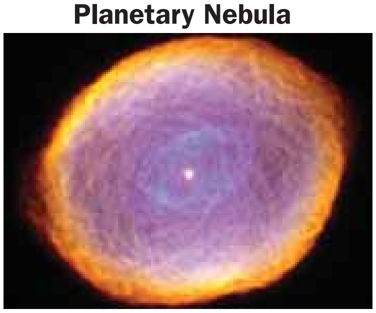
Investigating Stars Name:____Block:_____________

Comparing Images and Spectra **E2:A3**

Although most objects in the night sky that are visible to the naked eye appear as similar points of light, the universe actually contains a diverse variety of objects. Astronomers use powerful telescopes, multi-wavelength imaging, and spectroscopy to gather pieces of evidence that can be combined to determine the physical nature of these objects. In this activity, you will prepare for the Challenge by determining what pieces of evidence are needed to positively identify astronomical objects.

1. Examine the table below. It lists common astronomical objects along with a sample image and descriptions of major physical and spectral characteristics that help astronomers identify them.

Object	Description	Major Spectral Features
Star  **Figure 4-24**	Large, glowing ball of gas that generates energy through nuclear fusion in its core.	Continuous spectrum superimposed with dark absorption lines due to cooler outer atmosphere.
Galaxy  **Figure 4-25**	A collection of anywhere between a few hundred million and a trillion stars, all bound together by gravity.	The spectrum of a galaxy is the combination of the spectra of all its stars, plus gas and dust if they are present. Because these stars are of many different spectral types (temperatures), a galactic spectrum usually does not look exactly like the spectrum of any particular type of star, and from that you can tell that it is not the spectrum of a single star.
Planetary Nebula  **Figure 4-26**	The glowing cloud of gas ejected from a low-mass star at the end of its life. These colorful nebulae generally appear symmetric in shape, expanding from a central hot white dwarf star. Some planetary nebulae appear spherical, while others are bi-polar or some other complex shape.	Colorful line emission from chemical elements present in stellar atmospheres, such as hydrogen, oxygen, and nitrogen.

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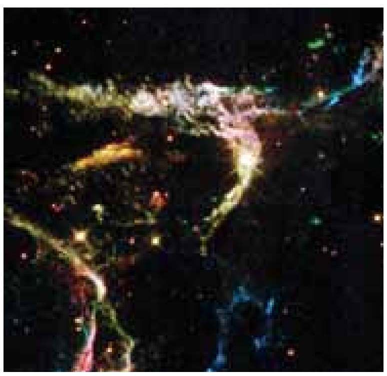
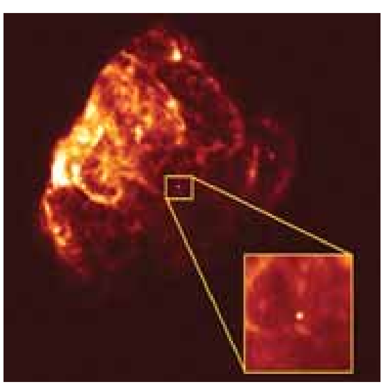
Object	Description	Major Spectral Features
White Dwarf  **Figure 4-27**	Inert stellar core left over after a low-mass star sheds its outer layers to create a planetary nebula. A white dwarf consists mostly of carbon and oxygen and has a high surface temperature, such that it glows white when it is very young. Since it has no source of energy, a white dwarf will gradually radiate away its energy and cool down to temperatures at which it is no longer visible.	Spectrum is similar in general appearance to that of a normal star, but with an extremely high temperature (tens of thousands of Kelvins), low luminosity, and broader (and sometimes split) absorption lines.
Supernova Remnant (SNR)  **Figure 4-28**	A glowing, expanding cloud of debris left over from the violent explosion of a high-mass star. The SNR is typically less symmetric than a planetary nebula, contains hotter gas, and often has a neutron star at its core. Sometimes, near the center of a remnant, there is hazy blue radiation, known as synchrotron radiation, which is generated by high-energy electrons as they spiral at relativistic speeds in the magnetic field from the neutron star.	Colorful line emission similar to that found in planetary nebulae, but often containing signatures of heavier elements such as gold, silver, and lead. Synchrotron radiation at the center of the SNR produces a smooth, featureless spectrum similar in appearance to one side of a blackbody spectrum (continuously increasing or decreasing).
Neutron Star  **Figure 4-29**	The dense, compact corpse of a high-mass star left over after a supernova; typically contains a mass comparable to the mass of the sun, but has a radius of just a few kilometers.	Smooth, featureless spectrum similar to one side of a blackbody spectrum (continuously increasing or decreasing). Shape of the spectrum is like that of synchrotron emission.

2. Look at the spectrum in Figure 4-30. Based on the features you observe,

   What type(s) of object(s) could have produced this spectrum?

   Is there more than one possibility?

   If there is more than one possibility, what additional evidence is required to make a definitive identification?

