Rainbows and the Spectrum of Visible Light

Teacher Background

This Activity, while clearly grounded in the content of this Weather and Climate Module, allows students to explore some of the basics of optics and the electromagnetic spectrum—that essential, but sometimes rather abstract set of phenomenon that are central to the science curriculum.

What we may think of as "white light" from the Sun, in fact, consists of all the colors of the rainbow. Or as scientists would say, "all the colors of the spectrum of visible light." This might be a time to introduce a glass prism, and repeat Isaac Newton's breakthrough demonstration showing the colors "hiding" in white light: see the "Exploring the Electromagnetic Spectrum" Activity published online as part of the LIVE FROM THE SUN Module, http://passporttoknowledge.com/sun There you will also find links to some excellent online diagrams and graphics. Each color travels at a different wavelength, but unless something bends the white light you will not see the separate colors.

Air molecules bend white light just enough to allow us to see the shorter wavelengths. This is mainly blue light and explains why the sky appears blue. (Violet is also bent, but our eyes do not pick up violet as well as they do blue.)

A rainbow appears when raindrops bend and reflect white light revealing all of (or most of) the colors of the spectrum. Each droplet of rain produces all the colors of the spectrum. To observe a rainbow you must stand with your back to the Sun and there must be rain falling in another part of the sky. Each person is seeing a different set of drops and thus observes a slightly different rainbow. A secondary or fainter rainbow can form if the light is hitting the raindrops at just the right angle. (see http://www.ssec.org/idis/gate/Images/rainbow.htm)

Objectives

Students will observe the separation of white light into the colors of the rainbow and be able to list the colors according to their wavelength.
Students will observe how some wavelengths of visible light can be bent more than others and compare their observations to how water droplets in the sky transform white light into the colors of the rainbow.

Vocabulary

- electromagnetic spectrum
- spectrum of visible light
- prism
- refraction
- wavelength

Materials (either for each team of students or one set for a teacher demonstration)

- small aquarium (must have flat sides)
- flashlight
- prism
- eyedropper
- blocks or something that will raise the flashlight about 2 centimeters off the table
- water
- milk

Engage

Ask students, "Why is the sky blue?" Discuss that visible light contains all the colors of the rainbow, but that molecules in the atmosphere bend the blue wavelength, causing the sky to appear blue. Using prisms, have students split white light into the colors of the spectrum. (See procedure suggested in the LIVE FROM THE SUN Activity referenced above.) Discuss the order in which the colors appear. Which has the longest wavelength? Which has the shortest wavelength?

Explain/Explore

Procedure

This Activity may be implemented as a Teacher Demonstration if there are insufficient sets of materials to accommodate all teams. But if you are undertaking many or all of the "Making Weather in Class" activities in sequential workstations—as you see Master Teacher Eileen Bendixsen doing in the Teacher Resource Video—then each team can have their turn at doing this Activity hands-on.

Hand out Student Worksheet 2.5 and review the procedure with students. Have students implement the Activity, circulating among the groups to ensure safety procedures are being followed, answering questions and generally encouraging them. Remind students to record their observations in their journals.

Teacher Tips

(Note: the words appearing in quotes are taken directly from key steps in the Student Worksheet.)
"Fill the aquarium with water." I used a 2 ½ gallon aquarium and needed approximately 5 liters of water.
"Begin to add drops of milk to the water. Stir to mix the water and milk." I found that it took approximately 8 drops per liter of water to get the desired effect for this part.
"Look at the flashlight through the milky water and record the color of the light." At this point the color should be a light yellow.
"Look at the beam of light from the side. Record your observations." The light beam will look white. Students may also see a faint blue color which is the blue wavelength of the light.
"Continue to add drops of milk to the water. Stir to mix the water and milk." I found that it took approximately 12 drops of milk to get the desired effect for this part.
"Look at the flashlight through the milky water and record the color of the light." At this point the color should be orange.
"Look at the beam of light from the side. Record your observations." The light beam will look white. The faint blue color should be easier to see at this point, but some students may still have difficulty seeing this.
"Alternate adding milk and stirring to mix the water and milk until you get the final color change." I found that it took approximately 25 drops per liter of water to get this last color change. Do not add this all at once. Students may find that the water becomes too milky and they can no longer see the light beam. Have the students look at the flashlight every 10 drops of milk to see if the light has changed color. They will see various shades of orange before the final change in color.
"Look at the flashlight through the milky water and record the color of the light." It should now be red.
"Which color appeared first, second, third?" Yellow, orange, red.
Why did the colors appear in this order? Of these 3 colors, yellow has the shortest wavelength, followed by orange and then red.
Eileen Bendixsen, Hazlet Middle School, NJ

Expand/Adapt/Connect

If you have an outside faucet and a garden hose available take the students outside. Have the class stand with their back to the Sun. Be sure you are the one in charge of the hose! Stand so that you are in front of the class, but in a position where everyone in the class will be able to see the spray when you spray the hose. Make a rainbow!

Suggested URLs

http://www.unidata.ucar.edu/staff/blynds/rnbw.html
Good background information on rainbows and how they are made.

http://www.geom.umn.edu/education/calc-init/rainbow/
Rainbow Lab: the mathematics of rainbows.

http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/opt/wtr/rnbw/frm.rxml
Background information and diagrams showing how rainbows are formed.

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