# Stars and Galaxies

## The Sun and Other Stars

**Key Concepts**
- How do stars shine?
- How are stars layered?
- How does the Sun change over short periods of time?
- How do scientists classify stars?

### Before You Read

**What do you think?** Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

| Before | Statement | After |
|---|---|---|
| | **3.** Stars shine because there are nuclear reactions in their cores. | |
| | **4.** Sunspots appear dark because they are cooler than nearby areas. | |

Study Coach

**Building Vocabulary** Work with another student to write a question about each vocabulary term in this lesson. Answer the questions and compare your answers. Reread the text to clarify the meaning of the terms.

**Key Concept Check**
**1. Explain** How do stars shine?

______________________________

______________________________

______________________________

______________________________

### Read to Learn

## How Stars Shine

The hotter something is, the more quickly its atoms move. As atoms move, they collide. If a gas is hot enough and its atoms move quickly enough, the nuclei of some of the atoms stick together. **Nuclear fusion** *is a process that occurs when the nuclei of several atoms combine into one larger nucleus.*

Nuclear fusion releases a great amount of energy. This energy powers stars. *A* **star** *is a large ball of gas held together by gravity with a core so hot that nuclear fusion occurs.* A star's core can reach hundreds of millions of degrees Celsius. When energy leaves a star's core, it travels throughout the star and radiates into space. As a result, the star shines.

## Composition and Structure of Stars

The Sun is the closest star to Earth. Because it is so close, scientists easily can observe it. They can send probes to the Sun. They can study its spectrum using spectroscopes on Earth-based telescopes. Spectra of the Sun and other stars provide information about the composition of stars. The Sun and most stars are made almost entirely of hydrogen and helium gas. A star's composition changes slowly over time as hydrogen in its core fuses into more complex nuclei.

## Interior of Stars

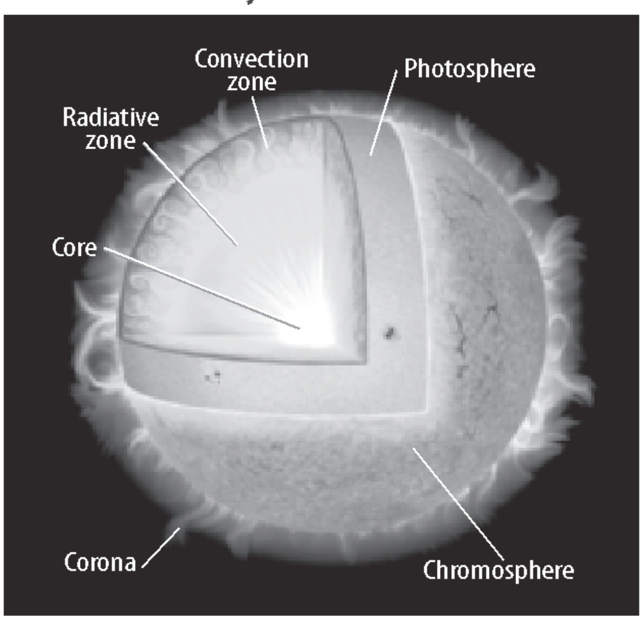
When first formed, all stars fuse hydrogen into helium in their cores. Helium is denser than hydrogen, so it sinks to the inner part of the core after it forms. A typical star has three interior layers. The layers are shown in the figure at the bottom of this page. The core is the center layer. *The* **radiative zone** *is a shell of cooler hydrogen above a star's core.* Hydrogen in this layer is dense. Light energy bounces from atom to atom as it gradually makes its way upward, out of the radiative zone. Above the radiative zone is the **convection zone,** *where hot gas moves up toward the surface and cooler gas moves deeper into the interior.* Light energy moves quickly upward in the convection zone.

## Atmosphere of Stars

Beyond the convection zone are the three outer layers of a star. These layers make up a star's atmosphere. *The* **photosphere** *is the apparent surface of a star.* In the Sun, it is the dense, bright part you can see, where light energy radiates into space. From Earth, the Sun's photosphere looks smooth. But like the rest of the Sun, it is made of gas.

Above the photosphere are the two outer layers of a star's atmosphere. *The* **chromosphere** *is the orange-red layer above the photosphere,* as shown in the figure below. *The* **corona** *is the wide, outermost layer of a star's atmosphere.* The temperature of the corona is higher than the photosphere or the chromosphere. It is irregular in shape and can extend outward for several million kilometers.

