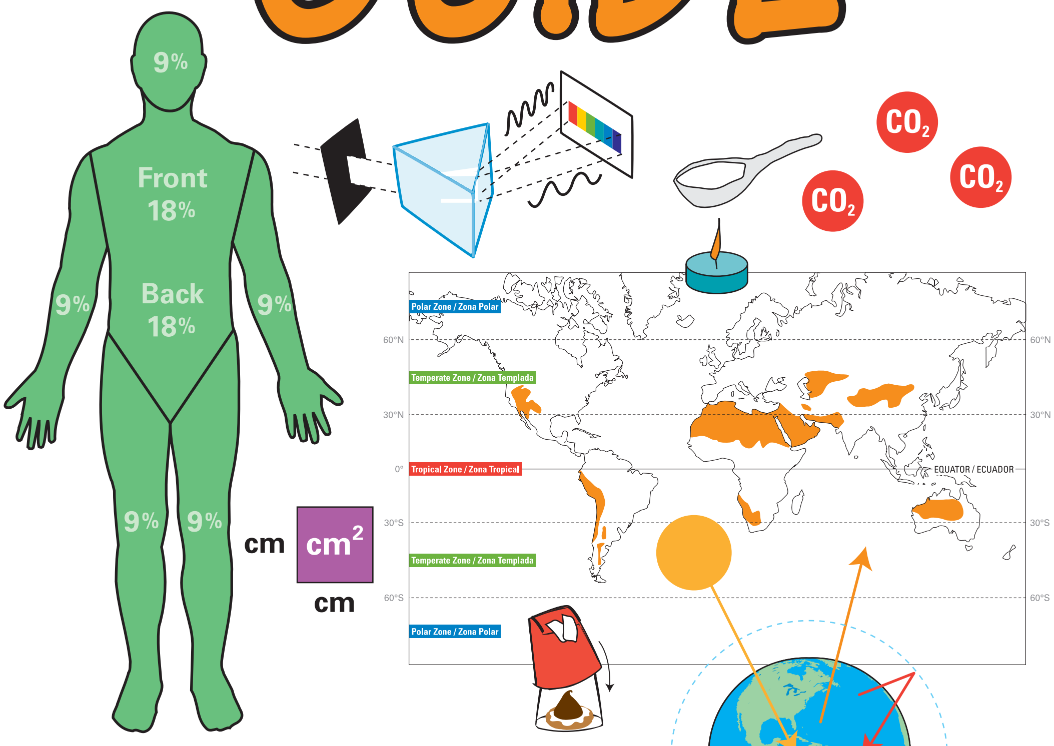
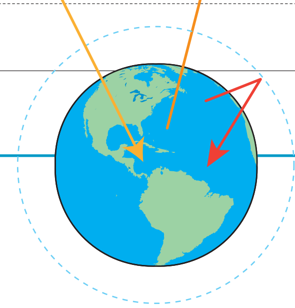
THE SCIENCE OF
Global
Atmospheric
Change

TEACHER'S GUIDE





Written by
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Barbara Z. Tharp, M.S.
Judith Dresden, M.S.

BCM
Baylor College *of* Medicine

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Teacher Resources from the
Center for Educational Outreach at
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SOURCE URLS

BAYLOR COLLEGE OF MEDICINE
www.bcm.edu

CENTER FOR DISEASE CONTROL AND PREVENTION (p. 26)
cdc.gov/climatechange

KOEN VAN GORP - ASTRONOMY AND PHOTOGRAPHY (p. 1)
www.koenvangorp.be/events/eclipse_2006.html

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (p. 40)
ipcc.ch

NASA EARTH OBSERVATORY (p. 4, 18, 30, 37, 40)
earthobservatory.nasa.gov

NASA'S EYES ON THE EARTH (p. 40)
climate.nasa.gov

NATIONAL ACADEMIES OF SCIENCES (p. 26)
dels.nas.edu/Climate/Climate-Change/Reports-Academies-Findings

NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES (p. 26)
niehs.nih.gov/about/od/programs/climatechange

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, CLIMATE SERVICES (p. 40)
climate.gov/#education

NATIONAL PARK SERVICE, CLIMATE CHANGE RESPONSE PROGRAM (p. 40)
nature.nps.gov/climatechange

DAVID SHAND (p. 12)
www.flickr.com/photos/14508691@N08/with/5187817955/

TAU'OLUNGA (p. 39)
http://en.wikipedia.org/wiki/File:North_season.jpg

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES (p. 26)
sis.nlm.nih.gov/enviro/climatechange.html

U.S. GEOLOGICAL SURVEY, OFFICE OF GLOBAL CHANGE (p. 26, 40)
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U.S. GLOBAL CHANGE RESEARCH PROGRAM (p. 1, 13, 32, 40)
globalchange.gov

GRAY WATSON (p. 32)
http://en.wikipedia.org/wiki/File:Solar_panels_on_house_roof.jpg

ALAN E. WHEALS, PH.D., UNIVERSITY OF BATH (p. 24)
http://www.bath.ac.uk/bio-sci/research/profiles/wheals-a.html

WORLD HEALTH ORGANIZATION (p. 26)
who.int/globalchange/environment

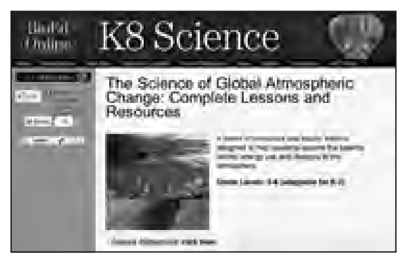
Contents

THE SCIENCE OF GLOBAL ATMOSPHERIC CHANGE

The Science of Global Atmospheric Change Teacher's Guide may be used alone. It also is integrated with the following unit components.

- ***Mr. Slaptail's Curious Contraption*** (illustrated adventure story)
- ***Explorations*** (magazine for use in class or at home)
- ***The Reading Link*** (black-line masters for reading and language arts connections)
- ***The Math Link*** (black-line masters for mathematics connections)

TEACHER RESOURCES



Downloadable lessons and supplemental materials in PDF format, annotated slide sets for classroom use, streaming video lesson demonstrations, and other useful resources are available free at K8 Science (www.k8science.org).

Where Do I Begin?

WHERE DO I BEGIN?

The Science of Global Atmospheric Change Teacher's Guide may be used as a stand-alone set of science lessons. However, the other unit components are designed to be used with the guide. To begin the unit, some teachers prefer to generate student interest by reading part or all of the student story. Others use the cover of the magazine to build student enthusiasm. Still others begin with the pre-assessment lesson in this guide.

You may find it helpful to use the Sequence Guide on the following page to integrate the unit components into your schedule. When teaching for 45 to 60 minutes daily, most teachers will complete an entire unit with their students in two to three weeks. If you use the unit every other day or once per week, it will take three to nine weeks to teach, depending on the amount of time spent on each session.

The Science of Global Atmospheric Change Teacher's Guide provides background information for you, the teacher, at the beginning of each activity. In addition, a listing of required materials, estimates of time needed to conduct activities, and links to other components of the unit are given as aids for planning. Questioning strategies, follow-up activities and appropriate treatments for student-generated data also are included. Student pages are provided in English and in Spanish. The first and final activities in this guide are appropriate for assessing student mastery of concepts.

ABOUT THIS UNIT

The Science of Global Atmospheric Change activities, explorations and adventures provide students, teachers and parents with science educational materials that are integrated across several subjects of the curriculum. Prepared by teams of educators, scientists and health specialists, this unit focuses on a variety of physical and life science themes. The inquiry-based, discovery-oriented approach of the materials is aligned with National Science Education Standards and National Health Education Standards.

The Science of Global Atmospheric Change's integrated components help students understand important science, health and environmental concepts related to changes in Earth's environment.

- ***The Science of Global Atmospheric Change Teacher's Guide*** provides inquiry-based lessons that entice students to discover concepts in science, mathematics and health through hands-on activities.
- ***Mr. Slaptail's Curious Contraption***, an illustrated storybook, presents an engaging mystery adventure, featuring cousins Riff and Rosie, that teaches science and health concepts.
- ***Explorations*** is a colorful magazine full of activities, information, and fun things for children and adults to try in class or at home.
- ***The Reading Link*** provides language arts activities related to the story.
- ***The Math Link*** extends each unit by connecting the story and hands-on science activities to mathematics skill-building and critical thinking exercises.

The Science of Global Atmospheric Change unit offers flexibility and versatility, and is adaptable to a variety of grade levels and teaching and learning styles.

USING THE UNIT AT THE K-1 LEVEL

The Science of Global Atmospheric Change unit easily can be adapted for use with younger students. To begin, introduce students to the main characters in the storybook, *Mr. Slaptail's Curious Contraption*. Then read the beginning of the story to students. Demonstrate the activity in the back of the storybook and help students do it themselves.

Each story session should cover only about five pages of the book, accompanied by science concepts. The *Explorations* magazine also is an appropriate teaching tool. With very young children, it may be more fitting to conduct some of the activities as teacher demonstrations, unless you have several helpers to assist with the hands-on activities.

Sequence Guide

The Science of Global Atmospheric Change unit components can be used together in many ways. The chart below may help you coordinate the activities in this guide with the unit's student storybook, *Mr. Slaptail's Curious Contraption*, and the *Explorations* magazine. Similar information is provided in the "Unit Links" section of each activity in this book.

Additional classroom materials for this unit, including *The Math Link* and *The Reading Link* (PDF format), annotated slide sets for classroom use, streaming video lesson demonstrations, and other useful resources, are available free at K8 Science (k8science.org).

The Science of Global Atmospheric Change activities are designed to be conducted by students working in collaborative groups. Assign the following roles to group members.

- **Principal Investigator:** Asks others to help, asks questions
- **Materials Manager:** Collects materials, helps the Principal Investigator
- **Recorder:** Writes or draws results, tells teacher when the group is done
- **Safety Scientist:** Follows the safety rules, directs clean-up

ACTIVITY	CONCEPTS	CLASS PERIODS TO COMPLETE	LINKS TO OTHER UNIT COMPONENTS	
			Mr. Slaptail's Curious Contraption	*Explorations*
1. Earth's Energy Sources Pre-assessment	There is much to learn about energy and resources.	1		
2. Rainbow in the Room	Light consists of many wavelengths.	1	Story, p. 1–5	
3. Modeling Earth's Atmosphere	The atmosphere is a layer of gases surrounding the Earth.	1–2	Story, p. 6–9	Swirled World, p. 4
4. Fossil Fuels and the Carbon Cycle	Fossil fuels are found in layers of soil and rock.	1	Story, p. 10–12; Science box, p. 12	Let's Talk About the Atmosphere and Health, p. 2–3
5. Finding the Carbon in Sugar	Plant-based fuels give off carbon when burned.	2	Story, p. 12–15	Let's Talk About the Atmosphere and Health, p. 2–3
6. Fuel for Living Things	Organisms give off carbon when using food.	1	Story, p. 16–20	Lief Sigren, p. 7
7. Measuring and Protecting Skin	Skin is vital and must be protected.	2	Story, pp. 21–22; Science box, p. 20	What Is It? p. 6; SkinWise, p. 8
8. Using Heat From the Sun	Heat from the sun can be harnessed.	1	Story, p. 22–24; Science box, p. 20	Sunpower, p. 4; We Can Make a Difference! p. 5
9. Greenhouse S'Mores	Different materials absorb and trap heat differently.	1	Story, p. 24–27 and 30–31	Not Such a New Issue, p. 6; Lief Sigren, p. 7
10. People and Climate	Climate affects all aspects of human life.	2 or more	Science boxes, p. 27–29	Cover activity; What Is Climate? p. 2
11. Global Atmospheric Change Post-assessment	Our own health and the environment are linked.	1 or 2	Review Science boxes throughout.	Tips for Healthy Living, p. 3

Materials

You will need the following materials and consumable supplies to teach this unit with 24 students working in six cooperative groups. See Setup sections within each activity for alternatives or specifics.

ACTIVITY 2 (p. 5)

24 sheets of white paper
2 cups, 9-oz clear plastic (or clear glass jars or glasses)
Clear beaker, 1,000-mL size (or qt-sized glass jar or other similar clear container)
Crayons or colored markers
Overhead projector

ACTIVITY 3 (p. 7)

36 sheets of construction paper, asst. colors, 9 in. x 12 in.
6 glue sticks or rolls of tape
6 pairs of scissors
Crayons or colored markers
Large sheet of white or brown wrapping or banner paper, 1 m x 3 m (approx.)

ACTIVITY 4 (p. 11)

24 prepared GeoMuffins (see Setup)
24 aluminum baking cups and a cookie sheet (see Setup)
24 cotton swabs
24 plastic serrated knives
24 sections of plastic straw about 8 cm (3 in.) in length
24 toothpicks
2 envelopes of bran muffin mix (plus ingredients for mix)
2 envelopes of corn muffin mix (plus ingredients for mix)
Crayons or colored markers
Food coloring, red
Food coloring, green

ACTIVITY 5 (p. 19)

12 sheets of paper towels
7 tea candles
6 small pieces of aluminum foil (15 cm sq.)
3 tsp of white sugar (1/2 tsp per group)
Clear beaker, 1,000-mL size (or tempered glass bowl)
Matches
Water (to moisten paper towels)

ACTIVITY 6 (p. 23)

12 cups, 9-oz clear plastic
12 spoons or coffee stirrers
7 clear resealable plastic bags, (4 in. x 6 in.)
7 cups of warm water
7 handfuls of finely sliced raw red or purple cabbage
6 tsps of sugar
6 tsps of dry yeast
1 tsp of baking soda
Vinegar, a few drops

ACTIVITY 7 (p. 25)

18 ft of wax paper
6 oranges or tangerines
6 plastic knives
6 sheets of centimeter graph paper
6 sheets of paper or a notebook
Crayons or colored markers
Metric tape measure
Paper towels
Tape

ACTIVITY 8 (p. 31)

12 cups, 9-oz clear plastic
6 graduated cylinders, 100-mL size or metric measuring cups
6 student thermometers, plastic

ACTIVITY 9 (p. 35)

24 chocolate candies ("kisses" or squares)
24 cups, 9-oz clear plastic
24 plain round cookies
24 toothpicks
6 plastic knives (or spreaders)
6 sheets of aluminum foil, approx. 12 in. sq. (30 cm sq.)
6 sheets of black construction paper, 9 in. x 12 in.
6 sheets of white construction paper, 9 in. x 12 in.
6 trays or paper plates
1/4 cup of marshmallow creme (or frosting) per group
Tape or a stapler

ACTIVITY 10 (p. 38)

6 large sheets of paper or poster board
Construction paper, asst. colors, 9 in. x 12 in. (several sheets per group)
Flashlight
Flashlight batteries
Globe, large inflated balloon or ball
Glue sticks or paste

ACTIVITY 11 (p. 42)

Crayons or colored markers
Drawing paper
Pencils or pens

Safety Issues: Always follow all district and school science laboratory safety procedures. It is good practice to have students wash hands before and after any laboratory activity. Clean work areas with disinfectant.