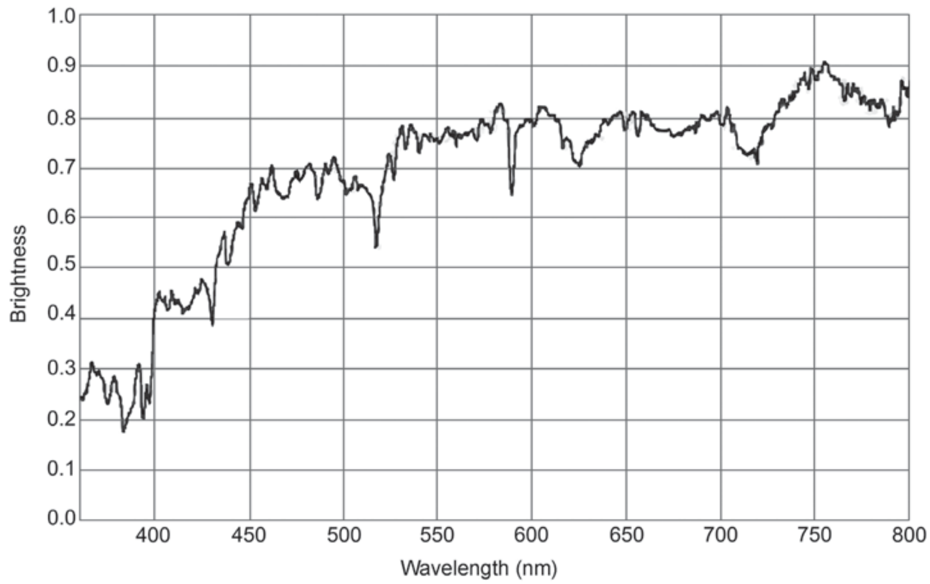


Figure 4-30: Spectrum for mystery object in Step 2

   Explain your reasoning.

3. Look at the spectrum in Figure 4-31. Based on the features you observe,

   What type(s) of object(s) could have produced this spectrum?

   Is there more than one possibility?

   If there is more than one possibility, what additional evidence is required to make a definitive identification?

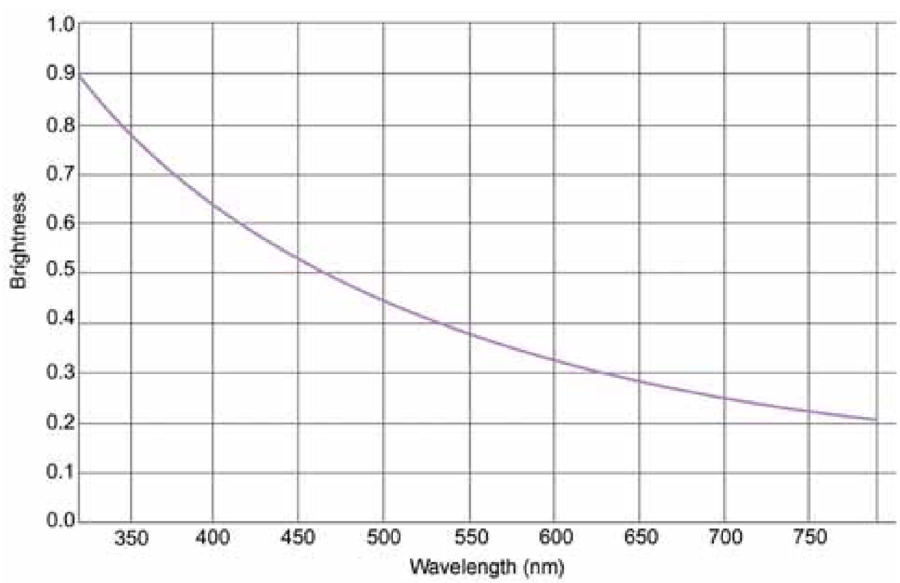


Figure 4-31: Spectrum for mystery object in Step 3

   Explain your reasoning.

4. Look at the image in Figure 4-32. Based on the features you observe,

   What type(s) of object(s) could it be?

   Is there more than one possibility?

   If there is more than one possibility, what additional evidence is required to make a definitive identification?

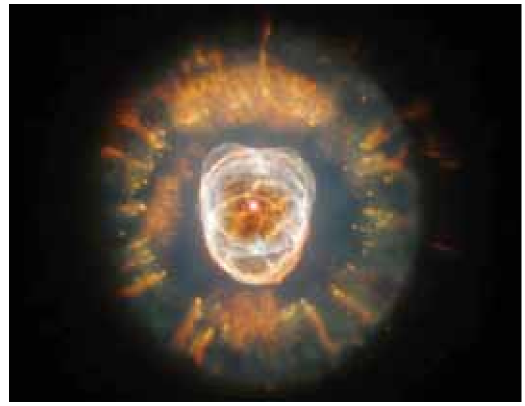


Figure 4-32: Image of the Eskimo Nebula taken by the Hubble Space Telescope

Explain your reasoning.

Pause and Reflect

1. Why do stars have both a continuum (continuous spectrum) and an absorption spectrum?

2. What are the physical properties or processes that make planetary nebulae and supernova remnants appear similar in images?