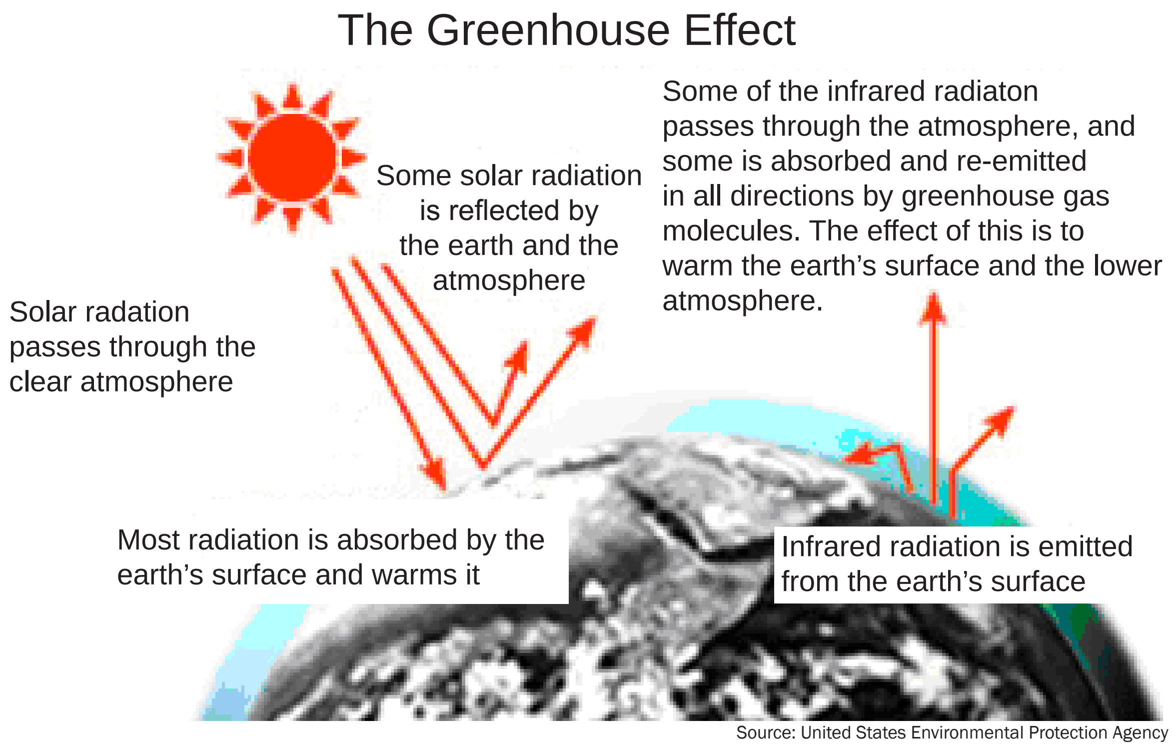
volcanic eruptions) or human activities. Climate is average weather (including temperature, precipitation, and wind) over a period of time (from months to millions of years).[1] When we examine weather over many years, climate patterns emerge. Weather events not only make up climate, but they can also be affected by changes to the climate.

Earth's Greenhouse Effect

To study climate change, we need to understand Earth's **greenhouse effect**. The greenhouse effect is an important phenomenon that makes conditions on Earth suitable for life; without it Earth would be a much colder planet. Some of the sun's radiation that reaches Earth's surface is absorbed by the earth, but some of it is reflected back into space by clouds, air particles, snow, ice, and deserts. When reflected back, the radiation changes into infrared radiation (or heat). Certain gases in Earth's **atmosphere** act like a blanket to retain (and reflect back down to the earth) much of this infrared radiation, making surface temperatures on Earth about 34°C (61°F) warmer than they would be otherwise.[2]

Some **greenhouse gases** occur naturally, and some are man-made. Water vapor is a greenhouse gas that occurs naturally, as a result of Earth's water cycle. Other greenhouse gases such as chlorofluorocarbons (CFCs) are manufactured entirely by humans.

Many greenhouse gases that occur naturally are also released through human activities. For example, carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) are all cycled through Earth's atmosphere during processes that occur in nature. Carbon dioxide is released by all living things, nitrous oxide is released by organisms in the soil, and methane is a natural byproduct of decomposition. Human activities such as burning **fossil fuels** (when we drive gasoline-powered cars, for example) in-



crease the amounts of these gases in Earth's atmosphere, affecting the balance of natural cycles.

Scientists who study climate change often focus on carbon dioxide because the concentration of CO_2 in the atmosphere is greater than any other greenhouse gas, excluding water vapor. CO_2 accounts for 74% of global greenhouse gas emissions from human activities.[3] CO_2 can remain in the atmosphere for up to 200 years.[4]

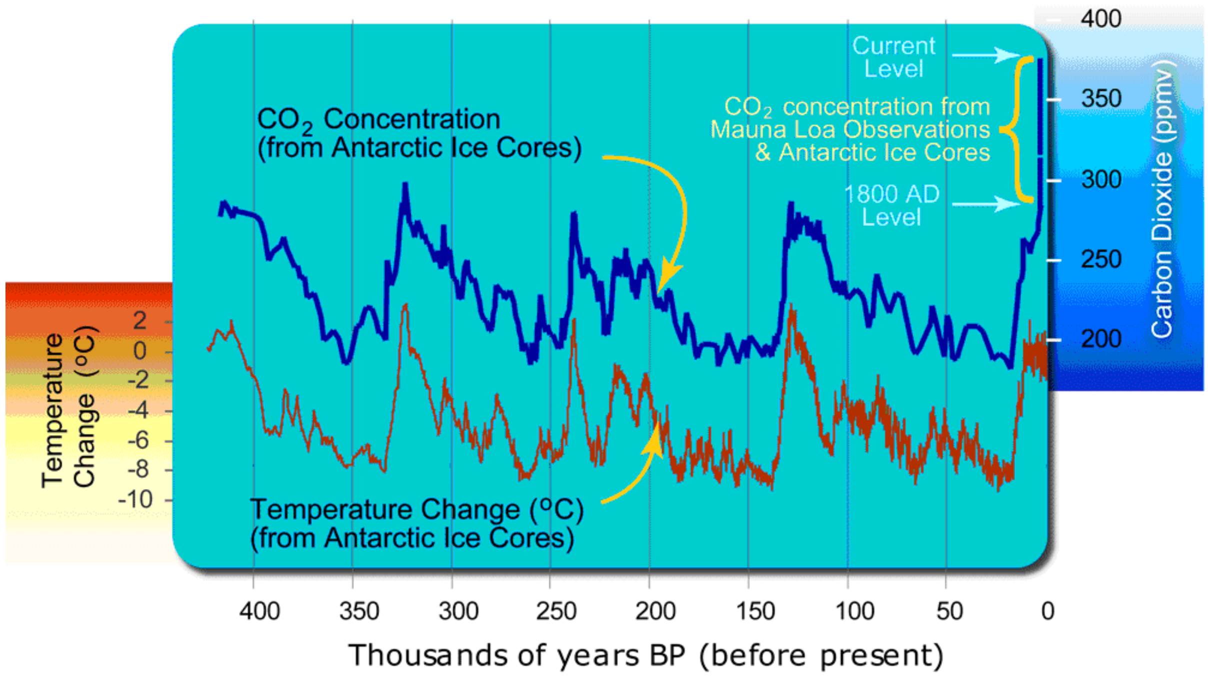
CO_2 levels in the atmosphere have continued to rise since 1750. Because this increase coincides with industrial activities (manufacturing, processing, and transporting goods), many experts attribute the increased CO_2 to humans. The Intergovernmental Panel on Climate Change estimates that CO_2 levels have increased by about 35% during the industrial era, primarily due to deforestation and consumption of fossil fuels.[5]

Carbon Sources and Sinks

Carbon is one of the two elements that make up carbon dioxide (the other is oxygen). Many processes are **carbon sources** that add CO_2 to the atmosphere by emitting more carbon to the atmosphere than they absorb. Carbon sources include burning fossil fuels (coal, petroleum oil, natural gas), deforestation, and agricultural processes, such as tilling soil and raising livestock. Many industrial/manufacturing processes, such as making cement, steel, and agricultural fertilizers, are also carbon sources.[6]

Certain places called **carbon sinks** can retain carbon for a long time, keeping it out of the atmosphere. They tend to absorb more CO_2 than they emit. Forests, oceans, and soil are currently the main carbon sinks on Earth.