Earth's Energy Sources

Pre-assessment

Global warming, ozone depletion, skin cancer risk… all of these themes appear frequently in the news. Yet, there are many misconceptions about them. This unit allows students to explore the science behind energy use and changes in the atmosphere. At the same time, students learn basic physical and earth/space science concepts related to light and electromagnetic radiation, the atmosphere, fossil fuels and combustion. Students also learn about the carbon cycle, the role of carbon dioxide in living systems and the important role of skin in protecting living organisms. Finally, students have opportunities to integrate their knowledge through explorations about the greenhouse effect, climate and alternative energy sources. Overviews of the science content covered in each section of this guide can be found in the one-page Physical Science, Life Science, and Environment and Health Basics overviews. The introduction to each activity also provides a summary of science concepts covered.

This pre-assessment is designed to allow you, the teacher, to estimate students' existing knowledge about these topics before beginning the unit. It also can be used for self-assessment by students once the unit is completed.

SETUP

Have students work individually to complete the pre-assessment.

PROCEDURE

1. Initiate a class discussion about sources of energy and energy use. Ask questions such as, *What is the source of energy for your family's car? What about for your computer? Where does the energy we need come from?* To build awareness, have students make a class list of the many different ways in which they rely on energy each day.
2. Follow by asking, *Do you think our uses of energy affect the environment?* Tell students that they will find answers to these and other questions over the next few weeks.
3. Give each student a copy of the pre-assessment. Have students complete the pre-assessments individually. Tell students that they will not be graded. Rather, they will use the pre-assessments to gauge how much they have learned over the course of the unit.
4. Collect completed pre-assessments and save them. Students will refer back to their answers at the conclusion of the unit.

CONCEPTS

- Allows teacher to estimate students' prior knowledge related to the atmosphere, carbon cycle, skin and skin cancer risk, and climate change.

OVERVIEW

Unit pre-assessment designed for use with students before beginning any unit activities. Will be revisited as part of Activity 11.

TIME

Preparation: 5 minutes
Class: 30 minutes

MATERIALS

Each student will need:

- Copy of "Do You Know" student sheet (p. 2–3)

GLOBAL CHANGE

Global atmospheric change affects ecosystems, water, energy, transportation, agriculture and human health. The impacts differ from region to region and will grow under projected climate change.

Source: U.S. Global Change Research Program.

ANSWER KEY

1.	b	6.	a
2.	c	7.	c
3.	b	8.	d
4.	d	9.	c
5.	a	10.	a

Photo © Koen van Gorp.

Do You Know?

Name ____________________

Circle the letter beside the correct answer to each question below.

1. Where are fossil fuels found?
   a. In a Geomuffin
   b. Underground
   c. In a tree
   d. In the atmosphere

2. Why is your skin important?
   a. It sends messages to the circulatory system.
   b. It can get sunburned.
   c. It helps keep germs out of the body.
   d. It has no layers.

3. What is the source of almost all energy on Earth?
   a. The moon
   b. The sun
   c. Electricity
   d. The water cycle

4. Most air pollution is found in which layer of the atmosphere?
   a. Thermosphere
   b. Mesosphere
   c. Stratosphere
   d. Troposphere

5. Which of the following contains carbon?
   a. Sugar
   b. Water
   c. Spoon
   d. Glass

6. Which answer about greenhouse gases is not true?
   a. They are present in large amounts in the atmosphere.
   b. They are produced by things people do.
   c. We can't see them.
   d. They help trap heat in the atmosphere.

7. Which of the following zones has a climate with warm temperatures year-round?
   a. Polar
   b. Temperate
   c. Tropical
   d. Desert

8. How could you estimate how much skin an orange has?
   a. Squeeze out the juice.
   b. Use the Law of Nines.
   c. Make a rectangle.
   d. Peel it and lay the skin out flat.

9. A rainbow is made of:
   a. tiny colored specks.
   b. microwaves.
   c. wavelengths of light.
   d. a prism.

10. When should a person wear sunscreen?
    a. Every day
    b. Only if a person gets sunburned easily
    c. Only at the beach
    d. Only if it is hot outside

Mide Tu Conocimiento

1

Mi Nombre ______________________________

Haz un círculo alrededor de la letra que corresponde a la mejor respuesta.

1. ¿Donde se encuentran los combustibles fósiles?
   a. En un Bizcocho Geológico
   b. Bajo tierra
   c. En un árbol
   d. En la atmósfera

2. ¿Porque es importante la piel?
   a. Envia mensajes al sistema circulatorio.
   b. Puede quemarse con el sol.
   c. Ayuda a mantener los gérmenes fuera del cuerpo.
   d. No tiene capas.

3. ¿De donde proviene casi toda la energía en la Tierra?
   a. La luna
   b. El sol
   c. La electricidad
   d. El ciclo del agua

4. ¿Cual capa de la atmósfera tiene más contaminación?
   a. Termósfera
   b. Mesófera
   c. Estratósfera
   d. Tropósfera

5. ¿Donde se puede encontrar el carbón?
   a. En el azucar
   b. En el agua
   c. En una cuchara
   d. En un vaso

6. ¿Cual es la respuesta incorrecta acerca de los gases de invernadero?
   a. Se encuentran en grandes candidades en la atmósfera.
   b. Se producen por medio de acciones humanas.
   c. No los podemos ver.
   d. Ayudan a atrapar el calor en la atmósfera.

7. ¿Cual zona tiene un clima con temperaturas cálidas durante todo el año?
   a. La zona polar
   b. La zona templada
   c. La zona tropical
   d. El desierto

8. ¿Como podrías estimar la cantidad de piel cubriendo una naranja?
   a. Exprimir todo el jugo.
   b. Usar la regla de los nueve.
   c. Hacer un rectángulo.
   d. Pelar la naranja y extender la piel sobre una superficie plana.

9. Un arcoíris se hace de:
   a. unos puntitos de colores.
   b. las microondas.
   c. diferentes longitudes de onda de la luz.
   d. un prisma.

10. Los fotoprotectores deben aplicurse:
    a. todos los días.
    b. tan solo si alguién se quema facilmente del sol.
    c. tan solo en la playa.
    d. tan solo si hace calor afuera.

Energy and the Atmosphere

Physical Science Basics

THE SPECTRUM

Radiation travels in waves. The wavelengths that we see as visible light represent a small portion of the entire electromagnetic spectrum.

Light usually is measured in nanometers (one nanometer equals 0.000,000,001 meters). Wavelengths that we can see fall between 400 and 700 nm. During photosynthesis, green plants capture energy from wavelengths in this range.

Some kinds of radiation are listed below, from longest to shortest wavelengths.

- Long wave radio
- Short wave radio
- Radar
- Microwave
- Infrared
- Visible light
- Ultraviolet light
- X-ray
- Gamma ray
- Cosmic ray

FOSSIL FUELS

Fossil fuels — coal, oil and natural gas — consist of the remains of ancient plants, animals and one-celled organisms that have been buried under intense pressures and high temperatures for millions of years. The resulting substances deliver much more useful energy than raw plant materials, such as wood.

The sun is the source of Earth's energy. Every second, approximately five million tons of matter within this relatively small star are converted into energy, which is sent outward into space. We feel part of this energy as heat and see another part as light. Heat and light that we can detect, however, represent only a small portion of the radiation emitted by the sun.

Radiation travels in waves, similar in some ways to waves on the surface of a lake. The distance between the peaks, or crests, of two successive waves is known as the wavelength. The longest wavelengths—between 1 and 1,000 meters—correspond to television and radio signals. The shortest wavelengths, those of cosmic rays, are only 0.000,000,000,000,01 meters long!

Radiation traveling toward Earth passes through a thin layer of gases called the atmosphere. Without this protective layer, life on Earth would be impossible. Earth's atmosphere consists primarily of nitrogen and oxygen, along with other argon, carbon dioxide and water vapor. The atmosphere keeps the planet warmer than it would be otherwise; provides oxygen, moisture and carbon dioxide; and prevents most harmful radiation from reaching the surface.

Green plants and algae (related plant-like organisms that usually grow in water) are able to absorb energy from the sun and use it to combine carbon dioxide (CO_2) from the atmosphere with water to make energy-rich molecules, such as sugars and carbohydrates. Green plants and their products form the base of almost all food webs on Earth. They also are the source of our most common fuels.

Fuels such as wood, coal, oil and natural gas all are composed of matter originally produced by plants and other organisms. Each holds energy, originally trapped during photosynthesis, in the chemical bonds of carbon-containing molecules. When these substances are burned, they release heat energy that can be used for many purposes.

Our use of fossil fuels has grown dramatically since the 1800s. During the Industrial Revolution, coal was used to power steam engines in mines, factories, locomotives and ships. Later, it was used to generate electrical power. The discovery of large deposits of petroleum led to widespread use of fuels for transportation, heating and production of electricity. When fossil fuels are burned, carbon-containing molecules combine rapidly with oxygen. This chemical reaction releases energy in the form of heat. It also releases CO_2 into the air. Many other chemical substances also are produced by the burning or incomplete burning of fossil fuels.

Photo courtesy of NASA.

Rainbow in the Room

Physical Science

Light that we can see is just part of the entire spectrum of radiation produced by the sun (electromagnetic radiation). The sun bombards Earth with radiation of many different wavelengths at the same time. Some radiation emitted by the sun can be classified as infrared (which we feel as heat) or visible (which we see as light and color). However, the sun also produces higher energy radiation, such as ultraviolet (or UV) radiation, x-rays, and gamma rays.

Radiation from the sun, including light, behaves as if it travels in waves. The distance between wave crests (wavelength) and the speed with which they pass a fixed point (frequency) are related to the amount of energy contained in photons (basic units of light) that make up the wave. Radiation of shorter wavelengths (which travel at higher frequencies) has more energy than radiation of longer wavelengths. Visible light falls between the longer wavelengths of infrared radiation and shorter, higher energy wavelengths of ultraviolet radiation.

Visible light consists of a mix of wavelengths that we detect as different colors. We can see these colors when white light (light as we usually see it) passes through a prism—or drops of water—and forms a rainbow.

The colors of the rainbow always appear in the same order, because they correspond to different wavelengths of light. You may have learned the acronym, "ROY G. BIV," to help you remember the colors of the rainbow from longest to shortest wavelengths: red, orange, yellow, green, blue, indigo and violet.

Unit Links

Mr. Slaptail's Curious Contraption
Story, pp. 1–5

SETUP

This activity requires no prior preparation. However, for dramatic effect, you may want to set it up while students are out of the classroom for lunch or another activity.

Have students work in groups to share materials as they create their own rainbow designs.

PROCEDURE

1. Fill a clear, liter-sized glass or plastic container with water and place it on the lighted "stage" of an overhead projector.
2. Darken the classroom as much as possible. You and your students will be able to observe a circular rainbow projected around the classroom.
3. Allow a few moments for students to observe the rainbow. Ask, *Have you ever seen anything like this before?* Students will provide a variety of responses. Follow by asking, *Do you think the colors are the same in every rainbow?*

CONCEPTS

- Visible light is composed of many different wavelengths of radiation.
- We can see different wavelengths of light as the colors of the spectrum.

OVERVIEW

This activity generates student excitement about light through the creation of a room-sized rainbow.

SCIENCE, HEALTH & MATH SKILLS

- Observing
- Predicting
- Identifying patterns
- Drawing conclusions

TIME

Class: 20 minutes

MATERIALS

- 2 cups, 9-oz clear plastic (or clear glass jars or glasses)
- Clear beaker, 1,000-mL size (or qt-sized glass jar or other clear container)
- Overhead projector

Each student will need:

- Crayons or colored markers
- Sheet of white paper

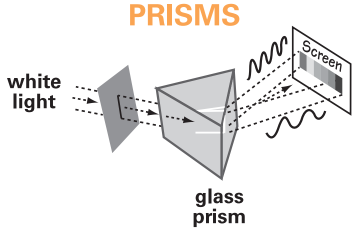
IMAGE CITATIONS

Source URLs are available at the front of this guide.

SPEED OF RADIATION

All radiation, including light, travels at the same speed—about 300,000,000 meters per second when in a vacuum.

PRISMS



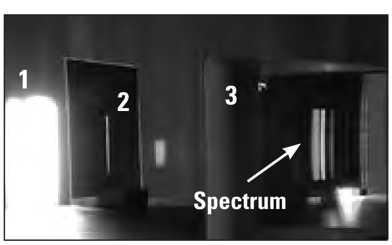
More than 300 years ago, Sir Isaac Newton, a famous physicist, demonstrated how a prism splits white light into a continuous spectrum.

RAINBOWS

A rainbow forms when white light passes at an angle from one transparent material (such as air) into another (such as water or glass). The waves corresponding to different colors of light travel at different frequencies, so they are dispersed differently by the second material.

A SIMPLE SPECTROSCOPE

A basic spectroscope can be made using the following components: 1) source of white light, 2) a piece of cardboard with a slit in the center, 3) prism. Seen from an alternate viewpoint (below, in grayscale), white light is split into the spectrum.



Source: Wikimedia Commons.

4. After students have shared or written their predictions, place another, smaller cup or glass filled with water on the overhead. Have students observe and compare the sequence of colors in the rainbow produced by the second cup.
5. Repeat with a second cup or glass of water. Repeat the question, *Do you think think the colors are the same in every rainbow?* Make sure students are able to observe that the sequence of colors always follows the same pattern. With older students, explain that the colors of light represent energy of different wavelengths.
6. Have students identify the source of light for the rainbow (white light from the overhead projector). Then, help them understand that the light is being separated into its constituent colors as it passes through the water in the container.
7. Let each student make his or her own "rainbow" drawing that incorporates the sequence of colors observed in the classroom rainbow. Display the rainbow drawings.

VARIATIONS

- Conduct further explorations of the spectrum by using prisms outside with sunlight and/or indoors with light from incandescent or fluorescent bulbs.
- Help students understand waves by modeling wave motion with a spring toy ("slinky"). Lay the spring on a table top and wave one end from side to side. Students will be able to see waves move along the length of the spring.
- Explore the vast differences among wavelengths in the electromagnetic spectrum by measuring out the lengths of some of the following kinds of waves in the classroom and/or on the playground.

100 m	AM radio waves
10 m	FM radio waves
1 m	television waves
1 cm	microwaves, such as those used to cook food
less than 1 mm	infrared waves, felt as heat

- Printers use cyan, magenta, yellow and black inks to create all of the colors in a printed document. Have students examine color photographs, comics or advertisements printed in the newspaper using a hand lens or magnifier. Have them identify the combinations of colored dots used to create colors such as orange, green and purple.

Modeling Earth's Atmosphere

Physical Science

The air surrounding Earth is known as the atmosphere. Gas molecules in the atmosphere are held relatively close to Earth's surface by gravity. The atmosphere is mostly nitrogen (78%) and oxygen (20%). The amount of water vapor in the atmosphere varies, but can be as much as 5% by volume. Other gases, present in much smaller amounts, also are extremely important parts of the atmosphere. Carbon dioxide (CO_2), methane (CH_4) and other gases, including water vapor, help radiate heat back toward Earth's surface, thus keeping it much warmer than it would be otherwise. Ozone, which is present in tiny amounts in part of the atmosphere, filters out most of the harmful ultraviolet radiation from the sun.

