Name _____ Class _____ Date _____

SECTION 2 The Life Cycle of Stars

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How do stars change over time?
- What is an H-R diagram?
- What may a star become after a supernova?

How Do Stars Age?

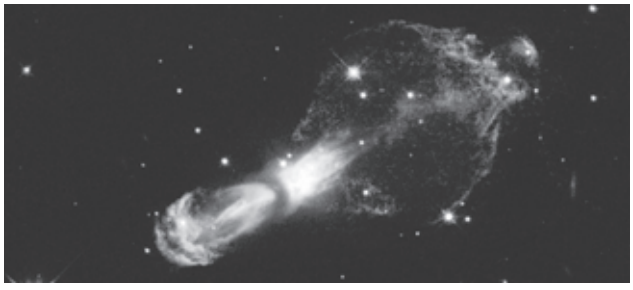
Stars do not remain the same forever. Like living things, stars go through a life cycle from birth to death. The actual life cycle of a star depends on its size. An average star, such as the sun, goes through four stages during its life.

A star enters the first stage of its life cycle as a ball of gas and dust called a *protostar*. Gravity pulls the gas and dust together. As the ball becomes denser, it gets hotter. Eventually, the gas becomes so hot that it begins to react. These reactions produce energy, which keeps the new star from collapsing more.

The second, and longest, stage of a star's life cycle is the *main sequence star*. During this stage, hydrogen in the center of the star reacts to form helium. This produces a great deal of energy. As long as a main-sequence star has enough hydrogen to react, its size will not change very much.

When a main-sequence star uses up all of its hydrogen, it can start to expand and cool. This forms a huge star called a **red giant**.

In the final stage of its life cycle, an average star is classified as a white dwarf. A **white dwarf** is the small, hot, leftover center of a red giant.



STUDY TIP

Compare Make a chart comparing the steps in the life cycles of average stars and massive stars.

Critical Thinking

1. Infer A star can live for billions of years. Therefore, scientists can't watch a star through its entire life. How do you think scientists figure out the life cycle of a star?

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TAKE A LOOK

2. Identify This average star is in the last stage of its life cycle. What is that stage?

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Life Cycle of an Average Star

1. **Protostar** A *protostar* is a ball of gas and dust. Gravity pulls the gas and dust together, and its center gets hotter.

2. **Main-Sequence Star** The *main sequence* is the longest stage of a star's life cycle. The fusion of hydrogen atoms makes energy in the star.

3. **Red Giant** When a main sequence star uses up all its hydrogen, it can no longer give off energy. The star's center contracts and the outer layers expand and cool, forming a red giant.

4. **White Dwarf** A white dwarf is the leftover center of a red giant. It is a small, hot, and dim star that can shine for billions of years.

TAKE A LOOK

3. Identify What causes a main sequence star to become a red giant?

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What Is an H-R Diagram?

An **H-R diagram** is a graph that shows the relationship between a star's temperature and its brightness. The H-R diagram also shows how stars change over time. The diagram is named after Ejnar Hertzsprung and Henry Norris Russell, the scientists who invented it. ☑

READING CHECK

4. Identify Which two characteristics of a star must a scientist measure to make an H-R diagram?

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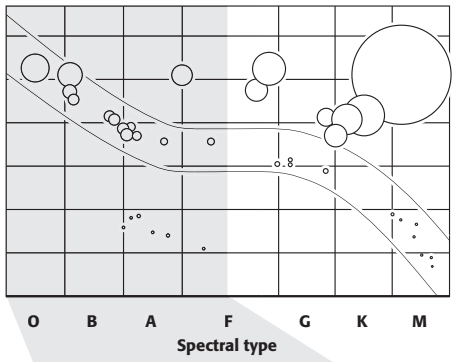
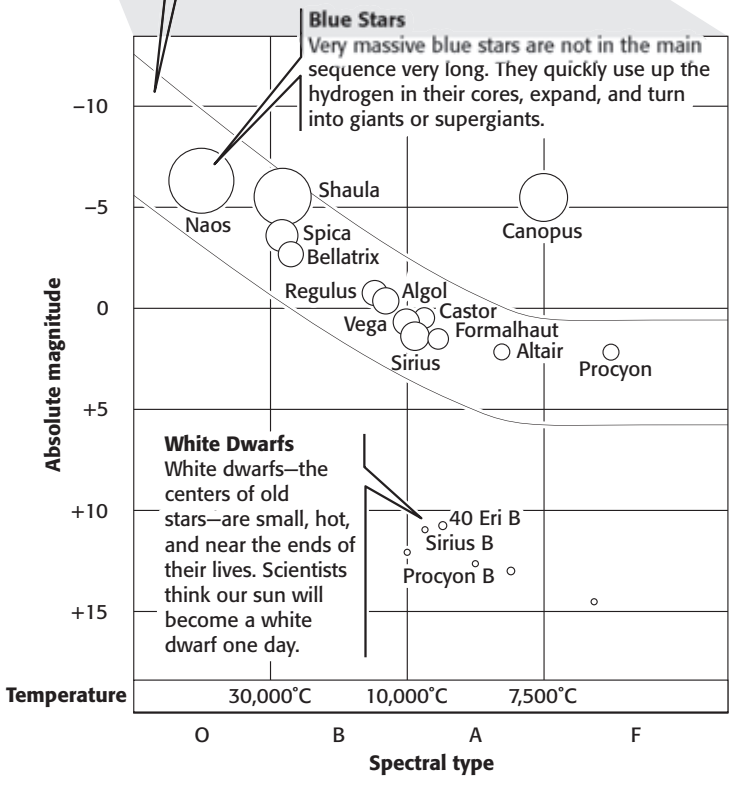
Temperature is given along the bottom of the diagram. Hotter (bluer) stars are on the left, and cooler (redder) stars are on the right. Brightness, or absolute magnitude, is given along the left side of the diagram. Bright stars are near the top, and dim stars are near the bottom. The bright diagonal line on the H-R diagram is called the **main sequence**. A star spends most of its life on the main sequence.

