



Name: \_\_\_\_\_

Date: \_\_\_\_\_

## Student Exploration: Herschel Experiment

**Vocabulary:** electromagnetic radiation, infrared radiation, prism, ultraviolet radiation, visible spectrum

**Prior Knowledge Questions** (Do these BEFORE using the Gizmo.)

All stars emit **electromagnetic radiation**. Sunlight is part of the electromagnetic radiation emitted by the Sun.

1. What happens when sunlight passes through a **prism**? \_\_\_\_\_

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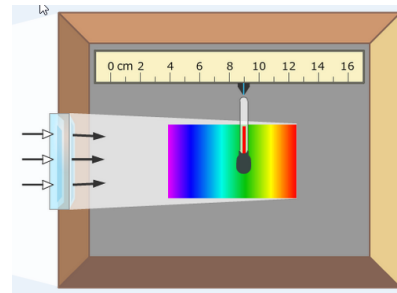
2. The colors you see in a rainbow or when white light is separated is called the **visible spectrum**, shown at right. What is the order of colors in the visible spectrum?



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### Gizmo Warm-up

William Herschel was a British astronomer famous for discovering the planet Uranus in 1781. While observing the Sun through various colored filters, Herschel noticed that the different filters seemed to transmit different amounts of heat. Herschel hypothesized that different colors in the visible spectrum have different temperatures. As he was testing this hypothesis in 1800, Herschel made a remarkable discovery.



The *Herschel Experiment* Gizmo allows you to reconstruct Herschel's experiment. The Gizmo shows sunlight shining through a prism and into a box. A thermometer can be moved to different positions on the floor of the box. To begin, move the thermometer to 9 cm.

1. Click **Play** (▶), and wait about 10 simulated minutes.

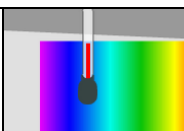
A. What is the color of light where the thermometer is located? \_\_\_\_\_

B. What is the temperature at this location? \_\_\_\_\_

2. Move the thermometer to the blue light at 6 cm, and wait another 10 simulated minutes.

What is the temperature at this location? \_\_\_\_\_



<b>Activity A:</b> <b>Light and temperature</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>Click <b>Reset</b> (↺). The <b>Temperature in the shade</b> should be 20.0 °C.</li> </ul>	
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**Question: Which part of the Sun’s spectrum has the highest temperature?**

1. Observe: What is the current **Temperature in shade**? \_\_\_\_\_

2. Predict: Which color of light do you think will yield the highest temperature? Explain.  
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3. Gather data: Click **Play**. Place the thermometer in each of the positions listed in the table for about 10 minutes. For each position, list the color and the thermometer temperature. (As you collect data, do not click **Reset**.) Leave the last column blank for now.

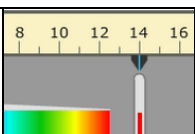
Position	Color	Temperature (°C)	$\Delta T$ (°C)
4 cm			
6 cm			
8 cm			
10 cm			
12 cm			

4. Calculate: The symbol  $\Delta T$  stands for “change in temperature” and represents the difference between the temperature of that color and the temperature in the shade. To calculate  $\Delta T$  for each position, subtract the temperature in the shade from the temperature in the table.

5. Analyze: What does your data show? \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

6. Think and discuss: Why do you think some colors of light yield different temperatures than others? If possible, discuss your answer with your classmates and teacher.  
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 \_\_\_\_\_  
 \_\_\_\_\_



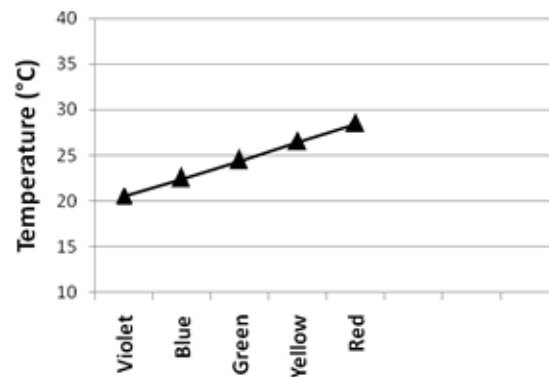
<b>Activity B:</b> <b>Invisible light</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>Click <b>Reset</b>.</li> </ul>	
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**Introduction:** After gathering data on the temperature of each color, William Herschel found that red was the hottest color of visible light. Herschel then moved the thermometer just past the red end of the visible spectrum.

**Question:** Is any energy transmitted beyond the edges of the visible spectrum?

1. Observe: What is the current **Temperature in shade?** \_\_\_\_\_

2. Predict: A graph of temperature vs. color data might look like the graph at right. (Shade temp. = 20 °C.) Fill in the right side of the graph to show what you think the graph would look like beyond the red end of the spectrum.



Explain your graph: \_\_\_\_\_

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3. Test: Place the thermometer at 12 cm and press **Play**. Wait for about 15 minutes.

A. What is the temperature after 15 simulated minutes? \_\_\_\_\_

B. Move the thermometer to 13 cm. Notice that the thermometer is no longer in the visible light. Wait for 10 minutes.

What is the temperature now? \_\_\_\_\_

4. Evaluate: Is this the result you expected? Explain. \_\_\_\_\_

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5. Think and discuss: What do you think is happening here? \_\_\_\_\_

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**(Activity B continued on next page)**



**Activity B (continued from previous page)**

6. Gather data: When Herschel did his experiment in 1800, he was astounded to find a higher temperature beyond the red end of the visible spectrum. He inferred that there must be a kind of invisible radiation beyond the red end of the spectrum. Herschel dubbed these invisible rays “caloric rays.” Today, it is called **infrared radiation**.

Click **Play**. Measure the temperature of each position for at least 10 simulated minutes to complete the table below. Calculate the  $\Delta T$  values based on the temperature in the shade.

Position	Color	Temperature ( $^{\circ}\text{C}$ )	$\Delta T$ ( $^{\circ}\text{C}$ )
2 cm	None		
3 cm	None		
4 cm	Violet		
12 cm	Red		
13 cm	None		
14 cm	None		
15 cm	None		
16 cm	None		

7. Analyze: Look at the data on both ends of the spectrum.
- A. What is the peak temperature, and at what location does it occur? \_\_\_\_\_  
\_\_\_\_\_
- B. How far beyond the red end of the spectrum does infrared radiation cause significant heating? \_\_\_\_\_
- C. From this experiment, is there any evidence of radiation falling to the left of the violet end of the visible spectrum? Explain. \_\_\_\_\_  
\_\_\_\_\_

In fact, radiation does exist beyond the violet end of the visible spectrum. **Ultraviolet radiation** was discovered in 1801 by Johann Wilhelm Ritter.

8. Draw conclusions: What was the importance of the Herschel experiment? \_\_\_\_\_  
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