Life on Earth would not be possible without the atmosphere, which protects the planet's surface from extremes of temperature and harmful radiation, and also provides essential water, carbon dioxide, oxygen and nitrogen. This activity helps students learn about Earth's atmosphere by creating a scale model.

Unit Links

Mr. Slaptail's Curious Contraption
Story, pp. 6–9

Explorations
Swirled World, p. 4

SETUP

Divide the class into six groups of four students. Each group will be responsible for creating a different part of the model, which should be assembled and displayed on the floor or the wall. Copy and cut out the Job cards prior to class.

PROCEDURE

1. Ask students if they ever have seen pictures of astronauts in space. Ask, *Why do the astronauts wear special suits?* Mention that the space suits keep astronauts warm, provide them with air to breathe and protect them from harmful rays from the sun. Follow by asking if we need to wear space suits on Earth. Help students recognize that the thin layer of gases surrounding Earth—the atmosphere—provides protection for all of the planet, as space suits protect the astronauts.
2. Mention that, as a class, the students will create a scale model of Earth's protective layer of gases. Lay a sheet of brown or white paper (at least 2.5 m long) on the floor where students can work on it. Discuss the scale of the model with students (1 cm = 1/2 km; 2 cm = 1 km).
3. Distribute the Job cards to student groups. Each group will create and decorate a different part of the atmosphere model. Older students should measure and draw their own lines on the model. To facilitate work in groups, you may want students to cut off their sections of the model to complete in separate

CONCEPTS

- The atmosphere consists of layers of gases surrounding Earth.
- The layers have different characteristics.

OVERVIEW

By creating a scale model of the atmosphere, students learn about its composition and structure.

SCIENCE, HEALTH & MATH SKILLS

- Measuring
- Modeling
- Inferring

TIME

Preparation: 10 minutes
Class: One or two sessions of approximately 30 minutes

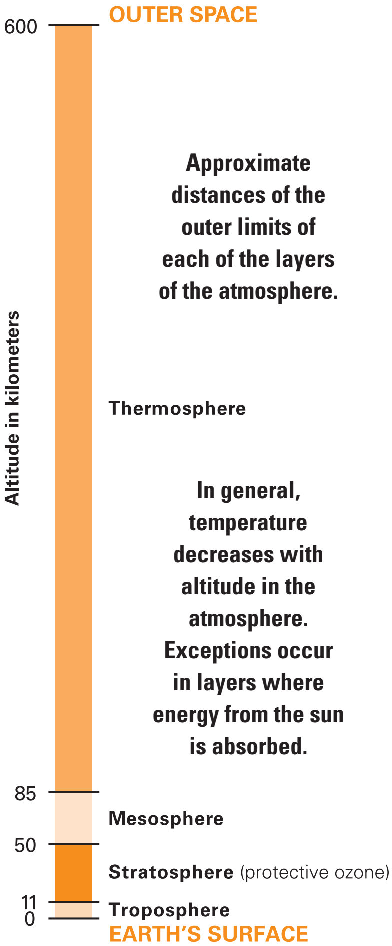
MATERIALS

- Large sheet of white or brown wrapping or banner paper, 1 m x 3 m (approx.)

Each group will need:

- 6 sheets of construction paper, asst. colors, 9 in. x 12 in.
- Crayons or markers
- Glue stick or roll of tape
- Pair of scissors
- Job cards from "Atmosphere Model" student sheets (p. 9–10)

The word "atmosphere" comes from the Greek word *atmos* (vapor) and the Latin *sphaera* or Greek *sphaira* (ball). The names of the layers are based on *tropos* (to turn), *stratum* (layer), *mesos* (middle) and *therme* (heat).



Ozone, a highly reactive gas molecule made of three oxygen atoms, is found naturally in the stratosphere. Even though it is present only in tiny amounts, ozone is vital to the planet. It absorbs most of the harmful ultraviolet radiation emitted by the sun and prevents it from reaching Earth's surface.

Near the ground, ozone often is produced as a byproduct of burning fossil fuels. Unfortunately, in this instance, ozone is very harmful. It can damage lungs and is harmful to other living things, such as plants.

In the atmosphere model created by students, 1 cm represents 0.5 km. Based on these proportions, the diameter of the Earth would have to be drawn as approximately 25,000 cm. The sun would be positioned 300,000,000 cm away!

locations. (Groups 1 and 2 work on the same section.) Once completed, the sections can be taped together.

Group 1–Planet Earth. Draws a vertical line about 15 cm from the bottom of the sheet of paper (this line represents the Earth's surface); creates figures (mountains, forests, cities, etc.), using construction paper or other materials and adds them to the model. Remind students that the figures they create should be no more than 5 cm tall.

Group 2–First layer of the atmosphere (troposphere). Draws a line about 22 cm from the line designating Earth's surface (represents the upper limit of the first layer); adds figures of weather phenomena (clouds, rain, lightning, etc.), as well as low-flying aircraft and hot air balloons. Point out to students that much of the pollution produced by burning wood and fossil fuels remains in the troposphere. The gases responsible for keeping Earth warm (greenhouse gases) are found in this layer. Temperatures within the troposphere decrease with altitude.

Group 3–Second layer of the atmosphere (stratosphere). Draws a line about 100 cm from the line for the Earth's surface (represents the upper limit of the second layer); adds figures of storm clouds, jet aircraft, wind, and a representation of the protection provided by ozone molecules in this layer. The stratosphere is warmer due to absorption of UV light by ozone.

Group 4–Third layer of the atmosphere (mesosphere). Draws a line about 170 cm from the line for the Earth's surface (represents the upper limit of the third layer); adds figures of feathery ice clouds and weather balloons. The mesosphere is very cold.

Group 5–Fourth layer of the atmosphere (thermosphere). Adds figures of spacecraft, satellites and meteors (shooting stars) to the model. If students were to draw a line, the upper limit of the thermosphere would be 1,200 cm (12 m) from the baseline of the model. This group may use the remainder of the space on the sheet. This layer is very hot in some parts—up to 1,700°C or more—due to absorption of radiation by different atoms and molecules.

Group 6–Space outside Earth. Creates figures representing other components of the solar system and universe, and places them around the room. The exosphere contains very small amounts of hydrogen and helium, and continues until it merges with space.

4. Have each group label its layer on the model. Display the model somewhere in the classroom. Encourage students to note that most activities involving the atmosphere occur very close to Earth's surface. Leave the model available for students to refer to throughout the unit.

Atmosphere Model

Job Cards

Group 1 — Surface of Planet Earth

1. Draw a line across one end of the sheet of paper, about 15 cm from the bottom. This line represents Earth's surface.

2. Make figures that show different things found on the surface of Earth (like mountains, oceans, forests and buildings). The figures should be no taller than 5 cm. Glue or tape your figures onto the model.

Group 2 — First Layer of the Atmosphere: The Troposphere

1. Draw a line about 22 cm above the line for Earth's surface. This line represents the top of the first layer of the atmosphere.

2. Make figures to represent weather (like clouds, rain, lightning and wind), as well as low-flying aircraft and hot air balloons. Glue or tape your figures onto the model within the troposphere.

Group 3 — Second Layer of the Atmosphere: The Stratosphere

1. Draw a line about 100 cm above the line for Earth's surface. This line represents the top of the second layer of the atmosphere.

2. Make figures of storm clouds, jet aircraft, winds, and the protection provided by ozone. Glue or tape your figures onto the model within the stratosphere.

Group 4 — Third Layer of the Atmosphere: The Mesophere

1. Draw a line about 170 cm above the line for Earth's surface. This line represents the top of the third layer of the atmosphere.

2. Make figures of feathery ice clouds and weather balloons. (Temperatures in this layer are very cold.) Glue or tape your figures onto the model within the mesophere.

Group 5 — Fourth Layer of the Atmosphere: The Thermosphere

1. Use the remaining portion of the sheet to represent the thermosphere.

2. Make figures of spacecraft, satellites and meteors. (This layer is very hot.) Glue or tape your figures onto the model.

Group 6 — Space Outside Earth's Atmosphere

1. Make figures representing other parts of the solar system and universe.

2. Place your figures anywhere around the room.

Modelo de la Atmósfera

Tarjetas de Trabajo

Grupo 1 — Superficie de la Tierra

1. Dibujen una línea a lo largo de uno de los extremos del papel. Esta línea representa la superficie de la Tierra.
2. Hagan figuras de diferentes cosas que se encuentran sobre la Tierra (por ejemplo, montañas, océanos, bosques y edificios). Las figuras no deben de tener más de 5 cm de alto. Usen pegamento o cinta para colocar las figuras en el modelo.

Grupo 2 — Primera Zona de la Atmósfera: La Tropósfera

1. Dibujen una línea aproximadamente 22 cm de la línea que representa la superficie. La nueva línea representa el límite superior de la primera zona.
2. Hagan figuras de aviones, globos y que corresponden al tiempo (por ejemplo, nubes, lluvia y rayos). Usen pegamento o cinta para colocar las figuras en el modelo.

Grupo 3 — Segunda Zona de la Atmósfera: La Estratósfera

1. Dibujen una línea aproximadamente 100 cm de la línea que representa la superficie. La nueva línea representa el límite superior de la segunda zona.
2. Hagan figuras de cosas como nubes de tormentas, aviones de reacción, viento y la capa de ozono. Usen pegamento o cinta para colocar las figuras en el modelo.

Grupo 4 — Tercera Zona de la Atmósfera: La Mesósfera

1. Dibujen una línea aproximadamente 170 cm de la línea que representa la superficie. La nueva línea representa el límite superior de la tercera zona.
2. Hagan figuras de cosas como nubes de hielo y globos meteorológicos. (La mesófera es muy fría.) Usen pegamento o cinta para colocar las figuras en el modelo.

Grupo 5 — Cuarta Zona de la Atmósfera: La Termósfera

1. Su grupo puede usar el resto del papel para sus figuras.
2. Hagan figuras de cosas como naves espaciales, satelites y meteoros. Usen pegamento o cinta para colocar las figuras en el modelo.

Grupo 6 — El Espacio Fuera de la Atmósfera:

1. Hagan figuras que representan otras partes del sistema solar y del universo.
2. Coloquen sus figuras dondequiera en el salon.

Fossil Fuels and the Carbon Cycle 4

Physical Science

In the United States, more than 75% of the energy used in homes and businesses, and for transportation comes from coal, oil or natural gas. These fuels are known as "fossil" fuels because they are the remnants of ancient plants and other living things buried under intense heat and pressure over millions of years. They are very efficient sources of energy. However, it is important to keep in mind that the energy in fossil fuels originally came from the sun and was trapped by plants and similar organisms during photosynthesis. During this process, plants also consumed carbon dioxide (CO_2) from the atmosphere. So when fossil fuels are burned, trapped carbon is released back into the atmosphere, principally as CO_2.

- **Petroleum**, or crude oil, is a thick, gooey liquid that can be found within Earth's crust on land or beneath the sea floor. It was formed principally from tiny marine organisms that were buried in layers of sediment, such as sand. In addition to containing high-energy carbon compounds, petroleum contains varying amounts of substances such as oxygen, sulfur and nitrogen. Crude oil must be heated and distilled to separate it into gasoline, heating oil, diesel oil, asphalt and other materials. Some components of crude oil are used to manufacture industrial chemicals, fertilizers, pesticides, plastics, medicines and other products.
- **Natural gas** is a mixture of methane (CH_4) and smaller amounts of related gases. It often is found above deposits of crude oil. Natural gas burns hotter and produces less air pollution than any other fossil fuel. When burned, it also releases less CO_2, relative to the amount of energy produced.
- **Coal** is a solid that is formed in several stages. It is a mixture of many different substances, with varying amounts of water, nitrogen and sulphur. Coal is formed from peat—a moist soil substance made of partially decayed plant material. When peat is subjected to intense heat and pressure, it becomes lignite—a brown coal. Lignite will become bituminous coal if it is placed under more heat and pressure. Bituminous coal often is used as fuel because it produces high levels of heat and is abundant. The most desirable form of coal is anthracite, a hard mineral that results from the transformation of bituminous coal under more conditions of very high heat and pressure. Anthracite is a very attractive fuel because it burns cleanly and produces great quantities of heat.

Unit Links

Mr. Slaptail's Curious Contraption
Story, pp. 10–12;
Science box, p. 12

Explorations
Let's Talk About the Atmosphere and Health, pp. 2–3

CONCEPTS

- Fossil fuels are found within Earth's crust.
- The presence of certain layers of soil and rock helps predict the presence of oil.
- The supply of fossil fuels cannot be replenished.

OVERVIEW

Students will learn how geologists locate fossil fuels by using a straw to extract core samples from a model that has different layers.

SCIENCE, HEALTH & MATH SKILLS

- Predicting
- Observing
- Identifying patterns
- Mapping
- Drawing conclusions

TIME

Preparation: 45 minutes
Class: 30–45 minutes

MATERIALS

- 24 aluminum baking cups and a cookie sheet (see Setup)
- 2 envelopes of bran muffin mix (plus ingredients)
- 2 envelopes of corn muffin mix (plus ingredients)
- Green and red food coloring

Each student or team of 2 will need:

- Prepared GeoMuffin (see Setup)
- Cotton swab
- Crayons or colored markers
- Plastic serrated knife
- Section of plastic straw about 8 cm (3 in.) in length
- Toothpick
- Copy of "GeoMuffin Observations" sheet (p. 16–17)

One kind of fossil fuel, coal, can be found between layers of earth and rocks. The coal seam shown above (darkest layer) is in cliffs that are approximately 335 million years old. Earth has a finite amount of fossil fuels.

Photo © David Shand.

CARBON CYCLE

Carbon is the basic building block for many molecules in living organisms. Producers take carbon from carbon dioxide gas (CO_2) and create substances such as glucose (a kind of sugar) through photosynthesis. All other living things rely on producers for food.

When food is broken down or digested, carbon is converted back into CO_2, which is released into the atmosphere.

Other processes, such as burning and decomposition, also release CO_2 back into the atmosphere. In the oceans, some carbon is incorporated into the shells of organisms and becomes deposited in sediments.

When geologists look for fossil fuels, they often drill deep into Earth. They remove narrow cores of rock and sediments and examine them for clues about the presence of oil and other fuels. This activity lets students explore the layers in a muffin representing Earth's crust, using a straw to drill "cores."

SETUP

You will need to bake 24 GeoMuffins (see recipe, p. 15) in advance, using two envelopes of prepared bran muffin mix and two envelopes of prepared corn muffin mix, plus ingredients listed on the packages. (Other flavors may be substituted as long as they are different colors and contain no fruit or nuts.) You will need 24 aluminum baking cups on a cookie sheet or 24 paper liners and a muffin pan.

