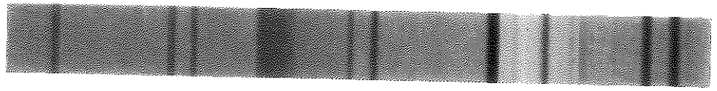
Figure 5
These star spectra were made by placing a diffraction grating over a telescope's objective lens. A diffraction grating produces a spectrum by causing interference of light waves. *What causes the lines in spectra?*



Properties of Stars

The color of a star indicates its temperature. For example, hot stars are a blue-white color. A relatively cool star looks orange or red. Stars that have the same temperature as the Sun have a yellow color.

Astronomers study the composition of stars by observing their spectra. When fitted into a telescope, a spectroscope acts like a prism. It spreads light out in the rainbow band called a spectrum. When light from a star passes through a spectroscope, it breaks into its component colors. Look at the spectrum of a star in **Figure 5.** Notice the dark lines caused by elements in the star's atmosphere. Light radiated from a star passes through the star's atmosphere. As it does, elements in the atmosphere absorb some of this light.The wavelengths of visible light that are absorbed appear as dark lines in the spectrum. Each element absorbs certain wavelengths, producing a certain pattern of dark lines. Every chemical element produces a unique pattern of dark lines. Like a fingerprint, the patterns of lines can be used to identify which elements are in a star's atmosphere.

Section 1 Assessment

1. What is a constellation?
2. How does Earth's revolution affect the viewing of constellations throughout the year?
3. If two stars give off equal amounts of light, why might one look brighter?
4. If the spectrum of a star shows the same absorption lines as the Sun, what can be said about the star's composition?
5. **Think Critically** Several thousand stars have large enough parallaxes that their distances can be studied using parallax. Most of these stars are invisible to the naked eye. What does this indicate about their absolute magnitudes?

Skill Builder Activities

6. **Recognizing Cause and Effect** Suppose you viewed Proxima Centauri through a telescope today. How old were you when the light that you see left Proxima Centauri? Why might Proxima Centauri look dimmer than Betelgeuse, a large star that is 520 light-years away? **For more help, refer to the Science Skill Handbook.**
7. **Using Graphics Software** Use graphics software on a computer to make a star chart of major constellations visible from where you live during the current season. Include several reference points to help others find the charted constellations. **For more help, refer to the Technology Skill Handbook.**

SECTION 2

The Sun

The Sun's Layers

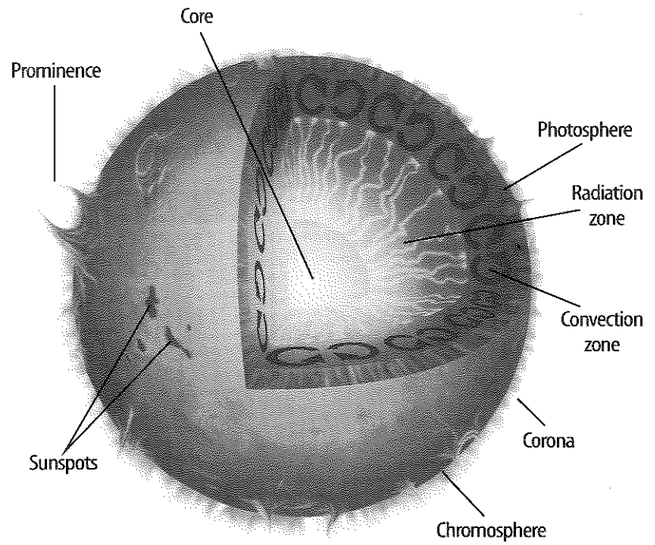
Within the universe, the Sun is an ordinary star—not too spectacular. However, to you it's important. The Sun is the center of the solar system, and it makes life possible on Earth. More than 99 percent of all the matter in the solar system is in the Sun.

Notice the different layers of the Sun, shown in **Figure 6,** as you read about them. Like other stars, the Sun is an enormous ball of gas that produces energy by fusing hydrogen into helium in its core. This energy travels outward through the radiation zone and the convection zone. In the convection zone, gases circulate in giant swirls. Finally, energy passes into the Sun's atmosphere.

