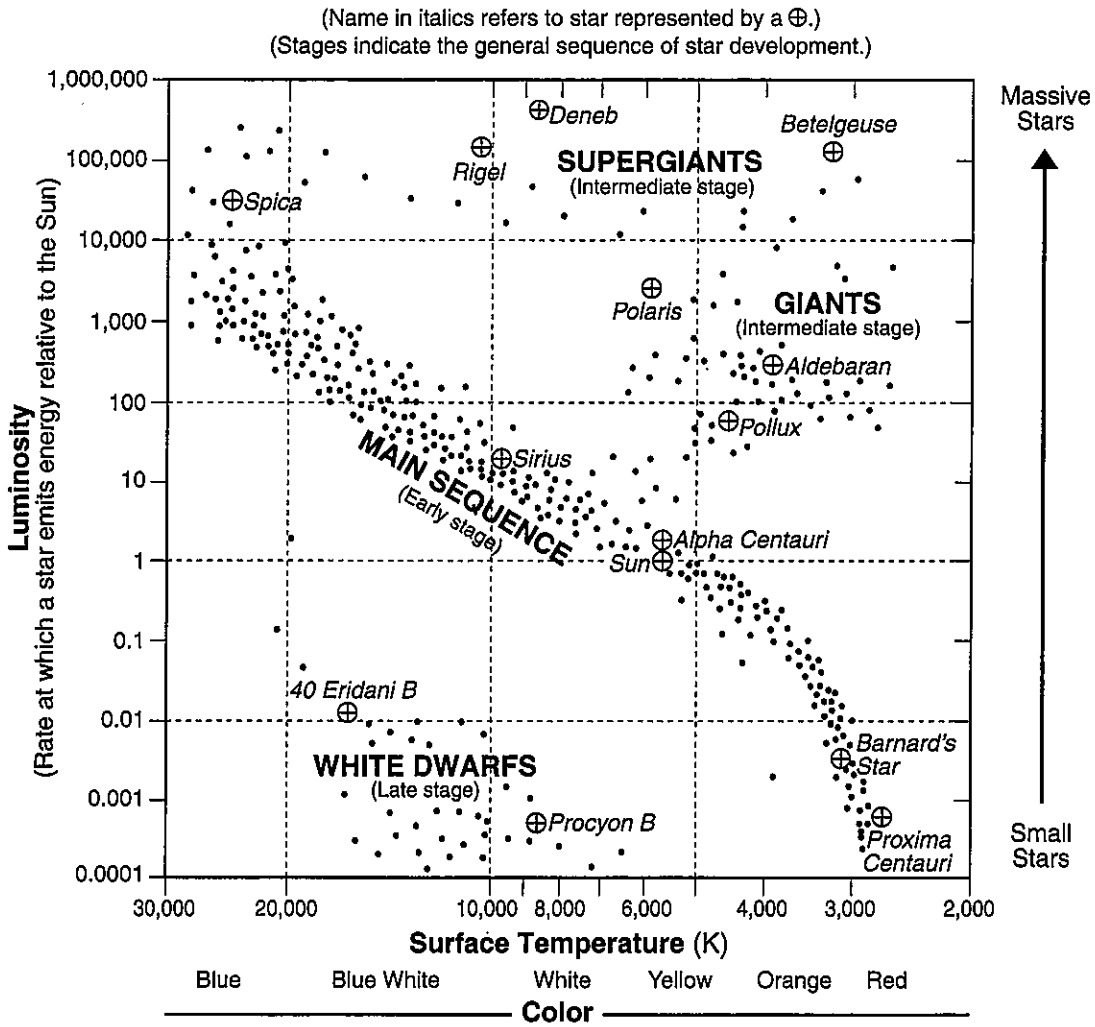
Characteristics of Stars



Overview:

When the temperature and luminosity (brightness) of stars were first plotted on a graph, a pattern is observed. Most of the stars fell within a specific region that ran diagonally across the graph, later to be named the main sequence. Stars off the main sequence fell mainly into groups of giants, supergiants and white dwarfs. Years later it was discovered that this pattern revealed stellar evolution according to the position of a star on this graph. The two scientists that independently produced this chart, Hertzsprung and Russell, are credited for making a tremendous contribution to astronomy. Thus, this graph is referred to as the H-R diagram.