Note. Cake mixes usually are less satisfactory because the baked texture is too soft.

Cut straws into 3-in. lengths for students to use.

Students may work individually or in groups.

PROCEDURE

1. Show the muffins to the class. Point out that all of the muffins look the same on the surface. Tell students that the muffins are made of layers that look similar to those visible in a cross section of Earth's crust. Explain that they will be exploring their muffins to discover whether or not the muffins hold petroleum deposits, and where those deposits might be located. Lead the class in a discussion of how fossil fuels were formed under the ground, how they are mined and how they are used.
2. Give a muffin and a "GeoMuffin Observations" sheet to each student or team of students. Ask, *What do you think the inside of the muffin looks like?* Without touching or removing the baking cup, instruct students to draw their predictions on their student sheets. They also should predict whether or not they will find oil (see "Geomuffin Legend," right).
3. Have students insert a toothpick near the edge of their muffins to represent "North." Based on what they can observe on the top surface of the muffin, have students identify six places on the muffin to "drill."
4. Demonstrate the technique to be used. Show the students how to take a core sample by gently twisting a section of plastic drinking straw into a muffin and then pulling it back out. Use a cotton swab to dislodge the core by inserting it in the top of the straw and pushing the core out the bottom.
5. Encourage students to take at least six samples, recording each

GEOMUFFIN LEGEND

- RED = Oil
- GREEN = Predicting layer for oil
- YELLOW = Soil or rock layer
- BROWN = Soil or rock layer

sample's location on their worksheets, and then drawing and coloring the samples in order.

6. Once they have finished sampling, recording and coloring, students should evaluate their information, looking for a pattern. Based on their cores, students should draw an estimate of a side view of the muffin, showing all the layers.
7. Now instruct students to cut through the center of the muffin. They should compare their predictions with their muffins. Ask, *Did the core samples give you valuable information? Why or why not? Did you find anything that predicts the presence of oil?* Mention that geologists frequently look for certain patterns of layers in the cores. Certain patterns predict or suggest that oil might be present.
8. Have students consider petroleum as a resource. Ask, *What happens when we burn products made from oil? Does burning oil produce carbon dioxide? Do you think we could run out of oil?* Help students understand that oil and coal are resources that cannot be replaced once they have been "used up."
9. Initiate a discussion about where oil and other fossil fuels come from. Use the "Carbon Dioxide and the Carbon Cycle" page as an overhead to help students understand how photosynthesis by ancient plants and similar organisms is responsible for the carbon now found in fossil fuels. Challenge students to figure out what happens to the carbon in fossil fuels when the fuels are burned (carbon returns to the atmosphere as carbon dioxide).

VARIATIONS

- Instead of having students cut their muffins in half after making their predictions, challenge them to restore the "landscape" on the top of their muffins before proceeding with the rest of the activity.
- Encourage students to use resources in the library or on the Internet to learn about other important cycles in ecosystems. Nitrogen is another example of an atmospheric gas that cycles through non-living and living parts of ecosystems in many different forms.
- As an alternative to baking, use different colors of clay or modeling dough to make the layered GeoMuffins.

QUESTIONS FOR STUDENTS TO THINK ABOUT

How many different uses of fossil fuels are there? Have students use the library or the Internet to look for answers.

What will happen when we use up the supplies of fossil fuel? Do you think that we can get any more? Why or why not? Are there any good substitutes for fossil fuels?

How much oil and natural gas still are left on Earth? Have students look for answers in the library or on the Internet. *What might be done to ensure wise use of these resources?*

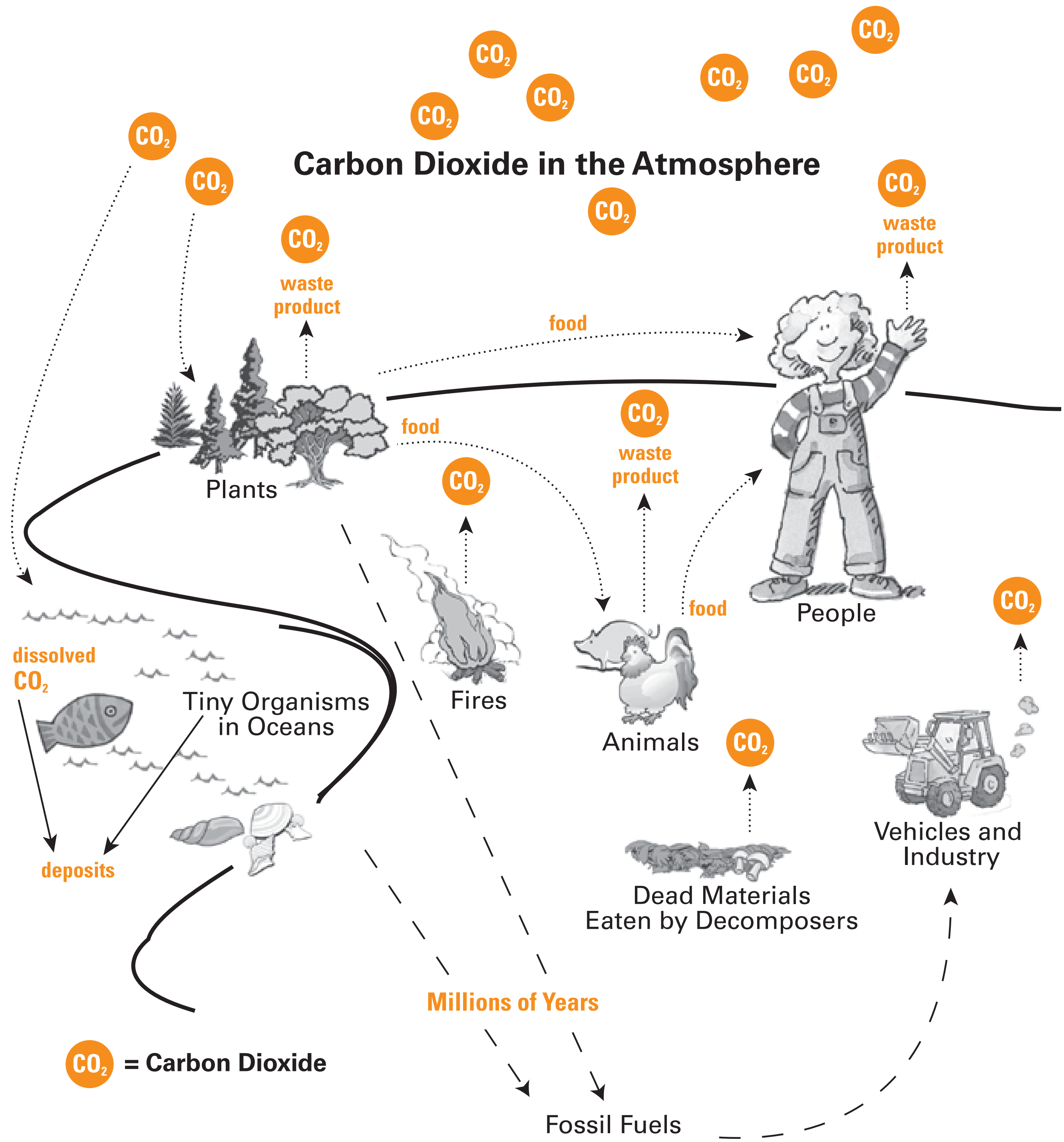
Modern society relies heavily on energy generated by burning fossil fuels—coal, oil and natural gas.

Photo courtesy of the U.S. Global Change Research Program, *Climate Literacy: The Essential Principles of Climate Science.*

LEGACY OF FOSSIL FUELS

Fossil fuels have supported unprecedented economic growth during the last century. Use of these fuels also is responsible for much of the world's air and water pollution, and has increased the levels of heat-trapping gases, such as carbon dioxide and methane, in the atmosphere.

4 Carbon Dioxide and the Carbon Cycle



GeoMuffin Baking Instructions

Materials and Ingredients

- 24 aluminum baking cups and a cookie sheet (or 24 paper liners and 2 muffin pans)
- 2 medium-sized mixing bowls
- 2 small mixing bowls
- 2 envelopes of bran muffin mix (plus ingredients listed on package)
- 2 envelopes of corn muffin* mix (plus ingredients listed on package)
- Green and red food coloring

*** Note:** Other types of muffin mixes without fruit or nuts may be substituted. *Do not use cake mixes.*

Baking Instructions

1. Preheat oven to temperature specified on the muffin mixes. If different temperatures are given on the two kinds of mixes, set oven to the lower temperature.
2. Set aluminum baking cups on the cookie sheet (or line muffin pans with paper baking cups).
3. **Bran muffin mix.** Combine both packages of bran muffin mix in one medium-sized bowl and prepare batter by following the instructions on the packages. If the mixture is very stiff, add additional milk or water so that the consistency of the batter is slightly runny.
4. **Corn muffin mix.** Prepare the packages of corn muffin mix in the second medium-sized bowl.
   - Remove about 1/4 cup of the corn batter to one small mixing bowl and color it deep red.
   - Remove about 1/2 cup of the corn batter to the second small mixing bowl and color it deep green.
5. Add batters in layers to the baking cups in the following order (see illustration, right).

   Layer 1: 1 Tbs of bran batter spread across bottom of the cup

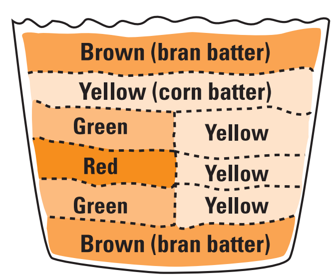
   Layer 2: 1/2 tsp of green batter on one side of muffin
   1 tsp of yellow batter next to the green

   Layer 3: 1/2 tsp of red batter spread over the green batter
   1 tsp of yellow batter next to the red

   Layer 4: 1/2 tsp of green spread over the red batter
   1 tsp of yellow batter next to the green

   Layer 5: 1 Tbs of yellow over entire muffin

   Layer 6: 1 Tbs of bran over entire muffin
6. Bake according to package instructions.
7. Cool before using with students. Muffins are firmer and easier to sample if they are baked a day in advance.



The colored layers in the muffin represent the following.

- RED = Oil
- GREEN = Predicting layer for oil
- YELLOW = Soil or rock layer
- BROWN = Soil or rock layer

GeoMuffin Observations

Name ____

1. Look at your GeoMuffin. Do not peel or eat it. Write a sentence to describe your GeoMuffin.

2. What do you think the GeoMuffin would look like if you cut it in half? Draw a cross section based on what you can observe.

3. Draw a top view of your GeoMuffin. Mark North on your muffin with a toothpick. Starting just right of your North marker, make your first core sample. Push the core out of the straw. Draw the core and color the layers. Mark it Sample Number 1.

4. Make at least 5 more samples. Draw each core in order in the space below.

5. Now, use the information from your core samples to draw what you predict a side view of your GeoMuffin would look like if you cut it in half. Then cut the muffin half and draw what you see. Compare your two drawings.

6. Do you think there is any "oil" in your GeoMuffin? Is there a pattern in the layers that predicts where oil will be?

Bizcochos Geológicos

La Buzqueda para los Combustibles Fósiles

Mi Nombre ____

1. Examina tu Bizcocho Geológico sin tocarlo o comerlo. Escribe una oración que describe tu bizcocho.

2. Como piensas que se vería si partieras el bizcocho a la mitad? Dibuja una vista de la mitad del bizcocho basado en lo que puedes observar.

3. Dibuja el bizcocho visto desde arriba. Usando un palillo marca el Norte. Empezando a la derecha del marcador del Norte, toma tu primera muestra con un popote. Saca la sección de bizcocho del popote. Dibuja la sección y colorea las capas. Márcala Muestra Número 1.

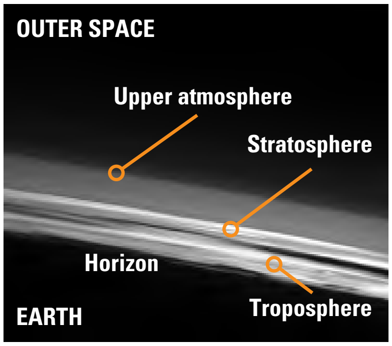
4. Toma por lo menos 5 muestras más. Dibuja cada muestra en el espacio abajo.

5. Ahora, utiliza la información de tus muestras para dibujar lo que piensas sería una vista de tu bizcocho si lo cortaras a la mitad.

6. ¿Piensas que hay "petroleo" en tu bizcocho? ¿Demuestran las capas algunas características que predicen la presencia de petroleo?

Solar Energy and Living Things

Life Science Basics



Reductions in the amount of ozone in the stratosphere are allowing more ultraviolet radiation (UV) from the sun to reach Earth's surface.

The effects of some kinds of UV exposure are cumulative and may not show up for many years.

In humans, increased exposure to UV radiation (especially UV-B, with wavelengths between 290–320 nanometers) is linked to skin cancer, the development of cataracts and effects on the immune system. UV-B radiation also is toxic to plants, including crop plants, and phytoplankton, which forms the basis of marine food chains.

Photo courtesy of NASA.

SUN AND SKIN

Skin is especially vulnerable to the effects of ozone depletion in the upper atmosphere. Ultraviolet radiation produced by the sun can damage skin, causing premature wrinkling and loss of elasticity, as well as skin cancer. As increased amounts of UV radiation reach the surface of the planet, the risks for skin damage also increase. Sunburns and suntans both are evidence that skin has been exposed to too much damaging radiation.

Life on Earth depends directly or indirectly on energy from the sun. Solar energy, which reaches us as heat, light and other types of electromagnetic radiation (such as ultraviolet, or UV, radiation), also can be harmful to living things.

Most of the energy we use each day comes in some way from materials photosynthesized by plants and other producers, such as algae. During photosynthesis, energy from the sun is trapped to build molecules necessary for life. The oil, natural gas and coal that have been essential for the development of our modern industrial world all are made up of the remains of dead organisms that relied on photosynthesis. Similarly, all of our food, which provides energy for our bodies, ultimately comes from plants and other producers—whether we eat plants directly or eat other organisms that consume plants.

The pathway of energy through Earth's living and non-living systems closely parallels the routes followed by carbon in the carbon cycle. This simple element (the fourth most abundant element in the universe) forms the backbones of the molecules produced and used by all living things—from DNA to fossil fuels. Plants and similar organisms create food molecules from carbon dioxide (CO_2), water and energy from the sun. They use this energy to drive all other processes necessary for life. When carbon-containing substances (wood, oil, natural gas or coal, for example) are burned, CO_2 is released back into the atmosphere. Similarly, when living cells use the chemical energy stored in food, CO_2 is released. This process is known as respiration.

Shorter wavelengths of solar radiation (such as UV radiation) can damage cells. This is important because more UV radiation is reaching Earth's surface as a result of ozone depletion in the statrosphere. Stratospheric ozone, which absorbs UV radiation, is destroyed by certain chemicals, particularly those known as chlorofluorocarbons (CFCs). Exposure to UV radiation can increase a person's chances of getting skin cancer or of developing cataracts. Other organisms, from frogs to marine algae, also can be harmed by UV radiation.