We can alter the ability of carbon sinks to retain carbon. For example, when we remove trees from a forest or till soil, the carbon they have been holding is released into



Data Source C02: ftp://cdiac.ornl.gov/pub/trends/co2/vostok.icecore.co2

Data Source Temp: http://cdiac.esd.ornl.gov/ftp/trends/temp/vostok/vostok.1999.temp.dat

Graphic by Michael Ernst, The Woods Hole Research Center

the atmosphere as CO_2. Fossil fuels can also be considered carbon sinks because CO_2 is locked inside them for thousands of years. It is only when we burn them for energy that they release CO_2.

Measuring Carbon Dioxide and Temperature Trends

Historic levels of atmospheric CO_2 can be measured by analyzing ice cores. Tiny gas bubbles trapped deep in the ice provide evidence of many gases present in Earth's atmosphere thousands of years ago. One dataset, from ice cores at the Russian Vostok research station in East Antarctica, has allowed scientists to determine CO_2 levels from over 400,000 years ago.[7]

A much shorter and more recent dataset has been obtained in a different manner, by sampling air from atop a volcano. The world's most complete and continuous CO_2 record has been collected since the 1950s at an observatory near the summit of the Mauna Loa Volcano in the U.S. state of Hawaii.[8] Because this volcano is far from many human activities (a carbon source) and vegetation (a carbon sink), it is an ideal site for accurately measuring CO_2.

Carbon dioxide trends from the Vostok ice cores show that atmospheric CO_2 concentrations have risen faster during the past two centuries than at any time in the preceding 400,000 years.[9] The ice cores reveal a strong link between CO_2 concentrations and temperature changes on Earth. CO2 concentrations measured at Mauna Loa also indicate a steep increase over the past 50 years.

The increasing CO_2 concentrations have numerous documented consequences. Eleven years between 1995 and 2006 are among the twelve hottest years recorded since 1850, when global surface temperatures were first recorded by instruments. Warming air and ocean temperatures have caused snow and ice to melt. Melting glaciers and

The Spirit Lake Community School District in Iowa powers it buildings by using wind turbines. *Photo from Spirit Lake Community School District*

snow have led to sea level rise, resulting in decreased salinity of oceans. Oceans have become more acidic due to increased CO_2 levels. Wind and precipitation patterns have changed in many regions during the past century, resulting in increased rainfall in some places and droughts in others.[10]

Where Do We Fit In?

The exact amount of climate change that can be attributed to human actions is not clear. However, it is clear that increasing greenhouse gas emissions result in warmer global temperatures and that human activities emit greenhouse gases. While climate change may not be due solely to human activities, it is very likely that the changes observed during the past 50 years are not due to natural causes alone.[11]

Is it too late to become part of the solution? No--we already have the knowledge and technology to start making positive changes. For example, a change in lifestyle (consuming fewer resources, conserving energy, reducing travel, etc.) can help mitigate climate change.[12] Switching from fossil fuels to sources of clean, renewable energy sources like wind and solar can reduce greenhouse gas emissions. Even how we eat can make a difference. Eating foods that are grown closer to home can reduce greenhouse gas emissions from transporting food long distances.[13]

Schools, organizations, businesses, cities, and governments around the world are taking steps to respond to the challenges of climate change. These groups are all made up of individuals like you. For better or worse, your actions can have an impact far beyond your own life. You can start making positive changes today to reduce your impact on our climate.

Vocabulary

atmosphere—a layer of gases, including nitrogen, oxygen, and carbon dioxide, surrounding the Earth

carbon sink—a place (ecosystem) or organism that can store carbon for long periods of time; examples include oceans, plants, and other organisms that use carbon dioxide from the atmosphere during photosynthesis

carbon source—anything that adds carbon to the atmosphere by emitting more carbon than it absorbs

climate change – any variation in global or regional long-term weather patterns

fossil fuels—energy sources such as petroleum, coal, and natural gas that are produced by the decomposition of ancient plants and animals

greenhouse effect – process by which gases in Earth's atmosphere retain infrared radiation (heat) from the sun to warm the earth's surface

greenhouse gas—any gas in the atmosphere capable of absorbing infrared radiation (or heat) reflected from the earth's surface

Checking for Understanding

1. How is carbon dioxide related to climate change? Include a discussion of the greenhouse effect in your explanation.
2. List three activities that you did today (or things that you used) that emitted greenhouse gases.
3. List three specific ways that you can personally reduce greenhouse gas emissions.
4. Imagine yourself 50 years from now. What do you want the earth to look like in 50 years?
5. What are some steps you can take now to ensure your vision of the future?

[1]H. Le Treut, et al., "Historical Overview of Climate Change Science," in Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, ed. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller (Cambridge, UK: Cambridge University Press, 2007), 93-128. http://ipcc-wg1.ucar.edu/wg1/wg1-report.html.

[2]Ibid.

[3]U.S. Environmental Protection Agency. 2007. "Global Greenhouse Gas Data," http://www.epa.gov/climatechange/emissions/globalghg.html.

[4]IPCC, "Technical Summary," in Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, ed. J. T. Houghton, Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden and D. Xiaosu (Cambridge, UK: Cambridge University Press, 2001), 21-83. http://www.ipcc.ch/pub/wg1TARtechsum.pdf.

[5]H. Le Treut, et al.

[6]U.S. Environmental Protection Agency. 2007. "Human-Related Sources and Sinks of Carbon Dioxide," http://www.epa.gov/climatechange/emissions/co2_human.html.

[7]See Vostok Ice Core Data on the National Oceanic and Atmospheric Administration's website: http://www.ncdc.noaa.gov/paleo/icecore/antarctica/vostok/vostok.html.

[8]See Mauna Loa Observatory data on the National Oceanic and Atmospheric Administration's website: http://www.mlo.noaa.gov/home.html.

[9]Woods Hole Research Center, The Warming of the Earth, http://www.whrc.org/resources/online_publications/warming_earth/index.htm (accessed September 23, 2007).

[10]IPCC, "Summary for Policymakers," in Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, ed. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H. L. Miller (Cambridge, UK: Cambridge University Press, 2007), 1-18. http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_SPM.pdf.

[11]Ibid.

[12]IPCC, "Summary for Policymakers," in Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, ed. B. Metz, O. R. Davidson, P. R. Bosch, R. Dave, and L. A. Meyer (Cambridge, UK: Cambridge University Press, 2007), 1-23. http://www.mnp.nl/ipcc/pages_media/FAR4docs/final_pdfs_ar4/SPM.pdf.

