Name: _____ Date: _____

Student Exploration: H-R Diagram

Vocabulary: giant, H-R diagram, luminosity, main sequence, star, supergiant, white dwarf

**Prior Knowledge Questions** (Do these BEFORE using the Gizmo.)
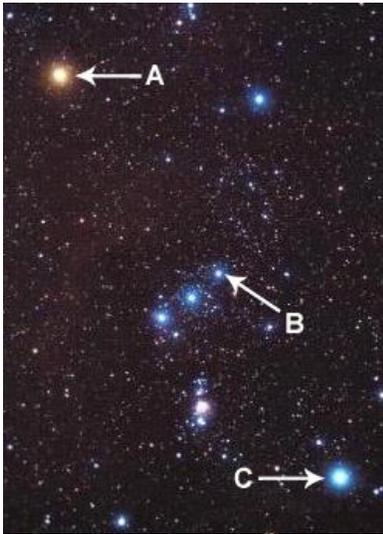
1. The image at left shows three **stars** in the constellation Orion: Betelgeuse (A), Mintaka (B), and Rigel (C). How do the appearances of **stars** A, B, and C compare?

   _____

   _____

2. What are some ways the stars in the photo could be grouped

   or classified? _____

   _____

   _____

Gizmo Warm-up

In the early 1900s, astronomers identified many star characteristics such as color, size, temperature, and **luminosity**—or how bright a star is. Using the *H-R Diagram* Gizmo, you will discover how some of these characteristics are related.

Start by moving your cursor over the stars in the **Star collection**. Star information is displayed on the right side of the Gizmo. The numbers given for **Luminosity**, **Radius**, and **Mass** are in comparison to the Sun. So, a star with a radius of "2 Suns" is twice as large as the Sun. **Temperature** is given using the Kelvin scale, where 273.15 K = 0 °C and 373.15 K = 100 °C.
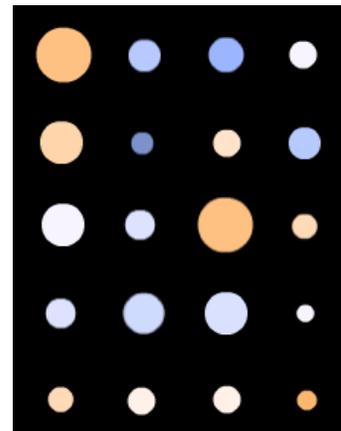
1. Find Betelgeuse in the **Star collection**. Fill out the chart at right.

2. The Sun has a radius of 695,500 km.

   What is the radius of Betelgeuse? _____

Betelgeuse	
Temperature	
Luminosity	
Radius	
Mass	

Activity A:	Get the Gizmo ready:	
Color and temperature	• Make sure **Arrange stars** is selected and **Color** is selected on the **Arranged by** menu.	
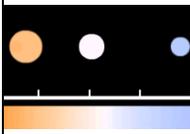
Question: How is the color of a star related to its temperature?

1. Predict: If you look closely at some stars in the night sky, you can see slight differences in their color. Some stars look reddish. Others appear orange, white, or blue.

   What do you think the color of a star indicates about its temperature? _____

   _____

   _____

2. Organize: Compare the colors of the following stars in the **Star collection**: Aldebaran, Betelgeuse, Sirius B, Spica, the Sun, and Vega. Drag the six stars to position them where you think they would fit on the Gizmo's color scale.

   Click **Sort stars** on the Gizmo to check your placements. Mark the location of each star on the scale below. Use abbreviations for the star names. For example, "Ald" could represent "Aldebaran" and "Veg" could represent "Vega."

