



Planetary Nebula NGC 2440

NGC 2440: The Exciting End to an Ordinary Star's Life

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. First, the stars expand in size and become red giants. Then they shed their outer layers and become unique and colorful works of art called planetary nebulae.

NGC 2440 is a planetary nebula. In this image, taken by the Hubble Space Telescope, the white star near the center of the nebula is ending its life by shedding its outer layers of gas. The nebula is 5,000 to 7,000 light-years away in the constellation Puppis.

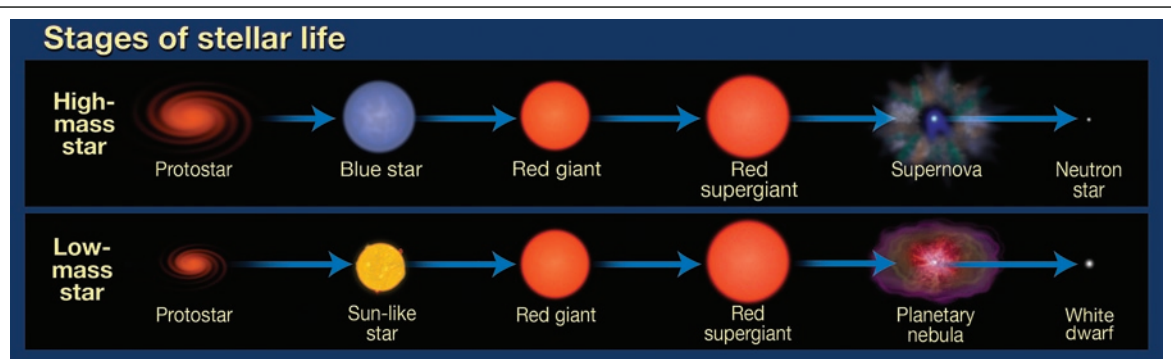
Ultraviolet light from the dying star makes the castoff material glow. The burned-out star is called a white dwarf. Our Sun will eventually run out of fuel and shroud itself with stellar debris, but not for another 5 billion years.

Our Milky Way Galaxy has about 1,500 of these stellar relics. The glowing objects have nothing to do with planets. Eighteenth- and nineteenth-century astronomers named them planetary nebulae because through small telescopes they resembled the disks of the distant planets in our solar system. The dying star at the center of NGC 2440 is one of the hottest known white dwarfs, with a surface temperature of nearly 400,000 degrees Fahrenheit (200,000 degrees Celsius).

NGC 2440's chaotic structure suggests that the aging star shed its mass several times. Each time, the star expelled material in a different direction, which produced the nebula's bow-tie-shaped lobes.

The nebula's colors correspond to material expelled by the star. Blue corresponds to helium; blue-green to oxygen; and red to nitrogen and hydrogen.

While ordinary stars like NGC 2440 end their lives by puffing off their outer layers of gas, a different fate awaits stars more than eight times the Sun's mass. Their lives end in titanic supernova explosions. The end begins when a massive star exhausts its nuclear fuel. The star's compressed outer layers squeeze a dense iron core that cannot sustain nuclear fusion, the process that makes stars



The Life and Death of Stars. This illustration shows some of the stages of life for high- and low-mass stars. High-mass stars here are at least eight times more massive than our Sun. They live their lives in the fast lane as blue supergiants, consuming their hydrogen fuel in just a few million years. When this happens, their outer layers expand, and they become red giants. These stars lose substantial amounts of mass in stellar winds. Eventually, they

explode as supernovae. Many of these stellar blasts create neutron stars.

Low-mass stars like our Sun live much longer and quieter lives. They shine for billions of years until they exhaust their hydrogen fuel. Then they, too, become red giants as their outer layers expand. These layers are shed into space and shaped by winds from the core to become planetary nebulae. The stars' burned-out cores are called white dwarfs.

shine. The core collapses to extremely high densities, and the shock wave that results blasts away the remaining outer material in a gigantic supernova explosion. Its brilliance briefly outshines a galaxy's collection of 100 billion Sun-like stars.

Planetary nebulae and supernova explosions play a crucial role in the "ecology" of our galaxy. They recycle heavier elements into space. These elements, such as carbon, oxygen, and nitrogen, were created inside the star.

The blast waves created by supernova explosions can also compress neighboring gas clouds. These compressed clouds then collapse, triggering a second generation of stars. This same process may have initiated our Sun's birth 4.6 billion years ago.

VOCABULARY

Red giant: When a star nears the end of its life, its outer layers expand in size and become cooler, forming a

bright star much larger and cooler than the Sun.