[13]Paul Rauber, "Decoder: Miles to Go Before You Eat," Sierra Magazine, May 31, 2006. www.sierraclub.org/sierra/200605/decoder.asp

What Size Is Your Footprint?

Student Reading 2

Organizing a walk to school day is a fun way to reduce your carbon footprint and get others involved. *Photo from the National Center for Safe Routes to School, the coordinating agency for Walk to School events in the USA*

A carbon footprint is one way to measure your impact on the climate. It is an indicator of the amount of **greenhouse gases** your activities produce. It is often measured in pounds of carbon dioxide (CO_2) emissions. We call it a footprint because it's like the mark you leave on the earth as you go about your daily activities. When you walk

> It takes less energy to make an aluminum can, plastic bottle, or piece of paper from recycled materials than from raw materials.

Recycling uses less energy than creating new items from raw materials. *Photo by Gilda Wheeler*

on a sandy beach, you leave behind a footprint. When you participate in an activity or use an item that emits greenhouse gases, you leave behind a **carbon footprint**.

Parts of a Footprint

Two major components of your footprint are transportation and electricity. We need energy for all of our daily activities, but transportation and electricity require the largest amounts of energy. We often rely on fossil fuels as energy sources. Fossils fuels emit greenhouse gases when burned to produce energy. Because increasing greenhouse gas emissions affect climate, our energy use can have a huge impact on the climate.

Think about all the things you do in the morning before you even leave your home. You may turn off your alarm clock, turn on the light, take a hot shower, get orange juice from the refrigerator, heat up a frozen sausage biscuit in the microwave, or make toast. All of those things require electricity.

In many places, our electricity is generated by burning fossil fuels such as coal, natural gas, propane, or heating oil. Greenhouse gases like carbon dioxide (hear that carbon word in there?) warm the planet and are released every time we use electricity that was created by burning fossil fuels.

How about the juice, sausage, and toast you might have eaten for breakfast? Most of us don't have orange trees, cattle ranches, or wheat fields in our yards. Our food is produced somewhere else. Modern food production usually requires fertilizers. Creating nitrogen fertilizers produces nitrous oxide (N_2O), another greenhouse gas. Tilling soil to plant crops like wheat also releases N_2O. (Thankfully, many crops can be planted without much tillage or fertilizers.) The meat for the sausage requires livestock such as pigs or cows. Raising livestock produces large amounts of methane (CH_4), another greenhouse gas, from livestock waste and gas.

Whenever our food is produced elsewhere, it has to be transported to us. Carbon dioxide (CO_2) and other greenhouse gases are released any time we use gasoline or diesel for transportation, including driving the farm equipment and taking the harvested crops or livestock to a market. When we eat processed foods (like that frozen sausage biscuit), we are contributing to the release of more greenhouse gases because even more energy is used to transport ingredients from one stage of production to another. And then there's all the packaging for our food. Much of it is made of plastic, and fossil fuels are required to make plastic.

There are other components of a carbon footprint that we often forget about. Many things that we use require energy to produce. For example, making a polyester shirt takes many steps. The polyester began as petroleum, perhaps drilled off the coast of Nigeria. The petroleum was transported to another country, where it was refined into usable compounds, and then processed in a third country into a material that can be used to make cloth.[1] Each step required energy for transportation and electricity.

	Small Foot	Big Foot
Food	fruits, vegetables, grains, some meat	lots of processed foods and meat
Travel	by bicycle and bus	mostly by car
Home	apartment with energy-efficient appliances	large 4-bedroom house with a lawn
Hobby	riding a skateboard	playing games on the computer
Recycle?	everything	nothing
Carbon Footprint	3 tons of CO_2 per year	8 tons of CO_2 per year

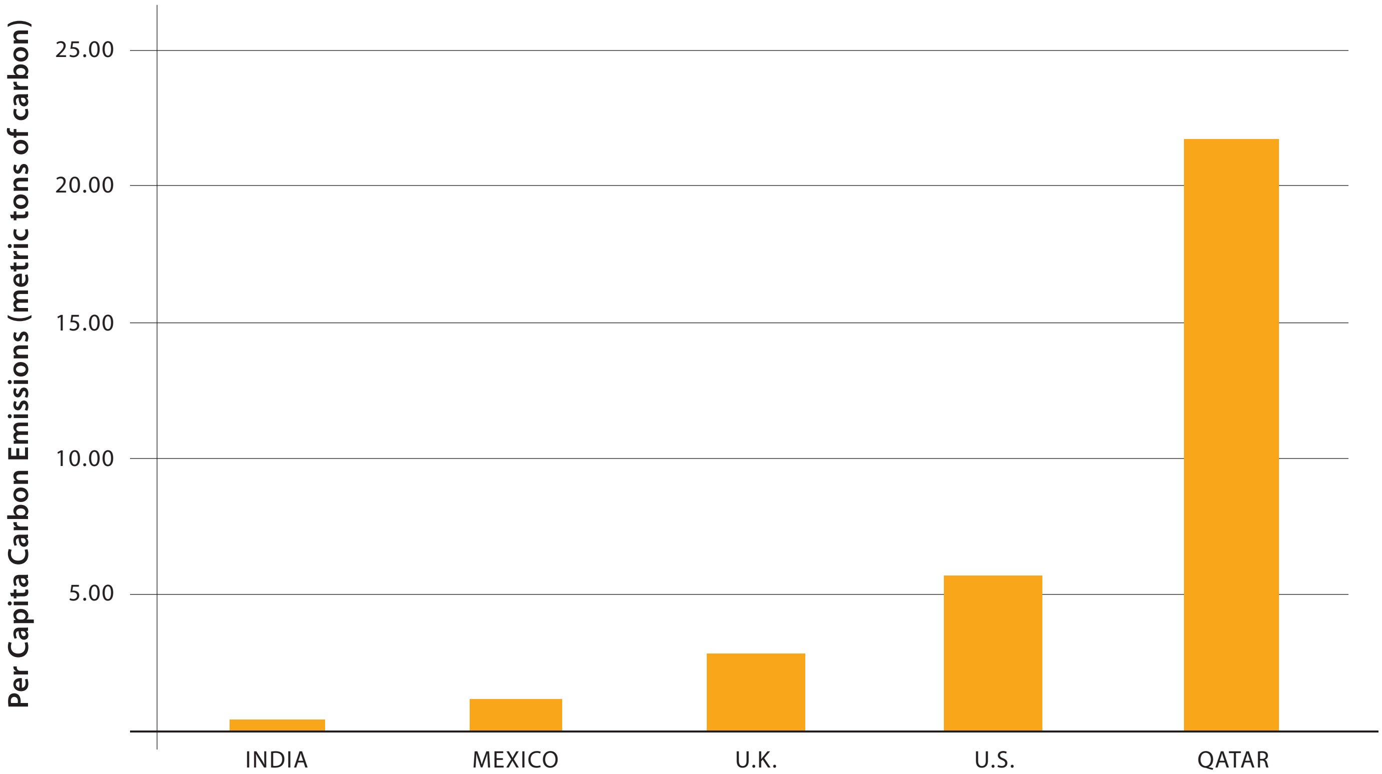
Footprints around the World

High-income countries have a higher per capita footprint due to CO_2 from fossil fuels. Just to name a few, the United Arab Emirates (a country that borders Saudi Arabia), Kuwait, and the United States all release large amounts of CO_2 per person from fossil fuel use. Low-income countries tend to have much smaller carbon footprints. For example, several countries in Africa and South America have almost zero per capita CO_2 emissions from fossil fuel use.[2] Their primary energy source is burning biomass (living material), such as wood and animal manure.

