PART 1

It's Happening Now All Over the World

Earth's average temperature has risen about 1.3°F over the past century—a sudden increase that's extremely rare over Earth's 4.6-billion-year history. Why the temperature increase? The cause is basically the greenhouse effect. In the greenhouse effect, carbon dioxide and other greenhouse gases trap heat in Earth's lower atmosphere, and this warms the planet. Since the 1850s, the concentration of atmospheric greenhouse gases has risen sharply, in step with increasing consumption of fossil fuels. In addition to fossil fuel use, deforestation is a major cause of increased atmospheric CO_2, enhanced greenhouse effect, and a warmer Earth. Trees that would remove CO_2 from the atmosphere are cut down and are therefore no longer around to help absorb this greenhouse gas.

The effects of Earth's one-degree temperature rise are already with us. Drought, flooding, wildfires, hurricanes, sea-level rise, changes in currents, melting permafrost, and the extinction of some species as well as the northward and upward migration of others are just some of the effects.

Even more ominous is the fact that the warming is accelerating. The Intergovernmental Panel on Climate Change, or IPCC, is probably the world's leading authority on climate change. It is made up of more than 1,300 scientists from around the world who volunteer to review the credible scientific research on climate. The IPCC predicts that Earth's average temperature will increase between 2.5°F (1.4°C) and 10°F (5.6°C) over the next century, depending on human activities. If a one-degree rise has caused the effects we are observing now, you can imagine that a temperature rise of several degrees more could be catastrophic indeed! The time to start reducing CO_2 emissions and preserving the world's forests to stabilize climate is now.

PHYSICS FOCUS: HOW DOES THE GREENHOUSE EFFECT WORK?

Earth's lower atmosphere contains many substances, including *greenhouse gases* (such as carbon dioxide, methane, and water vapor). Greenhouse gases are important to temperature because they allow light energy from the sun to pass through them. Visible light, or "shortwave electromagnetic radiation," thus passes through the atmosphere and is absorbed once it reaches Earth's surface. Some of this incoming energy is retained by the ground and warms it. However, much of the incoming shortwave radiation is not absorbed by the ground. Instead, it is reemitted as longer-wavelength infrared radiation by Earth's surface. But unlike shortwave radiation—that is, visible light—the longer-wavelength infrared radiation cannot easily escape Earth's atmosphere since greenhouse gas molecules absorb it. So, due to greenhouse gases, infrared radiation is retained in the lower atmosphere, and this increases Earth's temperature.

The greenhouse effect is actually a natural and necessary phenomenon. Without it, the atmosphere would be a frigid –18°C. The present concern is about the *anthropogenic greenhouse effect. Anthropogenic* means "human caused." The global average temperature rise observed over the past century correlates with increased levels of greenhouse gases in the atmosphere, which in turn result from certain human activities, especially the increased consumption of fossil fuels. Thus the enhanced greenhouse effect today, which has led to higher temperatures, is known to be anthropogenic rather than naturally caused.

A good place for youth to begin is with the film *Kids vs Global Warming* and the following activity. It integrates a bit of mathematics as an "appetizer." It shows students that small actions can add up to big gains for the planet.

INTRO ACTIVITY: TRAINS, PLANES, AND AUTOMOBILES

Show your students the trailer for the film *Kids vs Global Warming.* Point out that producer Lynne Cherry introduces an important theme—transportation. We see her on an Amtrak train riding from Washington, D.C., to Los Angeles, California. She has decided to skip driving and avoid flying. Why?

Pose the following problem: *Estimate how much carbon dioxide is not released into the atmosphere as a result of Lynne's choice to take the train.* Give students the following facts:

- The distance from Washington, D.C., to Los Angeles, California, is about 2,700 miles.
- A passenger plane gets about 23 passenger miles per gallon if it is full. The average car gets about 21 miles per gallon on the open highway. A passenger train gets about 45 passenger miles per gallon.
- Combusting a gallon of gasoline releases about 20 pounds (9 kg) of carbon dioxide into the atmosphere.

Answer

If Lynne had driven, she would have used 129 gallons of gas for the trip; if she had flown she would have used about 117 gallons; by taking the train she used 60 gallons. Therefore, by taking the train, Lynne saved the atmosphere 1,140 pounds of CO_2 versus a plane and 1,380 pounds of CO_2 versus a car. (See Appendix II for full calculations.)

