Based on observations of binary star systems, astronomers have determined the masses of a number of stars. Figure 1 represents a plot of the masses of stars as a function of their luminosities.

1) Describe the general trend between the masses of stars and their luminosities.

2) Are there any stars which do not appear to follow this trend? If so, circle them.

It turns out that the more massive a star, the more luminous it is. Mathematically, we can say that the luminosity of a star is almost directly proportional to the mass of the star raised to the 3.5 power.

\[ \text{Luminosity} \sim \text{Mass}^{3.5} \]

A majority of a star’s lifetime (roughly 90%) is spent on the main sequence. The remainder of its life is proportional to the amount of time it spends as a main sequence star. The amount of time it spends as a main sequence star depends on how fast it “burns” its fuel (or, more precisely, how fast it fuses hydrogen into helium in its core).
3) If a star’s fuel is just how much hydrogen it has, what stellar property represents how much “fuel” it has? Explain your reasoning.

How quickly a star uses up its fuel depends on how quickly it consumes it, which is related to the rate at which it gives off energy over time.

4) What stellar property represents how quickly a star is consuming its fuel? Explain your reasoning.

The main sequence lifetime of a star, then, is simply the amount of fuel it has divided by how quickly it consumes that fuel.

5) Based on this, how can you write the lifetime of a star in terms of the physical properties that you listed in questions 3 & 4?

Using the formula at the bottom of the first page, can you simplify this equation such that the lifetime of the star depends on only one stellar property?

6) For stars on the main sequence, how is lifetime related to mass? Explain your reasoning.
7) Consider the following debate between two students.

**Student 1:** Stars with more mass live longer lives, because they have more fuel to burn.

**Student 2:** I disagree. While they have more hydrogen, they also fuse that hydrogen at a much higher rate, such that they actually live much shorter lives.

Do you agree or disagree with either or both students? Why?

8) For stars on the main sequence, how is lifetime related to temperature? (Hint: Think about how temperature is related to luminosity and how luminosity is related to mass).