Shrinking Your Footprint

Does all of this information mean you should make your own clothes, sell your family car, and grow all of your own food? Not necessarily. However, by being aware of the impacts created by the choices you make every day, you can better choose how big your carbon footprint will be. Think of that sandy beach. You could tiptoe and leave a small footprint, or take big, heavy steps and really leave your mark.

Per Capita Carbon Emissions from Selected Countries



Carbon emissions vary widely by country. Shown are per capita emissions by country. Total carbon emissions for a country, however, can be quite different. For example, India has the fourth highest total carbon emissions in the world, but India's per capita emissions are ranked 129th in the world![3]

What are some things you can do to shrink your carbon footprint? Well, for starters you can think twice about the things you do and use every day. Here are some examples of how you can conserve energy and emit less CO_2:[4]

- Turn off lights, appliances, and electronics when you're not using them.
- Travel on foot, by bicycle, or on public transportation when you can.
- Eat fewer processed foods and less meat.
- Eat more organically grown and more locally grown food.

You can also do things on your school campus to reduce your carbon footprint. Here are a few ideas to get started:[5]

- **Reduce energy use.** Help your school save money and energy by doing an energy audit and finding ways to reduce energy use. Using natural daylight saves energy and improves the learning environment.
- **Reuse.** Buy used instead of new. Not only will it save you money; it cuts down on the energy that would have gone into making another book, CD, shirt, or gizmo.
- **Recycle.** It takes less energy to make an aluminum can, plastic bottle, or piece of paper from recycled materials than from raw materials.
- **Walk to school.** Organize a walk to school day[6] or create a walking school bus.[7]
- **Out with gray. In with green!** Replace concrete and asphalt at school with plants and trees that absorb CO_2.

Shrinking your carbon footprint doesn't need to be painful. When you shrink your carbon footprint, you're not just giving things up. You're getting a lot, too. Not only are you helping to stabilize climate change for current and future generations, you are also working to improve your own **quality of life**. Quality of life is all about making choices that you feel good about.

Another part of quality of life is the impact your choices have on you and other people. Let's take that polyester shirt as an example. It may be that you can afford the new shirt (and it does look good), but you realize that you could find similar shirts at a vintage or used clothing store, pocket the change, and have money left over to buy yourself some tasty snacks for the ride home. Nicely done. You've reduced your carbon footprint a bit because that new shirt is still hanging on the rack. You're not done though. What about those snacks? Where were they made, and how much packaging do they come in? Could you buy something that was made closer to home and that comes with less packaging?

It's your quality of life. It's your carbon footprint. But the carbon affects us all.

Vocabulary

carbon footprint—a measure of humanity's impact on Earth's climate through activities that emit greenhouse gases; usually reported as weight of carbon dioxide emitted

greenhouse gas—any gas in the atmosphere capable of absorbing infrared radiation (or heat) reflected from the earth's surface

quality of life—the level of well-being and physical conditions in which people live

Checking for Understanding

1. Explain why you think carbon footprints for high- and low-income countries are so different.
2. Name three benefits to you and your family from reducing your carbon footprint.
3. What is one way you can reduce your footprint today, with little or no effort?
4. What, if anything, is stopping you from making this footprint reduction? How can you overcome this obstacle?

[1] Ryan, John C. and Alan Thein Durning, Stuff: The Secret Lives of Everyday Things (Seattle: Northwest Environment Watch, 1997).
[2] WWF, Living Planet Report 2006 (Gland, Switzerland: WWF - World Wide Fund For Nature, 2006). http://www.panda.org/livingplanet.
[3] G. Marland, T. Boden, and B. Andres, Oak Ridge National Laboratory, 2004. http://cdiac.ornl.gov/trends/emis/top2004.tot and http://cdiac.ornl.gov/trends/emis/top2004.cap
[4] Guy Dauncey and Patrick Mazza, Stormy Weather: 101 Solutions to Global Climate Change (Gabriola Island, BC: New Society Publishers, 2001).
[5] Ibid.
[6] Learn more about International Walk to School at: http://www.iwalktoschool.org.
[7] Learn more at: http://www.walkingschoolbus.org.

Save Your Energy!

Student Reading 3

It takes many kinds of energy to fuel our lives. We use energy from the food we eat to power our daily activities. We also use different sources of energy to transport us, to heat and cool our homes, and to power our computers and televisions. In many cases, this energy use emits greenhouse gases that contribute to climate change.

When people work together like these Earth Day volunteers, they can have a large impact. *Photo by Jesse Stanley*

Getting Around

Transportation is a major source of greenhouse gas emissions, generating 17% of worldwide carbon dioxide (CO_2) emissions.[1] Gasoline, diesel fuel, and jet fuel – all of which are typically derived from **fossil fuels**—account for almost all the energy consumed for transportation. Gasoline-powered cars release CO_2 and nitrous oxide (N_2O), along with other air pollutants. These emissions are commonly called "tail-pipe emissions."

There are over 605 million passenger cars on the road in the world, and car production shows no sign of slowing down.[2] The vast majority of these cars are fueled by gasoline or diesel, both of which are typically derived from petroleum. Burning a single gallon of gasoline emits 20 pounds of CO_2.[3] A light-weight vehicle in the United States, like a four-door sedan, emits 54 tons of CO_2 during its lifetime.[4] Larger, heavier cars, such as full-size SUVs, produce even more CO_2 because they use more gasoline.

Many technologies are available that can reduce tailpipe emissions. A variety of alternative fuel sources have been developed to reduce dependence on fossil fuels. For example, gasoline-electric hybrid cars rely partially on a gasoline engine and partially on an electric motor. Biodiesel is a fuel created from vegetable oil; it can be used as an alternative to petroleum-based diesel. Ethanol is an alcohol made from grain or other plant material. It can be mixed with gasoline to create a fuel that produces less CO_2 when burned.

Unfortunately, some of these "fixes" have their own problems. In some cases, hybrid technology is being used to increase horsepower and acceleration without saving much fuel.[5] Also, making ethanol may require more energy than we get out of it![6] In the U.S., simply raising automobile fuel efficiency standards (getting more miles per gallon of gasoline) would make a major contribution to meeting energy needs while mitigating climate change.[7]

> Transportation is a major source of greenhouse gas emissions, producing 17% of worldwide carbon dioxide (CO_2) emissions.

Biodiesel derived from vegetable oil can be used to power cars and buses, like this one.
Photo by Stanford Berryman

Of course, we can always drive less to reduce CO_2 emissions from transportation. Many people around the world are using public transportation and biking where they need to go. Bicycle production and use is on the rise. Some cities like Arcata, California, in the U. S., and Lyon, France, have communal bikes that can be used by citizens for a fee.[8]

Staying Inside

Another major use of energy is for heating and cooling buildings where we live, work, and go to school. Electricity, heating oil, and natural gas are commonly used to heat buildings and cook food. Firewood or other burning **biomass** (plant or animal matter) is also used for heating and cooking. Burning fossil fuels like natural gas and heating oil, as well as burning biomass, all produce greenhouse gas emissions, including carbon dioxide (CO_2). Some air conditioners and refrigerators use hydrochlorofluorocarbons (HCFCs), a group of potent synthetic greenhouse gases.

We use electricity to power appliances and electronics, and to light buildings and streets. Electricity can come from **renewable energy** sources like the sun, wind, and water. However, it is often produced by burning coal in large power plants. Energy from burning coal often travels long distances through wires to homes, schools, and businesses. Coal-burning power plants are a major source of CO_2 emissions.

