Explore
Star Light, Star Bright

What sort of things do you see at night in stars? The main thing that you can probably detect is their light. Color differences are subtle. But there are several other kinds of "light," even if you cannot detect them with your eyes. Examples are X-rays or infrared radiation. Your teacher will show you a transparency of stars. What do you notice about their light? What else do you see in the image?

In this activity, you will explore how temperature, color, and the brightness of stars are related. Properties of light tell astronomers about stars.

Part I: Exploring Light

Process and Procedure

You will use some simple tools in this activity to explore light at a series of stations. First, review all stations and how to use tools at the station. You will be working in teams of 4 students at the stations.

Caution
The lightbulbs will be hot. Do not touch the bulbs at any station.

Station 1: Watt's Up?

Materials
3 different bulbs (25, 40, and 60 Watts clear glass bulbs) with a socket attachment
1 multimeter set-up (includes solar cell)
1 power strip
1 ruler (optional)

Your teacher will set up a simple tool to measure how bright a light is. The power of light from a bulb is its **luminosity**. Follow Steps 1–3 to explore how luminous different bulbs are.

1. The multimeter set-up tells the electricity made when light hits a solar cell (figure 3). Set the multimeter to "mA." Test the set-up by moving the solar cell toward and away from a light. What if you cover, or partially cover, the solar cell with your hand? Measure the brightness of a bulb as recorded on the multimeter (figure 3).

   Wattage of a bulb tells its power. The multimeter tells the current of electrons in milliAmperes, or "mA."

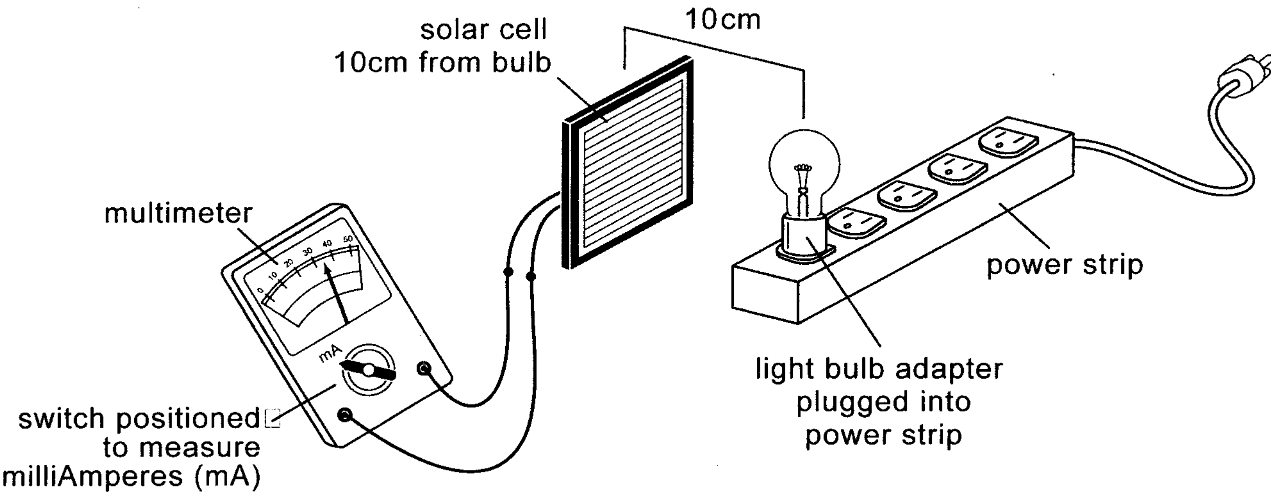

Figure 3: Multimeter set-up with solar cell. Use this set-up to measure the power of a light bulb. The scale on the multimeter shows an electric current of 35 milliAmperes (35 mA) from the bulb on the power strip.

2. Use the multimeter to test 3 bulbs. Test them one at a time. Copy the table and axes in figure 4 into your notebook. Record in the table (figure 4a) a value for wattage and current of each bulb. Make all measurements with the solar cell 10 centimeters (cm) away from the bulb.

3. Graph the data from your observations. Show how current on the multimeter varies with the wattage of the bulbs (figure 4b).

a.

Bulb Number	Bulb Wattage (Watts)	Multimeter Current (mA)
#1		
#2		
#3		

b.

