National Aeronautics and Space Administration

The Butterfly Nebula (NGC 6302)

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A butterfly emerges from a dying star

Ordinary stars like our Sun live undistinguished lives. They steadily churn out heat and light for billions of years. Oddly enough, their lives become more exciting when they run out of hydrogen fuel and reach retirement age. This is when these stars begin to stand out. As the fuel is exhausted, they first expand to enormous sizes, becoming what are called "red giants." Then they shed their outer layers into space, producing the beautiful shapes of planetary nebulae. Finally, the remnant star at the center settles down into an object about the size of the Earth, called a "white dwarf."

The Butterfly Nebula, catalogued as NGC 6302, was ejected from a dying star that was once about five times the mass of the Sun. After about 100 million years, it exhausted its nuclear fuel, and has recently ejected its outer layers. Now the remnant star at the center is unleashing a stream of ultraviolet radiation that is making the ejected material glow. This object is an example of a planetary nebula, so-named because many of them have a round appearance resembling that of a planet when viewed through a small telescope.

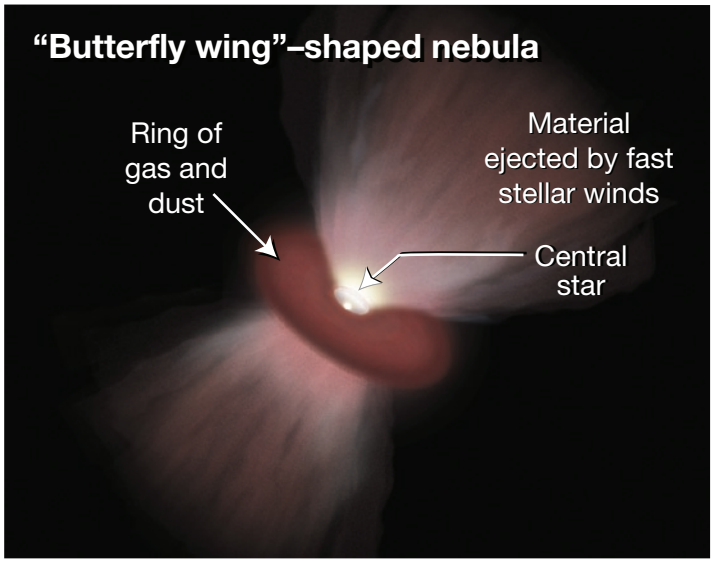
NGC 6302 lies within our Milky Way galaxy, roughly 3,800 light-years away in the constellation Scorpius. The glowing gas is the star's outer layers, expelled about 2,200 years ago. The central star itself cannot be seen, because it is hidden within a doughnut-shaped ring of dust, which appears as a dark band pinching the nebula in the center.

The thick dust belt constricts the star's outflow, creating the classic hourglass or butterfly shape displayed by some planetary nebulae. The "wings" of this cosmic butterfly are rough and lumpy, unlike the smooth, thin wings of butterflies seen on Earth. For example, numerous finger-like projections pointing back to the star are visible in both wings. These features may mark denser blobs in the star's outflow that have resisted the pressure from the stellar wind.

The "butterfly" stretches for more than two light-years, which is about half the distance from the Sun to the nearest star, Alpha Centauri.

The Wide Field Camera 3 (WFC3), a new camera aboard NASA's Hubble Space Telescope, snapped this image of the planetary nebula. WFC3 was installed by NASA astronauts in May 2009, during the servicing mission to upgrade and repair the 19-year-old Hubble telescope.

Credit for Hubble image:NASA, ESA, and the Hubble SM4 ERO Team.



This illustration reveals a complex history of ejections from a dying star. The star first evolved into a huge red giant, with a diameter of about 1,000 times that of our Sun. It then lost its extended outer layers. Some of this gas was cast off from its equator at a relatively slow speed, perhaps as low as 20,000 miles an hour, creating a doughnut-shaped ring, shown in the illustration. Other gas was ejected perpendicular to the ring at higher speeds, producing the elongated "wings" of the butterfly-shaped structure. Later, as the central star heated up, a much faster stellar wind, traveling at more than 2 million miles an hour, plowed through the existing wing-shaped structure, further modifying its shape.

VOCABULARY

Light-year: The distance that light travels in a year (about 6 trillion miles or 10 trillion kilometers).

Planetary nebula: A well-defined shell of gaseous material ejected by a dying, Sun-like star. Radiation emitted by the dying star makes the material glow.

Stellar wind: Streams of charged particles flowing from the star at millions of kilometers per hour.

You can get images and other information about the Hubble Space Telescope on the World Wide Web. Visit our website, **http://www.stsci.edu/outreach/**, and follow the links.

You can find the corresponding Classroom Activity for this lithograph at **http://amazing-space.stsci.edu/** or by contacting the Office of Public Outreach at the Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218.

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Goddard Space Flight Center
8800 Greenbelt Road
Greenbelt, Maryland 20771

www.nasa.gov

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In Search of … Stellar Death

Description

Use "The Butterfly Nebula (NGC 6302)" lithograph as the initial source of information to engage your students in a Level One Inquiry activity. Students will use the images and text on this lithograph to generate questions about how Sun-like stars end their lives as planetary nebulae. They will conduct research to answer their questions. This curriculum support tool is designed to be used as an introductory activity in a unit that incorporates scientific inquiry or that has a stellar evolution theme.

