Lesson #1: Remote Sensing and the Electromagnetic Spectrum

Introduction/Rationale

Students have seen rainbows in the sky, on a soap bubble, or even from the spray of a garden hose. They should already possess an understanding that white light is the combination of all colors of the spectrum. In addition, students should already know that the climate is warmest around the equator and coolest around the poles.

The purpose of this lesson is two-fold; to teach students that energy from the Sun can be measured with a thermometer, and that there is measurable energy beyond the visible spectrum, specifically, the ultraviolet and infrared wavelengths. From these realizations, students will have the foundation of knowledge to help understand how satellites measure sea surface temperature from space.

Lesson Concepts and Skills

Infrared radiation
Ultraviolet radiation

Materials

Six to eight ultraviolet beads strung together, per group
Flashlight (labeled "incandescent bulb, white light")
Fluorescent work light (labeled "fluorescent bulb, white light")
Halogen light source (labeled "halogen bulb, white light")
Ultraviolet light (labeled "ultraviolet light")
Glass prisms for each group
Three alcohol thermometers per group
Black paint or black permanent marker (for blackening thermometer bulbs)
Cardboard box per group
Stopwatch per group
Copies of "Beyond the Red" packets for each student
Spectrum posters
Transparencies of world map for pairs of students
Orange and blue transparency markers for each pair
Overhead projector
Computer with projector for teacher demonstration
Access to computer lab, if possible (for Extension)

Preparation

- Blacken the bulbs of the thermometers using black paint (careful to use the same amount on each bulb) or a black permanent marker.
- Secure three thermometers together, making sure the scales line up.
- Cut a notch out of the top edge of the box so that it holds the prism securely but allows for rotation.
- Make transparencies of a world map (preferably with the Pacific in the center) for each pair of students

Teaching Strategies Employed

Guided discovery
Cooperative learning
Direct instruction

Time Frame

One 90 minute class period

Target Audience

Grade five

National Science Content Standards

As a result of their activities in grades 5-8, all students should develop abilities necessary to do scientific inquiry.

As a result of their activities in grades 5-8, all students should develop an understanding of transfer of energy.

Behavioral Objectives

Students will conclude that each color of the spectrum has a different amount of thermal energy by measuring temperature with a thermometer.

Students will infer that there is an invisible band of the spectrum by measuring temperature beyond the visible light.

Engagement

Play the song "Rainbow Connection" by the Muppets. While they are listening, have students brainstorm all of the different places rainbows

appear naturally. (In the sky, soap bubbles, surface of an oil or gas spill, through a decorative prism, on a CD)

Have students share their ideas with the class. Review the order and colors of the spectrum (ROY G. BIV). Tell students that today they are going to learn about energy that is not visible, but is measurable.

Divide students into groups of three or four. Provide each group with a string of ultraviolet beads, telling them only that they are "special beads." (Make sure that classroom shades are closed and/or students are working away from sunlight.)

Instruct them to conduct an initial observation of the beads in the classroom (they should be colorless). Shut off the lights. Provide groups with different light sources to observe any changes in beads. Students should discover that the beads change to bright colors only when exposed to ultraviolet light.

Open the window shades or send students outside to observe what effect natural light has on the beads (they change to bright colors).

Exploration

Distribute "Beyond the Red" handouts to students. Read through and discuss as a class.

Divide students into the same groups as those from the Engagement. Provide each group with a prism, thermometer, box, and stopwatch. Lead groups outside, in direct sunlight. Circulate to monitor and assist the groups. Remind students to answer the questions at the end of the experiment.

Explanation

Lead the class in a discussion of what they observed during the "Beyond the Red" experiment. They should have observed the highest temperature in the colorless area beyond the red.

Display the poster of the visible spectrum. Explain that there is energy traveling all around us that we cannot see. When the temperature rose in

the area beyond the red, that thermometer was actually measuring **infrared** energy. Infrared energy can be detected in the form of heat. Additionally, the beads from the beginning of the lesson can sense the energy beyond the violet, called **ultraviolet radiation**. (Identify the infrared and ultraviolet wavelengths' location on the spectrum poster with labeled sticky notes.)

Ask students if a person must touch an object to tell whether it's hot or cool. (No.) Ask them to cite examples as proof. (Standing near a fire, opening the door to the refrigerator, etc.)

Tell students that scientists can detect **infrared** energy all around us by using special sensors, cameras, or even satellites in space! Direct students to the infrared images at http://coolcosmos.ipac.caltech.edu/image_galleries/ir_profiles.html. Click on a portrait and ask students why they think the faces are different colors. (The colors show different temperatures.) Point out the scale next to each image, which indicates temperature based on color.

Ask where the colder parts of a person's head are (hair, tip of nose, ears). Where are the warmer parts? (Forehead and neck generally.)