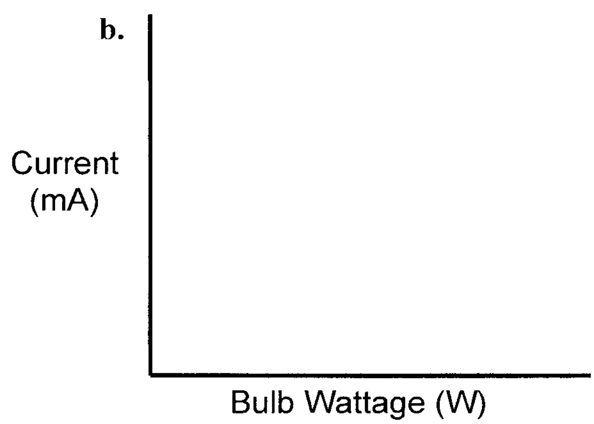

Figure 4: Current and Watts. Use (a) the table and (b) graph for your work. They help you show how the power of a bulb relates to its wattage.

Station 2: Distant Lights

Materials

1 bulb (near bulb) attached to the end of an electrical extension cord, using a socket attachment
1 bulb across the room (distant bulb) attached to a power strip using a socket attachment

1. Note the bulb in front of you at the station. A distant bulb is across the room. Move your head to the level of the near bulb so that the distant bulb lines up with the near bulb (figure 5). Have your head about 40 cm away from the near bulb.

   You have line-of-sight when you close one eye and the distant bulb is directly beyond the near bulb.

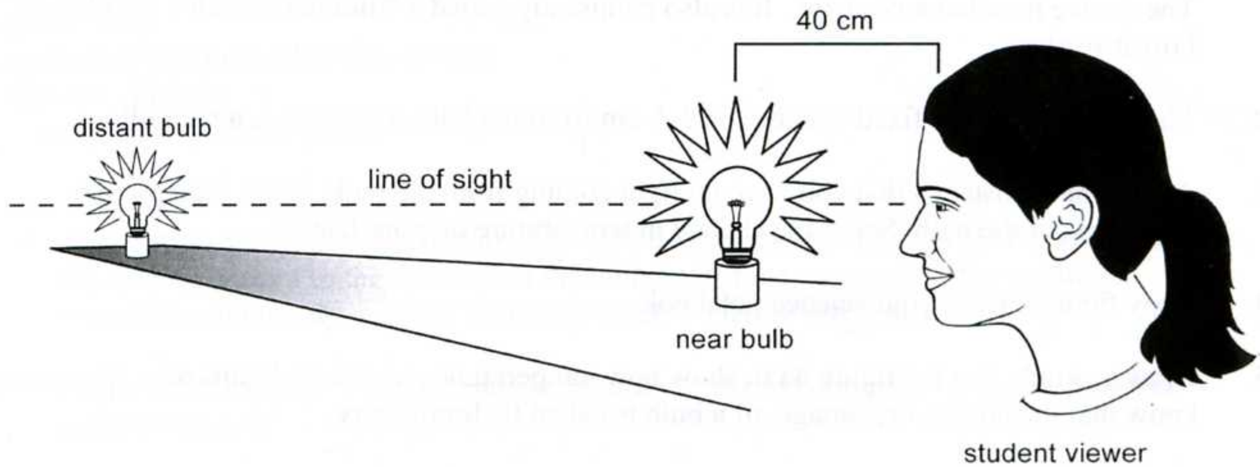

Figure 5: Near and Distant Lights. View a near and distant bulb along the same line-of-sight. Which one appears to be brighter?

2. Which light appears the brightest—the near or distant light? Write the answer in your notebook.

3. Turn off the light in front of you. Record the bulb wattage in your notebook. Select a person from your team to do the same for the far bulb.

   The wattage, or power, of a bulb is also called its **luminosity**. Luminosity for a bulb tells the energy output for a given time.

4. Which light *appeared* to be the brightest? Which light actually had the greatest luminosity?

5. Could a bright light look like it was dim? What factor(s) could make this happen? Discuss this with your team. Explain in writing or with a sketch in your science notebook.

6. How might this station relate to stars in space? If a star appears dim in the sky, are we sure that it is not bright? Write 2 sentences using these words: *luminosity, wattage, distance, brightness.*

Station 3: Temperature and Luminosity

Materials
1 bulb attached to rheostat using a socket attachment
1 bulb (Frosted, 100 W)
1 power strip

1. This station has a bulb attached, using a socket attachment, to a device with a "sliding controller". The "sliding controller" varies the electric current to the filament in the bulb. The device is called a *rheostat*. It is also commonly called a "dimmer switch". Gently test how it works.

2. Place your hand at a fixed distance of 7–8 cm from the bulb. Do not touch the bulb.

3. Adjust the rheostat so that you have no light coming from the bulb. Then, increase the brightness of the bulb. Sense the change in temperature on your hand.

4. Copy figure 6a into your science notebook.

5. Draw a simple line for figure 6a to show how temperature varies with luminosity. You may know that the power, or wattage, of a bulb is called its **luminosity**.

