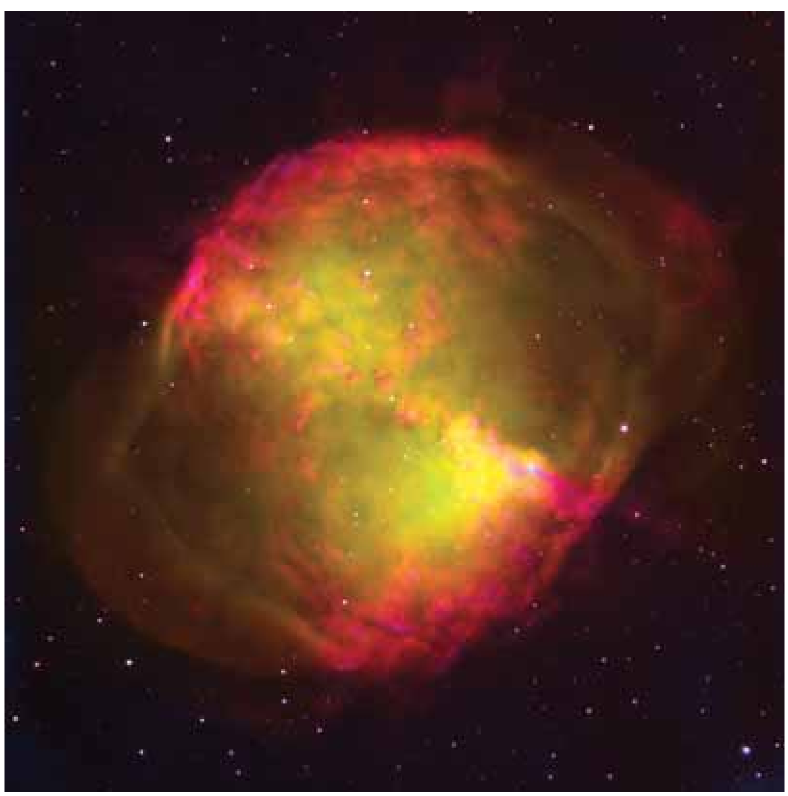
Investigating Stars Name:_________________________________________Block:____________

**Unstable Stars: Planetary Nebulae and White Dwarfs** **E4:A1**

As the hydrogen in the core of stars is depleted and shell burning begins, the balance between forces of expansion and contraction in the star is disturbed. The late stages of a star's evolution are marked by episodes of instability that result in the formation of several types of cosmic features. In this activity, you will develop a classification scheme for one such feature, the planetary nebula.

1. Working in groups of three or four, devise a multi-stage classification scheme for a series of 12 images of planetary nebulae.
   - Observe a demonstration that shows how to make a multi- stage classification.
   - Separate the 12 planetary nebula images into four or more groups using observable structural characteristics.
   - Use boxes and lines to construct a multi-stage classification on a piece of notebook or plain white paper.
     - Begin with a box with all 12 planetary nebulae, numbered (1- 12), inside.
     - Separate the group of 12 into two groups of approximately equal size using a single observable characteristic.
     - Separate each of those groups into two additional groups using a different characteristic.
     - Keep classifying the nebulae into groups until you cannot separate them any further.
   - When you are finished, compare your classification system with another group's effort.

2. Read FYI: *Planetary Nebulae.* Complete the reading guide and questions after reading.



**An image of a planetary nebula called the Dumbell**

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# FYI Planetary Nebulae

When you look at the objects in the night sky with your naked eye or a small telescope, almost every one is a point source of light—stars, planets, and moons. When larger telescopes were developed in the 18th century, early astronomers like Charles Messier recognized that some objects in the sky looked more like fuzzy objects than pinpoints of light. One group of these objects appeared to look similar to Uranus and Neptune, which are greenish in color. Messier called them planetary nebulae for this reason. Today's much more powerful telescopes reveal that planetary nebulae are actually glowing shells of gas and dust that often have a visible hot star, a white dwarf, near their center.

**Figure 3-2: Image of the Helix nebula, which has a spherical shape to the naked eye, with a hot, white dwarf in the center that floods the entire cloud with intense ultraviolet radiation**

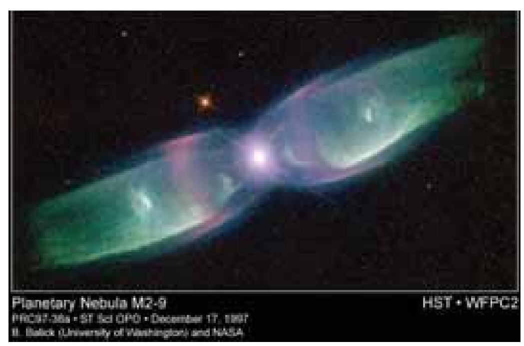


**Figure 3-3: Image of the planetary nebula M2-9, which has a two-lobed structure**

These shells of gas are what you might expect when a star becomes unstable after leaving the main sequence. The fact that very few planetary nebulae are found in the vicinity of star-forming regions provides further evidence that these are likely the remnants of stellar death. As most stars reach the end of their lives, they go through a phase of contraction and expansion. During this phase they shed between 10% to 25% of their mass. In some cases this mass forms a uniform spherical shell around the dying star; in other cases the mass forms a much more complicated structure. As a star ejects mass from its surface, layers closer to the central core are exposed. Eventually, all that remains of the star is a very hot central core. Astronomers think that these cores ultimately become white dwarf stars.

Even though stars in our galaxy likely produce billions of planetary nebulae, only 1,500 are visible in our galactic neighborhood. That is because these nebulae quickly expand and fade while their matter spreads into space, so the average lifetime of a planetary nebula is only 10 thousand to 30 thousand years. When you view a planetary nebula, you are seeing a snapshot of a star's death throes, a period of time less than 0.0001% of a star's total life span.

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When we look through a telescope, it is easy to forget we are observing three-dimensional objects, not flat, two-dimensional ones. For instance, the Helix nebula, a planetary nebula 650 ly from Earth, appears ring-shaped, but is not. The Helix nebula is a sphere, a ball of gas 1.5 ly in diameter. We are looking through an increasing amount of gas as we move our eyes from the center star and nebula toward the edge of the sphere, so the opaqueness increases, giving the nebula a ring-like appearance. Other planetary nebulae eject two lobes of material instead of one and have a very non-ring-like appearance.

The white dwarf at the core of a planetary nebula is very hot (50,000 to 200,000 K) and gives off a huge amount of ultraviolet radiation. This radiation ionizes gas atoms in the cloud, reaching great distances from the central star. Most images of planetary nebulae are taken with filters that bring out the presence of nitrogen (cooler gas), hydrogen, and oxygen (hotter gas).

Planetary nebulae are important objects in astronomy because they play a crucial role in the chemical evolution of the galaxy, returning material to space that has been enriched with heavy elements and other products of nuclear fusion such as carbon, nitrogen, oxygen, and calcium. Planetary nebulae may be the only objects that can provide useful information about chemical abundances in galaxies other than our own.

*Activity & Reading Reflection Questions:*

3. Are there characteristics that all planetary nebulae share?

4. Why do you think planetary nebulae vary so much in size (diameter)?

5. Why isn't the central star visible in each image?

6. Explain how you would determine how long ago a certain star began its planetary nebula stage.

7. How does a dying star produce a planetary nebula?

8. What creates the different colors observable in a planetary nebula?