Discussion

Brainstorm with students all of the factors that enter into estimating the true fossil fuel consumption in miles per gallon for various modes of transportation. For example, airplane travel requires not just the plane but the energy needed to run the airport. Driving a car 2,700 miles often means meals in restaurants and nights spent in hotels. So the use of planes and cars actually costs more energy than stated here. On the other hand, trains sometimes include both passenger cars and freight cars, so their efficiency can be greater than the "bare numbers" indicate. Trains are the most energy-efficient way to move products and passengers across the country. Even when students understand that their calculations are by necessity just estimates, the calculations here lead to the correct conclusions about the efficiency of trains, planes, and single-passenger cars.

STANDARDS

Common Core: Estimation

CCSS.Math.Content.3

- Solve problems involving measurement and estimation.

CCSS.Math.Content.4.NBT.A.3

- Use place value understanding to round multi-digit whole numbers to any place: Estimate differences.

CCSS.Math.Content.7

- Solve real-life and mathematical problems using numerical and algebraic expressions and equations: Estimate sums, differences, and products using decimals.

NGSS: Practices of Science

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Notes

Alec Loorz

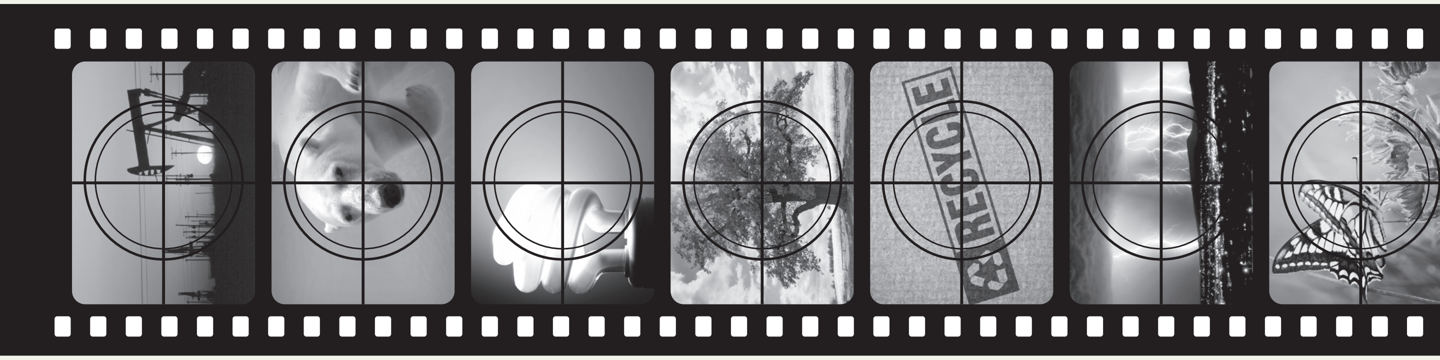
Kids vs Global Warming

Activities in This Chapter:

Activity 1.1. STEAM It Up! Communicate Through the Arts

Activity 1.2. Researching Climate Change—Many Methods, Many Mentors

Activity 1.3. Rising Sea Levels, Sinking Hopes



It's hard to predict what will start a fire in youth. For twelve-year-old Alec Loorz, it was Al Gore's documentary movie *An Inconvenient Truth*. The specter of global climate change wouldn't fade away for him.

Alec's mother was his first mentor. She understood. She didn't suggest that his ideas were unrealistic or too big for one person to tackle. She helped him arrange a meeting with paleoclimatologist Richard Norris of the Scripps Institute in San Diego, California. At Scripps, Alec saw evidence of Earth's climate in ancient ice cores and got answers to some of his questions. He also met climate researcher Lisa Shaffer.