Why Does a Star's Position on the H-R Diagram Change?

As a main-sequence star ages, it becomes a red giant. When this happens, the star moves to a new place on the H-R diagram. The star's position on the diagram changes again when it becomes a white dwarf. These changes happen because the brightness and temperature of a star change throughout its life. ☑



Main-sequence Stars
Stars on the main sequence form a band that runs accross the H-R diagram. The sun is a main-sequence star. The sun has been shining for about 5 billion years. Scientists think that the sun is in the middle of its life and will remain on the main sequence for another 5 billion years.



An H-R diagram can show the life cycle of a star.

READING CHECK

5. Explain Why does a star's position on the H-R diagram change at different stages of its life cycle?

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TAKE A LOOK

6. Identify Where in the H-R diagram are the brightest stars located?

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7. Identify Where in the diagram are the hottest stars located?

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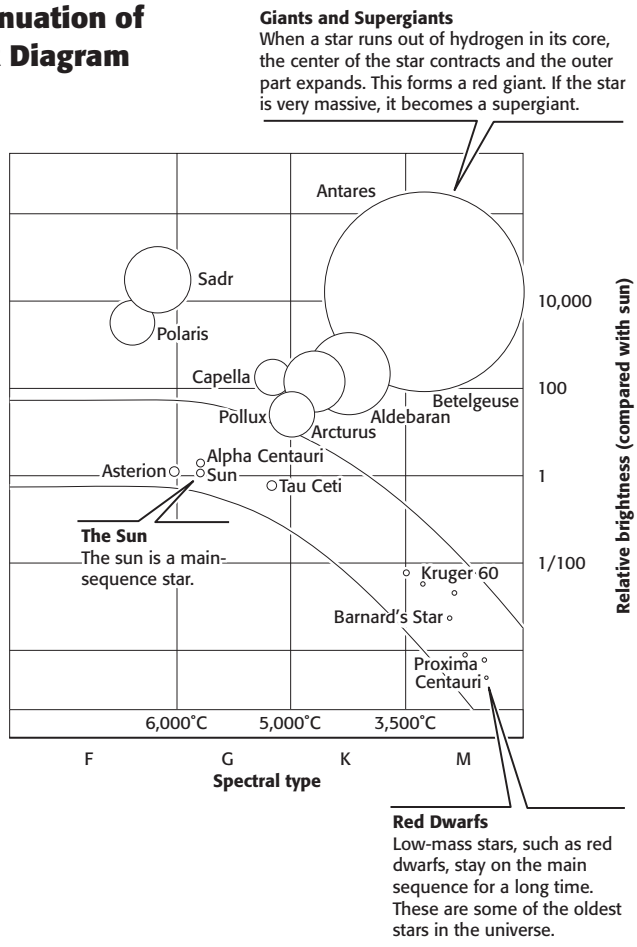
A Continuation of the H-R Diagram



TAKE A LOOK

8. Compare Which star is hotter—Antares or Polaris?

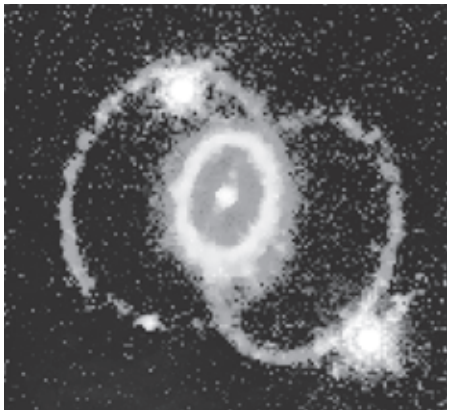
9. Read a Graph Is Betelgeuse on the main sequence?

What Happens to Massive Stars as They Age?