Tell students that the reason they can detect these hot and cold temperatures is because of the **infrared** waves traveling through the air. Additionally, scientists who are studying coral reefs use satellites that sense infrared energy so that they can monitor the temperature of the ocean at any time of the day. N.B. Since infrared energy is not part of the visible spectrum, it can be detected 24 hours a day, no matter whether it is dark or light out.

Evaluation

Assign students to work with a partner. Distribute transparency maps and markers. Tell the students that they are going to do the job of an infrared-sensing satellite and identify the temperature of the ocean.

Using what they know of Earth's climate, instruct students to shade in orange the parts of the ocean that are the warmest and shade blue the parts that are the coolest. (Depending on your students' background knowledge, this might work better as a whole-class activity.) Have each pair

display their transparency on the overhead projector for the rest of the class to see. Students should explain their reasoning behind the predicted hot and cold areas.

Display maps of sea surface temperature from http://coralreefwatch.noaa.gov/satellite/current/key_sst_50km_field.html. Discuss which are the warm areas and which are the cooler areas of water. (Be sure to point out that ice is white on the image.)

Have students continue to work with their partners to complete Part II of the "Beyond the Red" packet. Display the Earth image taken from the visible spectrum http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=4573 to help with their answers.

Extension

Have students see the world with infrared vision on the website http://coolcosmos.ipac.caltech.edu/cosmic_games/what/img11.html. They are shown an infrared image and then must guess what it is. By moving the mouse over the image, a caption detailing the answer is revealed.

Bibliography

Thaller, M. (n.d.). *Herschel infrared experiment*. Retrieved June 25, 2004, from http://coolcosmos.ipac.caltech.edu/cosmic_classroom/classroom_activities/herschel_experiment2.html.

Further Resources

Cosmic Colors
http://spaceplace.jpl.nasa.gov/en/kids/cosmic/index.shtml#
Kid-friendly information about the electromagnetic spectrum, including interactive images of solar system objects viewed at different wavelengths.

Pixel This!
http://spaceplace.jpl.nasa.gov/en/kids/p_imager/pixel_this.shtml#
Game in which children must identify an object when shown a low resolution image of it.

UV beads are available from

Educational Innovations, Inc.
362 Main Avenue
Norwalk, CT 06851
Toll Free: 888-912-7474
Direct link to UV Bead page
http://www.teachersource.com/direct/33370

or

Arbor Scientific
P.O. Box 2750
Ann Arbor, MI 48106-2750
Direct link to UV Bead page
http://www.arborsci.com/Products_Pages/Light&Color/LightBuy6.htm

Student _____

Assessment (Rubric)

Areas Assessed	Points Possible	Points Earned
Student's responses indicated a basic understanding of the infrared part of the spectrum.	6	
Each response included two or more reasons citing strengths of visible or infrared images	4	
Student worked cooperatively, participating in all activities	2	
TOTAL	12	

Comments:

Student _____

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Comments:

Name _____
Date _____

Beyond the Red activity

PART I

QUESTION: Do different colors of the spectrum have the same temperature?

HYPOTHESIS:

_____

_____

because_____

_____

MATERIALS

Cardboard box (from photocopier paper)
Glass prism
Three thermometers with blackened bulbs
Tape
White sheet of paper
Stopwatch