The good news is that there are already many technologies available to reduce the climate impacts from heating, cooling, and providing electricity. According to scientists at Princeton University, we can stabilize CO_2 emissions at current levels (currently 7 billion tons of CO_2 are emitted every year) by using things we already know about.[9] We can rely more on energy sources like solar and wind power that don't contribute greatly to greenhouse gas emissions.

Of all approaches to reducing greenhouse gas emissions, energy **conservation** is the easiest and least expensive. Increasing insulation (which keeps inside air warmer in the

Electricity can be generated from renewable energy sources. Solar energy is captured by rooftop solar panels. Energy from flowing water is captured by hydroelectric dams.

winter and cooler in the summer) and using energy-efficient appliances (which do the same amount of work using less energy) can help to reduce our emissions.

Did you know that 5% or more of your home's electricity is "leaked" from appliances and other electronics that are turned off but still plugged in?[10] When you turn your TV off, it's actually still using electricity as long as it is still plugged in. You can start conserving energy today just by unplugging the electronics you aren't using.

Turning the thermostat down 1°F during the day and 10°F at night can save 811 pounds of CO_2 from being emitted in one year for a 1,600 square-foot house. You can save another 718 pounds of CO_2 in a year simply by replacing four incandescent light bulbs with compact fluorescent light bulbs, which last for up to 10 years and use 75% less energy than incandescent bulbs.[11] Conservation not only saves energy and reduces human impacts on the climate, but it also saves money!

Consumer Demand

It is important for consumers to be aware of different options for increasing energy efficiency through programs to label products and implement efficiency standards. By being informed and demanding more efficient, climate-friendly products when you go shopping, consumers like you will influence manufacturers to care more about their effects on the climate.

There are plenty of examples of consumer-driven solutions to climate change. For example, Toyota has expanded production of the hybrid Prius due to consumer demand for fuel-efficient cars. BP, historically a petroleum distributor, is researching and developing fuels such as biofuels and hydrogen power that can help consumers reduce their carbon footprint. Electronics giant Hewlett-Packard is using renewable energy sources and investing in green power, as well as partnering with groups like the World Wildlife Fund (WWF) to find ways to reduce our contributions to climate change.

You Are Not Alone

You may not think that your actions alone can make a difference. Think of one, simple thing that you could do today. Now, what if everyone in your school worked together to reduce CO_2 emissions from energy use? What if schools around your country joined in the effort? And what if your efforts were joined by people all around the world? It could have a huge impact on our climate, and that's a good thing!

Vocabulary

biomass—living and recently dead biological material or biodegradable waste that can be used as fuel; examples include wood, grains, and grasses

conservation—protection, preservation, management, or restoration of wildlife and natural resources

fossil fuels—energy sources, such as petroleum, coal, and natural gas that are produced by the decomposition of ancient plants and animals

renewable energy—energy derived from sources that are naturally replenished as they are used, such as sunlight, wind, water, and geothermal heat

Checking for Understanding

1. What are some ideas for reducing greenhouse gas emissions from transportation?
2. What are some ways to reduce greenhouse gas emissions in our homes and schools?
3. Which of these ideas do you think could contribute the most to mitigating climate change? Why do you think it would have the largest impact? Will it be easy or difficult to implement, and why?
4. Why might it be difficult for everyone to buy energy-efficient appliances or hybrid cars?
5. What actions can *everyone* take to reduce greenhouse gas emissions?

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[3] U.S. Energy Information Administration, “Voluntary Reporting of Greenhouse Gases Program: Fuel and Energy Source Codes and Emission Coefficients,” http://www.eia.doe.gov/oiaf/1605/coefficients.html (accessed September 24, 2007).

[4] Jeffrey Langholz and Kelly Turner, You Can Prevent Global Warming (and Save Money!): 51 Easy Ways (Kansas City, MO: Andrews McMeel Publishing, 2003).

[5] Matthew Wald, “Hybrid Cars Burn Gas in the Drive for Power,” New York Times, July 17, 2005.

[6] Susan Lang, “Cornell Ecologist’s Study Finds that Producing Ethanol and Biodiesel from Corn and Other Crops is Not Worth the Energy,” Cornell University News Service, July 5, 2005.

[7] World Resources Institute, “Climate Change and Energy Security Impacts and Tradeoffs in 2025,” May 11, 2007. http://www.wri.org/climate/topic_content.cfm?cid=4368

[8] Gary Gardner, “Bicycle Production Up,” in Vital Signs 2006-2007, Worldwatch Institute (New York: W. W. Norton & Company, 2006), 66-7.

[9] Robert Socolow and Stephen Pacala, “A Plan to Keep Carbon in Check,” Scientific American, September 2006, 50-7.

[10] Michael Woods, “Pulling the Plug on Electricity Leaks,” Pittsburg Post-Gazette, May 8, 2005.

[11] Langholz and Turner.

Climate Justice

Student Reading 4

Just as climate change does not affect all places in the same way, it does not affect all people in the same way either. Many environmental hazards, such as water pollution and drought, impact the lives of poorer people to a greater degree. Climate change is no exception. The world's poorest people are likely to be the ones most affected by climate change.

Poor communities are disproportionately affected because they often rely heavily on resources such as local water and food, which are vulnerable to the impacts of climate change. They tend to have less access to resources from elsewhere and a reduced ability to cope with or adapt to climate change. Climate change can intensify existing stresses on low-income populations, such as population growth, poverty, improper land use, and pollution.

The irony of the disproportionately large effect of climate change on **developing countries** is that they contribute the least to climate change on a per person basis. Low-income populations typically have smaller carbon footprints than wealthier populations. They consume fewer manufactured goods and use less energy for home and travel.[1]

Health Effects

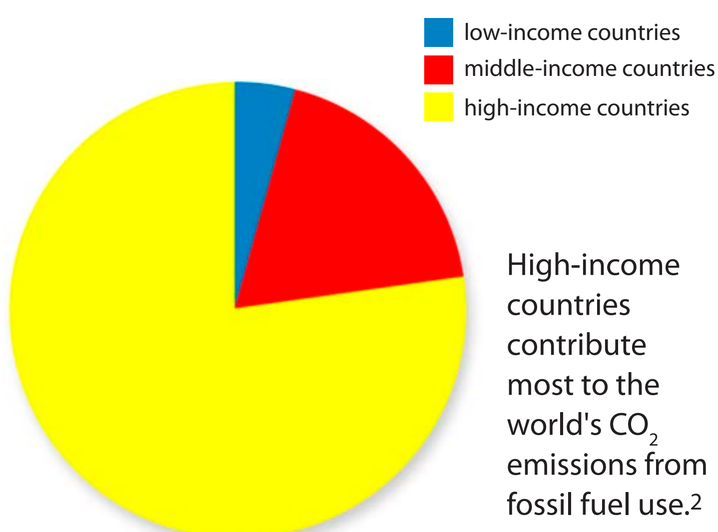
According to the Intergovernmental Panel on Climate Change (IPCC), climate change is already contributing to diseases and premature deaths. Negative effects of climate change on human health disproportionately affect low-income countries. Certain subsets of low-income populations, such as children and elderly persons, are most susceptible to climate change impacts.[3] The World Health Organization estimates that the 150,000 deaths per year currently attributed to climate change will double by 2030.[4]

Malnutrition poses a major risk to health. The primary cause of malnutrition is lack of availability of staple foods.[5] Climate change may affect food production by causing water scarcity, salinization of soils, increased frequency and/or intensity of storms and floods, and increased numbers of pests and plant diseases.[6] Climate change may exacerbate difficult crop growing conditions in arid regions of Africa and other environmentally sensitive areas. Small farmers and fishermen and the urban poor will be most impacted.

