Cat's Eye Nebula (NGC 6543)

National Aeronautics and Space Administration
Goddard Space Flight Center

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A Sun-like Star's Last Hurrah

This image reveals new details of the Cat's Eye Nebula (catalogued as NGC 6543), one of the most complex planetary nebulae ever seen. A planetary nebula is the glowing gas ejected during the final stages of evolution of a star similar in mass to our Sun.

Planetary nebulae are like snowflakes: no two look alike. When a Sun-like star nears the end of its life, it expands in size to become a bloated red giant, with a diameter about 100 times greater than its original size. The star then ejects its outer layers into space, exposing its hot core. Ultraviolet radiation from the central core streams out into the surrounding ejected gas, causing it to glow. The glowing gas is called a planetary nebula, so-named because its round shape resembles that of a planet when viewed with a small telescope. Over the next several thousand years, the nebula will gradually disperse into space, and then the star will cool and fade away for billions of years as a white dwarf. Our Sun is expected to undergo a similar fate, but not for another 5 billion years. Astronomers still do not fully understand many details of the process that lead a star to lose its gaseous envelope. The study of planetary nebulae is one of the few ways to recover information about these last few thousand years in the life of a Sun-like star.

The expelled gas from the dying, central star has intriguing symmetrical patterns as well as more chaotic structures. Scientists are trying to understand how a spherical star can produce such prominent, non-spherical symmetries in the gas that it ejects.

Astronomers have considered several mechanisms to explain the shapes of planetary nebulae. One possible explanation is that the star's magnetic field affects the shape. Another is that a companion star exerts a strong gravitational force on the ejected gas and sculpts it into the patterns we see. Trying to explain these complex patterns is difficult because we view planetary nebulae from Earth and cannot move around them to see their three-dimensional structure.

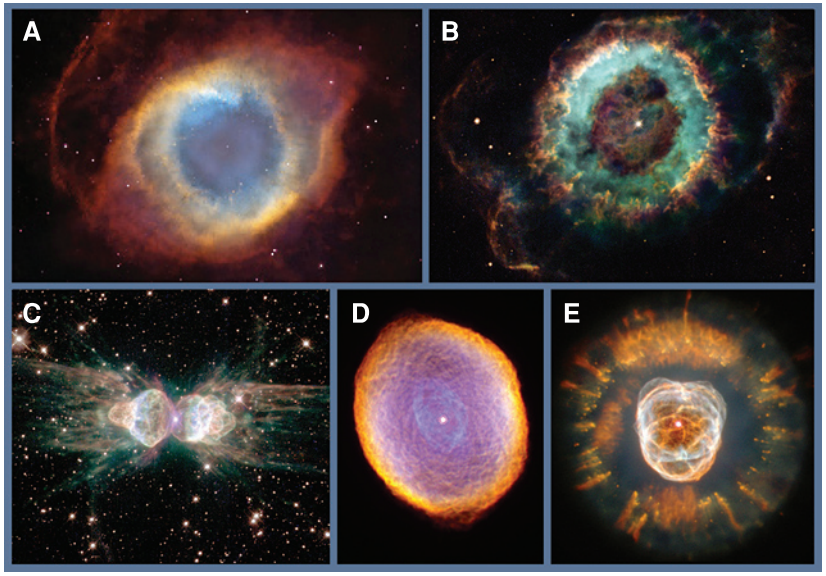
The Hubble telescope has made several observations of the Cat's Eye. This image, taken with Hubble's Advanced Camera for Surveys, reveals the full beauty of a bull's eye pattern of 11 or more concentric rings, or shells, around the dying star. Each ring is actually the edge of a spherical bubble seen projected onto the sky — that is why the nebula appears bright along its outer edge. These rings suggest that the initial ejection of gas from the star was episodic, recurring about every 1,500 years. Observations with the Hubble telescope were the first to reveal these puzzling concentric rings, which have now been seen around a number of planetary nebulae.

Hubble's images of the Cat's Eye and other planetary nebulae are revealing many new mysteries of these glowing patterns of gas spun into space by dying stars.

VOCABULARY

Red giant: When a Sun-like 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.



A Nebula Gallery. Above is a sampling of nebulae imaged by the Hubble Space Telescope: The Helix Nebula (*A*), Little Ghost Nebula (*B*), Ant Nebula (*C*), Spirograph Nebula (*D*), and Eskimo Nebula (*E*).

Credits: Helix Nebula: NASA, ESA, C.R. O'Dell (Vanderbilt University), and M. Meixner, P. McCullough (STScI); Little Ghost, Ant, and Spirograph Nebulae: NASA and The Hubble Heritage Team (STScI/AURA); Eskimo Nebula: NASA, A. Fruchter, and the ERO Team (STScI).

FAST FACTS

Location: Constellation Draco.
Distance from Earth: 3,000 light-years.

Credits: R. Corradi (Isaac Newton Group of Telescopes, Spain), Z. Tsvetanov (NASA).

