Life Cycle of Stars | Instructor Guide

Students explore objects representing various stages of the stellar life cycle and uncover how these stages fit together into two related sequences: one for Sun-like stars (similar in mass to our Sun) and one for massive stars (more than 8–10 times the mass of our Sun).

Overview

In this interactive about the life cycle of stars, students will

- Come to understand the cyclic process of star formation. Stars fuse new elements and return the enriched gas to space. New stars eventually form from this enriched gas and repeat the process.
- Approach this topic as astronomers do, by exploring each individual stage as we see them in the night sky.
- Model how the stellar life cycle, through nucleosynthesis, is responsible for the production and dispersal of the elements that we find in our bodies, on Earth, and in the Universe, embodied by the phrase, “You are star stuff.”

Grade Level: 9-12

Prerequisites:

- Students should know that gravity relates to mass (where more mass means stronger gravity).
- Students should know that nuclear fusion is the process of fusing atomic nuclei to form new elements, which releases energy.
- Students should be familiar with the periodic table of elements, and the meaning of atomic numbers.
- It is helpful (but not necessary) for students to know what isotopes are.

Suggested Time: One or two 50-minute class periods

Multimedia Resources

- Life Cycle of Stars WorldWide Telescope Interactive Materials

Sequence A, 1 day (Focus on the transitions between different stellar life stages):

- Activity sheets

    - Life Cycle of Stars: Schematic
    - Life Cycle of Stars: Stages & Transitions

Sequence B, 1 day (Focus on the formation of different elements through nucleosynthesis):

- Activity sheets
    - Life Cycle of Stars: Schematic
    - Life Cycle of Stars: Element Formation
    - Life Cycle of Stars: Atomic History

Sequence C, 2-day (Covers both topics):

- Activity sheets
    - Life Cycle of Stars: Schematic
    - Life Cycle of Stars: Stages & Transitions
    - Life Cycle of Stars: Element Formation
    - Life Cycle of Stars: Atomic History

Lesson Plan

The following represents one manner in which the materials could be organized into a lesson.

Learning Objectives:

1. SWBAT model how a star's initial mass relates to: what elements it will be able to fuse, how the star evolves, and how the star will die (Sequence A).
2. SWBAT communicate how stars synthesize common elements through nuclear fusion (Sequence B).

Activity Outline:

1. **Engage** - suggested activities:

    For Sequence B and C:

    a. Open the lesson with a class discussion centered around the concept, "We are all star stuff." Gather students' initial ideas about what this means, and what could be responsible for this reality. In this discussion, emphasize that 75% of the matter produced during the Big Bang was Hydrogen, and 25% of the matter was Helium (and a tiny proportion of the matter was Lithium). Students will need this information to trace where elements in their body came from.

    For Sequence A, B, **and** C:

    b. Stars live for millions or billions of years, going through many different life stages. The amount of time humans have observed stars for amounts to only a tiny snapshot of their lifetimes. Yet, we know how young stars form, how they evolve into stars like our Sun, and eventually die. How can we know so much just from looking at stars for one snapshot in time? What are your ideas?

You can make an analogy to aliens observing humans on Earth. At any one snapshot in time, the alien might see a baby, a toddler, a child, an adult, and a elderly person. Those individuals clearly do not represent different instances of the same human, but the alien could surmise that there is a trajectory in a human life cycle that a baby will move through to someday become an elderly person, perhaps giving birth to a new baby along the way. In a similar way, astronomers observe stars at different life stages, essentially in one moment of time, to understand the overall life cycle of stars.

There are 2 main pathways that stars evolve through, depending on their starting mass. You will explore both of those paths in this activity.

2. Investigate

For Sequence A, B, **and** C:

a. Break students into pairs on computers to work with the web-based *Life Cycle of Stars* interactive. Hand out a set of worksheets to each student.
b. The interactive shows 8 objects that represent different life stages of stars. Students should first complete the ***Schematic*** worksheet to help orient them in how those 8 stages fit together into two star life cycles (one for Sun-like stars and one for massive stars).

For Sequence A **and** C:

c. Next, students should complete the ***Stages and Transitions*** worksheet to build an explanation in their own words as to how gravity and fusion enable each of the transitions from one stage to another. (Note: a lot of the entries are pre-filled, to model for students what we are looking for). They should consult the web-based *Life Cycle of Stars* interactive as they work.

For Sequence B **and** C**:**

d. Students should complete the ***Elemental Formation*** worksheet, focusing on individual elements and the different stellar life stages that can produce them. They should consult the web-based *Life Cycle of Stars* interactive as they work. They will use information from the ***Element Formation*** worksheet to complete the ***Atomic History*** later.

3. Reflect

For Sequence A **and** C:

a. After students have had enough time to explore every stage and fill out most of the worksheets, bring the class back together for a concluding discussion. What

roles do nuclear fusion and gravity play in moving a Sun-like star through its different life stages?

What is happening at a particular life stage of a star depends on how gravity and fusion are balanced. When a new star is just forming,there is no fusion yet. Gravity works to assemble the gas and dust into a distinct object.
Gravity increases the temperature and density in the core, allowing fusion to start. The outward fusion energy balances against the inward pull of gravity.
When fuel runs out and fusion stops, gravity takes over again.

What role do fusion and gravity play in a massive star? How is the life cycle of a massive star different than that of a Sun-like star?
In a massive star, fusion can continue longer than in a Sun-like star because is has stronger gravity and can keep compressing the star to fuse heavier and heavier elements.

For Sequence B **and** C:

b. After students have had enough time to explore every stage and fill out most of the worksheets, bring the class back together for a concluding discussion. Return to some of the hanging questions from the discussion of the concept “We are all star stuff.” You can present a graphic representing the elemental composition of the human body to ask the class to explain how one or two of these elements might have ended up inside a human body 13.8 billion years after the Big Bang. Start with Hydrogen. First ask how it formed, then make sure to address how it made its way into the material of Earth. Then, time permitting, begin discussing another element, whichever the class likes.

c. Assign the ***Atomic History*** worksheet as homework. This should feed directly from the wrap-up conversation from the lesson.

Standards

NUCLEOSYNTHESIS
HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements. [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]

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