WorldWide Telescope

Life Cycle of a Star

Next Generation Science Standards Supported

- Scientific Practices:
  - Developing and Using Models
- Crosscutting Concepts:
  - Patterns
  - Energy and matter: Flows, cycles, and conservation
  - Stability and change
- Disciplinary Core Ideas:
  - Earth and Space Science ESS1.A: The universe and its stars
    - Stars produce elements heavier than hydrogen and helium
    - Stars go through a sequence of developmental stages
    - Material from earlier stars is recycled to form younger stars and their planetary systems.
    - The sun is a medium-sized star halfway through its 10 billion year life span

Lesson Objectives

Students will:

- View astronomical imagery to learn about different stages of a star's life cycle
- Recognize that stars follow a similar pattern of evolution that is predictable
- Be part of a kinesthetic model that helps them understand how the balance between gravity and light (radiation pressure) determines what's happening in the star; transitions between different life stages occur when this balance is disturbed.
- Learn that stars die in different ways, depending on how big they were when they formed
- Appreciate that their own bodies and all the things around them were made inside stars!

Materials Needed

- PC computer running Windows, with WorldWide Telescope installed
- A classroom projector

Preparation

Review the paper "Kinesthetic Life Cycle of Stars" from *Astronomy Education Review* by Erika Reinfeld and Mark Hartman. The table on pages 4-5 of that paper describes the kinesthetic model activity followed in this lesson.

See the "How to Use WorldWide Telescope" course on BetterLesson.com for more information on using the program.

How to use the Tour

- This activity takes about 45 minutes to complete.
- Make sure you have the latest version of WWT installed
- This tour was designed to be run on the instructor's computer, connected to a projector for students to view in class.
- The kinesthetic activity works best with groups of about 12-15 students, so most classes can be divided into two groups: one that acts out the life cycle of a star like our sun; and one that acts out the life cycle of a very large star.
    - Caution: During kinesthetic activity, try to avoid the word "push." (That encourages roughhousing!) Use neutral words like "touch your palms together".
- Press right arrow to advance between slides
    - The tour is broken roughly into 12 "sections," each ending with a slide that lasts for a very long time to allow for discussion and/or activity. At the end of each section, press the right arrow key to advance to the next section whenever your discussion concludes.
    - The Kinesthetic Activity for each section should take place before advancing to the next slide and beginning of the corresponding section. This tour is designed so that the students first act out a specific stellar life phase and then see it illustrated in the corresponding section of the WWT tour.

Introductory Slides/Sections

Section	Kinesthetic Activity	Discussion
1	None	*Out of order humans* If an alien were to observe different creatures on Earth as pictured here, do you think they could figure out some pattern about what they see?
2	None	*Humans in order* Likely, if they watched earthlings for long enough, the aliens could figure out that there's a pattern to how people evolve as they age
3	None	*Out of order stellar life cycle* Now, this is a series of images that have been observed by astronomers with telescopes at multiple wavelengths. In the same way that the alien could piece together the earthling life cycle, astronomers have been able to do the same for stars. Are there any things here in these images that you recognize? (See image at the end of this document for the names of each object.)

4	None	*Stellar life cycle in order* Discuss appropriate order.

Beginning Stages of Stellar Life Cycle

5	(Group 1: A Star Like Our Sun) Students in Group 1 are scattered around the room as a star forming nebula	*Zooming in on and viewing Orion Nebula*
6	*Protostar* Students slowly move towards largest group of "gas particles" (largest grouping of students= most gravity) and then organize into a protostar.	*Protostar* *****This image was NOT taken with a telescope. It is an artist's conception.
7	*Main Sequence* Core (inside grouping) students face outward; they'll be surrounded by an "envelope" of students facing inward. Core students should put palms together gently to show that the star is "balanced." Gravity is pushing inward by the same amount that the light is pushing outward.	*Zooming in on and viewing the sun* The sun's energy comes from "nuclear fusion" in the core of the star, where hydrogen atoms are smashed together to make helium, releasing massive amounts of energy. This energy "pushes" outward against the outer envelope, balancing gravity. Stars that are burning H->He in their core are main sequence stars.
8	None/Pause	*Overhead view of solar system* Our Sun is a main sequence star that has lived for 5 billion years and will keep doing what it's doing for 5 billion more years.

9	*Red Giant* Core runs out of Hydrogen to burn; gravity pushes harder against core and compresses the gas more than before. This ignites a new round a nuclear fusion in a shell around the core, which causes the star to expand. Here, core students extend their arms (gently!) and the envelope students have to back up (hands still touching) to show expansion of star to red giant phase	***After* Red Giant Kinesthetic Activity (*before* advancing tour), ask students: When this happens to our Sun, and it becomes a red giant, how far out do you think it will reach? Mercury's orbit, Venus', somewhere beyond? Let students vote, then advance to next slide. *Red Giant expansion* The sun will expand just past Earth's orbit, swallowing up the three inner planets – Mercury, Venus, and Earth. Never fear; this won't happen for 5 billion more years! **Now, select either "Medium Star" or "Large Star" to see the end of the life cycle for either medium stars or large stars.

Death of a Medium Star

Death of a Large Star

10a	Medium Star Path: Core students give one last gentle push to the envelope students; envelope students drift away slowly, but stay roughly in a circle. Core students crunch together to make a white dwarf.	*Planetary Nebula/White Dwarf* The envelope gas is lit up all around the nebula. The small white dot in the middle is the white dwarf core, which is really dense. Most of the mass of the star is packed into a ball about the size of the Earth. Ask: How much do you think a grape-sized blob of white dwarf material would weigh? Take some guesses. Answer: As much as a car! *Begin the cycle for Large Stars by clicking the "Back to Beginning of Stellar Life Cycle" link.	10b	Large Star Path: Core students scrunch up as tightly as they can. Envelope students fall in toward core then bounce off core and back out into space far away.	*Supernova remnant/Neutron star or Black hole* Big stars live much shorter lifespans than medium stars and die a more violent death. The very biggest stars become black holes at the core; stars that are big (but not the biggest) become neutron stars, which have the density of atomic nuclei. Possible discussion around black holes: they are NOT cosmic vacuum cleaners that suck in everything in their vicinity. If you stay safely outside the "event horizon" (and if you're moving close to

		Have the second group of students perform the kinesthetic activity this time, following all the same directions as last time except for at the very end. Point out that large stars live for, at most, 100 million years			the speed of light), you won't fall in!

Concluding Slides/Sections

11	None	*Gas* What happens to the gas released by the stars?
12	Non	*Recycled Star Dust* It gets recycled into new star systems and you. You are stardust.