**Layers of the Sun**




**Key Concept Check**

**2. Name** What are the interior layers of a star?

______________________

______________________

______________________

**Reading Check**

**3. Identify** What is the hottest layer of a star's atmosphere?

______________________

**Visual Check**

**4. Locate** Where is the photosphere located in relation to the Sun's other layers?

______________________

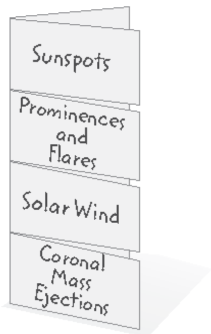
______________________

______________________

______________________

**FOLDABLES®**

Make a vertical four-tab book to organize your notes about the changing features of the Sun.




**Key Concept Check**

**5. Name** Which parts of the Sun change over short periods of time?

**Think it Over**

**6. Relate** Look up the word *binary* in a dictionary. How does the definition relate to a binary star system?

## The Sun's Changing Features

The interior features of the Sun are stable over millions of years. But the Sun's atmosphere can change over years, months, or even minutes. Some of these features are described below.

**Sunspots** Regions of strong magnetic activity are called sunspots. Sunspots are cooler than the rest of the photosphere and appear as dark splotches on the Sun. They seem to move across the Sun as the Sun rotates. The number of sunspots changes over time. They follow a cycle, peaking in number every 11 years. An average sunspot is about the size of Earth.

**Prominences and Flares** Prominences are clouds of gas that make loops and jets that extend into the corona. They sometimes last for weeks. Flares are sudden increases in brightness that often occur near sunspots or prominences. They are violent eruptions that last from minutes to hours. Both prominences and flares begin at or just above the photosphere.

**Coronal Mass Ejections (CMEs)** Huge bubbles of gas ejected from the corona are coronal mass ejections (CMEs). They are much larger than flares and occur over the course of several hours. Material from a CME can reach Earth, sometimes interfering with radio and satellite communications.

**The Solar Wind** Charged particles that stream continually away from the Sun create the solar wind. The solar wind passes Earth and extends to the edge of the solar system. Auroras are curtains of light created when they interact with Earth's magnetic field. Auroras occur in both the northern and southern hemispheres.

# Groups of Stars

There are no other stars near the Sun. The star closest to the Sun is 4.2 light-years away. Many stars are single stars, such as the Sun. Most stars exist in multiple star systems bound by gravity.

**Binary Star Systems** The most common star system is a binary system. In a binary system, two stars orbit each other. By studying the orbits of binary stars, astronomers can determine the stars' masses.

**Star Clusters** Many stars exist in large groups called clusters. There are two types of star clusters—open clusters and globular clusters. Open clusters contain fewer than 1,000 stars. Globular clusters can contain hundreds of thousands of stars.

All the stars in a cluster formed at about the same time and are the same distance from Earth. If astronomers know the distance to or the age of one star in a cluster, they know the distance to or the age of every star in the cluster.

## Classifying Stars

How do you classify a star? Which properties are important? Scientists classify stars according to their spectra. Recall that a star's spectrum is the light the star emits spread out by wavelength. Stars have different spectra and different colors depending on their surface temperatures.

### Temperature, Color, and Mass

Have you ever seen coals in a fire? Red coals are the coolest. Blue-white coals are the hottest. Stars are similar. Blue-white stars are hotter than red stars. The temperatures of orange, yellow, and white stars are between the hottest blue-white stars and cooler red stars.

There are some exceptions, but color in most stars is related to mass. Blue-white stars tend to have the greatest mass, followed by white stars, yellow stars, orange stars, and red stars. The most massive stars are normally the hottest. The smallest stars tend to be cooler and red.

The Sun is a yellow star. It is tiny compared to blue-white stars. However, scientists suspect that most stars—as many as 90 percent—are smaller than the Sun. These stars are called red dwarfs.

### Hertzsprung-Russell Diagram

When scientists plot the temperatures of stars against their luminosities, the result is a graph like that shown on the next page. *The* **Hertzsprung-Russell diagram** (or H-R diagram) *is a graph that plots luminosity v. temperature of stars.* The *y*-axis of the H-R diagram displays increasing luminosity. The *x*-axis displays decreasing temperature.

