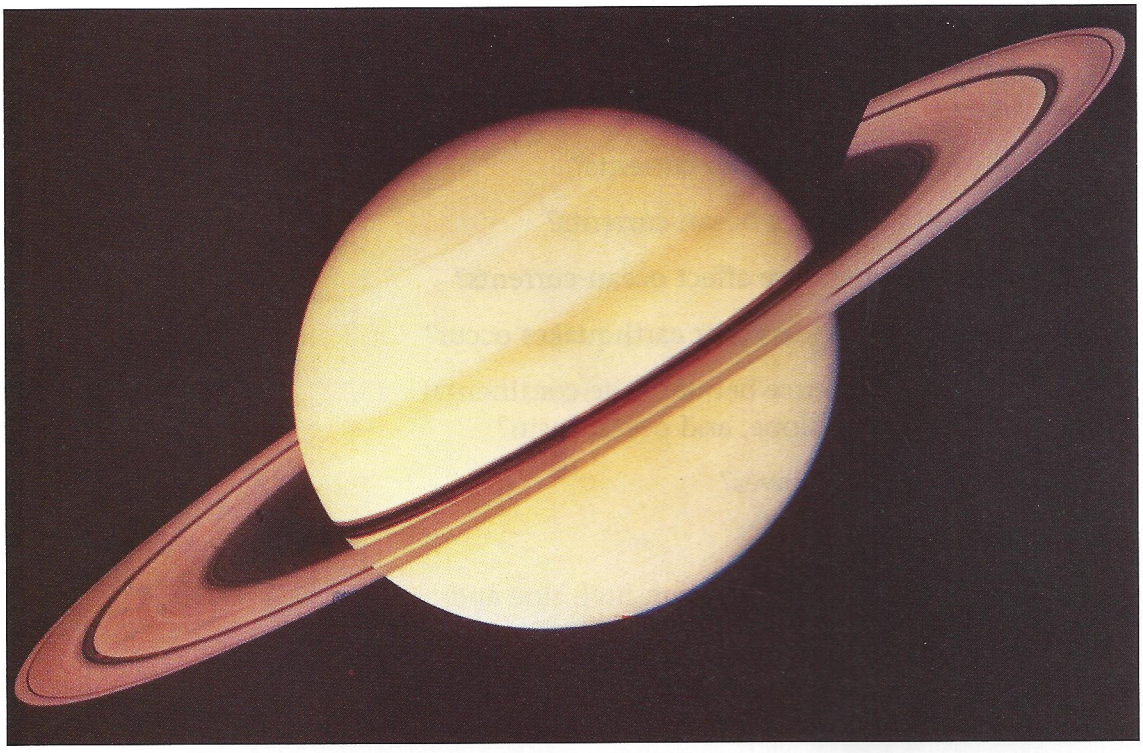
Chapter 27 Exploring Space



Saturn looks very different than Earth. There are no large areas of land and water. Thick clouds surround the planet. What else do you see in the photo that makes Saturn unusual?

Learning Objectives

- Describe the Milky Way.
- Describe the sun and its characteristics.
- Identify the nine planets in the solar system.
- Compare and contrast the inner and outer planets.
- Compare asteroids, comets, and meteoroids.
- Describe important events in the history of space exploration.
- LAB ACTIVITY: Observe the moon's phases.
- SCIENCE IN YOUR LIFE: Identify types of artificial satellites.

Words to Know

astronomy	the study of the stars, planets, and all of space
Milky Way	the galaxy that contains the Earth and the rest of the solar system
sunspot	a dark area that forms on the surface of the sun
satellite	an object that orbits a planet
asteroid	a small, rocky object that orbits the sun
comet	a ball of ice and dust that orbits the sun
meteoroid	a piece of rock or dust in space
meteor	a bright streak of light caused by a meteoroid burning up in the Earth's atmosphere
meteorite	a meteoroid that does not burn up completely in the Earth's atmosphere and falls to the Earth

27-1 The Last Frontier

Words to Know

astronomy	the study of the stars, planets, and all of space
Milky Way	the galaxy that contains the Earth and the rest of the solar system

The Study of Space

People have walked on the moon. They have sent spacecraft to several other planets. They have used telescopes to study distant galaxies. However, space is so vast that most of it will probably never be explored. The study of stars, the planets, and all of space is called **astronomy.** A scientist who studies space and all of the objects in it is an astronomer.

