**How Is White Light Separated into Colors?**

**Before You Begin**

One way of picturing light is as a wave. You are already familiar with some types of waves in nature—for example, water waves. Like water waves, light waves can vary in height, or amplitude, and in length, or wavelength. The diagram below shows a wave's amplitude and wavelength.

![Wave Diagram]

The human eye sees different wavelengths of light as different colors. White light, such as that from a light bulb or the sun, is actually made up of many different wavelengths of light. Today you are going to separate white light into its components, using a spectroscope and a prism. A spectroscope consists of a diffraction grating that bends light of different wavelengths through different amounts. A prism does the same thing. Using one of these tools, you can separate white light into its component wavelengths (colors). The range of colors that results is called a visible spectrum. When you see a rainbow, you are seeing a visible spectrum produced by nature.

**Materials**
- Student spectroscope
- Light filters (red, blue, green, orange)
- Lamp with 40- or 60-watt incandescent bulb
- White paper screen
- Prism
- Flashlight with concentrated beam
- White paper screen

**Procedure**

1. Using one eye, look through the diffraction grating of the spectroscope tube with the slit at the other end pointed toward a window. Aim the spectroscope toward the sky through the window. **CAUTION:** Do not aim it directly at the sun because you can burn your eyes. You will see light coming through the slit. If the slit is not vertical, rotate the end of the tube until it is.

2. Repeat step 1, using an incandescent bulb as the light source. Once again, record and draw your observations in the Data Collection section.

3. Looking through the spectroscope, aim it toward an incandescent light bulb. Place a red filter in front of the spectroscope so that only red light is seen. In the Data Collection section, describe the colors of the spectrum in the order that you see them. Make a drawing of the spectrum, indicating the relative size of each band of color.

4. Repeat step 3 with a blue filter, a green filter, and an orange filter.

5. Place a prism in front of the screen and shine light from the flashlight through it. Project the spectrum onto the screen. In the Data Collection section, describe the colors of the spectrum and the order of the colors. Make a drawing of the spectrum, indicating the relative size of each band of color.

**Data Collection and Analysis**

<table>
<thead>
<tr>
<th>Light Source</th>
<th>Order of Colors</th>
<th>Drawing of Spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunlight</td>
<td>R = red, O = orange, Y = yellow, G = green, B = blue, I = indigo, V = violet</td>
<td></td>
</tr>
<tr>
<td>Incandescent bulb</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Data Table (continued)

<table>
<thead>
<tr>
<th>Light Source</th>
<th>Order of Colors</th>
<th>Drawing of Spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent bulb + red filter</td>
<td>R = red, O = orange, Y = yellow, G = green, B = blue, I = indigo, V = violet</td>
<td></td>
</tr>
<tr>
<td>Incandescent bulb + blue filter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incandescent bulb + green filter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incandescent bulb + orange filter</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. Describe and draw the spectrum produced with a prism. Does it differ from the spectrum produced with a spectroscope?

### CONCLUDING QUESTIONS

1. For your classmates, write a brief explanation of what you have learned about the visible spectrum.

2. How do filters affect the light that passes through them? Support your answer with evidence from this activity.

3. When you passed light through a red filter, did it transmit only red light? Support your answer with evidence from your investigation.

4. What is the difference between the spectra produced by diffraction glasses and prisms?

5. With the help of drawings, explain how the light waves of red and blue light differ.

### FOLLOW-UP ACTIVITIES

1. Using the spectroscope, investigate the spectra produced by fluorescent bulbs or sodium lamps.
2. Investigate and report on the use of spectrosopes in astronomy.
3. Investigate the electromagnetic spectrum and the place of visible light in it.
4. Research electromagnetic waves and report your findings to the class.
5. Research and write a report about how rainbows form.
What Happens When Different Colors of Light Are Mixed by Addition or Subtraction?

**Materials**
- Flashlight
- Magenta, cyan, yellow, red, blue, and green filters
- Sheets of white paper

**Procedure**
1. Hold the magenta filter to the light and notice the color of light passing through it. Hold the cyan filter to the light and notice the color of light passing through it. Now overlap the magenta filter with the cyan filter and observe the color of light that you see through the two filters together. In Table I, record the color that is a component of both filters. To help you remember, most of the information for the first pair of filters has already been entered in the table.
2. Repeat step 1 with the magenta filter and the yellow filter.
3. Repeat step 1 with the yellow filter and the cyan filter.
4. Combine all three filters and describe the color you see.

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**Data Collection and Analysis**

<table>
<thead>
<tr>
<th>Color of Filter 1</th>
<th>Component Colors of Filter 1</th>
<th>Color of Filter 2</th>
<th>Component Colors of Filter 2</th>
<th>Observed Color After Overlapping (Mixing) Filters 1 and 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magenta</td>
<td>red + blue</td>
<td>Cyan</td>
<td>blue + green</td>
<td></td>
</tr>
</tbody>
</table>

1. The color seen when magenta, yellow, and cyan filters were combined is **blue**.

For each combination of filters listed in Table I, circle any color that is a component of both filter 1 and filter 2. (For example, in the first row of the table, you would circle "blue.")

<table>
<thead>
<tr>
<th>Color of Marker 1</th>
<th>Color of Marker 2</th>
<th>Color Observed After Mixing</th>
</tr>
</thead>
</table>

3. Predict the result of mixing different combinations of markers and test your predictions.
4. What did you learn by circling the colors in Table I?
1. The retina is the sensitive inner surface of the eye. The retina is made up of light receptor cells called rods and cones. Photons of visible light are received by the retina and changed to impulses. The impulses are carried by the optic nerves to the brain. There is an area on the retina called the “blind spot.” What do you think this is?

2. You can verify the blind spot. Draw a small circle and a small cross about 7.5 cm apart on a card. Hold the card at arm's length. Shut your right eye and look at the symbol on the right side of the card. Move the card slowly toward you. The symbol on the left will vanish at a certain distance. Try to find your own blind spot. How close was the card when the symbol on the left vanished?

3. When you look at an object you actually see two images, one with each eye. The two images that are combined in normal vision can be seen separately in the following activity. Hold a pencil about 30 cm in front of your eyes. While looking at a distant object, look quickly at the pencil. You should see a double image of the distant object. Why do you think this happens?

4. Your retina responds to an image for a fraction of a second after you see it. You can verify this by performing the following activity. Cut out the two drawings below and tape them together back to back. Insert a pencil between the two drawings and tape it in place. Rotate the pencil rapidly between the palms of your hands. What do you see? How can you explain this?