Why are Sunsets Red?
Through a series of experiments, students learn light travels in waves, how light is separated and the reason sunsets have brilliant colors.

Grade Level: 5th

Phenomena:
What is the scientific reason behind why Nevada has amazing sunsets?

Objectives:
- Students will identify parts of nature that are being modeled in the sunset experiment.
- Students will describe why sunsets are commonly red and orange.

Materials:
- Electromagnetic spectrum poster
- Medium glass tank - fish tank
- Water
- Whole milk
- Flashlight
- CDs
- Small lights - enough for each pair of students
- Prism

Appendixes:
- Student worksheet: Page 7
- Summary of electromagnetic spectrum: Page 8

Time Considerations:
Preparations: 20-25 minutes
Lesson Time: 50-60 minutes
  - Introduction: 15 minutes
  - Activity 1: 10-15 minutes
  - Activity 2: 5-10 minutes
  - Activity 3: 10 minutes
  - Activity 4: 5 minutes
  - Conclusion: 5 minutes

Related Lesson Plans:
Solar Energy, Energy Sleuths, Sun Rays

Next Generation Science Standards

5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Science and Engineering Practices (SEP):
Developing and using models

Disciplinary Core Ideas:
Earth materials and systems.

Crosscutting Concepts:
Systems and system models.

Excellence in Environmental Education Guidelines

Strand 2.1—The Earth as a Physical System
C) While they may have little understanding of formal concepts associated with energy, learners are familiar with the basin behaviors of different forms of energy.

Background
Solar radiation, light from the sun, provides light and heat to life on Earth. When light is analyzed it is referred to as the electromagnetic spectrum. The electromagnetic spectrum consists of several types of waves including radio, micro, infrared, ultraviolet, visible, X-Ray and gamma ray - more information can be found on page eight. However, the receptors in our eyes respond only to the narrow range of wavelengths called visible light (BBC).

When all the wavelengths of visible light are together, visible light is seen as “white light.” It is only when these wavelengths are separated, does visible light appear in different colors. The visible

<table>
<thead>
<tr>
<th>gamma rays</th>
<th>X-rays</th>
<th>ultraviolet rays</th>
<th>infrared rays</th>
<th>radar</th>
<th>FM</th>
<th>TV</th>
<th>shortwave</th>
<th>AM</th>
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<td>$10^{-3}$</td>
<td>$10^{-2}$</td>
<td>$10^{-1}$</td>
<td>$10^{0}$</td>
<td>$10^{1}$</td>
<td>$10^{2}$</td>
<td>$10^{3}$</td>
<td>$10^{4}$</td>
<td>$10^{5}$</td>
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</tbody>
</table>

Wavelength (meters)

Visible Light

Wavelength (nanometers)
light spectrum consists of an infinite number of colors that range from red to violet—as seen in the above picture. Our eyes cannot perceive all the subtle differences in the spectrum, so instead our eyes see the major changes from one color to another (Randy, R.).

In order for these different colors to be seen, visible light must be separated. This happens by way of refraction. A beam of light that is refracted has been bent and moved in another direction. Raindrops, prisms, and other media such as glass are examples of tools that refract light. This explanation is why rainbows exist. The vast amount of water molecules in the atmosphere provides the appropriate medium to refract or separate light, resulting in the display of colors seen in a rainbow (Physics Planet).

Each wavelength of color, in the visible light spectrum is unique to one another. All the wavelengths travel at the same speed, but have different frequencies. Frequency is the number of peaks and troughs of a wavelength that occurs between two points. Therefore wavelengths found to the left side of the spectrum, violets and blues, have longer frequencies compared to the right side of the spectrum, oranges and reds, which have shorter frequencies. This has been determined and supported through numerous fields of science including astronomy (Randy, R.).

Another reason that contributes to the brilliant colors of sunsets deals with the angle at which light travels across the sky. At noon, light typically enters the atmosphere close to a ninety degree angle. This angle results in less distance light travels through the sky, which minimizes the encounter of atmospheric particles. In the
evenings however, light travels at a much smaller angle across the horizon. Light therefore travels farther through the sky and the probability of contacting atmospheric particles are much greater. Thus, at the smaller angle, sunsets are redder due to the other wavelengths being refracted and scattered (Department of Atmospheric Sciences).

The sunsets in the western United States are well known for their amazing colors. Which differs from the eastern portion of the country. This is largely due to the dry, dusty environments of the west. Afternoon and evening winds lift dust and debris into the air, resulting in the shorter wavelengths to refract or scatter as discussed above. Thereby creating those picture perfect sunsets.

This lesson is an introduction to the electromagnetic spectrum and specifically visible light. Through hands on experiments, class discussion and exploration students will learn why western sunsets are well known and beautiful.

**Preparation**

Read background and research any additional information about light.