The Sun's Atmosphere

The lowest layer of the Sun's atmosphere and the layer from which light is given off is the **photosphere.** The photosphere often is called the surface of the Sun, although the surface is not a smooth feature. Temperatures there are about 6,000 K. Above the photosphere is the **chromosphere.** This layer extends upward about 2,000 km above the photosphere. A transition zone occurs between 2,000 km and 10,000 km above the photosphere. Above the transition zone is the **corona.** This is the largest layer of the Sun's atmosphere and extends millions of kilometers into space. Temperatures in the corona are as high as 2 million K. Charged particles continually escape from the corona and move through space as solar wind.

Figure 6
Energy produced by fusion in the Sun's core travels outward by radiation and convection. The Sun's atmosphere—the photosphere, chromosphere, and corona—shines by the energy produced in the core.



As You Read

What You'll Learn

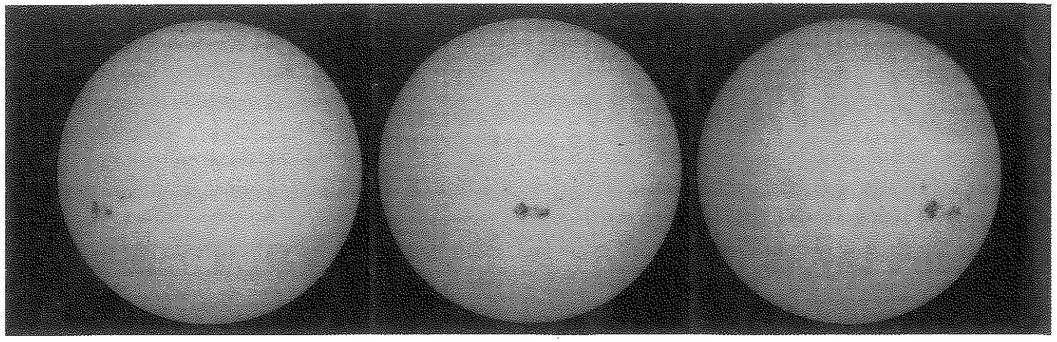
- **Describe** the strucure of the Sun.
- **Explain** how sunspots, prominences, and solar flares are related.
- **Explain** why the Sun is considered an average star and how it differs from stars in binary systems.

Vocabulary

photosphere
chromosphere
corona
sunspot

Why It's Important

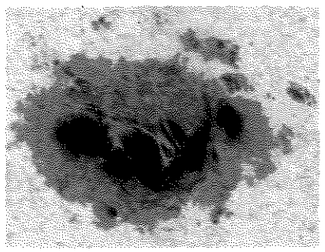
The Sun is the source of most energy on Earth.



A Notice how these sunspots move as the Sun rotates.

Figure 7
Sunspots are bright, but when viewed against the rest of the photosphere, they appear dark.

B This is a close-up photo of a large sunspot.



Surface Features

From the viewpoint that you observe the Sun, its surface appears to be a smooth layer. But the Sun's surface has many features, including sunspots, prominences, flares, and CMEs.

Sunspots Areas of the Sun's surface that appear dark because they are cooler than surrounding areas are called **sunspots.** Ever since Galileo Galilei viewed sunspots with a telescope, scientists have been studying them. Because scientists could observe the movement of individual sunspots, shown in **Figure 7,** they concluded that the Sun rotates. However, the Sun doesn't rotate as a solid body, as Earth does. It rotates faster at its equator than at its poles. Sunspots at the equator take about 25 days to complete one rotation. Near the poles, they take about 33 days.

Sunspots aren't permanent features on the Sun. They appear and disappear over a period of several days, weeks, or months. The number of sunspots increases and decreases in a fairly regular pattern called the sunspot, or solar activity, cycle. Times when many large sunspots occur are called sunspot maximums. Sunspot maximums occur about every 10 to 11 years. Periods of sunspot minimum occur in between.

Reading Check *What is a sunspot cycle?*

Prominences and Flares Sunspots are related to several features on the Sun's surface. The intense magnetic fields associated with sunspots might cause prominences, which are huge, arching columns of gas. Notice the huge prominence in **Figure 8A.** Some prominences blast material from the Sun into space at speeds ranging from 600 km/s to more than 1,000 km/s.