Diarrheal diseases, which can cause dehydration and death, are especially common in developing countries. (Developing countries are defined as those with a per person annual income of $6000 or less.) Diarrhea is often caused by bacteria and protozoans, which can thrive in warmer temperatures. Temperature increases in Peru and Fiji have led to reported increases in diarrhea.[7]

There are many other ways that climate change may impact human health. For

World Carbon Dioxide Emissions from Fossil Fuels



High-income countries contribute most to the world's CO_2 emissions from fossil fuel use.[2]

Hurricane Katrina flooded New Orleans, forcing thousands of people to leave their homes

Poor communities are often greatly impacted by environmental changes. *Photo by Kim Rakow Bernier*

example, an increase in infectious and vector-borne diseases, such as malaria, has been observed in countries such as Panama, Bolivia, and India. Injury and death due to heat waves and droughts have also been observed in many places.[8]

Human Migration

In addition to health effects, some people are becoming "environmental refugees," displaced from their homes due to environmental changes. Many gradual environmental changes have been linked to climate change. **Desertification**, reduced freshwater availability, and rising sea levels can all force people to leave their homes.[9]

Some island nations have experienced internal migrations due to environmental factors. People in Kiribati, the Maldives, Tuvalu, and the Solomon Islands have moved from low-lying islands to neighboring islands that are farther above sea level. As sea levels rise, further migration to higher lands may occur.[10]

"Climate refugees," as they are sometimes called, are not always people from developing or small island nations. During the last 35 years, hurricane frequency and intensity has increased, possibly due to warmer global temperatures.[11] It is estimated that 250,000 people in the United States became climate refugees in 2005 after Hurricane Katrina forced them from their homes.[12] Now that approximately half of the world's population lives in coastal areas, more people may become climate refugees as hurricane activity increases.

Adaptation Strategies

Many strategies have been suggested, and some have already been implemented, to adapt to climate change. Slowing population growth can mitigate effects of climate change. Changes in cropping patterns, such as planting earlier in the season and planting crops better adapted to new climate conditions, is another adaptation strategy.[13] Some communities, especially those in low-lying areas, may adapt by migrating to a more favorable environment.[14] Numerous other adaptation strategies will emerge as populations face the diverse effects of climate change.

Vocabulary

desertification—the onset of desert-like conditions, including reduced groundwater and vegetation

developing countries—countries with a low per person income

justice—the fair and moral treatment of all persons

malnutrition—the condition of lacking proper nutrients for normal body functioning

Checking for Understanding

1. Why do you think malnutrition is considered by the World Health Organization (WHO) to be the most important factor affecting human health? What additional problems could result from large numbers of people becoming malnourished?
2. Name some consequences (including economic, social, or environmental consequences) that might result from increased migration due to rising sea levels and changing environmental conditions.
3. Why do you think slowing population growth has been suggested as one way to reduce the impacts of climate change on human populations? What are some humane ways to reduce population growth?
4. While many communities are finding ways to adapt to climate change, we can all be proactive in preventing future climate change. In what ways can populations especially vulnerable to climate change prepare for increasing temperatures, rising sea levels, and other effects of climate change?

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[3]U. Confalonieri, et al., 2007, "Human Health," in Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, ed. M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson (Cambridge, UK: Cambridge University Press, 2007), 391-431. http://www.ipcc-wg2.org/.
[4]Christine Gorman, "How It Affects Your Health," Time, April 3, 2006.
[5]D. H. Campbell-Lendrum, C. F. Corvalan, and A. Pruss-Ustun, "How much disease could climate change cause?" in Climate Change and Human Health: Risks and Responses (Geneva: World Health Organization, 2003), 133-158.
[6]U. Confalonieri, et al.
[7]D. H. Campbell-Lendrum, et al.
[8]U. Confalonieri, et al.
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What's Happening Out There?

Student Reading 5

Seattle Mayor Greg Nickels launched the U.S. Mayors' Climate Protection Agreement. *Photo courtesy of the City of Seattle.*

Before you start to feel overwhelmed about our rapidly changing climate, first learn more about what is being done to combat climate change. Each one of us can take positive steps to slowing climate change on Earth, and many people have already begun to work together to make positive changes. Whether undertaken by business

> A good way to get involved in local, national, and even international efforts to address climate change is to learn more about the issues and to contact government representatives with your concerns and ideas

owners, mayors, members of a citizen's group, or United Nations representatives, efforts at local, national, and international levels have begun to stabilize our climate and reduce the impacts of climate change on citizens. By collaborating with people all over the globe, we can have a much greater impact than we can alone.

As you read these examples of groups taking action on climate change, don't forget that you can join their efforts to be part of the solution!

International Collaboration

The most famous international initiative addressing global climate change is the Kyoto Protocol.[1] The Protocol was officially adopted December 11, 1997, in Kyoto, Japan. To date, 175 nations have ratified the document, pledging to abide by its targets for reducing greenhouse gas emissions. The Protocol calls for a reduction in greenhouse gas emissions to at least 5% below 1990 levels, to be completed during the period 2008-2012.

The Kyoto Protocol outlines a number of ways to cut greenhouse gas emissions. Some of these include:

- Increasing energy efficiency—getting more energy from less fuel
- Preserving and enhancing carbon sinks (for example, oceans and forests)
- Promoting sustainable forestry—harvesting trees in such a way that forests continue to thrive
- Promoting sustainable agriculture—reducing soil tillage and water use
- Developing renewable energy sources (for example, solar, wind, and geothermal power)
- Reducing subsidies for greenhouse gas-emitting activities—making it less economically advantageous to pollute
- Limiting greenhouse gases from transportation – reducing emissions from cars, airplanes, and other means of transportation

The Kyoto Protocol promotes the use of sustainable agricultural methods and the protection of forests. *Photos by Laura Skelton*

Unfortunately, the Kyoto Protocol itself is not able to stop climate change, but it can certainly help to slow the rate of climate change. Some of the world's largest greenhouse gas producers have not agreed to meet the emissions reductions outlined in the Kyoto Protocol. Others who signed the Protocol may not actually be able to meet its goals. Even if all countries agreed to work toward the goals of the Protocol, greenhouse gas emissions would still be increasing. That's why it's important to take action at a national and local level, as well.

Local Adaptation

Local entities, such as cities and states, are not officially part of the Kyoto Protocol. However, some local governments have opted to meet Kyoto targets themselves. In 2005, Greg Nickels, the mayor of Seattle, Washington, launched the U.S. Mayors' Climate Protection Agreement. Hundreds of U.S. mayors have since signed on to the agreement, pledging to meet Kyoto targets for greenhouse gas emissions in their own communities.[2] Citizens can urge their local government to join this effort by visiting the Cool Cities website: http://coolcities.us.

Other local climate change agreements have emerged in the U.S. and abroad. Several western U.S. states and Canadian provinces have joined the Western Climate Initiative, which aims to reduce greenhouse gas emissions to 15% below 2005 levels by 2020.[3] In the UK, the government of London has launched the London Climate Change Partnership. This group of more than 30 organizations is "helping London prepare for the impacts of climate change."[4] Many other groups around the world are working to mitigate and adapt to climate change in their local communities.