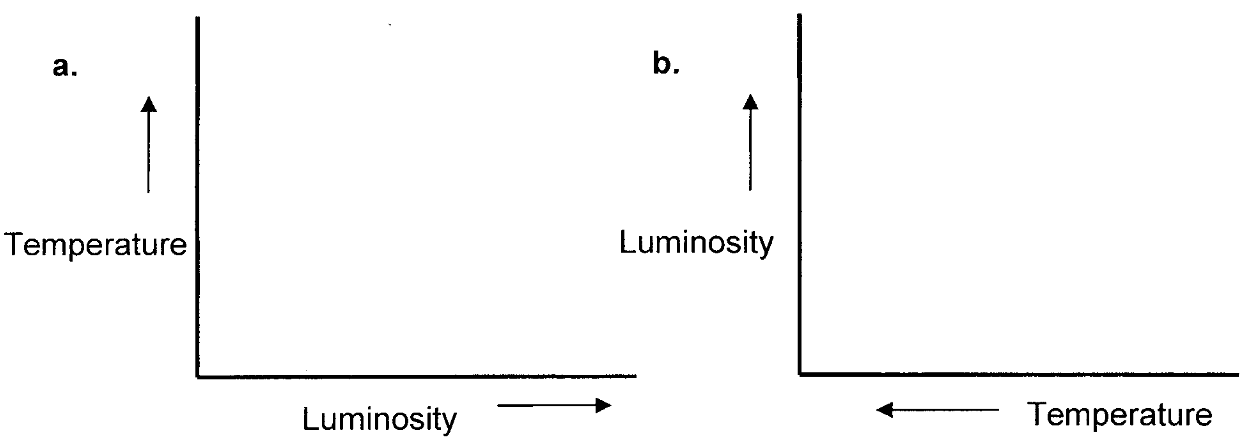

Figure 6: Temperature and Brightness. Use a line to show how temperature changes with luminosity (a). Show the same relationship another way in (b). You will use a graph like (b) later in this model lesson.

6. Use figure 6b to show the relationship between temperature and luminosity another way. You will use a graph like this later in the model lesson.

a. Note the temperature axis in figure 6b. The arrow shows the direction of increasing temperature. Write the words "*hot*" and "*cool*" at the correct ends of the temperature axis.
b. Note the axis for luminosity. Write the words "*high power*" and "*low power*" at the correct ends of the luminosity axis.

c. Recall that you used the rheostat to change luminosity and temperature. Draw a line on figure 6b that shows how luminosity changes with temperature.

Station 4: Temperature and Color

Materials
1 rheostat and bulb set-up
1 power strip
a cardboard box to block ambient light
diffraction glasses
colored pencil set (or crayons)
ruler

1. This station has a bulb attached to a *rheostat* using a socket attachment. The *rheostat* varies the electric current to the filament in the bulb by turning the knob on the controller. A *rheostat* is commonly called a "dimmer switch". Gently test how it works.

2. Notice what happens when you adjust the bulb so that it is brighter. Does the bulb get hotter or cooler?

3. Follow Steps 3a–d to see how color and temperature are related.

   a. Adjust the current until the filament BARELY glows. What color is it? This is color #1.

   b. Increase the current ever so slightly. The filament will barely change color. What is this next color? This is color #2.

   c. Increase the current very slightly again to a different color. This is color #3.

   d. Increase the current until the filament turns white. Did you see 3 distinctive colors for the filament before that? If not, try Steps 3a–c again so that you have 4 colors total. This includes the "white" of the filament at the last stage.

4. Copy figure 7a into your science notebook. Look at the *y*-axis.

   a. Write the names of colors 1, 2, and 3 on each dashed line below "white."

   b. Draw a line on your graph that shows how filament color changes with increasing temperature.