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 … the Complex Structures of Planetary Nebulae

Description

Using the "Cat's Eye Nebula (NGC 6543)" lithograph, engage your students in a Level One Inquiry activity to compare the complex structures of planetary nebulae. A Level One Inquiry activity can help prepare students to be more independent thinkers. Students conduct research to answer questions they have about planetary nebulae.

Grade Level

High school, grades 9–12

Prerequisites

Students should know that stars vary in brightness, color, age, temperature, and mass, and that mass determines a star's fate. Students should also be aware that normal stars, like the Sun, fuse hydrogen in their cores. The depletion of this fuel source initiates the final stages in the life of a star, resulting, for Sun-like stars, in a planetary nebula.

Misconceptions

Teachers should be aware of the following common misconceptions and determine whether their students harbor any of them. Students may have misconceptions regarding the evolution and fate of stars. The name planetary nebula in itself is misleading. Students may think that planetary nebulae are associated with planets, when, in fact, they have nothing to do with them. The name originates from William Herschel, who thought their "fuzzy" shapes resembled the disks of the outer planets as seen through small telescopes. The name remains despite the fact that it represents a late stage in the lives of low-mass, Sun-like stars.

Students may think all stars end their lives in the same way — as supernovae. Whether a star becomes a planetary nebula or a supernova depends on its original mass. The Sun and other less massive stars will form planetary nebulae.

Students may think that stars don't change. The fact is that stars evolve over billions of years. Most stellar changes, such as the birth of a star, occur over many human lifetimes.

Purpose

The purpose of this activity is to apply a Level One Inquiry technique, using images and text to compare the complex structures of planetary nebulae. In this activity, the components of inquiry learning that students can practice are: asking questions, planning and conducting investigations, using critical-thinking skills, making comparisons, and communicating results. Students will make comparisons, develop questions, and read for a purpose.

Materials

- "Cat's Eye Nebula (NGC 6543)" lithograph.
- Computer with Internet connection for researching answers.

Instructions for the Teacher

Preparation

- Obtain a lithograph for each student. Lithographs are available as PDF files at http://amazing-space.stsci.edu/eds/tools/type/pictures.php.
- Familiarize yourself with the evolution of Sun-like stars using a current astronomy textbook or the AstroFile: "The Glorious End of Stellar Life": http://hubblesite.org/newscenter/archive/1997/38/astrofile.
- Bookmark or identify as favorites the following suggested Web sites and/or prepare a list of Web sites that students can access to obtain additional information about planetary nebulae.

Space Telescope Science Institute (STScI): Stellar Evolution Press Releases and Images: http://hubblesite.org/newscenter/newsdesk/archive/releases/category/nebula/planetary/.

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

STScI — "Dying Star Creates Fantasy-like Sculpture of Gas and Dust": http://hubblesite.org/newscenter/newsdesk/archive/releases/2004/27/.

STScI — "Planetary Nebulae: A Cosmic Funeral": http://hubblesite.org/discoveries/tour_the_cosmos/july_98/nebula/index.shtml.

Procedure

Before beginning this activity, evaluate your students' misconceptions about planetary nebulae by having them write down anything they know and understand about the end of a Sun-like star's life. Have students tell what they know about planetary nebulae. From those ideas, identify their misconceptions and discuss them with the class. Or, collect the papers containing their ideas about planetary nebulae. From those ideas, compile a list of their misconceptions and discuss them with the class.

Ask students to look at the images of the Cat's Eye Nebula on the front and the other planetary nebulae on the back. After they have studied the photos, have them write down three questions they want answered about planetary nebulae. Compile a list of questions, and group students by common theme. Ask students to read the information on the back of the lithograph, and check if any of their questions have been answered. Allow students to refine their questions by discussing them with their group. Ask students to use the Internet to research their questions. The Internet sites listed previously can provide a starting point for their research. Instruct students on how to access other Web sites that may be appropriate.

Ask students to prepare a report in which they compare planetary nebulae morphology. 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 their 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 planetary nebulae. You may be asked to share this information with the rest of the class. Study the images of the planetary nebulae, and write down three questions about what you see in those pictures. Then read the back of the lithograph and check if any of your questions were answered.

Your teacher will assign you to a group to research the answers to your questions. You can search for your answers on Internet sites that your teacher will provide to you. To demonstrate your understanding, your teacher will ask you to give a report that compares the similarities and differences between planetary nebulae structures. This report could be 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 planetary nebulae. You may be allowed to work individually or in small groups, and make your presentations to another classmate, another group of students, or the entire class.

Education Standards

Benchmarks for Science Literacy

American Association for the Advancement of Science:
http://www.project2061.org/tools/benchol/bolframe.htm

1. The Nature of Science

A. The Scientific World View

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

• No matter how well one theory fits observations, a new theory might fit them just as well or better, or might fit a wider range of observations. In science, the testing, revising, and occasional discarding of theories, new and old, never ends. This ongoing process leads to an increasingly better understanding of how things work in the world but not to absolute truth. Evidence for the value of this approach is given by the improving ability of scientists to offer reliable explanations and make accurate predictions.

B. Scientific Inquiry

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

• Investigations are conducted for different reasons, including: to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.