3. Organize: On the **Arranged by** menu, select **Temperature**. Based on their given temperatures, plot the stars on the Gizmo scale. Mark each star on the scale below. (Note: On the logarithmic scale, the space between 1,000 K and 2,000 K is the same size as the space between 10,000 K and 20,000 K.)
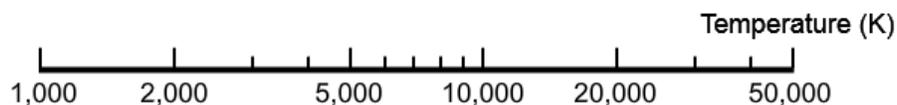
   When you are finished, click **Sort stars** to check your placements. Revise your chart if necessary.

(Activity A continued on next page)

Activity A (continued from previous page)

4. <u>Analyze</u>: What relationship, if any, do you see between a star's color and its temperature?

   _____

   _____

   _____

5. <u>Graph</u>: You will now create a graph to confirm any relationships you found between a star's color and temperature. Select **Graphical plot**. Using the dropdown menus at the top of the screen, select **Color vs. Temperature**. Position the six stars on the graphical plot.

   A. What pattern do you see in the graph? _____

   _____

   B. What does the graph show about the relationship of a star's color and temperature?

   Explain. _____

   _____

   _____

   C. Click **Move all** and then **Sort stars**. Is the relationship still evident? _____

6. <u>Infer</u>: Naos is a star in the Argos constellation. It has a very deep blue color. What do you

   think is the approximate temperature of Naos? _____

7. <u>Apply</u>: The flame of many stove burners is blue, but the wires of a toaster glow orange. How

   do you think the temperatures of these two cooking appliances compare? _____

   _____

   _____

Activity B:	Get the Gizmo ready:	
Luminosity, mass, and radius	• Click **Reset**. Select **Arrange stars**. • Select **Luminosity** on the **Arranged by** menu.	
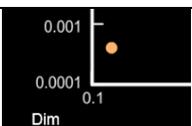
**Question: How are a star's luminosity, mass, and radius related?**

1. <u>Organize</u>: Position Aldebaran, Betelgeuse, Sirius B, Spica, the Sun, and Vega on the Gizmo's luminosity scale, and mark these positions on the scale below. (Remember to click **Sort stars** to check your placements.)

Luminosity (Suns)

```
      |     |     |     |     |     |     |     |     |
Dim  0.0001 0.001  0.01   0.1    1    10   100  1,000 10,000 Bright
```
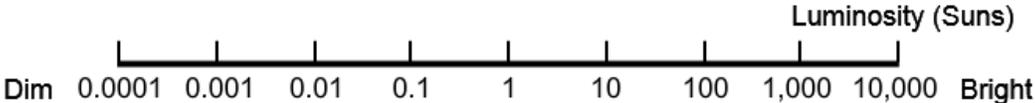
2. <u>Organize</u>: Select **Radius** from the **Arranged by** menu. Position the stars on the Gizmo's radius scale, and mark these positions on the scale below. (Remember to click **Sort stars** to check your placements.)

Radius (Suns)

```
      |           |           |           |           |           |
Small 0.01       0.1          1          10         100        1,000 Large
```
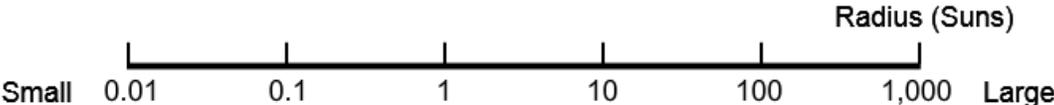
3. <u>Organize</u>: Select **Mass** from the **Arranged by** menu. Position the stars on the Gizmo's mass scale, and mark these positions on the scale below. (Remember to click **Sort stars** to check your placements.)

Mass (Suns)

```
    |                |                |            | |
   0.1               1               10            100
```
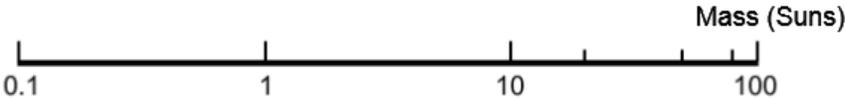
4. <u>Compare</u>: Study the scales you've made.

