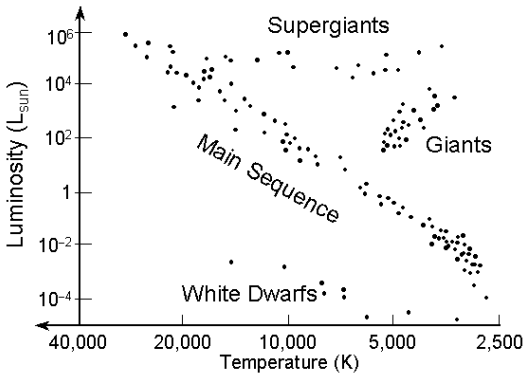
Name: _____ Date: _____ Period: _____

STAR IN A BOX ACTIVITY

Danish astronomer Ejnar Hertzsprung and American astronomer Henry Russell discovered a relationship between the **luminosity** of a star (as measured by its **absolute magnitude**) and its surface temperature. The graph of a star's absolute magnitude versus its temperature is called an **H-R Diagram**. The H-R Diagram allows astronomers to study how stars evolve over time.



To further investigate these concepts, go to the following website:

http://starinabox.lco.global/

Launch the "***Star in a Box***", keep the "slider" on "**Normal**" and open the lid. The graph (plot) you observe on the left side is a Hertzsprung - Russell diagram. As you can see, the graph show the **brightness** (***luminosity, absolute magnitude,*** *and* ***brightness*** *are terms for essentially the same concept*) on the y-axis and temperature (in degrees Kelvin) on the x-axis. On the right, the information panel allows you to choose the:

- size
- temperature,
- brightness,
- stage in a stars life

The animation above the information panel will show how the star will change as it goes through its life cycle relative to our star, the Sun. The starting parameters are for a star like the Sun (*a main sequence star*). The different stages in the life cycle of a star will be indicated in the upper right corner of the H-R Diagram. The time (*in millions of years is shown in the lower right portion of the graph*).

Follow the steps below and provide answers to the questions that are complete thoughts and in complete sentences (CSIQ).

STEP 1: SIZE

Select the "**Compare the size**" button on the information panel then click on the "**Information**" link on the upper portion of the panel and read the information provided.

1. Describe what will happen to our Sun during its life as a "**Main Sequence**" star. _____
   _____
   _____
2. Describe the characteristics of our Sun as it progresses into a "**Red Giant**". Be specific. _____
   _____
   _____
   _____
3. Describe what will happen to our Sun as it evolves into a "**White Dwarf**". _____
   _____
   _____

Select "**normal**" speed and click the "**play**" button below the information panel to start the evolution of the lifecycle of our Sun and observe the changes in its size.

4. How does the size of the Sun change over its lifetime? Make sure to indicate the "stage" when describing the size in relation to the size of our Sun now. _____
   _____
   _____
   _____
   _____

STEP 2: TEMPERATURE

Select the "**Surface Temperature**" button on the information panel, then select "**normal**" speed and click the "**play**" button below the information panel to start the evolution of the lifecycle of our Sun and observe the changes in temperature.

5. What is the starting temperature of the Sun as a **Main Sequence** star? _____
6. What happens to the surface temperature of the Sun as it progress through its life cycle as a "**Red Giant**"? (**Hint:** *look at the graph in addition to the thermometer*) _____
   _____
   _____
7. What is the temperature reached at approximately 10,000 million years of evolution just prior to the horizontal movement along the graph as our Sun goes through a **Red Giant** phase? You can move the cursor to the spot on the graph and get an exact temperature. _____
   _____
8. What happens to the surface temperature of our Sun from approximately 10,000 million years? (*you may need to slow this phase down because it occurs very quickly*) What is the highest temperature reached in the Red Giant phase? _____
9. Propose an explanation for why the temperature increases and why this stage progresses so quickly. _____
   _____
   _____
   _____
10. What happens to the temperature as our Sun goes through the "**White Dwarf**" stage? _____
    _____
11. How long does the "**Red Giant**" phase last (in millions of years)? _____
    _____

STEP 3: BRIGHTNESS

Select the "**Brightness**" button on the information panel, then select "**normal**" speed and click the "**play**" button below the information panel to start the evolution of the lifecycle of our Sun and observe the changes in brightness (luminosity).