It is particularly important to protect skin from the sun. Less than one millimeter in thickness, skin plays an essential role in the body. It protects inner tissues and provides communication (through the sensory system) with the outside environment. The skin also aids in maintaining a constant temperature within the body. The numerous blood vessels in the skin and sweat glands help cool the body when outside temperatures are warm.

The skin is composed of layers, each with different characteristics. The layers of skin act like thin boards pressed together in a sheet of plywood, giving skin greater strength than it would have otherwise.

Finding the Carbon in Sugar

5

Life Science

Most of the fuels we use come from dead plant or animal matter. The origin of fuel wood, of course, is obvious. However, all fossil fuels also are derived from decomposed organisms that have been buried at high temperatures and pressures for millions of years. The energy in these fuels was captured from the sun during photosynthesis by plants, some bacteria and algae.

When something burns, it combines rapidly with oxygen in a reaction that releases energy. Most of this energy is given off in the forms of light and heat. Other things are given off at the same time. Carbon dioxide, once trapped by green plants during photosynthesis, is formed again and released. Water, also essential for photosynthesis, is released as well. In addition, most fuels produce substances such as smoke and soot, and other gases like methane and carbon monoxide, when they are burned. Some fuels, such as natural gas, burn much more cleanly than others, such as coal. However, all fossil fuels release carbon back into the atmosphere during combustion.

Unit Links

Mr. Slaptail's Curious Contraption
Story, pp. 12–15

Explorations
Let's Talk About the Atmosphere and Health, pp. 2–3

SETUP

Conduct Session 1 as a demonstration. Session 2 may be conducted by students working in groups of 2–4, or as a teacher demonstration.

Safety note. Have students remove loose papers, tie back hair and secure loose clothing before lighting candles.

PROCEDURE

Session 1: What happens when something burns?

1. Have the following materials ready: large beaker or tempered glass bowl, candle, matches and several wet paper towels folded together to make a mat larger than the opening of the beaker or bowl.
2. Direct students' attention to the materials you have gathered. Light the candle and ask, *What is happening to the candle?* After students answer that it is burning, ask, *What do you think it means to burn something? Are we seeing a physical change in the candle or a chemical change?* Remind students that a chemical change produces substances different from the ones that originally were present. Chemical changes usually give off or take in energy.
3. Ask students to predict what might happen if the candle is covered with the beaker. After students respond, place the lighted candle on the wet towels and cover it with the container. Fold the edges of the towels around the lip of the container to create a seal.

CONCEPTS

- Burning or combustion takes place when a fuel combines rapidly with oxygen. This is a chemical change.
- When something burns, CO_2, water and other substances are given off.
- Fuels made from living materials contain carbon.

OVERVIEW

Students learn about combustion and energy by observing a burning candle in a sealed jar and the burning of white sugar.

SCIENCE, HEALTH & MATH SKILLS

- Observing
- Measuring
- Predicting
- Recording observations
- Inferring
- Drawing conclusions

TIME

Preparation: 20 minutes
Class: Two sessions of 30 minutes

MATERIALS

- Clear beaker, 1,000-mL (or tempered glass bowl)
- Matches
- Tea candle
- Wet paper towel

Each group will need:

- 1/2 tsp of white sugar
- Small piece of aluminum foil (15 cm square)
- Tea candle
- Wet paper towel

Each student or group will need:

- Copy of "Sugar as Fuel" student sheet (p. 21–22)

CARBON IN LIVING THINGS

All living things are made out of molecules containing carbon. Plants take in carbon as carbon dioxide from the air. During photosynthesis, plants make energy-rich molecules, such as sugars, that have carbon as a backbone. Plants and all other organisms use these simple molecules to provide energy and raw materials to manufacture other substances necessary for life. We can see the evidence of the carbon in sugar as a black residue that appears when the sugar begins to burn.

The formula for table sugar (sucrose) is: $C_{12}H_{22}O_{11}$.

COMBUSTION

Combustion is a chemical reaction. When something burns, it combines rapidly (sometimes violently) with oxygen. Energy is released in this process, which usually also yields water, carbon dioxide and small amounts of other chemicals.

The ultimate clean-burning fuel is pure hydrogen (H_2), which combines with oxygen to yield only pollution-free water (H_2O). However, practical daily applications of this explosive substance are still being designed.

4. Have students observe what happens to the candle. The flame will become smaller until it finally extinguishes (this usually takes less than a minute). Ask, *What happened to the candle? Did it run out of material to burn? Do you think it ran out of something else?* Help students understand that the candle used as much oxygen gas (one of the gases in air) as was possible.
5. Lift the container slowly and have students observe the other substances present: smoke and condensed water vapor on the sides of the container. Let them examine the candlewick. Ask, *What can we see or feel that was produced by the burning candle?* (heat, water, smoke, charred wick). *What was used by the burning candle?* (melted wax and the wick as fuel, oxygen gas from air).

Session 2: Sugar as fuel

1. Have each Materials Manager collect a candle, a square of aluminum foil, a wet paper towel and one or more copies of the student sheet. Students should clear all papers and place their candles on the wet toweling in the center of their work areas.
2. Let students create a "testing spoon" by forming the foil into a spoon-like shape with a long handle (see illustration, p. 21). The bowl of the spoon should be made of only one layer of foil.
3. When students have completed their spoons, have one person from each group measure about 1/2 teaspoon of sugar into the spoon.
4. Have the students in each group predict what will happen when they heat the sugar over a lighted candle. They should record their predictions on their student sheets.
5. Light the candles (which should be placed on the wet paper towels) for each group. Direct each principal investigator to hold the bowl of the "spoon" over the candle flame. Other group members should observe and record what happens to the sugar. (It will become liquid and turn amber-colored. This is caramel, similar to the topping used for desserts like flan and custard. Finally, the sugar will burn and become blackened.)
6. Ask, *What happened to the sugar?* Help students recognize that the sugar underwent a physical change (solid to liquid) and a chemical change (burning of liquid sugar). Also ask, *Where did the carbon in the sugar come from?* Lead students to understand that the carbon was taken from air as carbon dioxide during photosynthesis. Have students examine the bottom of the spoon. Ask, *Where did that carbon come from?*

QUESTIONS FOR STUDENTS TO THINK ABOUT

Where does wax come from? How have wax candles been used in the past? Have students look for answers in the library or Internet.

All plants make sugar during photosynthesis. *Which plants are used to manufacture sweeteners, such as table sugar and syrups?*

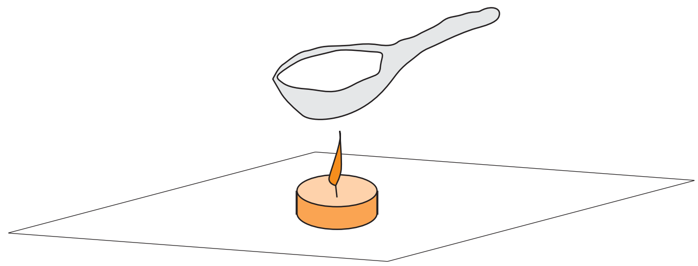
Sugar as Fuel

5

Name ________________________________

You will need:

1/2 teaspoon white sugar
candle
square of aluminum foil
wet paper towels



To carry out your investigation:

1. Mold the foil into a spoon with a long handle. Make sure that the bowl of the spoon is made of only one layer of foil.

2. Put the sugar into the bowl of the spoon.

   What do you think will happen to the sugar if you heat it for a long time over a candle flame? Write your prediction in the space below.

   ____
   ____
   ____

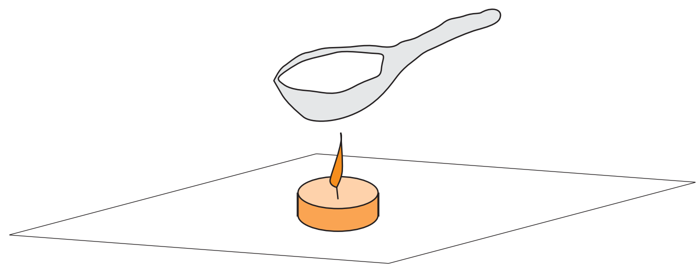
3. Hold the spoon by the handle and heat the sugar over a candle. For safety, place the candle on a wet paper towel, and follow your teacher's instructions.

4. Observe the changes in the sugar. Write your observations in the space below.

   ____
   ____
   ____
   ____
   ____
   ____
   ____
   ____

5 El Azucar como Combustible

Mi Nombre ____



Vas a necesitar:

1/2 cucharadita de azucar
una vela
un cuadrado de papel de aluminio
toallas de papel mojadas

Para hacer la investigación:

1. Usa el papel de aluminio para formar una cuchara con una asa larga. La parte honda de la cuchara debe hacerse de una sola capa de papel de aluminio.

2. Pon el azucar en la parte honda de la cuchara.

   ¿Que crees que pasará al azucar si lo calientas por mucho tiempo? Escribe tu predicción en el espacio abajo.

   ____
   ____
   ____

3. Toma la cuchara por el asa y calienta el azucar sobre una vela. Para mayor seguridad, pon la vela encima de unas toallas de papel mojadas.

4. Observa como cambia el azucar. Escribe tus observaciones en el espacio abajo.

   ____
   ____
   ____
   ____
   ____
   ____
   ____
   ____

Fuel for Living Things

Life Science

Some living things, especially plants and algae, are able to build all the materials they need from very simple substances. Using energy from light, carbon dioxide and water, these organisms, known collectively as producers, are able to make carbohydrates, which serve as fuel and raw material for the processes of life. All other organisms (consumers) rely on producers for food. Food provides energy and needed raw materials.

When organisms consume food, it is broken down to release energy and to obtain building blocks for other molecules. During this process, oxygen is consumed and some carbon is given off as carbon dioxide. This can be compared to the burning of fuels, which also uses oxygen and releases carbon dioxide. When something burns, most of the energy released is given off as heat. Inside living things, some of the energy is used to maintain the body and conduct reactions necessary for life.

All organisms (with a few exceptions) release carbon dioxide when they use food. In mammals, the released carbon dioxide is carried through the bloodstream to the lungs, where it is given off when we breathe out (exhale).

In this activity, students observe how carbon dioxide gas is given off by yeast cells, when the cells use sugar as food. Red cabbage "juice" will serve as an indicator for the presence of carbon dioxide. Cabbage "juice" turns bright pink in the presence of acids, such as the carbonic acid produced by dissolved carbon dioxide in water.

Unit Links

Mr. Slaptail's Curious Contraption
Story, pp. 16–20

Explorations
Lief Sigren, p. 7

SETUP

The indicator can be made in advance by the teacher or by student groups of 4. Session 2 is a teacher demonstration, followed by the investigation by student groups in Session 3. Consider having students read part of *Mr. Slaptail's Curious Contraption* or this unit's *Explorations* magazine between observations.

PROCEDURE

Session 1: Making the indicator (can be done in advance)

1. Have Materials Managers collect the materials for their groups.
2. Have students place the sliced red cabbage in the plastic bags, along with 1/2–1 cup warm water, and seal the bags tightly. Direct students to take turns gently rubbing the cabbage inside the bags until the water becomes dark purple (usually about 10–15 minutes). This is the indicator solution.

CONCEPTS

- All organisms need a source of energy.
- Plants and some other organisms (producers) take in energy from the sun.
- All other living things rely on producers for energy and raw materials.
- Carbon dioxide usually is given off when living things use food.

OVERVIEW

Students will observe what happens when yeast cells are provided with a source of food (sugar).

SCIENCE, HEALTH & MATH SKILLS

- Predicting
- Making qualitative observations
- Drawing conclusions

TIME

Preparation: 10 minutes
Class: 15 minutes to make indicator solutions; 15 minutes for demonstration; 30–60 minutes to conduct experiment

MATERIALS

- Tsp of baking soda
- Vinegar, a few drops

Each group will need:

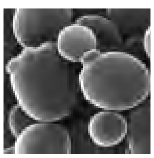
- 2 cups, 9-oz clear plastic
- 2 spoons or coffee stirrers
- 1/2 to 1 cup warm water
- Clear, resealable plastic bag, 4 in. x 6 in.
- Handful of raw, finely sliced red or purple cabbage
- Tsp of dry yeast
- Tsp of sugar

ACIDS AND BASES

ACIDS taste sour, conduct electricity and are corrosive. Common acids include vinegar, lemon juice, eyewash solutions (boric acid) and carbonated soft drinks.

BASES have a bitter taste and feel slippery when dissolved in water. Like acids, they can be very corrosive. Examples of bases include antacids, household ammonia and baking soda.

DECOMPOSERS



Baker's yeast *(Saccharomyces cerevisiae)* is used in food production. Yeasts are members of the same Kingdom as mushrooms and toadstools. Known as Fungi, members of this Kingdom are vital as decomposers. They obtain energy and nutrients by breaking down the bodies of dead organisms.

SEM image courtesy of Alan E. Wheals, Ph.D. © University of Bath.

FUEL FOR BODIES

When sugar is used for energy inside living things, CO_2 is released. This is comparable to what happens when fuels are burned for energy.

Students can observe how they exhale CO_2 by blowing vigorously with a straw into the cup of indicator solution for 5–10 minutes.

Session 2: Demonstration of cabbage juice indicator

1. Tell students that they will be using an indicator to look for the presence of an acid. If students are not familiar with things that are acidic, list some common examples, such as lemon juice and vinegar. Explain that the indicator will be used to test for the presence of carbon dioxide (CO_2), which becomes a weak acid in water.
2. Pour some indicator liquid into a clear cup. Ask, *What color is the liquid? What do you think will happen if I put something acidic into the water?* Add a few drops of vinegar to the solution until it turns pink. You also may show how the indicator solution reacts to bases by adding about 1/2 teaspoon (or more) of baking soda (the solution will turn pale blue or green).
3. Explain to students that they will be using the indicator to test for the presence of carbon dioxide (CO_2), a gas that is given off when living things use food for energy.

Session 3: Conducting the investigation

1. Talk about yeast with students. Ask, *Did you know that yeast is a living thing?* Explain that yeast is a living, microscopic single-celled organism. Under the right conditions, yeast begins to grow and multiply.
2. Direct the students to label two cups as "no food" and "food." Have them add about 1/2 cup of warm water and 1/2 teaspoon of yeast to each cup. Ask, *Do you think the yeast cells have very much to eat in the cup now?* Help students understand that all living things need food to survive and grow. Ask, *What do you think will happen if we add yeast food to one of the cups?* Have students record their predictions.
3. Have one person in each group add one teaspoon of sugar to one cup. He or she should swirl or stir the contents of the cup gently.
4. Direct the groups to set the cups side-by-side and to observe both cups at 5–10 minute intervals. The yeast in the cup with sugar will begin to produce CO_2 (making the liquid foamy) after a short period of time. Students should stir the cups (with separate stirrers) each time they make their observations.
5. After 30–45 minutes, instruct students to pour small, equal amounts of cabbage "juice" into both cups and to stir the mixture. Ask them to observe the colors. Have students record their observations. (The cup with sugar will be pinker in color than the other cup.)
6. Ask, *What happened when you fed the yeast?* Point out that the gas given off by the yeast is the same as that given off when wood, coal or oil is burned. Help students understand that the yeast cells were using the sugar as a source of energy.
7. Assess student understanding by having the members of each group write a paragraph describing its investigation and results.