About Inquiry-based Learning

The inquiry process is driven by a student's own curiosity, wonder, interest, or passion to understand an observation or to solve a problem. It involves a process of exploring the natural or material world. This exploration prompts students to ask questions and to make discoveries in the search for new insights. A Level One Inquiry activity uses questions and problem-solving methods directed by the teacher. In this activity, teachers will use the lithograph images to help students formulate questions about how Sun-like stars end their lives as planetary nebulae. Teachers will suggest selected resources about stellar death to help students answer their questions. Students will provide supporting evidence for their conclusions. This process can help prepare students to become more independent thinkers. Note: The preparation section below provides resources for inquiry-based learning.

Grade Level

High school, grades 11–12.

Prerequisites

Students should be aware that a star is a gaseous, self-luminous object held together by its own gravity. The core of a star is extremely hot and releases energy by fusing lighter atomic nuclei into heavier nuclei. Our Sun, the center of our solar system, is a yellow star of average temperature and size.

Misconceptions

Teachers should be aware of the following common misconceptions and determine whether their students harbor any of them. Students may have misconceptions about stars. They may think that all stars are the same, that stars live forever, or that all stars end their lives in the same way.

Vocabulary

These are terms students may encounter while doing further research on star death.

Fusion: A nuclear process that releases energy when light atomic nuclei combine to form heavier nuclei. Fusion is the energy source for stars like our Sun.

Supernova(e): The explosive death of a massive star whose energy output causes its expanding gases to glow extraordinarily bright for weeks or months.

See the lithograph for additional vocabulary terms.

Purpose

The purpose of this activity is to engage students in a Level One Inquiry activity with astronomical images and information. Students will gain experience using the Internet to search for information. They will practice the process skills of observing and analyzing. Students will also organize their material, present their findings, and reflect on what they have learned.

Materials

- "The Butterfly Nebula (NGC 6302)" lithograph.
- Computer with Internet connection for conducting research.

Instructions for the Teacher

Preparation

Obtain copies of the lithograph for each student. "The Butterfly Nebula (NGC 6302)" lithograph can be found at http://amazing-space.stsci.edu/capture/stars/preview-butterfly-nebula.php.

Preview the Overview page, found at: http://amazing-space.stsci.edu/eds/overviews/print/lithos/butterfly-nebula.php. Use the "Related Materials" section to (1) become familiar with inquiry-based learning and/or (2) become familiar with stellar death.

Bookmark or identify as favorites the following suggested Websites:

STScI: "The Glorious End of Stellar Life": http://hubblesite.org/newscenter/archive/releases/1997/38/background/

STScI: "Planetary Nebula Gallery": http://oposite.stsci.edu/pubinfo/pr/97/pn/photo-gallery.html

In Search of … Stellar Death

STScI: "The Colorful Demise of a Sun-like Star": http://hubblesite.org/newscenter/archive/releases/nebula/planetary/2007/09/

Procedure

Before beginning this activity, identify your students' misconceptions about stars by having them write down anything they know and understand about this topic. Use those statements to evaluate your students' misconceptions. Have students volunteer their ideas about stars. From those ideas, identify their misconceptions and discuss them with the class. An alternative method is to collect your students' written ideas about stars. From those ideas, compile a list of their misconceptions and discuss them with the class.

Ask students to study the image on the front and the illustration on the back of the lithograph. Then tell your students to write as many questions as they can about the features visible in the images. Collect the questions and group them by common themes. Ask students to read the information on the back of the lithograph. Then ask them if they found the answers to any of their questions. Tell students to use the Internet to research their questions. The Internet sites listed on the preview page provide a starting point for their research. Tell students how to access other Websites.

Ask students to prepare presentations that include answers to their questions. Their presentations should also address how Sun-like stars end their lives as planetary nebulae. This presentation can be in the form of a skit, a story, a graphic organizer, a PowerPoint show, or a written report — any method that conveys a student's understanding of the topic to another student, to a group of students, or to the entire class. Students may work individually or in groups. Ask students to check whether their original questions were answered during their research or from talking with other students. Then ask students if they have any additional questions.

Instructions for the Student

Your teacher will ask you to write down what you know and understand about stars. You may be asked to share this information with the rest of the class. Study the image of the Butterfly Nebula on the front of the lithograph, and then look at the illustration of the Butterfly on the back. Write down as many questions as you can about what you see in the image and the illustration. Read the back of the lithograph to find answers to your questions.

Using your questions as a guide, conduct research on the Internet to find the answers to your questions. Your teacher will provide Websites to use for your research. Your teacher will also ask you to create a presentation to demonstrate your understanding of the material you collected through your research. The presentation could be a skit, a story, a graphic organizer, a PowerPoint show, or whatever format that will communicate the information you learned about planetary nebulae. Your teacher will direct you to work individually or in small groups. You may make your presentation to another classmate, to another group of students, or to the entire class.

Education Standards

National Science Education Standards

http://books.nap.edu/html/nses/

Science as Inquiry

Content Standard A: As a result of activities in grades 9–12, all students should develop understandings about scientific inquiry:

Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists.

Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge.

Project 2061

http://www.project2061.org/publications/bsl/online/bolintro.htm

1. The Nature of Science

B. Scientific Inquiry

By the end of the 12th grade, students should know that:

• Sometimes, scientists can control conditions in order to obtain evidence. When that is not possible for practical or ethical reasons, they try to observe as wide a range of natural occurrences as possible to be able to discern patterns.

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Educational Product

Educators & Students | Grades 11–12