LESSON 2

PRISMS AND RAINBOWS

Purpose: Our eyes and brain interpret the simple mixing of only 3 colors of light (red, green, and blue) as white. The students were able to confirm this in the last lesson. In this lesson students will develop the understanding that "white" light from the Sun and "white" light from an artificial light source is a full range of colors from red to violet. Students will also learn how droplets of water function as prisms to separate this full range of colors into rainbows.

Benchmarks for Science Literacy:

- **Increasingly sophisticated technology is used to learn about the universe**. Visual, radio, and x-ray telescopes collect information from across the entire spectrum of electromagnetic waves; computers handle an avalanche of data and increasingly complicated computations to interpret them; space probes send back data and materials from the remote parts of the solar system; and accelerators give subatomic particles energies that simulate conditions in the stars and in the early history of the universe before stars formed. 4A/3(9-12)
- **Light from the sun is made up of a mixture of many different colors of light, even though to the eye the light looks almost white**. Other things that give off or reflect light have a different mix of colors. 4F/1 (6-8)
- **Human eyes respond to only a narrow range** of wavelengths of electromagnetic radiation—**visible light. Differences** of wavelength **within that range are perceived as differences in color.** 4F/5 (6-8)

National Science Education Standards:
Grades 5-8
Science As Inquiry

- **Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects**, organisms, **or events**; some involve collecting specimens; some involve experiments; **some involve seeking more information; some involve discovery of new objects and phenomena**; and some involve making models.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.
- **Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations**.

Physical Science – Transfer of Energy

- The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the earth, transferring energy from the sun to the earth. **The sun's energy arrives as light with a range of wavelengths, consisting of visible light**, infrared, and ultraviolet radiation.

History and Nature of Science – Nature of Science

- **Scientists formulate and test their explanations of nature using observation, experiments**, and theoretical and mathematical models.

Background: Visible light from the Sun is a <u>full spectrum</u> of colors ranging from red to violet and is not limited to red, blue and green (or even red, orange, yellow, green, blue, indigo and violet- Roy G. Biv). This means that 64 colors of crayons or even a hundred would not accurately reproduce the visible spectrum. There are an infinite number of colors gradually shading from red to violet, although our eyes cannot perceive all of these subtle differences. Understanding this is an essential first step to understanding the entire electromagnetic spectrum that ranges from radio waves to gamma waves. It is necessary for students to understand the visible spectrum

before they can fully understand that there are more parts to the electromagnetic spectrum outside of our visible range. The first exploration will help the students understand this critical concept. The existence of infrared light and ultraviolet light will be discovered in later activities, so it is counter-productive to mention these ideas now. (For background information on the electromagnetic spectrum visit the Education page of **http://stp.gsfc.nasa.gov**.)

Natural phenomena have explanations that can be modeled and understood. The second activity, **Exploring Rainbows**, is designed to help students make the connection between prisms and rainbows. Students often believe that lab equipment is somehow removed from the real world. It is helpful to point out that lab equipment was designed by scientists to help scientists study natural phenomenon more thoroughly. This activity is also included because knowing why a rainbow exists is just a wonderful thing. Some teachers have found it interesting (and poetic) to declare that each person, admiring a rainbow, stands looking at the center of his or her own personal rainbow. Then, challenge the students to explain.

Exploring Rainbows uses one of the topics in *Patterns in nature* (http://acept.la.asu.edu/PiN/info/patt.html), produced and supported by the Department of Physics and Astronomy at Arizona State University. This web site is rich in activities and readings. There are two activities and four readings for the exploration, **Exploring Rainbows**, beginning with the activity *What causes Rainbows?* (If students do not have access to computers, you may wish to cover this material in class as a lecture/demonstration.) Alternately, you might choose to do the two activities as a class demonstration and assign the readings. A third option is to make the entire assignment a reading assignment without doing the activities. The results are described clearly enough in the activity. The first two readings have links within the activity, *Seeing Rainbows*. The third and fourth readings have links in each preceding reading. There are two questions at the end of the fourth reading that you may use as enrichment readings.

Overview of Student Assignments for Prisms and Rainbows

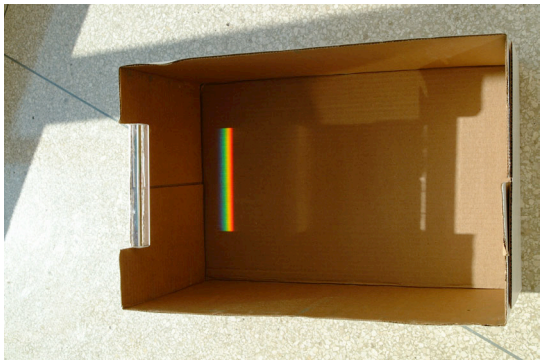
1. **Rainbows** is a journal assignment to be done in class.
2. **Exploration with Prism and Light** is a two-part lab investigation. Part 1 investigates the light from a light bulb and Part 2 uses light directly from the Sun.