Measuring and Protecting Skin 7

Life Science

Skin protects inner tissues of the body and provides communication (through the sensory system) with the outside world. The skin also helps maintain a constant temperature within the body by aiding in cooling (through increased blood flow to the surface and perspiration) and heating (by reducing blood flow near the surface).

The skin is comprised of different layers. The outermost layer, the epidermis, consists of an inner layer of living cells and a top layer of compacted dead cells. In fact, most skin that is visible on our bodies actually consists of dead cells! Skin color is determined by special cells, called melanocytes, located near the base of the epidermis. The lower layer, the dermis, is fibrous and gives strength to skin. Most nerve receptors that capture information from the outside world are located at the top of the dermis or the base of the epidermis.

Unit Links

Mr. Slaptail's Curious Contraption
Story, pp. 21–22;
Science box, p. 20

Explorations
What Is It?, p.6;
SkinWise, p. 8

Skin can be damaged by ultraviolet (UV) radiation from the sun or tanning lights, which can cause premature wrinkling and loss of elasticity of the skin, as well as skin cancer. Sunburns and suntans both are evidence that skin has been exposed to too much harmful radiation. Due to ozone depletion in the upper atmosphere, more UV radiation is reaching Earth's surface. This has increased the risks for damage to skin and eyes (particularly through the development of cataracts).

This activity builds awareness of skin by having students contrast and compare the "skin" of an orange to human skin. Students also will compare the surface area of an orange to the area of a person's skin.

SETUP

Begin with a class discussion. Have students conduct the activity in groups of 2–4.

PROCEDURE

Session 1: Estimating surface area of an orange

1. Generate student interest by brainstorming about things that have a skin. List student ideas on the board. Older students may record the list in their science notebooks.
2. Discuss the purposes of skin (tree bark, skin on a banana, lizard skin, bird skin, etc.) based on the list of things with skins.
3. Holding an orange, explain to students that they will be examining the skin of an orange and comparing it with their

CONCEPTS

- Skin is a vital part of the body.
- Skin must be protected from sun damage.

OVERVIEW

Students will compare and contrast their own skin (including the area covered) with that of an orange.

SCIENCE, HEALTH & MATH SKILLS

- Predicting
- Estimating
- Calculating
- Graphing
- Drawing conclusions

TIME

Preparation: 10 minutes
Class: Two sessions of 30–60 minutes

MATERIALS

Each group will need:

- 2–3 feet of wax paper
- Crayons or colored markers
- Metric tape measure
- Orange or tangerine
- Paper towels
- Plastic knife
- Roll of tape
- Sheet of centimeter ruled graph paper
- Sheet of paper or a notebook for observations
- Copy of "Skin Observations" sheet (p. 28–29)

own skin. Ask, *How is the skin of an orange like your skin? How is it different?*

4. Have Materials Managers collect materials for the groups. Each group will need: an orange, paper towels, plastic knife, tape measure, sheet of writing or notebook paper, and two or more sheets of centimeter square graph paper.
5. Begin the group activity by having one student (Recorder) list the group's observations about the skin of the orange. Then place a check next to all observations that also would apply to human skin.
6. Next, ask, *How much skin does an orange have? How could we find out?* Instruct students to estimate the amount of skin on their oranges by coloring a similar area on their graph sheets. They may want to measure their oranges using tape measures. With older students, use this opportunity to investigate the relationships among diameter, circumference and area.
7. Ask, *How could you check your estimates?* Have students peel the oranges and, within each group, trace the peelings onto graph paper. Have them color the traced areas orange. Have students calculate the area that is colored by counting or measuring the number of squares filled in, and decide how much skin their oranges really have. Let students devise their own methods for counting partially colored squares, or instruct them to count every other partial square. Ask, *Are you surprised about the area covered by the skin? Why or why not?*
8. Next, have the students examine the peeled oranges. Discuss what might happen if oranges didn't have skin.

Session 2: Estimating the amount of skin on a person

1. Explain that, just like oranges, our bodies need protection. Mention some of the characteristics of skin: it is the body's

CLIMATE CHANGE AND HUMAN HEALTH

For reliable information about climate change and human health, visit the following websites.

Center For Disease Control and Prevention
cdc.gov/climatechange

National Academies of Sciences
dels.nas.edu/Climate/Climate-Change/Reports-Academies-Findings

National Institute of Environmental Health Sciences
niehs.nih.gov/about/od/programs/climatechange

U.S. Department of Health and Human Services
sis.nlm.nih.gov/enviro/climatechange.html

U.S. Geological Services, Office of Global Change
usgs.gov/global_change

World Health Organization
who.int/globalchange/environment

SUNSCREENS

Commercial sunscreens protect the skin by shielding it from UV radiation. Without protection, the skin reacts to UV light by creating a protective layer of pigment. Unfortunately, even a tan that is acquired slowly with the benefit of tanning lotion still is evidence of skin damage that eventually could lead to premature aging and/or skin cancer.

Sunscreens may contain substances, such as zinc oxide, that physically block radiation or that provide chemical protection. Most broad spectrum sunscreens contain physical and chemical components.

The "Sun Protection Factor" (SPF) of a lotion serves as a measure of its protecting power. A product with an SPF of 10 reduces the the amount of radiation reaching the skin by a factor of 10. Most experts recommend that products with an SPF of at least 30 be reapplied every two hours.

It is particularly important for all children to wear sunscreen, even for short exposures.

Many aspects of circles and spheres are described mathematically using radius (r) and pi (π), (π = 3.14).

$2r$ = diameter
$2\pi r$ = circumference
$4\pi r^2$ = surface of a sphere
$4/3\pi r^2$ = volume of a sphere

largest organ; skin provides protection from germs; it houses our cooling and heating systems; skin contains receptors for our sense of touch, etc. Refer students to the diagram of skin on page 8 of the *Explorations* magazine.

2. Ask, *How much skin do you have and how do you protect it?* Students can record their estimates in cm^2 in their science notebooks and list ways they protect their skin.
3. Tell students that the area of skin on the body can be measured with relative accuracy by applying the Law of Nines. This rule of thumb was developed to help doctors estimate the amount of skin damaged on people with burns. Roughly, each of the 11 major sections of skin on the body accounts for 9% (or 1/11) of the total (see illustration, right). Using this rule, students can estimate the total surface area of skin on their bodies by measuring the area of one arm.
4. Working in teams of two, have one student wrap another's arm in wax paper. Have them mark any areas of overlap, so that they will not be counted for the estimate of surface area.
5. Have them spread the paper out over two or more sheets of centimeter graph paper and count the number of squares covered (or have older students measure the dimensions of the wax paper and calculate the area as if it were a rectangle, or a rectangle and one or more triangles, showing area calculations).
6. Once students have found the surface area of an arm, have them multiply that figure by 11 to obtain the total surface area of skin on the entire body.
7. Ask students to imagine how they might look and feel without their skin—just like the peeled orange. Mention the importance of protecting skin from damaging UV radiation. Discuss strategies for protecting skin, including wearing clothes with long sleeves, always applying sunscreen, wearing hats, etc.

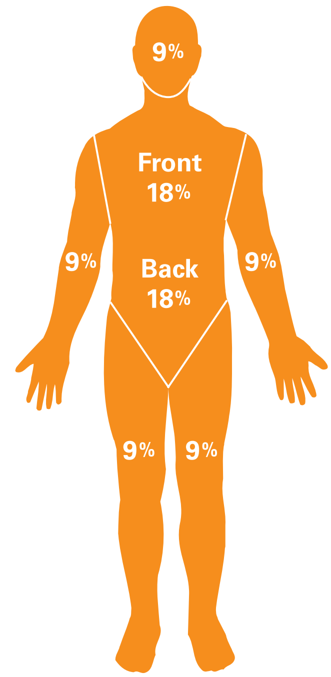
VARIATIONS

- Wrap the entire body of one or more students in wax paper; then spread the paper out and measure its area. Compare the result to the estimate calculated using the area of only one arm.
- Have students calculate the area covered by a t-shirt, shorts, bathing suit or other clothing. Challenge them to figure out the amounts of skin that are exposed when wearing short sleeves and shorts instead of long sleeves and trousers.

QUESTIONS FOR STUDENTS TO THINK ABOUT

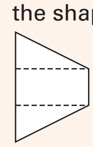
Read about ozone depletion and the role of CFCs (chlorofluorocarbons) on page 3 of the *Explorations* magazine for this unit. Ask students, *What else can you find out about the ozone layer? What is being done to protect this vital part of the atmosphere?*

LAW OF NINES



Each major part of the body represents about 9%, or 1/11, of the total amount of skin.

The area of an irregular geometric shape with straight sides (such as the students' wax paper "arm wraps") can be estimated by dividing the shape into one or more



rectangles and/or triangles. Find the area of each of the smaller shapes and sum the individual areas to find the total area.

To find the area of a rectangle, multiply length times width.

To find the area of a right triangle (a triangle with a 90° angle) multiply height times length of the base and divide the result by two.

Divide other kinds of triangles into two right triangles and calculate the areas as above.

7 Skin Observations

Name ____

Skin of an Orange

1. Observe the skin of an orange. Describe your observations on the back of this sheet.

2. Put a check beside the observations that are the same for human skin.

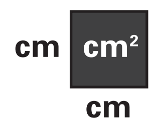
3. How much skin do you think is on an orange? Write your prediction in cm^2 beneath your observations.

4. Now, peel an orange, flatten the pieces of skin and lay them on graph paper.

5. Trace around the pieces. Color in the spaces that were covered by the orange skin.

6. Count the number of squares that are colored. How many centimeter squares did you count? Write the number below.

   Area of skin on orange = ______________________ cm^2



My Skin

1. How much skin do you think is on a person? Write your prediction in cm^2 beneath your predictions for the amount of skin on an orange.

2. Wrap your partner's arm in wax paper—making sure to cover only the arm.

3. Lay the wax paper over graph paper and calculate the area that is covered. This is the number of square centimeters of skin on the arm. Write the number below.

   Area of skin on arm = ______________________ cm^2

4. Multiply this number by 11 to figure out the total area of skin on the body.

   [ ] cm^2 **x 11 =** [ ] cm^2

Observaciones sobre la Piel

7

Mi Nombre ______________________________

Piel (cáscara) de una Naranja

1. Observa la piel de una naranja. Escribe tus observaciones en el otro lado de esta hoja.

2. Haz una marca junto a las observaciones que son similares para la piel humana.

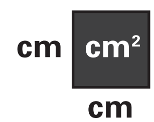
3. ¿Que tanta piel crees que tenga una naranja? Escribe tu predicción en cm^2 abajo de tus observaciones.

4. Ahora, pela la naranja, extiende los pedazos y colocalos sobre el papel cuadriculado.

5. Traza alrededor de los pedazos y colorea los espacios que fueron cubiertos por la piel de la naranja.

6. Cuenta el número de cuadros que están pintados. ¿Cuantos cuadros de un centímetro contaste? Escribe el número aquí.

   Area de la piel de una naranja = ______________________ cm^2



Mi Piel

1. ¿Que tanta piel crees que tenga una persona? Escribe tu predicción abajo de tu predicción de la piel de una naranja.

2. Envuelve el brazo de tu compañero en papel encerado — cuidando de cubrir justo el brazo.

3. Coloca el papel encerado sobre un papel cuadriculado y calcula el área que queda cubierta. Esto es el número de centímetros cuadrados de piel que hay en un brazo. Escribe el número aquí.

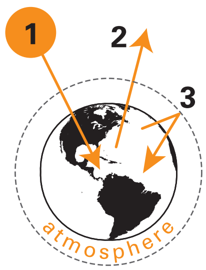
   Area de la piel del brazo = ______________________ cm^2

4. Multiplica este número por 11 para obtener el área total del cuerpo cubierto por la piel.

   [ ] cm^2 **x 11 =** [ ] cm^2

People and Climate Changes

WHAT IS THE GREENHOUSE EFFECT?



1. Sunlight passes through the clear atmosphere and warms the Earth's surface.
2. The warm surface reflects heat back into the atmosphere.
3. Greenhouse gases and water vapor trap some of the heat and send it back toward the Earth.

CFSs AND OZONE

The release of chemicals known as CFCs (chlorofluorocarbons) is contributing to changes in the atmosphere that will affect climate and human health and well-being. Freon and other CFCs are greenhouse gases that increase the amount of heat trapped near the surface of Earth. In addition, chlorine molecules released by these chemicals in the stratosphere break apart the ozone molecules responsible for shielding Earth from ultraviolet radiation.

Over the last decade, the amount of ozone in the stratosphere has decreased (especially in the polar regions)—leading to greater risks of skin cancer for people and also damaging vital populations of plants, animals and marine life.

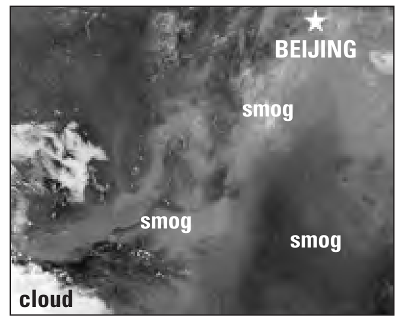
Life on Earth has been possible because of the very special characteristics of our atmosphere. The planet is warm enough to support life, thanks to the presence of certain gases in the lower atmosphere. The atmosphere also absorbs almost all of the potentially damaging radiation produced by the sun before it reaches the surface. Our atmosphere contains elements necessary for life—nitrogen, carbon and oxygen—as well as abundant water vapor to maintain the water cycle.

Human actions, particularly during the last several decades, are changing the composition of Earth's atmosphere. Since the industrial revolution, people have been removing stored carbon from Earth in the forms of coal, crude oil and natural gas, and burning it to make heat. In the process, water vapor, carbon dioxide and small amounts of other substances are produced. Other activities, such as clearing land (by burning) for agriculture, also have added CO_2 to the atmosphere. As a result, levels of carbon dioxide in the lower atmosphere have increased from around 260 parts per million (ppm) by weight to more than 350 ppm.

Carbon dioxide is one of the gases responsible for trapping heat near Earth's surface and lower atmosphere. Many scientists believe that increases in the amounts of CO_2 and other greenhouse gases, such as methane (CH_4), will lead to warmer temperatures on Earth. Even minor increases in the surface temperature of the planet could have far-reaching effects. Major climactic patterns of winds, temperature and rainfall could change drastically. This would impact water resources, coastlines, agriculture, forests, energy production and patterns of disease.

Climate, the characteristics of weather in a particular region over long periods of time, determines which kinds of plant and animal life are present, which crops can be grown, how people construct their houses and, to a great extent, people's clothing and diet. The climate of any given region depends on its distance from the equator, altitude and rainfall patterns.