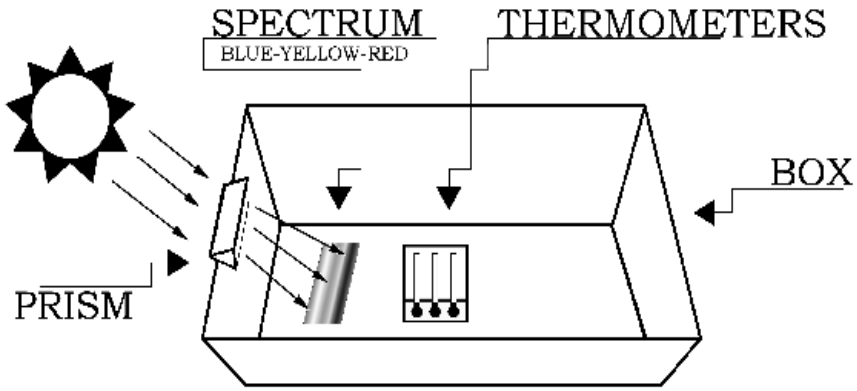
PROCEDURE

1. Find a sunny location outside. Set the box on the ground and place the white paper at the bottom.

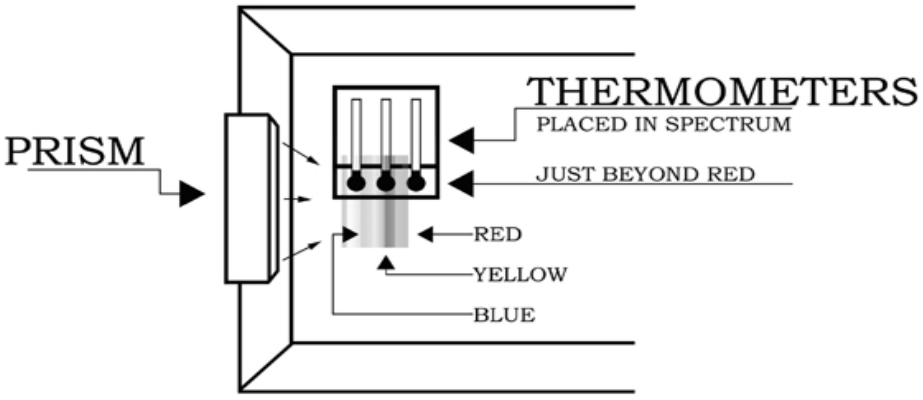
2. Place the thermometers in a shaded portion of the box. Use the stopwatch to time five minutes, then record the temperature of the three thermometers. This is the air temperature.

3. Turn the box so that the notch side is closest to the sun. Insert the prism into the notch.

4. Rotate the prism to find the widest spectrum displayed on a shaded portion of the white paper (see next page).



5. Place the thermometers on the spectrum so that one is in the blue area, another is in the yellow, and the third is just beyond the red area. (See below)



6. Using the stopwatch, observe and record the temperatures of the three thermometers during five minutes' time.

7. Answer the conclusion questions.

AIR TEMPERATURE

	Thermometer 1	Thermometer 2	Thermometer 3
Temperature (Celsius)			

SPECTRAL TEMPERATURES

Elapsed Time	Blue Temperature	Yellow Temperature	Beyond the Red Temperature
1 minute			
2 minutes			
3 minutes			
4 minutes			
5 minutes			

CONCLUSION QUESTIONS

Do different colors of the spectrum have the same temperature? (Prove it using what you observed.)

_____

_____

Was your hypothesis correct?

_____

_____

What do you think happened? (Try to explain any differences between the temperatures.)

_____

_____

_____

Beyond the Red
PART II

1. Compare the infrared picture that shows ocean temperature with the regular (visible light) picture of Earth. Why might a scientist choose to use an infrared image instead of a visible one?

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_____
_____
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2. Sometimes scientists need to use the visible pictures of Earth and not infrared. Describe any strengths that visible pictures might have over infrared.

_____
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3. Name the senses that a person uses to detect infrared energy. Explain your answer using what you have learned about the infrared part of the spectrum.

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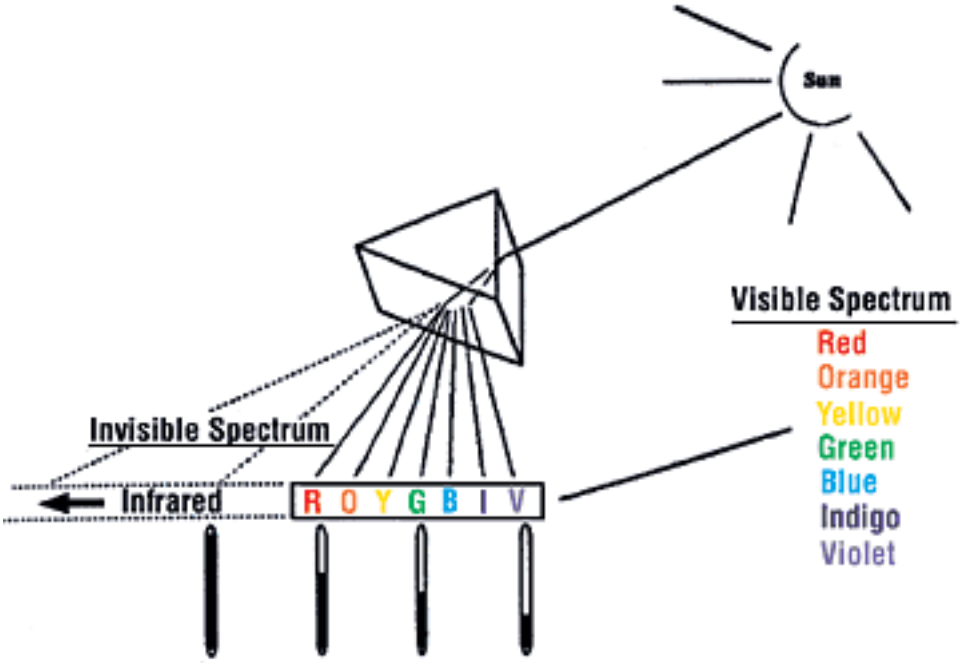
_____
_____

Spectrum poster


Sun
Visible Spectrum
Red
Orange
Yellow
Green
Blue
Indigo
Violet
Invisible Spectrum
Infrared
R O Y G B I V