12. What is the starting brightness (luminosity) of the Sun as a **Main Sequence** star? _____
    _____
13. What happens to the brightness of the Sun as it progress through its life cycle as a "**Red Giant**"? _____
    _____
    _____
14. How much brighter will our Sun be when it reaches its peak brightness as a **Red Giant** than it is now? You can move the cursor to the spot on the graph and get an exact temperature. _____
    _____
15. Propose an explanation for why the Sun gets so much brighter as it evolves from a **Main Sequence** to a **Red Giant**.
    _____
    _____
    _____
16. What happens to the brightness of our Sun as it moves from a **Red Giant** to a **White Dwarf**? _____
    _____
17. Propose an explanation for why the brightness decreases as it ends its life as a **White Dwarf**. _____
    _____
    _____
    _____

STEP 4: STAGES

Select the "**Stages**" button on the information panel, then select "**normal**" speed and click the "**play**" button below the information panel to start the evolution of the lifecycle of our Sun and observe the changes in the different stages over its lifecycle.

18. Which stage does our Sun spend a majority of its life in? _____
    _____
19. Describe what is occurring within the star during this stage. _____
    _____
    _____
    _____
20. Approximately how much of our Suns life will be spent as a **Red Giant** and a **White Dwarf**? _____
    _____
21. Describe what is occurring within the star during these stages. _____
    _____
    _____
    _____

STEP 5: DATA

Finally, click on the "**Data Table**" tab on the upper right portion of the H-R Diagram to see the final values for each stage in the lifecycle and include the data in the table below.

STAGE	**RADIUS** (as compared to the Sun)	**BRIGHTNESS** (as compared to the Sun)	**TEMPERATURE** (in degrees Kelvin)	**DURATION** (in millions of years)
MAIN SEQUENCE				
RED GIANT				
WHITE DWARF				

Based on the information in the table above, answer the questions below:

22. Describe how the Sun changes over its lifetime (using **ALL** of the characteristics you observed). _____
    _____
    _____
    _____
    _____
    _____
    _____
    _____
    _____
23. When will the Sun be at its brightest? _____
24. When will the Sun be at its hottest? _____
25. In which stage of its life does the Sun spend the longest time? _____
26. In which stage of life will the Sun undergo the most change? _____
27. What kind of star will the Sun be at the end of its life? _____
28. How long will the Sun live for? _____

By adjusting the mass of the star in the "**Star Properties**" you can explore the evolution of different stars.

29. What is the relationship between the mass of the star and the location on the main sequence? _____

_____

_____

_____

Follow the evolution for five stars with different masses. Make sure to complete one set of data for a star with **LESS** mass than our Sun. Complete the data table below filling in a row for each mass (*you will need to watch the evolution not just look at the Data Table summary*).

MASS OF STAR (M_{Sun})	**TIME ON MAIN SEQUENCE** (Myr)	**NUMBER OF STAGES**	**FINAL STAGE**	**TOTAL LIFESPAN** (Myr)	**MAXIMUM RADIUS** (R_{Sun})	**MAXIMUM LUMINOSITY** (L_{Sun})	**MAXIMUM TEMPERATURE** (degrees K)

Compare the data table for a range of stars and answer the following questions:

30. Are more massive stars the brightest and hottest types of star for their whole lives? _____

_____

_____

31. Which mass star gets the hottest? _____

_____

32. Which mass star gets the coolest? _____

_____

33. Which mass star becomes the most luminous? _____

_____

Deneb *and* ***Betelgeuse*** *are both 20x the mass of the Sun, but look very different. Deneb has 100 times the radius of the Sun and its temperature is about 8,000 K. Betelgeuse has 1,000 times the radius of the Sun and its temperature is about 3,500 K.* Select a star with 20x the mass of the Sun and run the animation, use this to find:

34. What stages of their lives are these two stars currently in? _____

_____

_____

35. How much longer will these two stars exist? Explain your answer. _____

_____

_____

_____