Even slight changes in the world's climate affect human health and well-being in countless ways.



The dense smog over China in the above image likely results from pollution held in place by a temperature inversion. Air high in the atmosphere is usually cooler than the air near the ground. As warm air rises through the atmosphere, it disperses its pollutants, but when cold air is trapped under a layer of warm air, it cannot rise.

Winter temperature inversions are not uncommon as residents rely on coal for electricity and heat. These conditions lead to frequent build-ups of smog.

Photo courtesy of NASA Earth Observatory.

Using Heat From the Sun

8

Environment and Health

We seldom think about the sun's importance to our planet. It is the ultimate source of almost all the energy we use. Besides the sun, the only other sources of energy on the planet are radioactive rocks and the molten core deep below Earth's surface. The sun keeps us warm. It is responsible for weather, which is caused by uneven heating of large masses of air. Our food and common fuel sources depend or depended on solar energy trapped by producers, such as plants.

This activity is designed to build student awareness of the importance of the sun as the ultimate source of almost all energy on Earth. It also provides insight into harnessing the sun's power directly as a source of energy, as Mr. Slaptail does with his solar water heater in the adventure story that accompanies this unit.

Unit Links

Mr. Slaptail's Curious Contraption
Story, pp. 22–24; Science box, p. 20

Explorations
Sun Power, p. 4; We Can Make a Difference, p. 5

SETUP

Place all materials in a central area for Materials Managers to collect for their groups. Have students work in groups of 4 to conduct the activity.

If you are teaching this activity during the winter, you will need to conduct it indoors in a sunny window. When the weather is warm, students may conduct the experiment outside.

PROCEDURE

1. Ask students, *How do we get hot water in our homes? Does the water come that way or do we have to heat it?* Lead students into a discussion about different energy sources, such as electricity or gas, that usually are used to heat water for houses.
2. Follow the discussion by asking, *What if we didn't have any electricity or fuel to burn? Are there other ways to heat water?* Guide students into a discussion of the sun's importance as a source of heat and other energy for Earth. Ask, *How could we find out if the sun provides energy to heat water?* Tell students they will be investigating this question.
3. Have each group of students label two identical cups—one as "light" and one as "dark." Next, have them measure 50 mL of water into each cup.
4. Direct students to measure the temperature of the water in each cup and to record the temperature on their student sheets. Have each group place the cup labeled "light" in direct sunlight (outside or inside the classroom). The other cup should be left

CONCEPTS

- Some of the energy given off by the sun can be felt as heat.
- Heat from the sun can be used as a source of energy.

OVERVIEW

Students conduct a discovery activity that allows them to observe how energy from sunlight can heat water.

SCIENCE, HEALTH & MATH SKILLS

- Measuring liquids
- Predicting
- Observing
- Comparing
- Drawing conclusions

TIME

Preparation: 10 minutes
Class: 30–60 minutes

MATERIALS

Each group will need:

- 2 cups, 9-oz clear plastic
- Graduated cylinder, 100-mL (or metric measuring cup)
- Student thermometer, plastic
- Copies of "Sunlight Observations" sheet (p. 33–34)

Did you know that heat energy is measured in calories? One calorie represents the amount of heat required to raise the temperature of 1 cubic centimeter of water (10 milliliters) one degree.

RENEWABLE ENERGY SOURCES

Some homes have solar panels to generate their own heat and electricity.

Photo courtesy of Gray Watson, Wikipedia.

Energy from the sun creates the air currents used to generate electricity from "wind power."

Photo courtesy of the U.S. Global Change Research Program. *Our Changing Planet.* 2011.

inside the classroom, preferably in a dark area, away from any heating vents or radiators.

5. Have students predict the final temperature of the water in each cup and write their predictions in the appropriate spaces on the "Sunlight Observations" sheet.
6. If possible, have students wait at least one hour before checking the "light" cup. Have them measure the temperature of the water in the cup and record it on their sheet. Afterward, have them measure and record the temperature of the water in the "dark" cup.
7. Ask, *What happened to the water in the cup that you placed in the sun? Did it become warmer or colder, or stay the same? What about the water in the cup you left inside?* Help students understand that energy from the sun warmed the water in the "light" cup. Ask, *Where are other places that we can observe energy from the sun?*

Even fossil fuels, energy sources that we use every day, owe their existence to the sun. They formed from plants and tiny living organisms that were buried at intense pressures for millions of years.

VARIATIONS

- Have students compare how different colored cups absorb heat from sunlight, or examine the effects of placing the cups on a reflector made of aluminum foil, or on black paper (which absorbs heat). Students also may want to compare results from cups placed on a grassy surface to those with cups sitting on a paved surface.
- Challenge students to come up with their own designs for solar water heaters. Let them draw their designs and/or build their heaters from recycled materials.

QUESTIONS FOR STUDENTS TO THINK ABOUT

In the story, *Mr. Slaptail's Curious Contraption*, Mr. Slaptail builds a solar water heater to supply his house with hot water. Ask students, *Do you think this is a practical use of solar power?* Encourage them to visit the library or search the Internet to learn what they can about houses that use power from the sun for heat, electricity or hot water.

Sunlight Observations

8

Name ____

You will need:

- 2 cups
- thermometer
- water
- graduated cylinder or measuring cup

1. Label one cup "Light." Label the other cup "Dark."

2. Measure 50 mL of water into each cup.

3. Take the temperature of the water in each cup using the thermometer. Write the temperatures in the boxes.

Light	**Dark**
°	°

4. Put the "Light" cup in bright sunlight. Put the "Dark" cup in a dark place. Wait about one hour.

5. Predict the temperature that will be reached by the water in each cup after one hour. Write your prediction in the top half of each box below. Now, measure the temperature of the water in both cups again. Write the temperatures in the boxes.

	Light	**Dark**
Predict	°	°
Actual	°	°

6. What happened to the temperature of the water in the "Light" cup?

7. What happened to the temperature of the water in the "Dark" cup?

8. Why do you think this happened?

8

Observaciones Solares

Mi Nombre ______________________________

Vas a necesitar:

2 vasos	agua
un termómetro	una taza o un cilíndro para medir

1. Marca un vaso "Luz." Marca el otro "Sombra."

2. Mide 50 mL de agua en cada vaso.

3. Mide la temperatura en cada vaso usando el termómetro. Escribe las temperaturas en los cuadros.

Luz	Sombra
°	°

4. Pon el vaso "Luz" en el sol. Pon el vaso "Sombra" en algun lugar obscuro. Espera una hora.

5. Predice la temperatura que alcanzará el agua en ambos vasos. Escribe tu predicción en la parte superior de cada cuadro. Ahora, mide la temperatura del agua en ambos vasos otra vez. Escribe las temperaturas en los cuadros.

	Luz	Sombra
Predicción	°	°
Actual	°	°

6. ¿Que pasó con la temperatura del agua en el vaso "Luz"?

7. ¿Que pasó con la temperatura del agua en el vaso "Sombra"?

8. ¿Que crees que pasó?

Greenhouse S'Mores

Environment and Health

Several transparent gases in the lower layer of the atmosphere (troposphere) have an important role in determining the temperature of Earth's surface. These gases, which act like glass windows in a greenhouse or automobile, let light and other forms of radiation from the sun pass through the atmosphere. Much of this energy is absorbed into Earth's surface, which becomes warmer (just like the seats in a car parked in the sun). Some heat, however, is radiated back into the atmosphere. There, gases like carbon dioxide, methane, ozone and water vapor (the so-called "greenhouse gases") absorb some of the heat and sent it out again in all directions, including back toward the surface. This warms Earth's surface and the lower atmosphere.

Without the warming effect of greenhouse gases, Earth's average surface temperature would be around –18°C (0°F), instead of the actual temperature of about 15°C (59°F). Much of the planet would be frozen. On the other hand, if there were more of the greenhouse gases, Earth's surface would be too hot to support life.

Scientists around the world are concerned that increased levels of greenhouse gases (especially carbon dioxide), resulting from human activities, are causing additional warming of the planet's surface. Levels of carbon dioxide in the atmosphere have increased more than 30% since the industrial revolution. This increase is due primarily to the burning of fossil fuels and changes in land use (burning forests to clear land for farming, for example).

Even minor increases in the surface temperature can have far-reaching effects. Major climactic patterns of winds, temperature and rainfall could change drastically, impacting water resources, coastlines, agriculture, forests and energy production, as well as patterns of disease.

This activity is designed to provide a simple introduction to the concepts underlying the greenhouse effect and to provide background information for thinking about climate change.

Unit Links

Mr. Slaptail's Curious Contraption
Story, pp. 24–27, 30–31

Explorations
Not Such a New Issue, p. 6; Lief Sigren, p. 7

SETUP

Place all materials in a central area for Materials Managers to collect for their groups. Have students work in groups of 4.

If you are teaching this lesson during the winter, you will need to conduct it indoors with a heat lamp or use a sunny window. When the weather is warm, students may conduct the experiment outside in an area that is protected from the wind.

CONCEPTS

- Different materials absorb and trap heat differently.
- Some materials allow light to pass through, but do not let heat escape.

OVERVIEW

Students will observe how some transparent materials allow light to pass through, but do not let heat escape. This will provide background for understanding the role of heat-trapping gases in the atmosphere ("greenhouse effect").

SCIENCE, HEALTH & MATH SKILLS

- Predicting
- Observing
- Modeling
- Drawing conclusions

TIME

Preparation: 10 minutes
Class: 30–60 minutes

MATERIALS

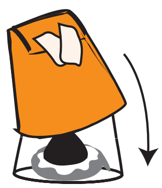
Each group will need:

- 4 chocolate candies ("kisses" or squares)
- 4 cups, 9-oz clear plastic
- 4 plain round cookies
- 4 toothpicks
- 1/4 cup of marshmallow creme (or frosting)
- Plastic knife or spreader
- Sheet of aluminum foil (approx. 12-in. sq. or 30-cm sq.)
- Sheet of black construction paper, 9 in. x 12 in.
- Sheet of white construction paper, 9 in. x 12 in.
- Tape or a stapler
- Tray or paper plate

S'MORES

S'Mores are traditional campfire treats made by roasting a marshmallow and a square of chocolate between two graham crackers. This activity challenges students to use solar energy to cook smaller versions of S'Mores.

GREENHOUSE S'MORES



Students will create covers of different materials for cups containing their "Greenhouse S'Mores." One way to make a cover is to roll a sheet of paper into a tube that will fit around the cup. Fold and tape (or staple) the top of the tube and place it over a cup.

TREATMENT

	Clear	Foil	Black	White
Group 1	4	1	3	2
Group 2	4	1	2	3
Group 3	3	2	4	1
Group 4				
Group 5				
Group 6				
TOTAL				

The windows of an automobile let sunlight through, but do not allow heated air to escape.

PROCEDURE

1. Ask students, *Have you ever noticed how warm a car can become when it is parked in the sun? Where do you think the heat inside the car comes from? How do you think we can learn more about light and heat?*
2. Tell students that they will investigate the heat-trapping qualities of different materials by using the sun to make a treat (see "Greenhouse S'Mores," left sidebar). Have Materials Managers collect 4 cups and 1 sheet of each of the 3 coverings for their groups. Have students make the following covers for three of the cups: white construction paper, black construction paper and aluminum foil. All covers should be about the same size and shape. Have students follow the instructions described at left OR challenge students to create their own cover designs. One cup will not have a cover.
3. After students have made covers for three cups, have each Materials Manager pick up four round cookies, four chocolate candies, a spreader and a small container of marshmallow creme or frosting.
4. Ask students if they have ever made S'Mores using marshmallows and chocolate squares. Tell students they will be using solar energy to make S'Mores in class. Each student will create one S'More by placing a small amount of marshmallow creme or frosting on the cookie, followed by a chocolate candy.
5. Direct students to place the cookies on a plate or tray and to cover each cookie with one of the cups. (If the experiment will be conducted outside, have students tape the cups to the plate.)
6. Within their groups, have students discuss the cover treatments and predict which treatment will result in the most softened or melted chocolate. Have students rank their predictions using a scale of 1 to 4, in which 1 = least softened and 4 = most softened.
7. Have students place the plates and cups in a sunny spot near a window, or outside in direct sunlight, preferably on a lawn. (Do not place the plates on hot pavement in the sun. The heat from the already warm surface will affect the results.)
8. Let students make their first observations after about 15 minutes. They should use a toothpick to test the candies. Depending on the air temperature, some of the chocolate candies may begin to soften by this time. Continue observing at 10–15 minute intervals, until at least one of the candies has become very soft. (Note: some chocolate candies may retain their shape even when they are very soft.)
9. Have students bring their plates indoors and observe the condition of each of the four chocolate candies. Ask students to rank the candies from least melted to most melted—giving a score of "1" to the least softened or melted and a score of "4" to the most softened or melted.

10. Make a chart on the board (see example, sidebar, p. 36) and have each group report its results.
11. Add (or have students add) all of the points received by each treatment. Usually, the clear /uncovered cup treatment will end up with the most points (clear cups result in the most melted chocolate, followed by the white cover and the black cover). The foil cover will have the fewest points (least melted chocolate). Because the observations are subjective, there usually will be some discrepancies among the results reported by each group. Use this as an opportunity to point out the importance of conducting an experiment more than once.
12. Discuss the results with the class. Ask, *Which treatment melted the chocolate the most? The least? Why do you think so?* Help students understand that more light energy was able to pass into the clear cup than into the others. Much of this energy was transformed into heat. The cup covered with foil reflected more light energy away. The white paper reflected some of the light energy away. The black paper absorbed more energy than the white cup.
13. Let each student eat his or her S'More, while you lead a discussion connecting their observations to what happens inside a car parked in the sun. You also may want to refer to page 9 in the story, *Mr. Slaptail's Curious Contraption*. Help students understand that certain gases in the atmosphere, especially carbon dioxide, act like the clear cups in their experiments. These gases keep the surface of the planet warmer than it would be otherwise.

VARIATIONS

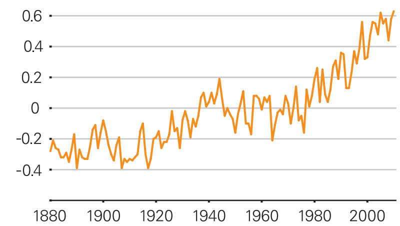
Before beginning, have students create a class chart of their predictions about the results of the investigation. Compare the predictions to the results and discuss the differences with students.

QUESTIONS FOR STUDENTS TO THINK ABOUT

The levels of some heat-trapping gases (especially carbon dioxide, methane and ozone) have increased in the atmosphere during the last several decades. Many scientists believe that these increases in greenhouse gases will cause additional warming of Earth's surface. Ask students, *Based on what you have observed, do you think that this is a reasonable prediction? What other information can you find about this topic in the library or on the Internet?*

Ask, *Based on what you have learned in this activity, how do you think Mr. Slaptail might have improved upon the design of his water-heating contraption?*

GLOBAL TEMPERATURE RECORDS



Global Temperature Anomalies (°C)

An analysis from the Goddard Institute for Space Studies shows that 2010 tied with 2005 as the warmest year on record, and was part of the warmest decade on record. Measures of temperature anomalies combine data representative of much larger regions than would be possible with absolute temperature, which varies markedly in short distances.