Alec's mentors respected his energy and his enthusiasm. Feeling the weight of the global situation and a sense that he could make a difference, Alec felt compelled to tell other kids about the problems he saw. Eventually he was invited by Al Gore to be formally trained with the Climate Project in October 2008. He has given more than 150 presentations on global warming—reaching almost 75,000 in his audiences. In the film *Kids vs Global Warming,* we see young Alec creating presentations specifically for youth. As this book goes to print, Alec is eighteen and in college in Canada. He has been a keynote speaker at conferences such as Bioneers and TED and at the United Nations. And he has won many awards for his work trying to move people to speak out for taking action on climate change. In fact, Alec and other youth brought a lawsuit against every U.S. state government for failing to regulate carbon emissions and protect their future. In his spare time, he creates presentations

Alec raised public awareness with sea-level awareness posts (SLAPs) to show where the water level would be with different degrees of warming. Young people in New York drew a blue line along city streets to show what would be submerged by the elevated water. What kinds of signposts or symbols can you create in order to engage your community? If you live by the ocean, you might create signs that depict sea-level rise. If you live by an inland lake, the water level will go down! (That's because warmer temperatures make less ice cover; with less ice cover, lake water evaporates faster in the winter, emptying the lake.)

If your community isn't near a conspicuous body of water, students can create visual symbols representing many other climate change effects. Will the balance among the common types of trees—the climax community—change? Will there be more erosion or fires? More carbon dioxide means more "C_4" plants like Kudzu and poison ivy and more heat-adapted animals like mosquitoes!

Once your students have created visual images of the near future, hold a gathering such as a "poetry slam," gallery walk, or video festival.

Are students' signs "ready for prime time"? If so, post them where they will have an impact in the community. Alec erected his SLAPs along the ocean promenade. Ask business owners to post the signs in windows and on community bulletin boards.

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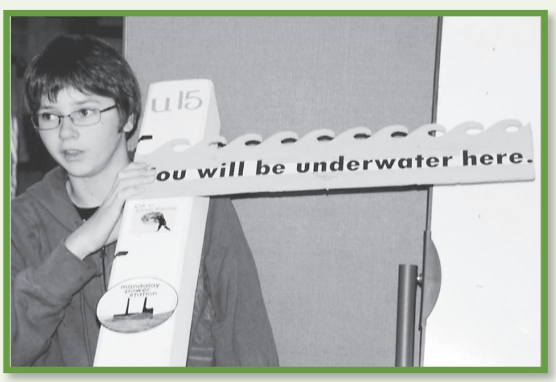

specifically for youth, full of videos, animation, and easy-to-understand science. His message is deeply rooted in hope, encouraging kids to speak up and let their voices be heard on this issue.

Mentors were crucial for Alec Loorz. But who is a mentor? While we most often think of scientists as mentors for science students, in your own community a mentor might be anyone who will listen! A mentor can be anyone—the teacher, the media specialist, the senior volunteer. The most important requirement for the role is a willingness to take the enthusiasm and the curiosity of young climate investigators seriously.

What *isn't* required? A white lab coat, a single scientific method, or a "smarter than thou" attitude. Mentors may need to inject some realistic caution and courtesy when the enthusiasm of one young voice or many spills over, but they should never be discouraging: "You may not be able to do all that right away, but what parts of your ideas are realistic first steps?" Many great efforts have begun with brainstorming and diagrams "on the back of an envelope."

Mentors are especially helpful for marginalized or disadvantaged students. It's important for everyone to recognize that climate advocates are diverse and creative. While climate change science can get very complex, its main ideas are quite simple. That's what Activity 1.2 will help students see. No matter what their skills and science acumen, all students have something to contribute to protecting the climate.

The Web quest in Activity 1.2 begins with five scientists who have worked with young people who have high aspirations. You might want to add others who you think could be relevant role models for your particular students. Scientists do make great mentors—but be sure to interpret the term *scientist* liberally. Science takes many forms, and mentors have many opportunities to guide youth through various applications of science.

Like Alec Loorz, your own students are looking for mentors. Once they've identified resources and people who might be able to help them on their journeys, encourage them to be bold. There are many, many researchers who—like Richard Norris—are happy to help youth get started.

In Activity 1.2, students imagine what it would be like if some of the "big-name" climate researchers were their mentors.

Sea-level rise is one of the effects of climate change that is already here and growing worse. It's a topic of obvious concern to people living along the world's coastlines, such as Alec Loorz. Sea level rises when the temperature of the ocean increases because seawater expands as it warms. Also, melting glaciers add water to the sea.

Activity 1.2

RESEARCHING CLIMATE CHANGE—MANY METHODS, MANY MENTORS

Each of the scientists listed below is involved in some aspect of climate change research. In this activity, students research the scientists. They find out one problem that each scientist researched or is researching, and they find out one method that the scientist has used. Students then imagine they could meet this scientist and ask him or her a question of interest.