Collect all materials for student experiments and instructor demonstration. Create electromagnetic spectrum poster and prepare examples of each wave’s use. Information about these waves can be found on page eight.

Fill tank with water set up for first sunset demonstration.

**Doing the Activity**

**Introduction: Sunsets**

Begin with students doing a mad dash on the question: Why are sunsets red and orange? A mad dash is a 60 second brainstorm students have with each other, where they share everything they know about the topic at hand.

When time is finished, record student thoughts on the board and clear up any extreme misconceptions about light or sunsets.

Let’s investigate! Explain to the class the demonstration will model a sunset. Students will record observations at the beginning, middle and end of the experiment, by using the student worksheet. Students will also predict and record what each material in the experiment is modeling in nature, on the same worksheet.

**Activity 1: What is Light?**

Share with students that light is an important factor in why Nevada has such spectacular sunsets. To understand why, we need to understand light a little bit more. Have students do a second mad dash on the topic of light. When finished, record student thoughts on the board.

**Activity 2: Visible Light**

Focus the class’ attention on the visible light spectrum. Ask students if they know what light looks like? What color is it?

**Spread materials students may do the activity**

Doing the Activity

Preparation

Sunset in Winnemucca, Nevada

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use on the front table in the classroom: CD’s, mini lights, prisms, etc. State the goal to the class and emphasize that students need to record what materials they use and to draw the best display of the visible light spectrum in their science journals.

Allow students to explore the different materials freely for 10 to 15 minutes. When finished, have students lay their drawings on their desk and have everyone tour the classroom to compare their classmates’ drawings to their own.

Using the electromagnetic poster, show students what light looks like when it is separated. If possible darken the classroom, and use a prism and flashlight to display the spectrum on the walls. Students should copy down the correct sequence of colors in their science journals.

Next, have students hypothesize why these colors are being displayed in this specific order, or are they?

Explain to the class that indeed, the order of these colors are based on two characteristics of light: wavelength and frequency. Define these terms to the class and if time allows, do the ribbon extension activity.

**Activity 3: Sunset Experiment**
Fill a glass fish tank at least 3/4 full of water. Place a flashlight to the side of the tank, so that the light shines upon a white wall. At this time students should record their initial observation. Then, darken the room as much as possible and add a teaspoon of whole milk to the water.

Continue to add a teaspoon of whole milk to the tank one at a time, until the milky-water displays an orange or red light upon the wall. Do not stir the milk into the water. A better result is achieved when the milk simply sinks into the tank.

After the demonstration, allow students to discuss how the sunset occurred and what the materials modeled first with their table groups, then with the entire class. These ideas and predictions will be the focus throughout the lesson.

Material key: flashlight - sunlight, water - sky, milk - particles in the air or dust, tank - atmosphere.

**Activity 4: Sunset Revisited**
Direct the class’ attention back to the original sunset experiment - only water in the tank. Based on what they have learned, challenge students to explain why the sunsets are orange and red?

If students are struggling with this thought, direct their attention to the colors of the sunset. What part of the visible light spectrum is seen? (orange and red)

These colors have longer wavelengths and smaller frequencies than other colors. Ask why it is we do not see the other colors in our sunsets? Does something happen to these colors as they travel...
through the sky/atmosphere? Refer back to the experiment and ask what part of nature is “mixed” into our sky? (milk - dust!)

To concrete student understanding, do the sunset experiment a second time. Have students describe what is happening and why it is we see brilliant orange and red sunsets in Nevada.

The last piece of information students should receive deals with the atmosphere. By drawing a diagram of Earth and the atmosphere, show students the two following scenarios:
1. At noon, the sun is directly overhead. The angle that sunlight passes through the atmosphere is nearly 90 degrees.
2. At sunset, the sun sinks toward the horizon. The angle that sunlight passes through the atmosphere is much smaller.

The atmosphere are the longer wavelengths of light, yellows, oranges and reds. Which produces beautifully-colored sunsets.

Students should now be able to put all the information together to come up with an explanation as to what makes sunsets certain colors such as red and orange.

### Conclusion

Ask the students at which time of day does the sun’s waves have to travel through more atmosphere? (sunset)

Sunlight enters the atmosphere at a much lower angle and therefore has to pass through more atmosphere before being seen by an observer; air molecules scatter away the shorter wavelengths of light, violet and blue, and the only light which penetrates through

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**Vocabulary**

**Electromagnetic Spectrum:** the complete range of electromagnetic radiation from the shortest waves (gamma waves) to the longest waves (radio waves)

**Frequency:** the number of vibrations per second in a light wave

**Light:** electromagnetic radiation with a range of wavelength between 3900 (violet) and 7700 (red) angstroms, capable of stimulating the subjective sensation of sight; sometimes considered to include ultraviolet and infrared radiation as well

**Prism:** a transparent polygonal solid object with flat faces and a usually triangular cross section, used for separating white light into a spectrum of colors

**Reflection:** change in direction of a wave front at an interface between two different media so that the wave front returns into the medium from which it originated

**Refraction:** the change in direction that occurs when a wave of energy such as light passes from one medium to another of a different density, for example: from air to water

**Wavelength:** the distance between one crest or trough of a wave of light or sound to the next

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**Assessment**

Assess students on their responses to questions asked throughout the lesson, especially the conclusion. Assess the students on their investigation with CDs and lights and what their final pictures and findings were.