The H-R diagram is an important tool for categorizing stars. Astronomers also use it to determine distances of some stars. If a star has the same temperature as a star on the H-R diagram, astronomers often can determine its luminosity. As you read earlier, if astronomers know a star's luminosity, they can calculate its distance from Earth.

**Think it Over**

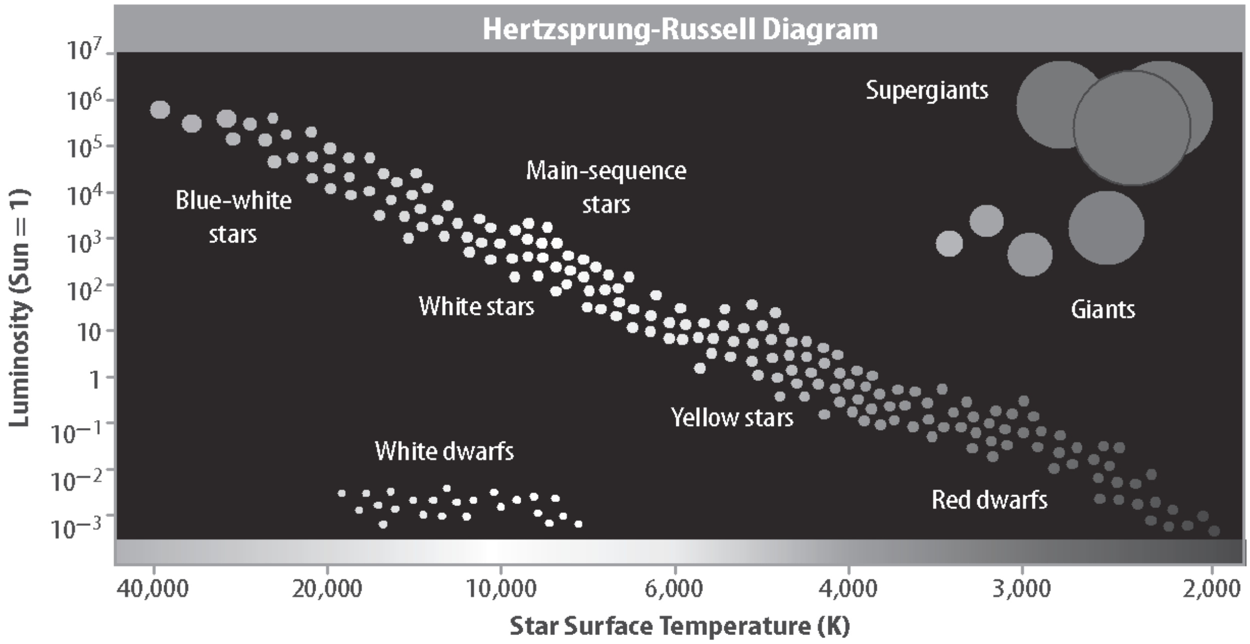
**7. Apply** Star *A* is 12 billion years old. Star *B* is in the same cluster. About how old is Star *B*? Why?

**Reading Check**

**8. Relate** How does star color relate to mass?

**Key Concept Check**

**9. Describe** What is the Hertzsprung-Russell diagram?




**Visual Check**

**10. Interpret** Where is the Sun on this diagram? Draw a circle to indicate the approximate location.

**Reading Check**

**11. Explain** Supergiants are cool yet luminous because ________. (Circle the correct answer.)

**a.** they produce more energy

**b.** they are farther from Earth

**c.** they are unusually large

## The Main Sequence

Most stars spend the majority of their lives on the main sequence. On the H-R diagram, main sequence stars form a curved line from the upper left corner to the lower right corner of the graph. The mass of a star determines both its temperature and its luminosity; the higher the mass the hotter and brighter the star. Because high-mass stars have more gravity pulling inward than low-mass stars, their cores have higher temperatures and produce and use more energy through fusion. High-mass stars have a shorter life span than low-mass strars. High-mass stars burn through their hydrogen much faster and move off the main sequence. A downside to a large-mass star is that the life span of the star is much shorter than average- or low-mass stars.

As shown in the figure above, some groups of stars on the H-R diagram lie outside of the main sequence. These stars are no longer fusing hydrogen into helium in their cores. Some of these stars are cooler, but brighter and larger, such as supergaints. Other stars are dimmer and smaller, but much hotter, such as white dwarfs.