Some of these scientists are profiled in the book *How We Know What We Know About Our Changing Climate: Scientists and Kids Explore Global Warming.* Students can use the Internet to research the scientists as well.

The student sheet corresponding to this activity appears in Appendix I. Copy it and distribute one sheet to each student.

TABLE 1.2.1 Climate Scientists and Their Research

SCIENTIST	PROBLEM	SCIENCE PRACTICES	QUESTION YOU WOULD ASK
Richard Norris			
Terry Root			
Steve Schneider			
Lisa Shaffer			
James Hansen			

RISING SEA LEVELS, SINKING HOPES

In this exercise, students analyze sea-level rise using topographic maps. Provide each student with a copy of Student Sheet 1.3. Also provide each student with six colored pencils, each of a different color.

In the first part of the activity, students examine the following topographical map of Manhattan Island, New York. They color-code the regions that would be flooded if sea level rose in 1-meter increments up to 6 meters. Explain that a 6-meter rise in sea level is a worst-case scenario and is not predicted to occur during this century. According to the Intergovernmental Panel on Climate Change, a 6-meter rise would occur if the entire Greenland ice sheet were to melt. The IPCC predicts that the most likely sea-level rise by 2100 is between 80 centimeters and 1 meter. Longer term, however, sea level will continue to rise even after CO_2 emissions have been reduced or eliminated.

Students will see that a 1-meter sea-level rise would flood a large land area. A 2- to 3-meter rise would also flood large areas. After that, 1-meter increments of sea-level rise would flood smaller geographic areas.

You may need to discuss topographic maps with your students in advance of this activity. If so, share the following information: A topographic map is a map that shows the elevation of Earth's surface features. Elevation is the height of something above sea level. The elevation of sea level is 0. Topographic maps, or "topos," show elevation with contour lines.

FIGURE 1.3.1

Contour lines are lines that connect places that are at the same elevation.

Call students' attention to the topographic map of Manhattan on the student sheet. Have them examine its contour lines. Tell them that the contour lines on the map reflect the shape of the land because they connect points of equal elevation.

After examining New York, students examine a map indicating sea-level rise in Florida. They identify the cities that are flooded at various increments of sea-level rise.

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STANDARDS

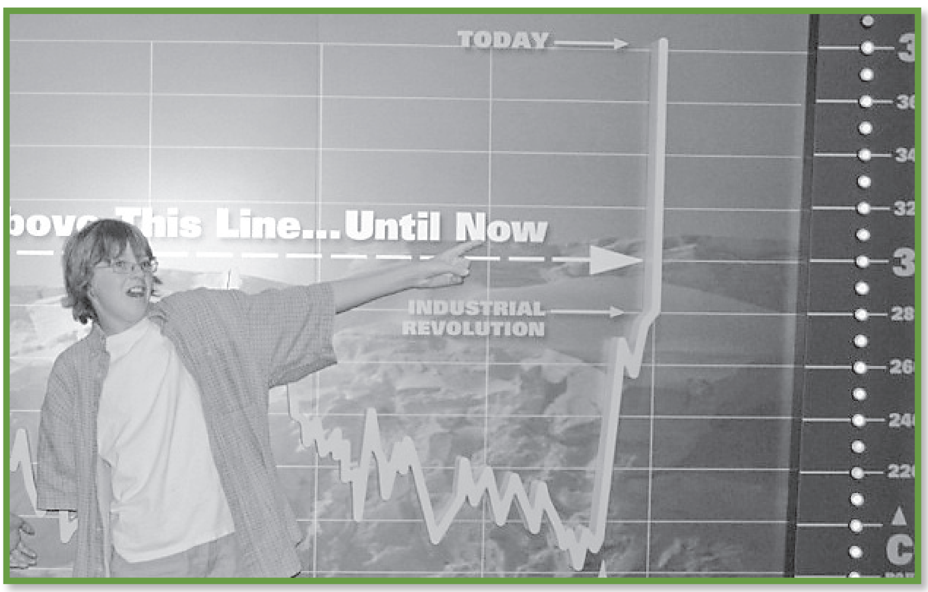
Sample NGSS Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems

- Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)



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