✓ **What do astronomers study?**

The Milky Way

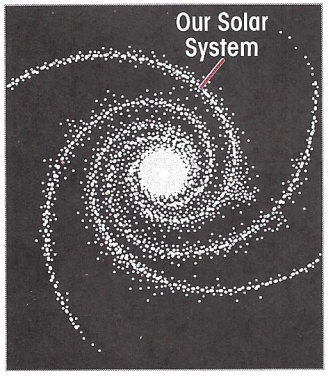


Figure 27-1 *The Earth is in the outer part of one of the Milky Way's arms.*

The Earth and the rest of the solar system are part of the **Milky Way** galaxy. Remember that a galaxy is a large group of stars that travel together through space. Astronomers group galaxies by shape. The Milky Way is a spiral galaxy. It has arms that spin around its center like a giant pinwheel. Other types of galaxies are elliptical, or oval-shaped, and irregular, which have no clear shape.

There are more than 100 billion stars in the Milky Way galaxy. There may be about 100 billion galaxies in the universe.

✓ **In which galaxy is the Earth located?**

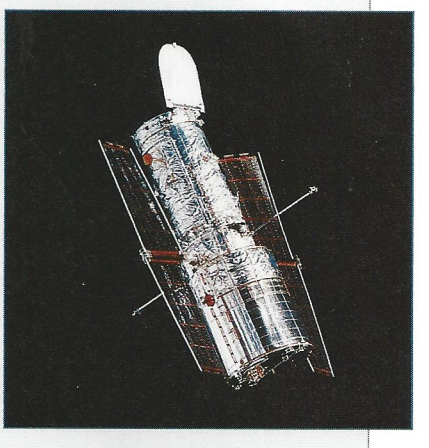
Lesson Review

1. How do astronomers group galaxies?
2. What type of galaxy is the Milky Way?
3. **CRITICAL THINKING** Why is it harder for astronomers to study their subject than it is for meteorologists to study theirs?

A Closer Look

A TELESCOPE IN SPACE

Telescopes can be very powerful. However, there are many objects in space they cannot see from the Earth because the Earth's atmosphere gets in the way. In 1990, the National Aeronautics and Space Administration (NASA) put the Hubble Space Telescope into Earth orbit. Radio signals from the Earth control the telescope. The telescope also beams its data back to the Earth by radio signals.



The Hubble Space Telescope is in orbit 380 miles (610 kilometers) above the Earth.

The Hubble has helped astronomers see objects in space in greater detail. It can detect objects a billion times dimmer than the sun as well as galaxies at the edge of the known universe. It has studied supernovae and black holes. A *supernova* is the sudden explosion of a huge star. A *black hole* is a collapsed star whose gravity is so strong that even light cannot escape from it.

Many galaxies contain huge clouds of gas and dust called *nebulae*. Some nebulae formed from stars that exploded. Others are places where new stars are forming. The Hubble has also helped us learn more about nebulae and how stars form.

CRITICAL THINKING How do you think people can repair the Hubble Space Telescope while it is in orbit?

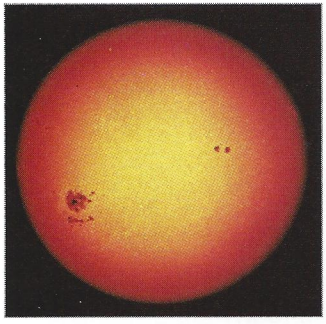
27-2 The Solar System

Words to Know

sunspot	a dark area that forms on the surface of the sun
satellite	an object that orbits a planet
asteroid	a small, rocky object that orbits the sun
comet	a ball of ice and dust that orbits the sun
meteoroid	a piece of rock or dust in space
meteor	a bright streak of light caused by a meteoroid burning up in the Earth's atmosphere
meteorite	a meteoroid that does not burn up completely in the Earth's atmosphere and falls to the Earth

The Sun

The sun is a star. Like all stars, it is a giant ball of hot, glowing gases. The sun's core is made up of hydrogen atoms that fuse together to form helium atoms. This gives off energy as light and heat.



Sunspots are dark areas on the sun's surface.

The sun is an average-sized star. It looks big to us because it is much closer to the Earth than any other star is. Even though the sun is only average in size, it is still huge. Its mass is 700 times greater than that of all the planets put together. Because it is so big, the sun's gravity is very strong. The sun's gravity keeps the nine planets and other objects of the solar system in orbit around the sun.