Stars, through nuclear fusion, convert hydrogen fuel into heavier elements, mostly helium. This nuclear reaction continues for millions or even billions of years, generating the star's energy. Eventually, when the hydrogen fuel starts to become exhausted, stars, in reaction to the force of gravity with its core, expand greatly becoming cooler giants or supergiant stars. In time, these dying giant stars will undergo a violent stellar explosion, becoming a supernova, or collapse becoming white dwarf stars.

Our Sun is an average yellow star and is presently positioned on the main sequence. When the hydrogen within its core is exhausted, the Sun will greatly expand becoming a red giant. This will vaporizes some of the inner planets, while toasting the Earth. It will eventually collapse becoming a hot white dwarf star. But not to worry, this will not happen this year, so concentrate on passing the regents.

The Graph:

The *x*-axis is the Surface Temperature of stars on the Kelvin (K) temperature scale. The surface temperature of a star produces its color. Red stars are the coolest, having a temperature around 2,500 K, while blue stars are the hottest having temperatures over 20,000 K. Our Sun is shown to have a surface temperature of just over 5,000 K, making it a yellow star. The y-axis is the Luminosity scale. This scale shows the relative brightness of a star compared to our Sun if they were placed side by side at a given distance from the Earth. Our Sun is assigned the luminosity value of 1. Brighter stars have a luminosity value higher than 1, while duller stars would have a value less than 1. On the far right side is a descriptive scale showing the size of stars from small to massive. As shown on the diagram, small stars have low luminosity values and would be dull stars in the night sky. Massive stars, having very high luminosity values are usually bright stars. For example, the white dwarf stars are shown to be quite hot, but being so small they are relatively dull, as shown by their low luminosity values. Betelgeuse is a red supergiant that has a relatively cool temperature of around 3,500 K, but due to its large size (a true monster of a star) it has a luminosity of 100,000 times that of our Sun. This red star is easily seen in the winter constellation, Orion.

Early Stage – As mentioned in the introduction, stars go through different stages. For most of their lives (young age), they are positioned on the main sequence. Their position on the main sequence is related to the mass of the star.

Intermediate Stage – Eventually, as a star runs low on the hydrogen fuel, it greatly expands, which causes its surface temperature to cool. This will reposition the star off the main sequence to the giant or supergiant position. It has now entered into its dying stages.

Late stage – These now massive stars, depending upon their masses, will either supernova (a short lived spectacular explosion) or collapses into a very dense, white dwarf star. These dwarf stars will continue to cool, eventually becoming black dwarfs.

Additional Information:

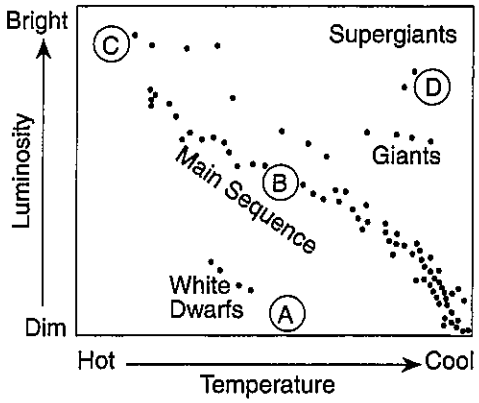
- Astronomers believe that a black hole is formed from the collapse of the core of a massive star. This black hole creates so much gravity that light can't escape. It is believed that most, if not all galaxies, rotate around a centrally located supermassive black hole.
- In nuclear fusion a small amount of matter is converted into a tremendous amount of energy in accordance with Einstein equation, $E = mc^2$, where E = energy, m = mass and c is the speed of light squared.
- Our Sun is approximately 4.6 billion years old and is expected to last another 4 to 5 billion years. Our universe is estimated to be 13-14 billion years old.
- There are two types of magnitude (brightness): absolute magnitude and relative magnitude. Relative magnitude is how bright a star appears to us in the night sky. Absolute magnitude (which this chart is based on) is a measurement of a star's luminosity (brightness) from a set distance from the Earth.