3. **Making Conclusions** should be completed immediately after the students complete **Exploration with Prism and Light.** The students can be working on this short-essay format conclusion outside of class while they are proceeding to the next exploration.
4. **Exploring Rainbows** is a computer-based activity that is explained in this Teacher Resource. If students do not have access to computers, you can conduct a lecture/demonstration using materials from the web site.
5. **Rainbows-Revisited** is a journal assignment that asks the same questions as **Rainbows,** the opening journal assignment of this Lesson. You can treat these as pre and post assessment tools.
6. **Prediction Reflection** is a journal assignment to compare their predictions from **Rainbows** with their answers to the same questions from **Rainbows-Revisited** or they might choose the prediction from the **Exploration with Prism and Light**.
7. **Inquiry Reflection – Prisms and Rainbows** This reflection is designed to focus the attention of your students on the process and elements of inquiry.

Materials per group for Exploration with Prism and Light:

- An equilateral glass prism
- Tape
- Cardboard box – a box that contained photocopier or printer paper is ideal
- White paper
- Colored pencils or crayons
- Overhead projector, slide projector or strong flashlight
- A dark room for first part of activity
- Direct sunlight into a somewhat dark room for **Part 2: Light from the Sun** (You may have to shade the window, allowing only a beam of sunlight to come into your experiment area.). You can also do this exploration outside
- **Rainbows** for each student
- **Exploration with Prism and Light** for each student
- **Making Conclusions** for each student

Note: Construct or have your students construct a prism holder. Use a copier paper box. Cut out a rectangle notch in the middle of the top edge of the narrow side of the box. The notch should provide a tight fit for the prism. Place the prism in the notch, and project the spectrum onto the bottom of the box. If the Sun is high in the sky and shines into the box or if the Sun is too low to get a spectrum in the box, prop up the box until a spectrum is visible in the darkened area inside the box. Don't do this exploration on concrete. The prism may shatter if it falls on the concrete.



Preparation and Procedures

1. Hand out **Prisms and Rainbows** Journal Assignment at the beginning of class. Students should spend about 10-15 minutes on the journal. Have colored pencils or crayons available as they walk into class. This should not be a homework assignment. The journal functions as a way of making a personal prediction. At home they might research the questions. You want them to tell you what their current ideas are. The journal helps you to know what pre-conceptions they have. Also, they will be more invested in testing their own answers during the exploration. Tell them to be aware of their thought process as they answer the questions. There will be a **Prediction Reflection** at the end of this lesson.
2. When they have finished their journal, give them **Exploration with Prism and Light**.
3. Students should then move into groups and begin the exploration by making the prediction at the beginning of **Exploration with Prism and Light**. Have them complete the **Observations** during the exploration in the lab.

Note: Students may have difficulty getting a "rainbow" either in Part 1 or in Part 2. In Part 1 students may get a broad "rainbow" with a wide area of white in the middle. They can get a better "rainbow" by rotating the prism and by moving the light source away from the prism. Be available and help students get a good "rainbow".

4. Assign **Making Conclusions** after the exploration has been completed and they have had time to write their observations. Give them time to think about the exploration and to write a good essay. "Students of all ages find it difficult to distinguish … between description of evidence and interpretation of evidence." (Benchmarks for Science Literacy, 332) Stress that a conclusion is not a restatement of evidence. A conclusion is an interpretation of evidence; it is a new understanding of the world based upon the evidence. They can begin the next exploration, **Exploring Rainbows**, in class while they work on the essay as homework.

Exploring Rainbows

Overview of Exploring Rainbows

First Activity: What Causes Rainbows?
http://acept.la.asu.edu/PiN/act/rainbow/rainbow.shtml

First Reading: Rainbows
http://acept.la.asu.edu/PiN/rdg/rainbow/rainbow.shtml#top

Return to Activity:
http://acept.la.asu.edu/PiN/act/rainbow/rainbow.shtml#Return

Second Reading: Rainbows, part II
http://acept.la.asu.edu/PiN/rdg/rainbow/rainbow2.shtml

Third Reading: Rainbow, part III
http://acept.la.asu.edu/PiN/rdg/rainbow/rainbow3.shtml

Fourth Reading: Rainbows, part IV
http://acept.la.asu.edu/PiN/rdg/rainbow/rainbow4.shtml

Materials per group for Exploring Rainbows:

- Computer with Internet connection

- Water glass
- Flashlight, or other directed beam of light
- Round-bottomed flask, or some spherical glass container (a round fishbowl would work)
- Small piece of cardboard or poster board that fits over the head of the flashlight
- 10"x14" piece of white poster board

Preparation and Procedures for Exploring Rainbows:

1. Provide the materials above in a "wet lab" away from the computers. Assign each group to a computer and, if possible, have each computer already connected to *Seeing Rainbows* at http://acept.la.asu.edu/PiN/act/rainbow/rainbow.shtml. Students should follow the procedures in the activity and readings.

2. After the students have completed the activity and readings, assign **Rainbows-Revisited**.
3. Have students complete a **Prediction Reflection** (Appendix) and compare their predictions from **Rainbows** with their answers to questions in **Rainbows-Revisited**.
4. Assign **Inquiry Reflection – Prisms and Rainbows**