A **sunspot** is a dark area that forms on the sun's surface. Sunspots are cooler than the rest of the surface. They can last a few hours or several months. Some sunspots are much larger than the Earth.

✓ **What type of object is the sun?**

Planets in the Solar System

The nine planets are among the biggest objects in the solar system. Each planet orbits the sun and spins on its axis. The planet orbits are shaped like ellipses. This means that a planet is closer to the sun at some times than at other times.

Remember
An orbit is a closed, curved path. An axis is an imaginary line running through a planet from pole to pole. An ellipse is shaped like an oval.

Each planet takes a different amount of time to orbit the sun. The Earth takes $365\frac{1}{4}$ days to orbit the sun once. That time period is called one year. Pluto takes 248 Earth years to circle the sun. It takes Mercury only 88 Earth days. As it orbits, a planet also spins. A planet's day is the time it takes to make one turn on its axis.

You can see several planets without a telescope. Planets do not twinkle, like stars. They have no light of their own. They seem to shine with a steady light.

The planets nearest the sun are the *inner planets*. These small, rocky planets are Mercury, Venus, Earth, and Mars. The planets farthest from the sun are the *outer planets*. The outer planets are Jupiter, Saturn, Uranus, Neptune, and Pluto. All of the outer planets, except Pluto, are much larger than the inner planets. These larger planets are made mostly of gases. They have rings and many moons.

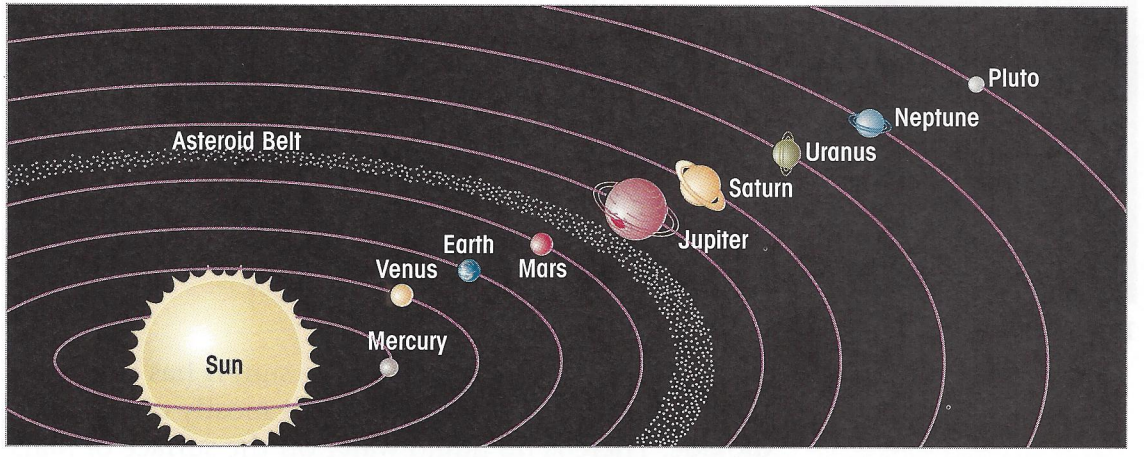
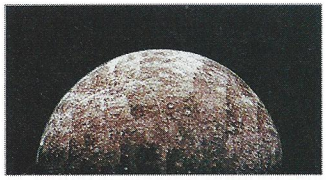


Figure 27-2 *The solar system has nine planets.*



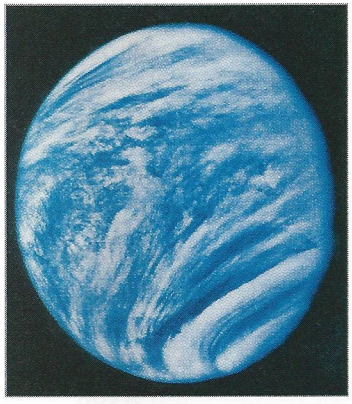
Huge dents called impact craters cover Mercury's surface.

Mercury

Mercury is the planet closest to the sun. The side of Mercury facing the sun is very hot. It has temperatures high enough to melt lead. The side facing away from the sun is freezing cold. Mercury has almost no atmosphere. Life as we know it could not exist on Mercury.