Strategies for Business and Industry

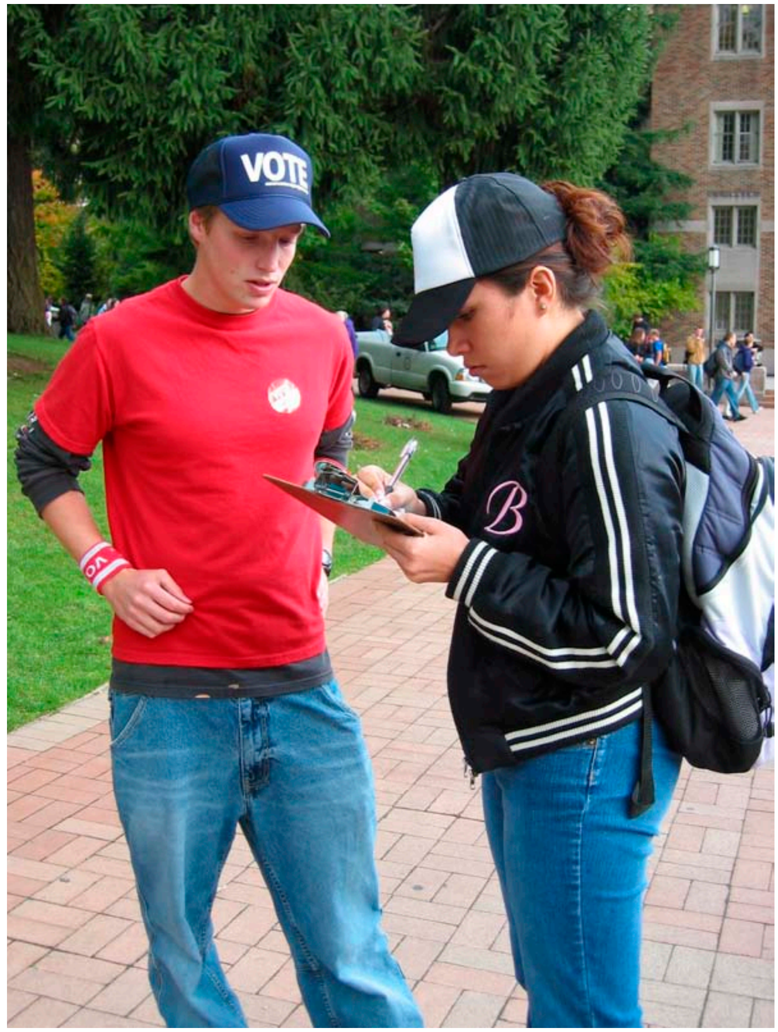
Many companies are taking steps to reduce their carbon footprints, often by using renewable energy or implementing energy-efficient technology. This can benefit companies by saving them money they would have otherwise spent on excess energy. Businesses also benefit when they are publicly recognized for reducing their contributions to climate change. Wal-Mart is one such business trying to reduce its environmental impacts by reducing product packaging and increasing the energy-efficiency of its stores and trucks. According to CEO Lee Scott, these changes will save Wal-Mart money.[5] What company wouldn't want to save money?

An altogether different approach for businesses is to reduce greenhouse gas emissions through emissions trading. A **cap and trade system** starts with a mandatory limit on total emissions, such as the limits outlined in the Kyoto Protocol. Businesses that are below their maximum allowed emissions (called allowances) may sell their extra allowances to businesses that are above the limit. In many cases, it is cheaper for a company to buy allowances from another business than to make the reductions within their own company.

There are many alternatives to a cap and trade system. For example, a "carbon tax" would require people or businesses to pay a tax on activities such as burning fossil fuels that emit greenhouse gases. Also, businesses may be required (usually by a government mandate) to use specific technologies to reduce emissions or to meet specific environmental performance standards. Refrigerator manufacturers were required to meet energy standards set by the California Energy Commission in the 1970s.[6] Car manufacturers are often required to meet certain fuel-efficiency standards so that cars achieve a minimum number of miles per gallon.

Individual Action

Some people are trying to reduce their carbon footprint by participating in emissions trading. Individuals can "balance out" the carbon emissions produced when they drive a car or fly in an airplane by investing money in projects that offset these carbon emissions. A **carbon offset** is like a counter-balance – it balances out your personal CO_2 emissions by reducing them elsewhere. For example, you can buy carbon offsets from private companies that spend your money on projects like preserving forests or building wind farms. In 2006, offset companies sold greenhouse gas reductions equivalent to 14.8 million tons of CO_2.[7] That sounds great, but don't forget that we actually emit 7 billion of tons of CO_2 each year. Many people agree that it is easier (and cheaper)



One way you can shape the future is by educating others about climate change and encouraging them to vote for policies and politicians who will work to reduce climate change. *Photo by Leah Barrett* to emit less CO_2 to begin with.

As with any attempted fix, there are problems that must be addressed if carbon trading systems are to create real change. Currently, there is no system in place to make sure that the same carbon offsets aren't sold more than once. Also, it is difficult to verify that all of the projects advertised to offset emissions are actually being implemented and that they are indeed reducing carbon emissions.[8]

There are countless other ways that individuals can join government and business initiatives to positively affect the climate. A good way to get involved in local, national, and even international efforts to address climate change is to learn more about the issues and to contact government representatives with your concerns and ideas for solutions. Elected officials rely on your input to make decisions that affect us all.

Vocabulary

cap and trade system—a system in which a regulatory agency (usually a government) sets a cap, or limit, on total greenhouse gas emissions allowed by industry; those who exceed their allowable limit can buy emission allowances from others who are below their limit

carbon offset—a voluntary payment by an individual or company to compensate for its greenhouse gas emissions; the money is usually spent in a way that balances the emissions (for example, by protecting forests, which are carbon sinks)

Checking for Understanding

1. Do you think that local climate change initiatives are as important as international initiatives? Why or why not?
2. Why do you think many businesses prefer a cap and trade system to other means of reducing greenhouse gas emissions?
3. What might be a more effective way to help businesses make a positive contribution to the environment?
4. Do you think carbon offsets are a good way to reduce our negative climate impacts? Why might these offsets not be feasible for everyone?
5. What ideas do you have for working to reduce climate change impacts within your own community? What groups in your community could you work with?

[1] United Nations, 1998, Kyoto Protocol to the United Nations Framework Convention on Climate Change. http://unfccc.int/kyoto_protocol/items/2830.php.
[2] US Mayors Climate Protection Agreement, http://www.seattle.gov/mayor/climate/ (accessed October 2, 2007).
[3] Western Climate Initiative (WCI), 2007, "Statement of Regional Goal," http://www.westernclimateinitiative.org.
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[5] Daren Fonda, "The Greening of Wal-Mart," Time, April 3, 2006.
[6] David Goldstein, Saving Energy, Growing Jobs (Berkeley, CA: Bay Tree Publishing, 2007), 260.
[7] Alan Zarembo, "Buy Your Way to Carbon Neutrality?" Seattle Times, September 23, 2007.
[8] Ibid.

What Do You Know about Climate Change?

Student Pre-Assessment

Name ______________________________

Multiple Choice

Circle the letter of the correct answer(s). If more than one answer is correct, circle all correct answers.

