

Tutorial: Star Formation and Lifetimes

(Adapted from *Lecture-Tutorials for Introductory Astronomy*, © CAPER Team, Preliminary Edition, 2002)

Stars like our sun begin life as a cloud of gas and dust. The birth of a star begins when a disturbance, such as the shockwave from a supernova, triggers the cloud of gas and dust to collapse inward.

Imagine that you are observing the region of space where a cloud of gas and dust is beginning to collapse inward to form a star (this region is called a protostar).

01. Will the material in the cloud become more dense, less dense, or stay about the same density? Explain your answer.

02. What physical force causes the cloud to collapse once it gets started? _____

03. Would you expect the temperature of the protostar to increase or decrease with time? Why?

04. Would you expect the pressure in the middle of the collapsing cloud to increase, decrease, or stay just about the same? Explain.

Mass of the Star (expressed as multiples of the Sun's mass)	Main Sequence Lifetime of the Star
$0.67 M_{sun}$	45 billion years [4.5 x 10 ¹⁰]
$1.0 M_{sun}$	10 billion years [1.0 x 10 ¹⁰]
$1.3 M_{sun}$	800 million years [8.0 x 10 ⁸]
$2.0 M_{sun}$	500 million years [5.0 x 10 ⁸]
$6 M_{sun}$	70 million years [7.0 x 10 ⁷]
$60 M_{sun}$	800 thousand years [8.0 x 10 ⁵]

05. This is quite obvious, but which live longer: high mass or low mass stars?

06. Based on your answer to question 5, would you think that the nuclear fusion rate for a high-mass star is greater than, equal to, or less than the nuclear fusion rate of a low-mass star? Why do the lifetimes imply this?

07. The nuclear fusion rate of a star depends on both the temperature and the density in the star's core. How would the temperature and density of the core for a high-mass star compare to that of a low-mass star?

08. Which of the following statements best describes how the lifetimes compare between a star that has a mass equal to the Sun and a star with 6 times the mass of the Sun? A star with a mass the same as the Sun will:

- a. live less than 6 times as long as a star with a mass 6 times the mass of the Sun.
- b. live 6 times shorter than a star with a mass 6 times the mass of the Sun.
- c. have the same lifetime as a star with a mass 6 times the mass of the Sun.
- d. live 6 times longer than a star with a mass 6 times the mass of the Sun.
- e. live more than 6 times longer than a star with a mass 6 times the mass of the Sun.

Explain your reasoning for the choice you made.

09. The Sun has a main sequence lifetime of approximately 10 billion years. If you could determine the rate of nuclear fusion for a star with twice the mass of the Sun, which of the following would it be?

- a. less than the nuclear fusion rate of the Sun.
- b. a little more than the nuclear fusion rate of the Sun.
- c. twice the nuclear fusion rate of the Sun.
- d. more than twice the nuclear fusion rate of the Sun.

Explain your reasoning for the choice you made.

10. Here is a figure from a text showing the “mass luminosity” relationship. How does this graph relate to the mass-lifetime relationship we’ve been discussing here?