Venus

Venus is the second planet from the sun. It has a thick atmosphere made up mostly of carbon dioxide. The heavy atmosphere traps the sun's heat around Venus. This makes Venus very hot. Venus is even hotter than Mercury, though it is farther from the sun.



Thick clouds hide the surface of Venus.

The Earth's moon

Earth

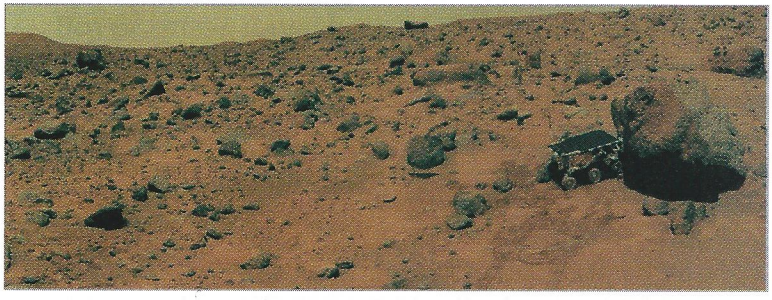
The Earth is the third planet from the sun. It is about the same size as Venus. The Earth is the only planet that is mostly covered with water. Its atmosphere is mainly nitrogen and oxygen. So far, the Earth is the only planet in the solar system known to have life.

A **satellite** is an object that orbits a planet. Natural satellites are called moons. Our moon makes one orbit around the Earth every $27\frac{1}{3}$ days.

Mars

Mars is the fourth planet from the sun. It has two tiny moons. The atmosphere is made up mostly of carbon dioxide. There is no liquid water on the surface of Mars and almost no water vapor in its atmosphere.

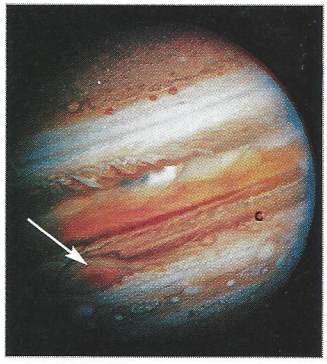
Mars is colder than the coldest places on Earth. The soil on the surface of Mars is reddish. That is why Mars is often called the "red planet."



Spacecraft have landed on parts of Mars and explored it.

Jupiter

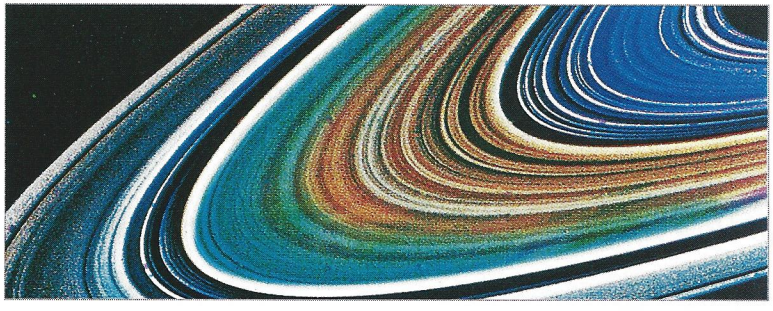
Jupiter, the fifth planet from the sun, is the largest planet. Its diameter is about 11 times that of the Earth's. Jupiter has a rocky core. But most of the planet is a large ball of ice and liquid wrapped in gas clouds. Jupiter has 16 moons and a thin set of rings. There are violent electrical storms in Jupiter's atmosphere. Jupiter's Great Red Spot is a large hurricane-like storm.



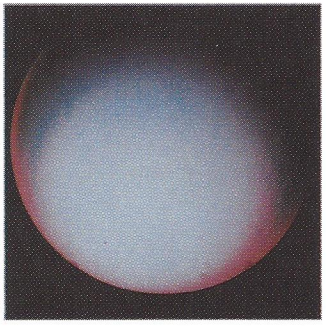
Jupiter's Great Red Spot (arrow) is a storm larger than the Earth.

Saturn

Saturn is the sixth planet from the sun. Like Jupiter, Saturn is a huge planet with no solid surface. It has a rocky core surrounded by liquid hydrogen and helium and thick clouds. Saturn has seven main rings. The rings are made of particles of ice and dust. Jupiter, Uranus, and Neptune also have rings, but they are much thinner. Saturn has 18 known moons.