1. The process that keeps Earth warm when gases in Earth's atmosphere trap heat energy from the sun is called the ______________.
   a. glasshouse effect
   b. greenhouse effect
   a. ozone effect
2. Which of the following is NOT a fossil fuel?
   a. firewood
   b. natural gas
   c. petroleum oil
   d. coal
3. In which of the following ways can climate change affect human communities?
   a. increased rate of disease transmission
   b. reduced availability of drinking water
   c. reduced number of deaths related to cold weather
   d. change in farming seasons
   e. migration away from coastal areas
4. Which of the following are greenhouse gases?
   a. carbon dioxide (CO_2)
   b. hydrogen (H_2)
   c. nitrous oxide (N_20)
   d. methane (CH_4)
   e. ethane (C_2H_6)
5. During the past century, average temperatures on Earth have ______________.
   a. increased
   b. decreased
   c. stayed about the same
6. Which of the following actions can reduce your impact on the climate?
   a. travel more often to other countries
   b. eat more food from different countries
   c. live farther away from where you go to school
   d. turn off your computer when you are not using it

Short Answer

Answer the following questions in complete sentences.

7. When you hear the words "climate change," what is the first thing that comes to your mind?

8. A carbon footprint is a measure of your impact on the climate. The more you contribute to climate change, the larger your carbon footprint is. Explain why you think your carbon footprint is large or small.

9. What are some possible obstacles to taking action on climate change? (List at least one.)

10. What are some possible negative repercussions of *not* taking action on climate change? (List at least two.)

All About Climate Change

Week 1 Assessment: Quiz

Name ______________________________

Multiple Choice

Circle the letter of the correct answer(s). If more than one answer is correct, circle all correct answers.

1. What process keeps our planet warm when gases in the atmosphere trap heat energy from the sun?
    a. climate change effect
    b. greenhouse effect
    c. glasshouse effect
2. How does an increase in carbon dioxide (CO_2) in the atmosphere affect average temperatures on Earth's surface?
    a. an increase in CO_2 tends to increase temperatures
    b. an increase in CO_2 tends to decrease temperatures
    c. an increase in CO_2 does not affect temperatures
3. What is the cheapest way to reduce greenhouse gas emissions from energy use?
    a. wind energy—build more wind turbines
    b. nuclear power—build more nuclear plants
    c. energy conservation—use less energy
    d. hydropower—build dams to generate electricity from moving water
4. Which of the following energy sources are renewable resources that are alternatives to fossil fuels?
    a. hydropower
    b. coal
    c. natural gas
    d. wind energy

Short Answer

Answer the following questions in complete sentences.

5. How would you explain "climate change" to someone who has never heard of it?
6. Name and describe three ways that climate change can affect ecosystems or organisms within those ecosystems.
7. What information does a carbon footprint give you?
8. Once the carbon footprint of a person or a business has been calculated, how can you use this information?
9. Name three activities you do or things that you use that contribute to climate change. Explain how they contribute to climate change.
10. Think about how you can make a positive contribution to climate change instead—what are some low-impact alternatives to the three activities or things you just listed?

What Do You Know about Climate Change?

Student Pre-Assessment—Teacher Master

1. b
2. a
3. a, b, c, d, e
4. a, c, d
5. a
6. d

All About Climate Change

Week 1 Assessment: Quiz—Teacher Master

1. b
2. a
3. c
4. a, d
5. Climate change refers to any change in average weather over time, whether due to natural factors or human activities.
6. Refer to Activity 3 (“Effects of Climate Change on Living Things”) for specific ideas.
7. A carbon footprint is a way to measure your impact on the climate. It indicates the amount of greenhouse gases your activities produce.
8. By measuring your carbon footprint, you can see the relative impact of your activities on climate change. This can help you to make informed choices in the future, by considering how your activities affect your carbon emissions.

Interconnections of Climate Change

Week 2 Assessment: Essay

Student Instructions

WRITE A 5-PARAGRAPH ESSAY explaining the interconnections of climate change.

Make sure to answer the following questions in your essay:

- How does climate change affect different locations in different ways?
- How can climate change impacts in one place also have an impact on another, distant location?
- How and why are low-income populations affected by climate change to a greater degree than high-income populations?
- What is one strategy for people to adapt to climate change?
- What is one strategy for us to prevent future climate change?

Each paragraph in your essay should contain at least 5 sentences. The essay should start with an introductory paragraph and end with a concluding or summary paragraph. Think about how you can answer the questions above in a single essay. Be sure to use correct grammar, including complete sentences and punctuation, as well as correct spelling.

Assessment Rubric

Assessment Component	3 Exceeds Expectation	2 Meets Expectation	1 Needs Improvement
Content	All 5 questions are answered thoughtfully and completely. Ideas are communicated clearly, for any audience.	At least 4 questions are answered, but essay is not as clear as it could be.	Not all questions were answered in the essay. Writing is difficult to understand; ideas are not fully expressed.
Grammar and Spelling	All grammar (sentence structure and punctuation) and spelling are correct.	There are a few grammar or spelling mistakes.	Most of the essay contains grammar and spelling mistakes.

Alternative Assessment

For students who express themselves better in spoken word than in writing, assign the same questions to be answered in a 3-minute speech given to the class. Rather than assessing students' writing skills (including grammar and spelling), assess their verbal communication skills.

Carbon Footprint

Summative Assessment

Small Group or Individual Work

1. Review the Carbon Footprint Assessment Rubric.
2. Think of one thing you use every day that you think contributes to carbon dioxide emissions. Here are some ideas:
    - a food item
    - a mode of transportation
    - a favorite object (toy, sports equipment, book, etc.)
    - a piece of clothing
3. Draw that item in the center of a large sheet of paper or a poster.
4. Think of what it took to produce that item:
    - What parts is it made of?
    - What materials are those parts made of?
    - Did the production of the item result in greenhouse gas emissions (methane, carbon dioxide, or nitrous oxide)?
    - Did any part have to be transported from somewhere else?
    - Was energy used to make it?
    - Were carbon sinks (like oceans, soils, or forests) harmed to make it?
5. Now, draw these connections around your central picture, starting with the parts your item is made of. For example, a hamburger is made of a meat patty, a bun, lettuce, and tomato. Your hamburger picture would be in the center of the page. Surrounding it would be pictures of the meat, bun, lettuce, and tomato. Draw lines to connect these parts to the central picture.
6. Now think about what each of those parts are made of and what was required to make them. To produce the meat, forest land might have been cleared for grazing (that releases CO_2 to the atmosphere). Cows release methane, which is another greenhouse gas. To drive the cow from a pasture to a feedlot required transportation, which relies on fossil fuels (which release CO_2). More transportation was required to drive the cow from the feedlot to a slaughterhouse (more CO_2 released). The meat might have been wrapped in plastic, which comes from petroleum, a fossil fuel that releases greenhouse gases….

    You get the picture!

    Once you have finished, your entire sheet of paper may be covered with ways in which the item you chose contributes to climate change.
7. At the bottom of your beautiful work of art, list 5 ways that this item could be produced (or used) in a more climate-friendly way.

Carbon Footprint Assessment Rubric

Assessment Component	3 Exceeds Expectation	2 Meets Expectation	1 Needs Improvement
Connections connections between the item (and its component parts) and greenhouse gas emissions	At least 5 realistic connections are provided.	3-4 realistic connections are provided.	0-2 realistic connections are provided.
Solutions ideas for producing the item in a more climate-friendly way	5 ideas are provided.	3-4 ideas are provided.	0-2 ideas are provided.
Presentation poster illustrations and design	Illustrations are easy to understand. Graphics are creative and eye-catching.	Illustrations are easy to understand, but the poster may not be entirely creative or eye-catching.	Little effort was put into illustrations. Poster is sloppy.