Source: NASA Earth Observatory.

VARIABLES

Experiment results often vary due to factors, known and unknown, that cannot be controlled by the investigator. Because of this variability, scientists use several to many experimental groups and repeat their experiments. This makes it possible to estimate the amount of variability present and to predict the consistency of the results.

This activity demonstrates the importance of conducting an experiment multiple times. It also shows how qualitative data can be handled using quantitative methods.

10 People and Climate

Environment and Health

CONCEPTS

- Major climate zones are determined by distance from the equator and angle of light received from the sun.
- Rainfall also is an important part of climate.
- Climate affects all aspects of human life.

OVERVIEW

Students will learn about Earth's major climate types and how they affect people's lifestyles.

SCIENCE, HEALTH & MATH SKILLS

- Observing
- Modeling
- Inferring
- Using maps
- Drawing conclusions

TIME

Preparation: 10 minutes
Class: Two or more sessions of 30–60 minutes

MATERIALS

- Flashlight
- Flashlight batteries
- Globe, large inflated balloon or ball

Each group will need:

- Large sheet of paper or poster board
- Several sheets of construction paper, asst. colors, 9 in. x 12 in.
- Glue sticks or paste
- One or more copies of "Global Climate Map" sheet (p. 41)

We don't often think about it, but many aspects of life are determined by climate, the characteristics of the weather in a particular region over long periods of time. Climate determines which kinds of plant and animal life are present, which crops can be grown, how people build their houses and, to a great extent, people's clothing and diet.

There are three major climate zones on the planet, determined by distance from the equator. The zone nearest the equator—the tropical zone—is warmest because it receives the most direct radiation from the sun. The zones closest to each pole—the polar zones—are the coldest, because they receive the least direct radiation. The broad areas between the tropical and polar zones—known as the temperate zones—generally have snow or rain during cool or very cold winters. The temperate zones lie between 30° and 60° latitude in both hemispheres.

Unit Links

Mr. Slaptail's Curious Contraption
Science boxes, pp. 27–29

Explorations
Cover; What is Climate? p. 2

Factors other than latitude also affect climate. Nearness to an ocean usually keeps temperatures cooler in summer and warmer in winter. Altitude also influences temperature; mountainous areas are colder than sea-level regions at the same latitude. In addition, rainfall varies from region to region depending on wind patterns and characteristics of the land. Some parts of the world receive little or no rainfall. Most of these desert areas are located near or within the tropical zone. Other parts of the tropical zone receive large amounts of rain during certain seasons.

Most scientists are concerned that human activities are modifying Earth's climate. The addition of greenhouse gases, such as carbon dioxide, may lead to increases in global temperatures (global warming). This could cause changes in rainfall and temperature patterns in many parts of the planet, with enormous consequences for ecosystems, cities and agriculture.

The release of chemicals known as CFCs (chlorofluorocarbons) also is contributing to atmospheric changes that affect climate and human health. Freon and other CFCs are greenhouse gases that contribute to the trapping of heat near Earth's surface. In addition, chlorine molecules released by these chemicals in the stratosphere break apart the ozone molecules that shield Earth from ultraviolet radiation. Over the last decade, the amount of ozone in the stratosphere has decreased (especially in the polar regions)—leading to greater risks of skin cancer for people and also damaging vital populations of plants, animals and marine life.

This activity is designed to raise students' awareness of how climate influences all aspects of people's lives.

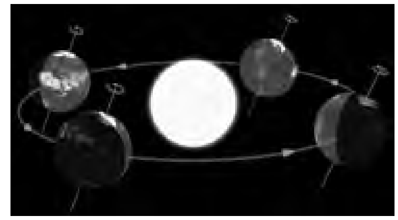
SETUP

Begin the activity with a whole-class discussion, and then have students work in groups of four.

PROCEDURE

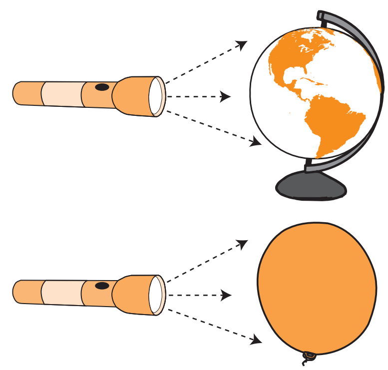
1. Darken the room and shine a flashlight at the center of a globe (or balloon, or large ball). Ask, *If the globe represents Earth and the flashlight represents the sun, which part of Earth receives the most direct light and heat from the sun?* Help students understand that the central part of the planet (near the equator) receives light at the most direct angle from the sun. Follow by asking, *Which part of Earth do you think might be warmest? Coldest? Why?*
2. Distribute copies of the "Global Climate Map" page to each student or group of students. Help students find the equator and relate it to the central portion of the balloon or ball used for your demonstration. Help students identify the polar and temperate regions.
3. Ask, *Is temperature the only important part of climate?* Lead students to understand that rainfall also is an important part of weather and climate. If students are not familiar with these concepts, introduce them at this point. *We use the term "weather" to describe conditions in the atmosphere at a given time or place. We usually measure several variables to describe weather, including temperature, rainfall, wind speed and humidity. The normal weather in a region over long periods of time is called climate. What is our climate like?* Lead a discussion of the climate characteristics in your location (winter conditions, amounts of rainfall, temperatures in summer, etc.).
4. Point out that regions with very little rainfall (deserts) also are shown on the "Global Climate Map" sheet.
5. Assign a climate zone and geographic area from the student page to each group of students. Examples might include: temperate zone of North America; tropical zone of South America; tropical desert zone of Africa; and so forth. Give more explicit geographic locations (by country or region) to older students, and have them use outside resources to gather additional information about their assigned regions. Explain that students should think about how people might live in the given climate type. Have each group discuss and decide the types of clothing that people might wear in summer and winter (or during rainy and dry seasons), what the houses might look like, and what foods people might eat. Refer students to the cover of the *Explorations* magazine accompanying this unit for ideas. Older students may

SEASONS



Earth is tilted as it revolves around the sun. When the Northern Hemisphere is tilted toward the sun, that half of the Earth has summer and the Southern Hemisphere has winter.

Illustration courtesy of Tau'olunga, Wikipedia Commons.



The center of the globe (or balloon) receives the most direct light.

TEMPERATURE AT HIGH ALTITUDES

Air temperatures are colder at higher altitudes because most heat on the planet is held near ground level. In fact, some mountains near the equator have snow at the top all year long.

VISUALIZATION ACTIVITY

As a supplemental activity to encourage students to think about the effects of air and water currents on the distribution of pollutants, have students conduct the "Swirled World" experiment found on page 4 of this unit's *Explorations* mini-magazine.

Photo by M.S. Young, Baylor College of Medicine

GLOBAL ATMOSPHERIC CHANGE RESOURCES

Intergovernmental Panel on Climate Change
ipcc.ch

NASA Earth Observatory
earthobservatory.nasa.gov

NASA'S Eyes on the Earth
climate.nasa.gov

National Oceanic and Atmospheric Administration, Climate Services
climate.gov/#education

National Park Service
nature.nps.gov/climatechange

U.S. EPA
epa.gov/climatechange

U.S. Geological Survey, Office of Global Change
usgs.gov/global_change

U.S. Global Change Research Program
globalchange.gov

want to use resources in the library or on the Internet to find additional information.

6. Have each group write a description of the climate in its region and a description of how people live in this region and climate. Have students illustrate their descriptions. Consider having students follow a format such as the one shown below.

Climate Zone ______________________________
Geographic Area ______________________________

DESCRIBE:
The Seasons ______________________________
Major Crops ______________________________
Major Foods ______________________________
Types of Clothes ______________________________
Types of Houses ______________________________
Other Important Factors ______________________________

7. Display each group's descriptions and pictures around the classroom.

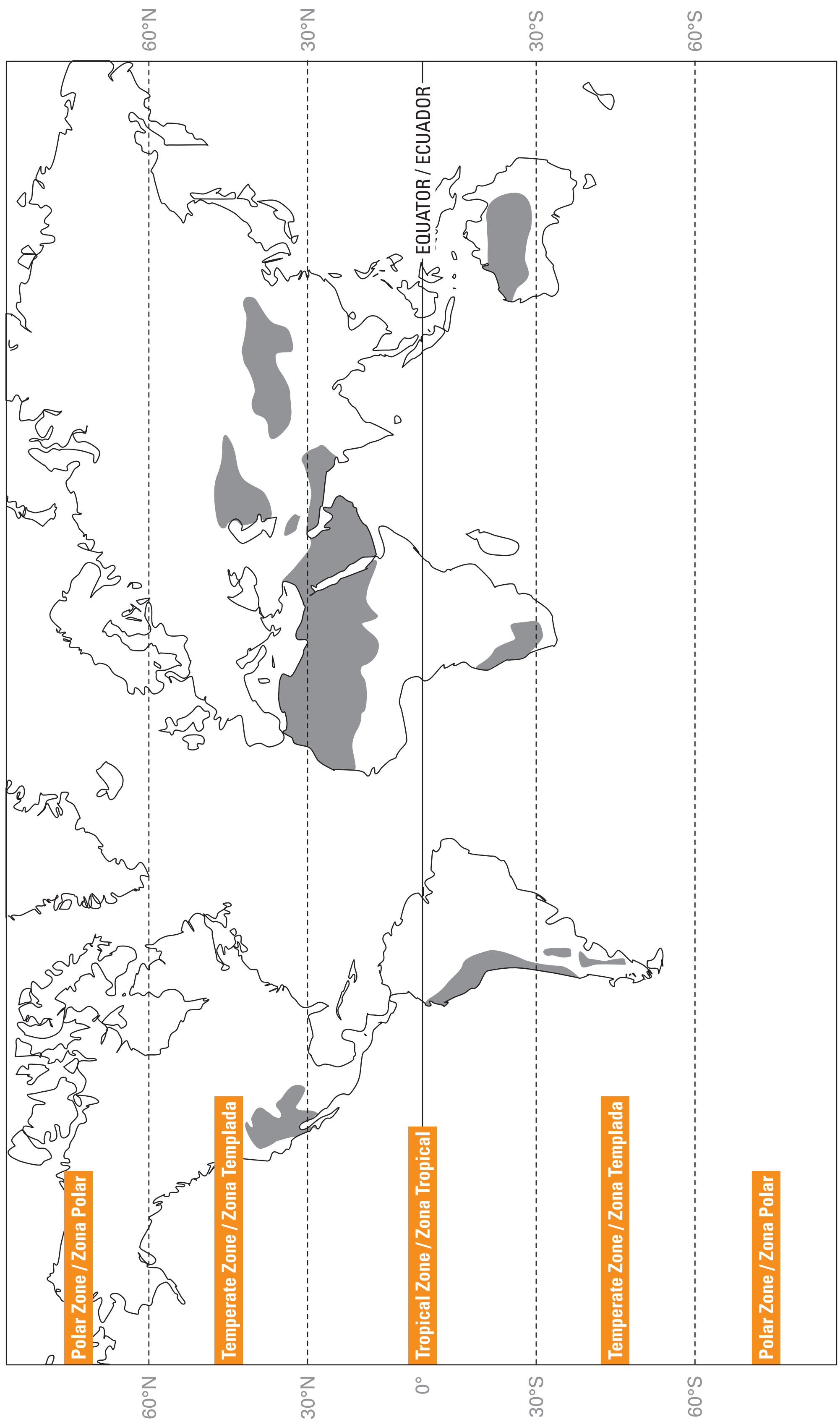
VARIATIONS

- The distribution of plants and animals on Earth is determined largely by climate. Have students research and learn about the principal plant and animal communities in their assigned climate zones and regions.
- On a large sheet of paper or poster board, have each group create a "torn paper art" picture of people and houses for their climate. To create "torn paper art," students should use only pieces of construction paper torn to any size, pasted onto a background.
  OR
  Instead of creating "torn paper art," have each student group choose the medium for its presentation.
- Have each student group select a city, identify where the city would fall on a map, and conduct research on the climate and lifestyles of people living in that city.

QUESTIONS FOR STUDENTS TO THINK ABOUT

Ask students, *What kinds of lifestyle changes would people have to make if the predictions of global warming are accurate? Do you think something that affects the Earth's atmosphere will impact everyone, or only certain regions?*

Global Climate Map / Mapa Mundial de Climas



Desert areas are shaded in gray. / Las áreas desérticas se señalan en gris.

11 Global Atmospheric Change

Post-assessment

CONCEPTS

- Students are able to improve their own health and that of the planet.

OVERVIEW

Students will review ideas covered in this unit and reach conclusions regarding the importance of the global environment to their health. Students will write persuasive letters and examine and revise the preassessment they completed at the beginning of the unit.

SCIENCE, HEALTH & MATH SKILLS

- Comparing
- Identifying relationships
- Inferring
- Applying prior knowledge to new situations

TIME

Preparation: 10 minutes
Class: 45 minutes

MATERIALS

Each group will need:

- Crayons or markers
- Drawing paper
- Pencils or pens

Each student will need:

- Copy of his or her pre-assessment

For more than 100 years, human actions have been changing the composition of Earth's atmosphere. Increases in the levels of heat-trapping greenhouse gases (especially carbon dioxide) and decreases in the amounts of stratospheric ozone both have been measured. These processes have the potential to impact humans in many ways.

This activity is designed to assess student understanding of concepts related to global atmospheric change. Each student will write a persuasive letter about a topic related to protecting the atmosphere.

Unit Links

Mr. Slaptail's Curious Contraption
Review Science boxes throughout

Explorations
Tips for Healthy Living, p. 3

SETUP

Begin with a whole-class discussion, after which students will work individually.

PROCEDURE

1. Tell students that they will write persuasive letters to each other related to global atmospheric change. Introduce letter writing skills if needed. Mention that global atmospheric change is a broad category that includes global warming and loss of atmospheric ozone. Also mention that all of us do things every day that contribute to these problems. Each student should try to convince the reader to help protect the atmosphere by changing behaviors to reduce the possibility or impact of global warming or ozone depletion.
2. Review the importance of our global environment to individual health and to the health of the planet. You may use the "Tips for Healthy Living" on page 3 of *Explorations* or pages 34–35 in *Mr. Slaptail's Curious Contraption*, or a review of the activities in this unit to guide students.
3. Each student should select one issue presented in this unit and write a letter to try to convince someone to help protect the atmosphere.
4. Distribute pre-assessments back to each student. Ask students to examine their answers and, using a different color, to circle new answers based on information they have learned.
5. Discuss students' changes as a group.

TEACHER RESOURCES

Downloadable lessons and supplemental materials on global atmospheric change and other science education topics are available free at www.k8science.org/ and www.bioedonline.org/.

THE SCIENCE OF
Global
Atmospheric
Change

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