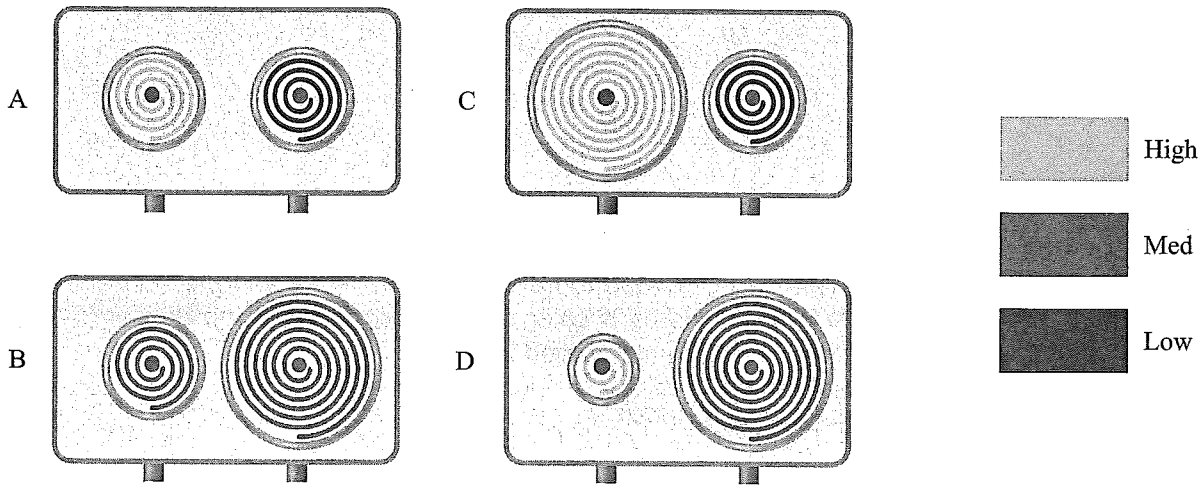
Part I: Luminosity, Temperature, and Size

Imagine you are comparing the ability of electric hot plates of different sizes and temperatures to fully cook two identical large pots of spaghetti. Note that all the pots are as large as the largest hot plate. The shading of each hot plate is used to illustrate its temperature. The darker the shade of gray the cooler the temperature of the hot plate.

1) For each pair of hot plates shown below, circle the one that will cook the large pot of spaghetti more quickly. If there is no way to tell for sure, state that explicitly.



2) If you use two hot plates of the same size, can you assume that the hot plate that can cook a large pot of spaghetti first is at the higher temperature? Which lettered example above supports your answer?

3) If you use two hot plates at the same temperature, can you assume that the hot plate that can cook a large pot of spaghetti first is larger? Which lettered example above supports your answer?

4) If you use two hot plates of different sizes, can you assume that the hot plate that can cook a large pot of spaghetti first is at a higher temperature? Which lettered example above supports your answer?

5) Two students are discussing their answers to Question 4:

Student 1: *In 1D, the hot plate on the left cooks the spaghetti quicker than the one on the right even though it is smaller. The hot plate's higher temperature is what makes it cook the spaghetti more quickly.*

Student 2: *But the size of the hot plate also plays a part in making it cook fast. If the hot plate on the left were the size of a penny, the spaghetti would take a really long time to cook. I bet that if the size difference were great enough, the one at the lower temperature could cook the spaghetti first.*

Do you agree or disagree with either or both of the students? Explain your reasoning.

The time it takes for the spaghetti to cook is determined by the rate at which the hot plate transfers energy to the pot. This rate is related to both the temperature and the size of the hot plate. For stars, the rate at which energy is given off is called **luminosity.** Similar to the above example, a star's luminosity can be increased by

- increasing its temperature; and/or
- increasing its surface area (or size).

This relationship between luminosity, temperature, and size allows us to make comparisons between stars.

6) If two hot plates have the same temperature and one cooks the pot of spaghetti more quickly, what can you conclude about the sizes of the hot plates?

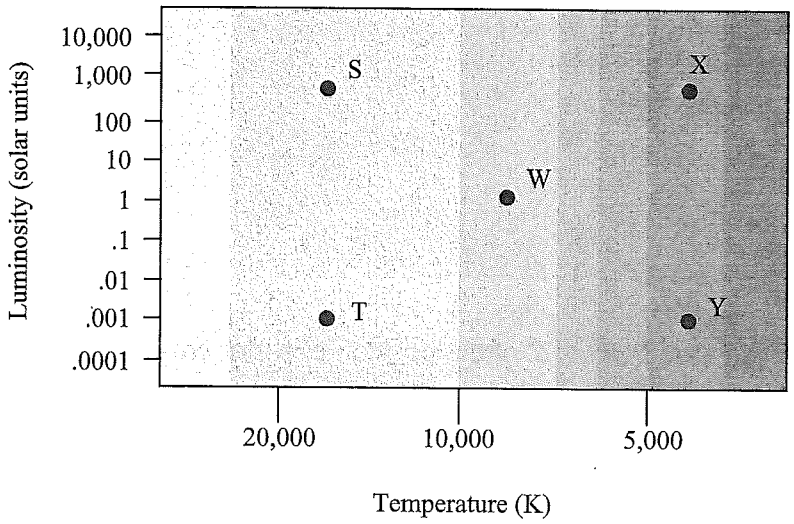
7) Likewise, if two stars have the same surface temperature and one is more luminous, what can you conclude about the sizes of the stars?

8) If two stars have the same surface temperature and are the same size, which star, if either, is more luminous? Explain your reasoning.

9) If two stars are the same size, but one has a higher surface temperature, which star, if either, is more luminous? Explain your reasoning.

Part II: Application to the H–R Diagram

The graph below plots the luminosity of a star on the vertical axis against the star's surface temperature on the horizontal axis. This type of graph is called an H–R diagram. Use the H–R diagram below and the relationship between a star's luminosity, temperature, and size (as described on the previous page) to answer the following questions concerning the stars labeled S–Y.



10) Stars S and T have the same surface temperature. Given that Star S is actually much more luminous than Star T, what can you conclude about the size of Star S compared to Star T? Explain your reasoning.

11) Star S has a greater surface temperature than Star X. Given that Star X is actually just as luminous as Star S, what can you conclude about the size of Star X compared to Star S? Explain your reasoning.

12) Based on the information presented in the H–R diagram, which star is larger, X or Y? Explain your reasoning.

13) Based on the information presented in the H–R diagram, which star is larger, Y or T? Explain your reasoning.

14) On the H–R diagram, draw a "Z" at the position of a star smaller in size than Star W but with the same luminosity. Explain your reasoning.

15) It is very difficult to accurately predict how the size of Star S will compare to that of Star W (without performing some kind of calculation). Explain what makes a comparison of the size of these stars so difficult.