Saturn's rings



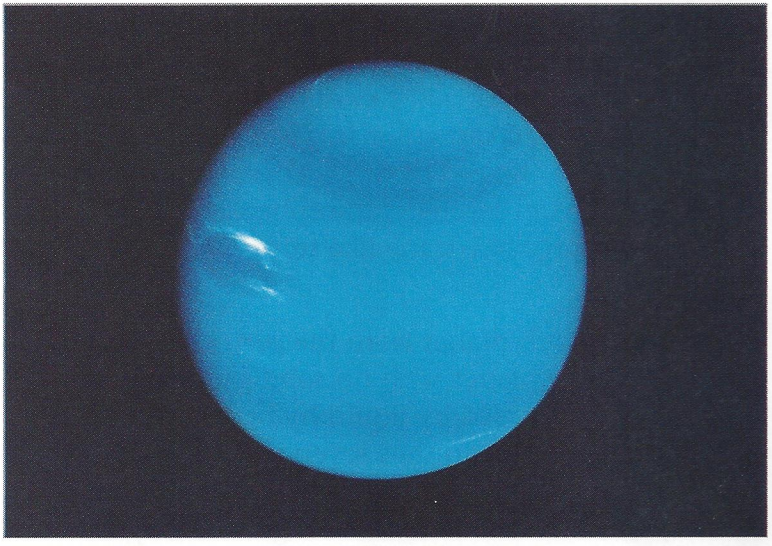
Uranus has hydrogen and methane in its atmosphere.

Uranus

Uranus is the seventh planet from the sun. It is made up of ice and liquid hydrogen around a solid core. Uranus is unusual because its axis runs sideways rather than up and down. As a result, Uranus seems to roll around on its side in orbit. Uranus has 18 known moons and a set of rings.

Neptune

Neptune is usually the eighth planet from the sun. But sometimes its path crosses the path of Pluto. Then, for a few years, it becomes the ninth planet. Neptune's thick gas clouds surround a liquid layer and a rocky, icy core. The planet has eight known moons and several rings.



Voyager 2 *took the first close-up photos of Neptune in 1989.*

Pluto is so far away that even powerful telescopes show little about its surface and its moon.

Pluto

Pluto is usually the planet farthest from the sun. Its surface is icy, and it is always dark there. Some astronomers think that Pluto may be an escaped moon of Neptune. Pluto has one moon.

✓ **How are the inner and outer planets different?**

Asteroids, Comets, and Meteoroids

An **asteroid** is a small, rocky object that orbits the sun. Most asteroids are found between Mars and Jupiter. Asteroids are rich in minerals that people may mine someday. Astronomers are not sure where asteroids came from. They might be the remains of a planet that broke up. Asteroids also may be left over from when the solar system formed.

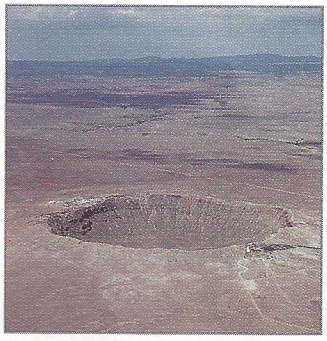
A **comet** is a ball of ice and dust that orbits the sun. When comets pass near the sun, some of the ice evaporates. The gas streams away from the sun, forming a glowing tail. Most comets are only about 10 miles (16 kilometers) across. However, their tails can extend for 100 million miles (160 million kilometers).

A **meteoroid** is a piece of rock or dust in space. Most meteoroids come from asteroids or comets. When a meteoroid enters the Earth's atmosphere, friction makes it burn and produce a bright streak of light called a **meteor.**

A large meteoroid may not burn up completely as it passes through the Earth's atmosphere. The part of the meteoroid that does not burn and falls to the Earth is called a **meteorite.** A few hundred meteorites fall to the Earth each year. Many are the size of baseballs. Most meteorites are heavy for their size because they contain a lot of iron.

✓ **How are asteroids different from comets?**

Comets are balls of gas and dust.



A huge meteorite made this hole, called Meteor Crater, in Arizona thousands of years ago.

Lesson Review

1. What is the sun made of?
2. Which are the solar system's inner planets? Which are its outer planets?
3. **CRITICAL THINKING** What do asteroids, comets, and meteoroids all have in common?

