Chapter 14: Family of Stars

Student Worksheet

Objective:

Learn the stages and durations of the stellar life cycle for a high mass, mid mass, and low mass star.

Engage:

In this activity you will increase your understanding of the life cycles of stars. Review what you have learned about the formation of planets. How would you describe the life cycle of a planet?

Introduction:

As a star moves through its "life" it goes through different stages, just as humans go through great physical changes from the time of their birth through their golden years. Stars, of course, are not alive in the same sense, but the term "life cycle" works well to describe their evolution.

Imagine arriving on Earth as an alien from a very different planet. Around you, you see many types of humans: children, adults, teens, babies, elderly people, and maybe even a pregnant person or two. It would be an important and possibly difficult task to decipher the life cycle of humans just by looking at a crowd. Astronomers do just that with stars. When astronomers look into the night sky, they see many types of stars: red giants, white dwarfs, stellar remnants, protostars, and main-sequence stars. Over the years, astronomers have used observation and physical modeling to piece together the life cycle of stars.

One property defines the life of a star – its mass. Massive stars run through their fuel very quickly and end their lives as a neutron star or black hole in just a few million years, while very low mass stars like red dwarfs can fuse hydrogen to helium for trillions of years

before finally ending up as white dwarfs.

One way to predict the life span of a star is to use the relationship:

$$t = 10^{10}\frac{M}{L}$$

The mass, M, and luminosity, L, are in solar units. Time is measured in years.

In this activity you will put the stages of a star's life in order and place the stages on a timeline to learn how long different stages typically last.

Your Task:

Your teacher will provide you with the Family of Stars cards. Sort the Family of Stars cards into three piles-- one pile for a red dwarf star, one pile for a Sun-like star, and one pile for a high mass star. Match the times to each card to reference how long the star stays in each stage.

Procedure:

Part one: Sorting the cards

1. Sort the cards into a pile for each type of star: red dwarf, Sun-like star, blue giant.

2. Put the cards within each pile into chronological order.

3. Check the piles you have made against those of the groups of students near you. Take some time to listen to why they chose their grouping/ordering and take time to share your rationale. Feel free to change your groupings based on insights that come from comparison.

4. Check with your instructor for the correct grouping and chronology.

Part two: Calculating life span

1. Use the equation $t = 10^{10}\frac{M}{L}$ to estimate the time spent on the *main sequence* for each star.
    a. The red dwarf has a mass of 0.2 M⊙ and a luminosity of 0.008 L⊙

Time on the main sequence:

b. The Sun-like star has a mass of 1 M⊙ and a luminosity of 1L⊙

Time on the main sequence:

c. The blue giant has a mass of 30 M⊙ and a luminosity of 30,000L⊙

Time on the main sequence:

2. Astronomers are not sure exactly how long it takes a star to form. They understand massive stars form more quickly than low-mass stars. A Sun-like star spends about 0.2% of its main sequence lifetime as a protostar. Calculate the length of the protostar phase for each of the stars assuming they too also spend about 0.2% of their main sequence lives as protostars.

    a. Protostar time for red dwarf

    b. Protostar time for Sun-like star

c. Protostar time for blue giant

3. Stars spend roughly 10% the length of their main sequence life as giants—that is, *if* they go through a giant phase at all which red dwarfs do not. Approximately how long will the Sun-like star and the blue giant spend as red giants?

    a. Red giant time for a Sun-like star

    b. Red-giant time for a blue giant star

4. Stellar remnant clouds like supernova remnants and planetary nebulae last several thousand years before integrating back into the interstellar medium. The Sun's planetary nebula is predicted to last 10,000 years. What percentage of the Sun's main sequence life is this?

5. White dwarfs and neutron stars will continue to exist without an end in sight, though after several billion years they cool and slow, making them harder to detect with current methods. Essentially, this is the longest stage of a star's life, even though the star is no longer a star. Why is the star no longer considered a star at this stage?

Extend:

- Browse Hubble Space Telescope images of planetary nebulae and super nova remnants. Based on your observations of these two groups, what are some good ways to tell them apart?

- Why are planetary nebulae given such a name when they have nothing to do with planets?