Massive stars use up their hydrogen much more quickly than smaller stars. As a result, massive stars give off much more energy and are very hot. However, they do not live as long as other stars. Toward the end of its main sequence, a massive star collapses in a gigantic explosion called a **supernova**. After such an explosion, a massive star may become a neutron star, a pulsar, or a black hole. ☑

READING CHECK

10. Identify What can cause a main-sequence star to turn into a neutron star, a pulsar, or a black hole?



These rings of dust and gas are the remains of a star that exploded in a supernova. Astronomers think that a neutron star or black hole was formed when this star exploded.

NEUTRON STARS

After a supernova, the center of a collapsed star may contract into a tiny ball of neutrons. This ball, called a **neutron star**, is extremely dense. On Earth, a single teaspoon of matter from a neutron star would weigh 100 million metric tons!

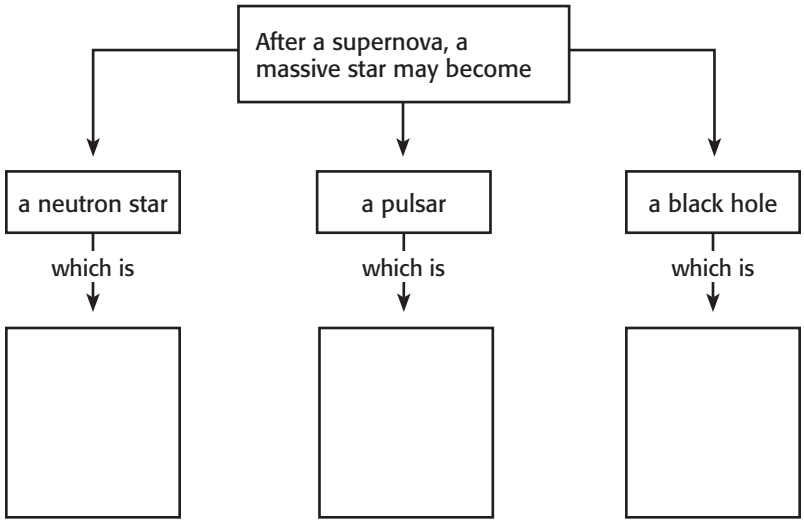
PULSARS

If a neutron star is spinning, it is called a **pulsar**. Pulsars send out beams of radiation that sweep through space. A radio telescope, an instrument that can pick up radiation with long wavelengths, can detect pulsars. Every time a pulsar's beam sweeps by Earth, scientists hear rapid clicks, or pulses, in the radio telescope.

BLACK HOLES

If the collapsed star is extremely massive, the force of its gravity may cause it to contract even more. This contraction crushes the dense center of the star, creating a **black hole**. Even though they are called holes, black holes aren't really empty spaces. A black hole is an object so dense that even light cannot escape its gravity.

Because black holes do not give off light, it can be hard for scientists to locate them. Gas and dust from a nearby star may fall into the black hole and give off X rays. When scientists find these X rays, they can infer that a black hole is close by.



Critical Thinking

11. Infer Could an average star, such as our sun, become a neutron star? Explain your answer.

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Say It

Discuss In a small group, talk about other places you have heard about X rays. Where were they used? What were they used for?

TAKE A LOOK

12. Describe Fill in the blank spaces to describe neutron stars, pulsars, and black holes.

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Section 2 Review

SECTION VOCABULARY

black hole an object so massive and dense that even light cannot escape its gravity

H-R diagram Hertzsprung-Russell diagram, a graph that shows the relationship between a star's surface temperature and absolute magnitude

main sequence the location on the H-R diagram where most stars lie; it has a diagonal pattern from the lower right (low temperature and luminosity) to the upper left (high temperature and luminosity)

neutron star a star that has collapsed under gravity to the point that the electrons and protons have smashed together to form neutrons

pulsar a rapidly spinning neutron star that emits pulses of radio and optical energy

red giant a large, reddish star late in its life cycle

supernova a gigantic explosion in which a massive star collapses and throws its outer layers into space

white dwarf a small, hot, dim star that is the leftover center of an old star

1. List What are the four stages in the life cycle of an average star?

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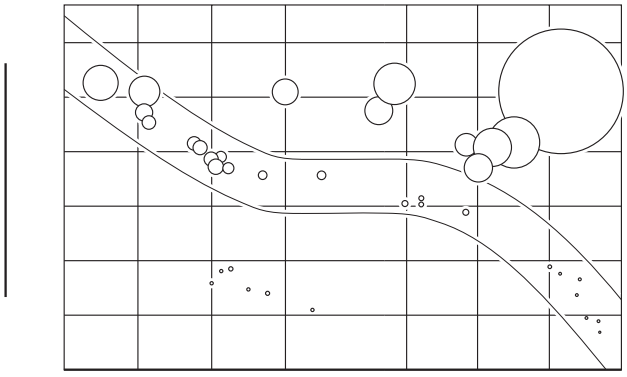
2. Identify Label the axes on this H-R diagram.



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3. Explain How does a star's temperature change as the star ages from a main sequence star to a red giant and from a red giant to a white dwarf?

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4. Compare How is the life cycle of a massive star different from the life cycle of an average star?

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