27-3 Space Exploration

Early Space Flights

The age of space exploration began in 1957. That is when the Soviet Union (today's Russia and many of its surrounding countries) launched *Sputnik 1*, the first artificial satellite. Over the next 12 years, the United States and the Soviet Union sent space probes to the moon, Venus, and Mars. A space probe is a spacecraft sent into space without people to gather information. These two countries also raced to put the first person on the moon.

In 1961, Alan Shepard became the first American to fly in space. This was just a few weeks after the Soviet Union sent Yuri Gagarin into space. In 1962, John Glenn became the first American to orbit the Earth. Several *Gemini* missions followed. *Gemini* astronauts tested equipment and techniques needed to reach the moon. This included walking in space, joining spacecraft in space, and testing the effects of space on people.

NASA's *Apollo* program began in the late 1960s. In 1968, astronauts flew around the moon for the first time. On July 20, 1969, *Apollo* astronauts landed on the moon. They photographed the surface, did experiments, set up instruments, and collected moon rocks.

✓ **Which two countries competed in space in the 1960s?**

Space Firsts
1957: Soviet Union's *Sputnik 1* is first satellite to orbit the Earth.
1958: *Explorer 1* is first U.S. satellite.
1961: Soviet Union's Yuri Gagarin is first person in orbit.
1962: John Glenn is first American in orbit.
1969: Neil Armstrong from *Apollo II* is first person on the moon.
1973: *Pioneer 10* probe flies by Jupiter—first close-up pictures of an outer planet.
1976: *Viking 1* and *Viking 2* send photos from the surface of Mars.
1979: *Pioneer 11* transmits first photos of Saturn and its rings.
1981: First space shuttle flight takes place.
1983: Sally Ride is first American woman in space.
1986: *Voyager 1* transmits first pictures of Uranus and its moons.
1997: *Mars Pathfinder* sends images and data from Mars.

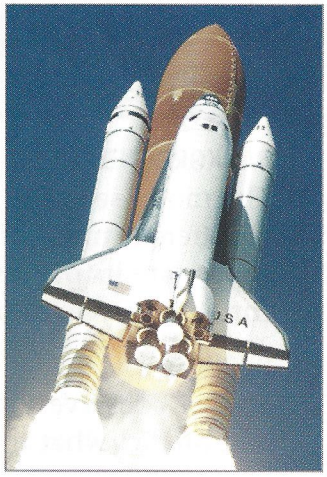
Exploring Space Today

In the 1980s, the space shuttle became the main spacecraft of the American space program. It now carries satellites and probes into space and returns. It is the first reusable spacecraft.

The shuttle does not leave the Earth's orbit. It lifts off like a rocket, then glides back to the Earth like an airplane. Shuttle crews conduct experiments. The shuttle is also being used to help build the International Space Station.

Today, several countries launch satellites and space probes. These include France, Germany, Russia, Japan, China, and India. NASA is hoping to send astronauts to Mars in the not too distant future.

How is the space shuttle different from past spacecraft?



The space shuttle is the first reusable spacecraft.

Lesson Review

1. What was the purpose of the *Gemini* and *Apollo* programs?
2. What are two future NASA space projects?
3. **CRITICAL THINKING** What big space project do you think people should try in the future? Explain your answer.

Modern Leaders In Science

MAE JEMISON

On September 12, 1992, Dr. Mae Jemison became the first African-American woman to travel in space. Dr. Jemison is a medical doctor. During her eight-day flight aboard the space shuttle *Endeavor*, she ran experiments on motion sickness. She also studied bone cell growth. In 1993, Dr. Jemison left NASA to work in health care and education.

CRITICAL THINKING Why is it important to study the effects of space on the human body?

Dr. Mae Jemison was the first African-American woman in space.

LAB ACTIVITY
Observing the Phases of the Moon

BACKGROUND
The moon seems to have a different shape at different times of the month. These shapes are its phases. The moon goes through a cycle of phases every $29\frac{1}{2}$ days.

Phases of the Moon	
New Moon (moon not visible)	
Waxing Crescent	
First Quarter	
Waxing Gibbous	
Full Moon	
Waning Gibbous	
Last Quarter	
Waning Crescent	

PURPOSE
You will observe some of the moon's phases and predict what the next phase will be.