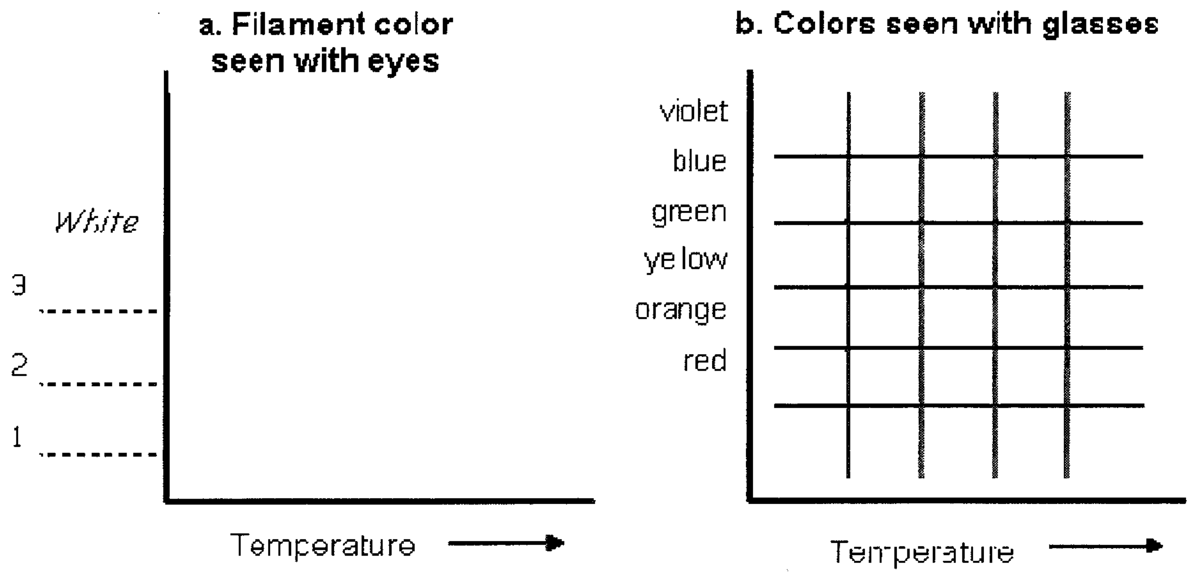

Figure 7: Color and Temperature. Write in (a) the colors that you saw along the y-axis. Use a line to show how color varies with temperature. Color in the grid in (b) to see what colors are part of the light that your eyes "see."

5. Obtain a pair of diffraction glasses. These glasses separate out the parts, or colors, that make up light.

   To use the glasses, do not look directly at the filament. Look at the color spectrum, or "echo," around the filament. Your teacher will arrange a box around the set-up to shield your viewing from other reflections in your classroom.

6. Steps 6a–e will help you see the colors from filament light at different temperatures.

   a. Copy figure 7b into your science notebook. Take turns using the rheostat to change the filament from dull red to bright white.

   b. Look at the colors along the y-axis of figure 7b. Start with red. Do you see red when you adjust the filament temperature from the lowest to the highest temperature? Use a red pencil to color across the band for red to show the range where you see red.

   c. Move to orange, then yellow. Use orange and yellow pencils to color across their bands to show the range of temperatures where you see these.

   d. Repeat the process in 6b–c for green, blue, and then violet.

   Hint: Do you see violet at the lowest possible temperature (where the filament BARELY glows)? Or, do you see violet at the highest temperature?

e. Are all color parts seen at low temperature? Are all seen at high temperature? Discuss this with your team, and write a phrase in your science notebook describing your answer.

7. Do blue and violet tend to be associated with cooler or hotter filaments? Complete the sentence below in your notebook using evidence from this station.

   I see blue when the filament is ________ (*hotter/cooler*) because with our glasses we sa that ____.

   It may help you to use a strategy of think-pair-share, and then revise with your team.

Station 5: Temperature and Color Applet (Optional)

Materials
computer with Web access

You will use a computer with access to the Web for this station. Applets can be used to show simple models. This applet helps you see how color changes with temperature.

1. Go to this Web site: http://phet.colorado.edu/web-pages/simulations-base.html.

2. Click on "Heat & Thermo" in the left column.

3. Click on "Blackbody Spectrum" in the right column.

4. Adjust the temperature slider on the applet. Watch how the color of the star changes with the temperature in Kelvin.

   Maybe you haven't heard of temperature in units of Kelvin. If not, complete the short reading, *Ho Warm Is Warm?*, with your team.

5. Copy the table in figure 8 into your notebook. Use the applet to find the color of a star for each temperature in Kelvin.

temperature (Kelvin)	Color
2,000	
3,000	
4,000	
5,000	
6,000	
7,500	
9,000	

Figure 8: Temperature and color table. Use the Blackbody applet to record how temperature relates to color for light.

6. Make a prediction using the applet. What temperature is an object when it is just starting to glow? Write your reasoning in your notebook.

7. Observe a burning candle at the station or in the front of the room. Complete Steps 7a–d.

   a. Sketch the candle and flame. Draw a scale, and add simple labels to show the colors of the flame.

   b. Use the applet to estimate the temperature of those colors.

   c. Write the temperature next to the color on your sketch.

   d. Write a complete sentence stating where the flame is the hottest.

8. Stars vary in temperature from about 2,500 K to 40,000 K. Write a simple sentence for the relationship between temperature and color for a star.

How Warm Is Warm?

Scientists use a special temperature scale when working with very cold and very hot temperatures. This scale uses a unit called a Kelvin. The word *degrees* or its symbol ° are not used in the Kelvin scale. The British physicist Lord Kelvin developed the scale.

The lowest point on the Kelvin scale is the coldest temperature possible. This is 0 K, or "absolute zero." The table in figure 9 shows an approximate comparison of the three temperature scales—Kelvin, Celsius, and Fahrenheit.