THE SCIENCE OF Global Atmospheric Change

Rainbow in the Room

Activity from *The Science of Global Atmospheric Change Teacher's Guide* and for *Mr. Slaptail's Curious Contraption*

Written by

Nancy P. Moreno Ph.D.
Barbara Z. Tharp, M.S.
Judith Dresden, M.S.

BioEd℠

Teacher Resources from the Center for Educational Outreach at Baylor College of Medicine

Third edition. First edition published 1998.
Printed in the United States of America

ISBN: 978-1-888997-75-0

BioEd℠

Teacher Resources from the Center for Educational Outreach at Baylor College of Medicine.

Development of this unit was supported, in part, by grant numbers R25 ES06932 and R25 ES010698 from the National Institute of Environmental Health Sciences (NIEHS) of the National Institutes of Health (NIH). The opinions, findings and conclusions expressed in this publication are solely those of the authors and do not necessarily reflect the official views of Baylor College of Medicine, NIEHS or NIH.

Authors: Nancy P. Moreno, Ph.D., Barbara Z. Tharp, M.S., and Judith H. Dresden, M.S.
Editor: James P. Denk, M.A.
Designer and Illustrator: Martha S. Young, B.F.A.

ACKNOWLEDGMENTS
The Science of Global Atmospheric Change educational materials, first developed as part of the My Health My World® project at Baylor College of Medicine, have benefited from the vision and expertise of scientists and educators representing a wide range of specialties. Our heartfelt appreciation goes to Michael Lieberman, M.D., Ph.D., William A. Thomson, Ph.D., and Carlos Vallbona, M.D., who have lent their support and expertise to the project.

Special acknowledgment is due to our original partners in this project, the Texas Medical Association and the American Physiological Society (APS). We especially thank Marsha Lakes Matyas, Ph.D., of APS, for her direction of field test activities and ongoing collaboration.

Several colleagues provided valuable assistance during the development of this guide. In particular, we would like to thank Cassius Bordelon, Ph.D., Ronald Sass, Ph.D., Saundra Saunders, M.A., Lief Sigren, Ph.D., and Ellison Wittels, M.D.

Special thanks go to the National Institute of Environmental Health Sciences, Allen Dearry, Ph.D., Frederick Tyson, Ph.D., and Liam O'Fallon for their support of the My Health My World project and the related Environment as a Context for Opportunities in Schools (ECOS) project.

We are especially grateful to the many classroom teachers in Washington, D.C., and Houston and Austin, Texas, who participated in the field tests of these materials and provided invaluable feedback.

BCM
Baylor College *of* Medicine

Center for Educational Outreach
Baylor College of Medicine
One Baylor Plaza, BCM411
Houston, Texas 77030
713-798-8200 | 800-798-8244 | edoutreach@bcm.edu
www.bcm.edu/edoutreach | www.bioedonline.org | www.k8science.org

SOURCE URLS

BAYLOR COLLEGE OF MEDICINE
www.bcm.edu

CENTER FOR DISEASE CONTROL AND PREVENTION
cdc.gov/climatechange

KOEN VAN GORP - ASTRONOMY AND PHOTOGRAPHY
www.koenvangorp.be/events/eclipse_2006.html

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
ipcc.ch

NASA EARTH OBSERVATORY
earthobservatory.nasa.gov

NASA'S EYES ON THE EARTH
climate.nasa.gov

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

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, CLIMATE SERVICES
climate.gov/#education

NATIONAL PARK SERVICE, CLIMATE CHANGE RESPONSE PROGRAM
nature.nps.gov/climatechange

DAVID SHAND
www.flickr.com/photos/14508691@N08/with/5187817955/

TAU'OLUNGA
http://en.wikipedia.org/wiki/File:North_season.jpg

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

U.S. GEOLOGICAL SURVEY, OFFICE OF GLOBAL CHANGE
usgs.gov/global_change

U.S. GLOBAL CHANGE RESEARCH PROGRAM
globalchange.gov

GRAY WATSON
http://en.wikipedia.org/wiki/File:Solar_panels_on_house_roof.jpg

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

WORLD HEALTH ORGANIZATION who.int/globalchange/environment

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.

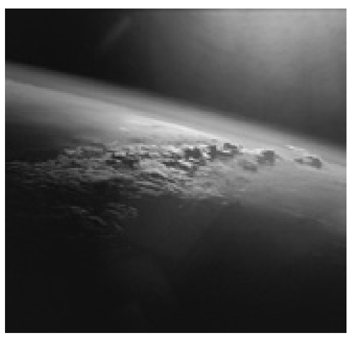
- Long wave radio
- Short wave radio
- Radar
- Microwave
- Infrared
- Visible light
- Ultraviolet light
- X-ray
- Gamma ray
- Cosmic ray

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

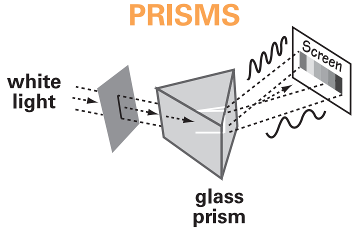
IMAGE CITATIONS

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



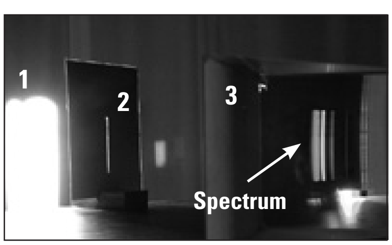
More than 300 years ago, Sir Isaac Newton, a famous physicist, demonstrated how a prism splits white light into a continuous spectrum.

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.