MATERIALS
paper, pencil

WHAT TO DO
1. Draw seven boxes side by side to represent a week on a calendar.
2. Observe the moon each night for seven days. Draw its shape each night on your calendar.
3. Compare each shape on your calendar with the pictures of the phases of the moon in the chart above. Label the moon phases for each drawing on your calendar.
4. Use your observations to predict the next phase of the moon after the last one on your calendar. Keep in mind how many phases there are, the order of the phases, and how long each phase lasts.

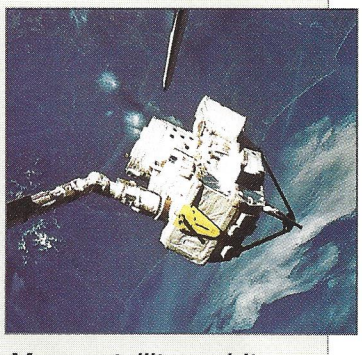
DRAW CONCLUSIONS
- How many of the phases did you observe?
- About how long does each phase last?
- What was the last phase you observed during this period? Predict which phase will come next and why.

SCIENCE IN YOUR LIFE
Artificial Satellites

When you think of space travel, you might think of astronauts landing on the moon. You might also think of space probes flying to Jupiter or Saturn. But the most common type of space traveler in our solar system is the artificial satellite.

There are more than 2,000 artificial satellites orbiting the Earth. They do many jobs that affect your life. Communications satellites broadcast TV shows. They connect long-distance phone calls. Weather satellites help meteorologists forecast the weather. Navigation satellites allow airplanes and ships to track their movements. Earth observation satellites locate minerals and other resources. They also produce data that scientists use to study the effects of pollution on forests and water.

Satellites orbit other bodies in space besides the Earth. Satellites have circled the moon, Mercury, Venus, Mars, the sun, and comets. Satellites have taken photos and sent back data. These data have helped us learn more about other bodies in space.



Many satellites orbit the Earth.

Name of Satellite	Purpose	Went Into Orbit
Tiros 1	First successful weather satellite	1960
Telstar 1	Sent first TV pictures across Atlantic	1962
MAGSAT	Mapped the Earth's magnetic field	1979
LAGEOS 1	Measured movement in the Earth's crust	1976
SOHO	Orbited and studied the sun	1995

The chart to the right shows a few of the things that satellites have done during the past few decades. Answer the questions, using the chart.

1. What was the name of the first successful weather satellite?
2. Which satellite orbited and studied the sun?
3. Which two satellites studied the Earth?

Critical Thinking

Why are satellites important to scientists?

Chapter 27 Review

Summary

The solar system contains the sun, planets, moon, and other objects. Many countries have sent spacecraft to explore objects in the solar system.

Lesson 27.1

The Earth is part of a galaxy called the Milky Way. There may be more than 100 billion galaxies in the universe.

Lesson 27.2

The inner planets of our solar system are small and rocky. Most of the outer planets are large balls of liquid and gas. The solar system also contains asteroids, comets, and meteoroids.

Lesson 27.3

The United States landed the first person on the moon. Many countries have sent probes and satellites into space. More missions are planned.

Vocabulary Review

Write *true* or *false* for each sentence. If the sentence is false, replace the underlined term to make the sentence true.

1. The Earth is part of the Milky Way galaxy.
2. An asteroid is a piece of rock or dust in space.
3. A comet is a piece of rock from space that has fallen to the Earth.
4. Geology is the study of the stars, planets, and all of space.
5. A sunspot is a dark area on the sun's surface.
6. A ball of ice and dust orbiting the sun is a meteor.
7. A meteoroid burning up in the Earth's atmosphere causes a streak of light known as a meteorite.

Chapter Quiz

Write your answers on a separate sheet of paper.

1. In what galaxy are the sun and our solar system found?
2. What is the sun, and what is it made of?
3. What kinds of bodies in space make up the solar system?
4. What are the solar system's nine planets in order, beginning from closest to the sun?
5. Which planets are fairly small and solid?
6. Which planets have rings?
7. What are two theories that scientists have about how asteroids were formed?
8. What is the tail of a comet made of?
9. What happens to a meteoroid that enters the atmosphere?
10. What are three important events in the history of space exploration?

Test Tip
To prepare for a test, find key words in the chapter. Be sure you know what they mean.

Research Project

Research NASA's plans to send astronauts to Mars someday. Work with a small group. Choose one part of the story to tell, such as what Mars is like, difficulties in getting to Mars, the type of spacecraft that might go, or when the project will get started. Write a report on what you learn. Make a poster showing some part of the journey.