National Aeronautics and
Space Administration

Goddard Space Flight Center

The Helix Nebula • NGC 7293

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The colorful end of a star's life

This "tie-dye" portrait offers a view down a trillion-mile-long tunnel of glowing gases that were ejected during the final years of an aging star. The glowing cloud, called the Helix Nebula, looks like a bubble in this Hubble Space Telescope image. Astronomers, however, believe that the Helix is actually shaped like a tube. We don't see the elongated shape because one end of the tubular-shaped nebula is pointed toward Earth.

The Helix is an example of a planetary nebula, the expanding shell of glowing gas around a dying, Sun-like star. In spite of the name, planetary nebulae have nothing to do with planet formation. These glowing gas clouds got their name because they look like the disks of planets when viewed through a small telescope. A planetary nebula is created late in a star's life when the star's outer layers of material escape into space.

In this detailed view, a forest of thousands of gaseous tentacles embedded along the inner rim of the nebula points back toward the central, dying star, a small but super-hot white dwarf that seems to float in a sea of blue gas [*white dot in center of nebula*]. These tentacles, which superficially resemble comets, formed when a hot "stellar wind" of particles plowed into colder shells of dust and gas ejected previously by the doomed star. The comet-like tentacles have been observed from ground-based telescopes for decades, but never have they been seen in such detail. They may actually lie in a disk encircling the hot star.

The Helix, located 650 light-years away, is one of the closest planetary nebulae to Earth. This glowing gas cloud appears very large in the sky: Its apparent size is about half the diameter of the full moon. (The Helix's actual diameter is about 2.5 light-years.) In fact, the nebula is so large that astronomers using the Hubble telescope couldn't squeeze the entire nebula into one or even two snapshots. That would be like trying to squeeze the entire Grand Canyon into one photograph. So, astronomers used Hubble's Advanced Camera for Surveys to take pictures of different regions of the Helix, and then pieced them together as a mosaic to make one photograph. But even that wasn't enough to encompass the entire nebula. Astronomers then combined their mosaic with a wider photograph taken with the mosaic camera at the Kitt Peak National Observatory near Tucson, Ariz.

VOCABULARY

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

Stellar winds: Streams of material flowing outward from a star.

Red giant: An old star that has greatly expanded in size and whose surface temperature has dropped so that it appears red.

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

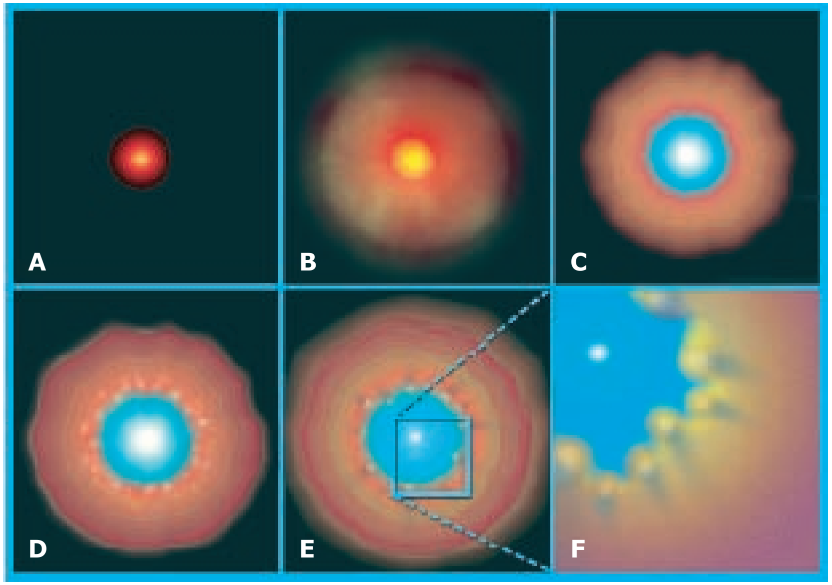
FAST FACTS

Location: The constellation Aquarius

Distance from Earth: About 650 light-years

Dimensions: The image is roughly 5.1 light-years across.

Credit: NASA, NOAO, ESA, the Hubble Helix Nebula Team, M. Meixner (STScI), and T.A. Rector (NRAO)



Recipe for a Planetary Nebula

A: The star puffs up and its surface temperature cools off as it becomes a red giant. *B:* The star ejects shells of gas and dust. *C:* A fast-moving stellar wind spreads outward from the star into the nebula. The star unleashes a torrent of ultraviolet radiation, making the surrounding hydrogen gas glow. The ultraviolet radiation continues to spread outward through the nebula. *D:* Comet-like tentacles form at the leading edge of the glowing cloud. *E:* Only the densest comet-like tentacles survive. *F (panel E inset, enlarged):* Starlight erodes away material between the tentacles.