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**Extensions**

**White Light Experiment**

The following experiment will show students the concept of white light and how the combination of colors creates the white color our eyes see.

Materials needed: 3 flashlights, white paper, colored pencils or markers, colored cellophane or filters - blue, green and red.

Cut pieces of colored cellophane and tape one color to the front of each flashlight.

Introduce the idea that white light is composed of different colors of light.

Give each group of students three flashlights covered with...
red, green and blue cellophane, a sheet of white paper and tape. Have students draw and label the colors that are seen. Students should observe that all three colors create a shade of white. Note the degree of “whiteness” will vary depending on the quality of the flashlight and cellophane)

Tape one piece of white paper to the wall or floor.

Demonstrate how to shine each flashlight on the wall. Start by shining one flashlight against the paper. Shine the second to side and slightly overlapping the first light. Do the same with the third flashlight.

Students should then use colored pencils or markers to draw the circles of color as they are seen. Special attention should be given to the areas where the light overlap.

Tape a clean sheet of white paper to the wall or floor. Shine all three flashlight to the center of the paper.

Have students draw and label the colors that are seen.

Wavelength Ribbon Activity

The goal of this activity is to connect with kinesthetic and visual learners on how different wavelengths display different types of frequencies.

Materials needed: 2-3 sets of ribbons - 7 colors to represent the main colors of the visible light spectrum ROYGBIV, rulers or wooden dowels, tape, visible light spectrum picture.

Groups need to first construct their “wavelengths” by taping one strand of ribbon to the end of each ruler. Each group should have seven wavelengths. Groups are to use the visible light spectrum picture and ribbons to create a life-size model of the all the wavelengths.

Sources


Images:

Sunset Experiment

Hypothesis: Why are sunsets red-orange?

Materials & Models in Nature

1. Tank .................
2. Water .................
3. Flashlight ...........
4. Milk. .................

Observations

Beginning

Middle

End

Visible Light Spectrum

Materials used: Draw your observations here

Actual visible light spectrum
## Electromagnetic Spectrum Summary

<table>
<thead>
<tr>
<th>Type of wave</th>
<th>Typical source</th>
<th>Example of detector</th>
<th>Approximate wavelength</th>
<th>Typical users</th>
<th>Dangers of over exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio: LW, MW, VHF</td>
<td>electronic circuits, cool objects</td>
<td>aerial and electronic circuit</td>
<td>1km 100m 1m</td>
<td>communications, radio, TV</td>
<td>safe (unless very concentrated)</td>
</tr>
<tr>
<td>Microwaves</td>
<td>electronic circuits, cool objects</td>
<td>aerial and electronic circuit</td>
<td>1cm ((10^{-2} \text{m}))</td>
<td>communications satellites, telephony, heating water and food</td>
<td>burning, if concentrated</td>
</tr>
<tr>
<td>Infra-red (ir)</td>
<td>electronic devices, warm objects, sun</td>
<td>electronic detectors, special film, blackened thermometer</td>
<td>0.1mm ((10^{-4} \text{m}))</td>
<td>magic eyes in security lighting, remote control (e.g. TV)</td>
<td>burning, if concentrated</td>
</tr>
<tr>
<td>Light</td>
<td>Red, Orange, Yellow, Blue, Indigo, Violet</td>
<td>electronic devices(LED), hot objects, sun</td>
<td>eye, film, electronic devices (e.g.LDR)</td>
<td>seeing, photography</td>
<td>burning, blindness, if concentrated</td>
</tr>
<tr>
<td>Ultra-violet (uv)</td>
<td>gas discharge, very hot objects, amps, sun</td>
<td>film</td>
<td>0.00001mm ((10^{-9} \text{m}))</td>
<td>sun-tan lamp, making ions, making Vitamin D</td>
<td>sunburn, skin cancer</td>
</tr>
<tr>
<td>X-rays</td>
<td>very fast electrons hitting a metal target</td>
<td>film</td>
<td>(10^{-16} \text{m})</td>
<td>imaging defects in bones, hidden devices</td>
<td>cell destruction, cell mutation, cancer</td>
</tr>
<tr>
<td>Gamma rays (γ)</td>
<td>radioactive nuclei decaying</td>
<td>film, GM tube</td>
<td>(10^{-12} \text{m})</td>
<td>medical tracers, killing cancerous cells, sterilisation</td>
<td>cell destruction, cell mutation, cancer</td>
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