Set 1 — Characteristics of Stars

1. Which star color indicates the hottest star surface temperature?

   (1) blue (3) yellow
   (2) white (4) red 1 _____

2. The graph below represents the brightness and temperature of stars visible from Earth.



   Which location on the graph best represents a star with average brightness and temperature?

   (1) *A* (3) *C*
   (2) *B* (4) *D* 2 _____

3. Compared with our Sun, the star Betelgeuse is

   (1) smaller, hotter, and less luminous
   (2) smaller, cooler, and more luminous
   (3) larger, hotter, and less luminous
   (4) larger, cooler, and more luminous

   3 _____

4. Which star is cooler and many times brighter than Earth's Sun?

   (1) Barnard's Star (3) Rigel
   (2) Betelgeuse (4) Sirius 4 _____

5. Which two stars have the most similar luminosity and temperature?

   (1) Betelgeuse and Barnard's Star
   (2) Rigel and Betelgeuse
   (3) Alpha Centauri and the Sun
   (4) Sirius and Procyon B 5 _____

6. Compared to the temperature and luminosity of the star Polaris, the star Sirius is

   (1) hotter and more luminous
   (2) hotter and less luminous
   (3) cooler and more luminous
   (4) cooler and less luminous 6 _____

7. In nuclear fusion what occurs?

   (1) Lighter elements are converted to heavier elements.
   (2) Lighter elements are converted to even lighter elements.
   (3) Heavier elements are converted to lighter elements.
   (4) Heavier elements chemically combine with lighter elements. 7 _____

8. Betelgeuse and Aldebaran are both red-giant stars. Give a statement comparing their luminosity and temperature values.

_____

9. A star located off the main sequence indicates what?

_____

10. Compared to the surface temperature and luminosity of massive stars in the Main Sequence, the smaller stars in the Main Sequence are

(1) hotter and less luminous
(2) hotter and more luminous
(3) cooler and less luminous
(4) cooler and more luminous 10 _____

11. Which star's surface temperature is closest to the temperature at the boundary between Earth's mantle and core?

(1) Sirius (3) the Sun
(2) Rigel (4) Betelgeuse 11 _____

Base your answers to 12 and 13 on the passage below.

The Future of the Sun

Hydrogen gas is the main source of fuel that powers the nuclear reactions that occur in the Sun. But just like many sources of fuel, the hydrogen is in limited supply. As the hydrogen gas is used up, scientists predict that the helium created as an end product of earlier nuclear reactions will begin to fuel new nuclear reactions. When this happens, the Sun is expected to become a red giant star with a radius that would extend out past the orbit of Venus and possibly out as far as Earth's orbit. Earth will probably not survive this change in the Sun's size. But no need to worry at this time. The Sun is not expected to expand to this size for a few billion years.

12. Identify the nuclear reaction referred to in this passage that combines hydrogen gas to form helium and produces most of the Sun's energy.