White dwarf: The hot, compact remains of a low-mass star like our Sun that has exhausted its sources of fuel for thermonuclear fusion. White dwarf stars are generally about the size of Earth.

Credits: NASA, ESA, and K. Noll (STScI).

Acknowledgment: The Hubble Heritage Team (STScI/AURA)

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

The corresponding classroom activity for this lithograph can be found at: <http://amazing-space.stsci.edu/>, or may be obtained by contacting the Office of Public Outreach at the Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218.

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In Search of ... Stellar Death

Description

Use the “Planetary Nebula NGC 2440” lithograph as the initial source of information to engage your students in a Level One Inquiry activity. Students will use the images and text to generate questions about the end of a star’s life. They will conduct research to answer their questions and compare and contrast the last stages of life for stars of various masses.

About Inquiry-based Learning:

The inquiry process is driven by the student’s own curiosity, wonder, interest, or passion to understand an observation or solve a problem. It involves a process of exploring the natural or material world. This exploration prompts students to ask questions and make discoveries in the search for new insights. A Level One Inquiry activity uses questions and problem-solving methods directed by the teacher. In the NGC 2440 lithograph activity, teachers use the images to help students ask questions about the end of a star’s life. Teachers suggest selected resources about star death to help students answer their questions. Students then determine the answers to their questions and provide supporting evidence for them. This process can help prepare students to be more independent thinkers. Note: The preparation section below can direct you to resources for inquiry-based learning.

Grade Level

High school: grades 11–12

Prerequisites

Students should be aware that stars change over time and vary in brightness, color, mass, temperature, and age.

Misconceptions

Teachers should be aware of the following common misconceptions and determine whether their students harbor any of them. Students may have misconceptions concerning 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.

Purpose

The purpose of this activity is to use the images and text on the lithograph to generate questions about stellar death. Students will use the Internet to search for the answers to their questions. They also will identify the factor(s) that determine the fate of stars. Students then will organize their material and present a report outlining the similarities and differences in the last stages of the lives of stars of various masses. Students will be asked if they answered their original questions and/or if, during their research, they came up with any new questions.

Materials

- “Planetary Nebula NGC 2440” lithograph
- Computer with Internet connection for researching the fate of stars.

Instructions for the Teacher

Preparation

- Obtain a lithograph for each student. The lithograph is available as a PDF file at: <http://amazing-space.stsci.edu/capture/stars/preview-ngc2440.php>.
- Preview the Overview page found at: <http://amazing-space.stsci.edu/eds/overviews/print/lithos/ngc2440.php>. Use the “Related Resources” to (1) become familiar with inquiry-based learning and/or (2) familiarize yourself with NGC 2440 and stellar death.
- Note that a similar list of “Related Websites” can be found on the preview page for the lithograph: <http://amazing-space.stsci.edu/capture/stars/preview-ngc2440.php>. Identify those that are appropriate for your students to use.

Procedure

Before beginning this activity, evaluate your students’ misconceptions about stars by having them write down anything they know and understand about this topic. You can use these 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. Or, collect their written ideas

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about stars. From those ideas, compile a list of their misconceptions and discuss them with the class.

Ask students to look at the image of NGC 2440 on the front of the lithograph and write three questions about features visible in the image.

Collect these questions and group them by common themes. Ask students to read the information on the back of the lithograph. Then ask students if they found the answers to any of their questions. Using the Internet, have students 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 a report in which they outline the similarities and differences in the last stages of the lives of stars of various masses. This report could be in the form of a slide show, a skit, a story, a graphic organizer, a Power Point presentation, or a written report—anything that conveys a student's understanding of the topic to another student, a group of students, or the entire class. Ask students to review their original questions to see if they were answered. Then ask them if they have any additional questions.

Instructions for the Student

Your teacher will ask you to write down things you know and understand about stars. You may be asked to share this information with the rest of the class. Study the image of NGC 2440, and write down three questions about what you see in the image. Then read the back of the lithograph, and check if any of your questions were answered.

Using your questions as a guide, conduct Internet research on NGC 2440 to find the processes of stellar death and the factor(s) responsible for determining the fate of stars. Your teacher will guide your search by providing some Websites to use. To demonstrate your understanding of the material you researched, your teacher will ask you to present a report in which you outline the similarities and differences in the last stages of the lives of stars of various masses. This

report could be in the form of a slide show, a skit, a story, a graphic organizer, a Power Point presentation, or whatever presentation you think will communicate the information you learned about the fate of stars. You can work individually or in small groups. You can make your presentations to another classmate, another group of students, or 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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