   A. How do the stars' luminosity compare with their radii? _____

   _____

   B. How do the stars' radii compare with their mass? _____

   _____

(Activity B continued on next page)

Activity B (continued from previous page)

5. <u>Predict</u>: Consider any relationships you see between a star's luminosity, radius, and mass.

    A. As the radius of a star increases, how do you think its luminosity might change?

        _____

    B. As the mass of a star increases, how do you think its luminosity might change?

        _____

    C. As the radius of a star increases, how do you think its mass might change?

        _____

6. <u>Graph</u>: Select **Graphical plot**. Using the dropdown menus, select **Luminosity vs. Radius**, and click **Move all** and then **Sort stars**. Describe any relationships you see.

_____

_____

7. <u>Explain</u>: Why would the size of a star affect its luminosity? _____

_____

8. <u>Compare</u>: Select **Luminosity vs. Mass**, and click **Sort stars**. How does this graph compare

with the Luminosity vs. Radius graph? _____

_____

9. <u>Graph</u>: Select **Mass vs. Radius**, and click **Sort stars**. Describe any relationships you see.

_____

_____

10. <u>Interpret</u>: Which star do you think is the densest: Antares, Spica, or Polaris? Explain. _____

_____

_____

Activity C:	Get the Gizmo ready:	Supergiants
Luminosity and temperature	• Click **Reset**. • Select **H-R diagram**.	
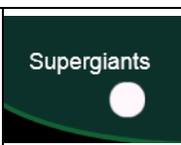
Introduction: In the early 1900s, two astronomers—Ejnar Hertzsprung and Henry Norris Russell—independently made a graph comparing star luminosity and temperature. This graph, now known as a Hertzsprung-Russell diagram, or **H-R diagram**, is still used today to classify stars into groups.

Question: What does an H-R diagram reveal about star types?

1. Observe: Look at the temperature axis on the diagram. What is unusual about this axis?

   _____

   The temperature scale goes backward because the original H-R diagram plotted luminosity vs. color, with the color ranging from blue to red.

2. Predict: How do you think the luminosity of a star is related to its temperature? _____

   _____

3. Classify: Click **Move all** and then **Sort stars**. Click the **Tools** palette at lower left and click **Screen shot**. Right click the image, click **Copy Image**, and paste a screenshot of the diagram in a blank document that you will turn in with this worksheet. Circle stars that you think belong in a group together. On the lines below, explain your groupings.

   _____

   _____

   _____

   _____

4. Identify: Turn on **Show star groups**.

   A. Which group are most stars found in? _____

   B. How would you characterize stars in this group? _____

      _____

      _____

(Activity C continued on next page)

Activity C (continued from previous page)

5. <u>Describe</u>: More than 90 percent of all stars in the universe, including the Sun, are **main sequence** stars. As main sequence stars age, they move up and to the right on the H-R diagram and become **giants** or **supergiants**.

What are the characteristics of giants and supergiants? _____

_____

Main sequence stars produce heat by fusing hydrogen atoms into helium in their core. Giants and supergiants form when the star's core runs out of hydrogen and begins to collapse due to the force of gravity. As this occurs, hydrogen-rich outer layers of the star heat up enough to start forming helium, causing the star to rapidly expand.

6. <u>Compare</u>: Study the H-R diagram.

    A. Which stars are **white dwarfs**? _____

    B. What are the characteristics of white dwarfs? _____

    _____

White dwarfs are small, hot stars that are near the end of their lives. They are the leftover cores of giants and supergiants.

7. <u>Classify</u>: Proxima Centauri is the nearest star to the Sun. It has a luminosity of 0.0017 and a temperature of 3,000 K.

    A. Which star group does Proxima Centauri belong to? _____

    B. On the H-R diagram, which star would Proxima Centauri be near? _____

8. <u>Describe</u>: Locate the Sun on the H-R diagram. How will the Sun's luminosity and temperature change as it ages? How will these changes affect its position on the diagram?

_____

_____

_____

_____

_____