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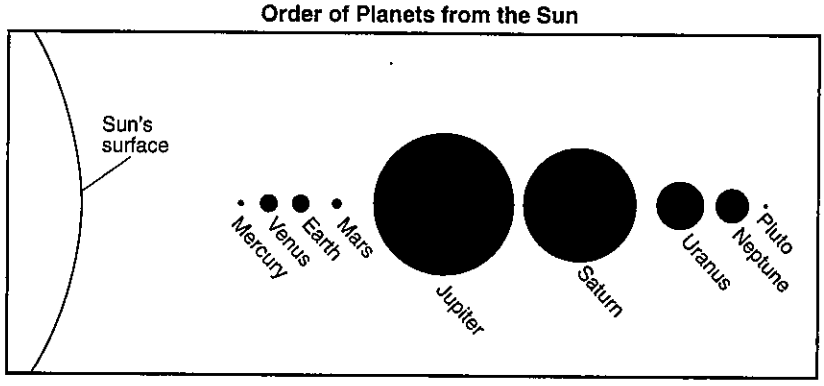
13. On the diagram of the planets and the Sun's surface, draw a vertical line to represent the inferred location of the Sun's surface when it becomes a red giant star.



14. Explain why a giant star that is cooler than our Sun, similar to Aldebaran, has a greater luminosity than the Sun. _____

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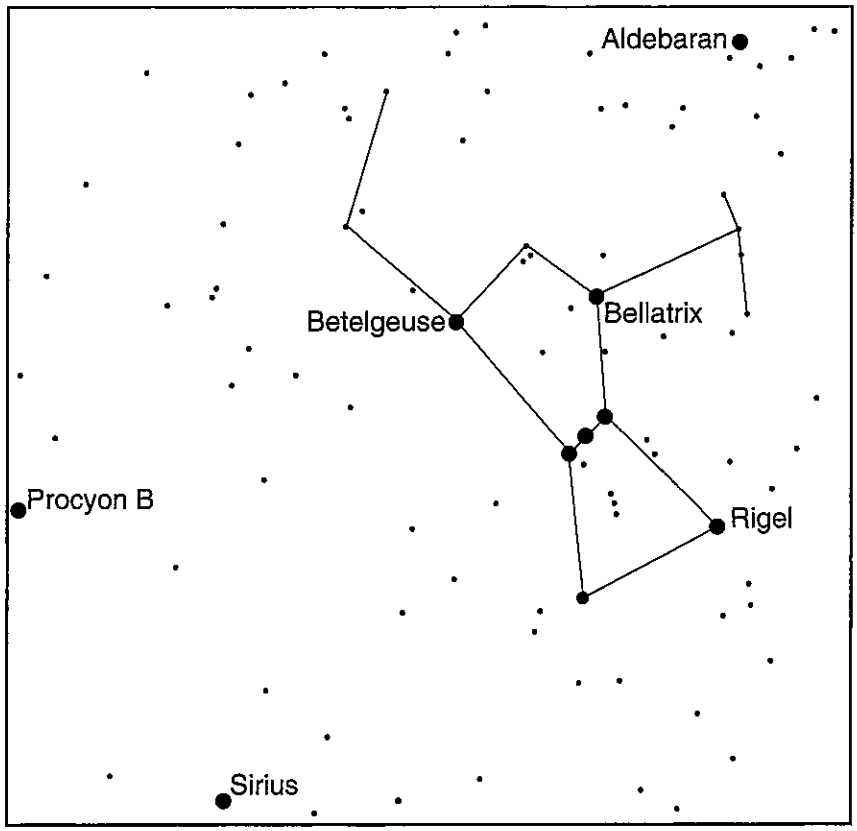
Base your answers to questions 15*a* and *b* on the accompanying star chart, which shows part of the winter sky visible from New York State. Some of the brighter stars are labeled and the constellation Orion is outlined.



15. *a*) Identify the color of the star Bellatrix, which has a surface temperature of approximately 21,000 K. _____

b) In the accompanying space, list the stars, other than Bellatrix, found on the chart in order of decreasing luminosity. Rigel, the most luminous star, has been listed.

Most luminous (1) Rigel

(2) _____

(3) _____

(4) _____

Least luminous (5) _____

16. Give a statement on the relationship between Temperature and Luminosity of the main sequence stars.

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