Gases near a sunspot sometimes brighten suddenly, shooting outward at high speed. These violent eruptions are called solar flares. You can see a solar flare in **Figure 8B.**

CMEs During a sunspot maximum, like the one that occurred in 2000, brilliant coronal mass ejections (CMEs) are emitted from the Sun. When a CME is released in the direction of Earth, it appears as a halo around the Sun.

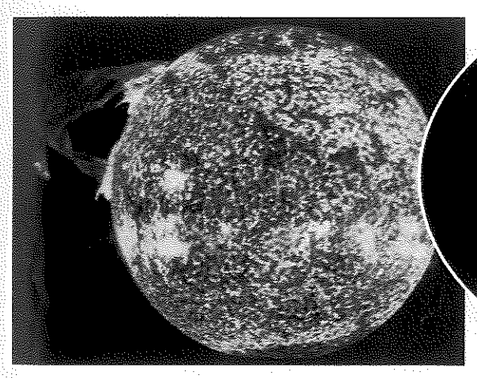
CMEs present little danger to life on Earth, but the highly charged solar wind material, along with ultraviolet light and X rays from solar flares, can reach Earth and cause disruption of radio signals. High-energy particles contained in CMEs are carried past Earth's magnetic field. This sets up electrical currents that flow toward the poles. The currents of electricity ionize gas in Earth's atmosphere. The ionized gases produce the light of an aurora, shown in **Figure 8C.** Power distribution equipment also can be affected.

SCIENCE Online

Research Visit the Glencoe Science Web site at **science.glencoe.com** for more information about sunspots, solar flares, prominences, and CMEs. Communicate to your class what you learned.

Figure 8
Features such as solar prominences and solar flares can reach hundreds of thousands of kilometers into space. CMEs are generated as magnetic fields above sunspot groups rearrange. CMEs can trigger events that produce auroras.

A Solar prominence



B Solar flare

C Aurora

Figure 9
Most stars were formed originally in large clusters containing hundreds, or even thousands, of stars.

The Sun—An Average Star

The Sun is a middle-aged star. Its absolute magnitude is typical, and it shines with a yellow light. Although the Sun is an average star, it is somewhat unusual in one way. Most stars are part of a system in which two or more stars orbit each other. When two stars orbit each other, they make up a binary system.

In some cases, astronomers can detect binary systems because one star occasionally eclipses the other. Algol, in the constellation Perseus, is an example of this. The total amount of light from the star system becomes dim and then bright again on a regular cycle.

In other cases, three stars orbit around each other, forming a triple star system. The closest star system to the Sun—the Alpha Centauri system, including Proxima Centauri—is a triple star.

Stars also can move through space together as a cluster. In a star cluster, many stars are relatively close to one another, so their gravitational attraction to each other is strong. Most star clusters are far from the solar system, and each appears as a fuzzy patch in the night sky. The double cluster in the northern part of the constellation Perseus is shown in **Figure 9.** On a dark night in autumn, you can see the double cluster with binoculars, but you can't see its individual stars. The Pleiades star cluster can be seen in the constellation of Taurus in the winter sky. On a clear, dark night, you might be able to see seven of the stars in this cluster.

Section 2 Assessment

1. What are the different layers that make up the Sun?
2. Describe the characteristics of sunspots.
3. How are sunspots, prominences, solar flares, and CMEs related? How does each affect Earth?
4. What characteristics does the Sun have in common with other stars? What characteristic makes it different from most other stars?
5. **Think Critically** Because most stars are found in multiple-star systems, what might explain why the Sun is a single star?

Skill Builder Activities

6. **Interpreting Scientific Illustrations** Use **Figure 6** to answer the questions below. **For more help, refer to the** Science Skill Handbook.
   a. Which layers make up the Sun's atmosphere?
   b. What process circulates gas in the Sun's convection zone?
7. **Communicating** Explain how the Sun generates energy. In your Science Journal, write a short paragraph hypothesizing what might happen to the Sun when it depletes its supply of hydrogen. **For more help, refer to the** Science Skill Handbook.