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 . . . Planetary Nebulae

Description of Classroom Activity

Using the Helix Nebula lithograph, students investigate how planetary nebulae form. Students use the image and text to formulate questions about how Sun-like stars end their lives. They then conduct further research to answer their questions. After organizing their material, students present a report to demonstrate their understanding.

Grade Level

High school, grades 9-12

Prerequisites

At the very least, students should be aware that stars have different masses and that mass determines a star's fate. Students should also be aware that normal stars fuse hydrogen in their cores. The depletion of this fuel source initiates the final stages in the lives of stars.

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, color, and fate of stars. The name planetary nebula in itself is misleading and can introduce misconceptions. 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 our knowledge that the planetary nebula phase represents a late stage in the lives of low-mass, Sun-like stars.

Students may think all stars end their lives the same way – as supernovae. Whether a star becomes a planetary nebula or a supernova depends on its original mass. Only massive stars will become supernovae. The Sun and other less massive stars will gently puff off their outer layers, forming an expanding shell of gas that is known as a planetary nebula. Then the exposed cores of these stars, called white dwarfs, will cool over time.

Students may think that stars don't change. After all, many constellations (star patterns) have been known since ancient times. 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. Some students may think all stars are the same color — white — because the stars they see in the night sky appear to be white. Normal, hydrogen-burning stars range in color from red — the coolest ones — to orange, yellow, white, and finally, blue (the hottest stars). Typically, stars are born in groups. "Blue stars," however, evolve faster than other stars. So the age of a group of stars can be judged by its color.

Vocabulary

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 use the image and text on the lithograph to introduce the last stages of Sun-like stars. Students formulate questions about planetary nebulae, use the Internet to search for answers, and then demonstrate an understanding of the topic by presenting a report of their findings. Students are also asked to reflect on their learning by checking if they answered their original questions and/or generated any new ones.

Materials

- Helix Nebula lithograph
- Computer with Internet connection for researching

Instructions for the Teacher

Preparation

• Obtain a lithograph for each student.

• 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 a favorite the following Web page:
STScI, Planetary Nebula Press Releases:
http://hubblesite.org/newscenter/archive/releases/nebula/planetary/

Procedure

Ask students to look at the image of the Helix Nebula on the front of the lithograph and formulate three questions about the image. Their questions may focus on how it was formed, the meaning of the colors, or what will happen to it in the future. Collect these questions and group them by common theme. Have the students read the information on the back of the lithograph and check if any of their questions have been answered. Using the Internet, have students research their questions. The Internet sites listed above can provide a starting point for the research. If students can access other Websites, instruct them how to do it. Tell them to prepare a report in which they demonstrate their understanding of the fate of Sun-like stars. This could be a slide show, a skit, a story, 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. Ask also if they have any additional questions. As an extension, teachers may ask students to research the endpoint of large-mass stars, and then compare the evolutional paths of the two types of stars.

Instructions for the Student

Study the image of the Helix Nebula, and write down three questions about the image. Then read the back of the lithograph and check if any of your questions were answered. Using your questions as a guide, research planetary nebulae on the Internet. Your teacher will guide your search by providing some sites to use. To demonstrate your understanding of the material you researched, your teacher will ask you to give a report. This report could be a slide show, a skit, a story, a Power Point presentation, or whatever you feel will allow you to express yourself completely. You may be allowed to work individually or in small groups, and make your presentations to another classmate, another group of students, or the class as a whole. Your teacher will ask you to review your original list of questions and reflect on whether they were answered fully, partially, or not at all through your research. Your teacher may also ask if you have generated any other questions while you were researching the answers to the original questions.

Education Standards

Benchmarks for Science Literacy

American Association for the Advancement of Science:

http://www.project2061.org/tools/benchol/bolframe.htm

4. The Physical Setting
A. The Universe

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

• On the basis of scientific evidence, the universe is estimated to be over 10 billion years old. The current theory is that its entire contents expanded explosively from a hot, dense, chaotic mass. Stars condensed by gravity out of clouds of molecules of the lightest elements until nuclear fusion of the light elements into heavier ones began to occur. Fusion released great amounts of energy over millions of years. Eventually, some stars exploded, producing clouds of heavy elements from which other stars and planets could later condense. **The process of star formation and destruction continues.**

McREL (Mid-continent Research for Education and Learning)

http://www.mcrel.org/compendium/browse.asp
Science Standard 3: Understands the composition and structure of the universe and the Earth's place in it.

Level IV (Grade 9-12)

Benchmark 3: Knows the ongoing processes involved in star formation and destruction.