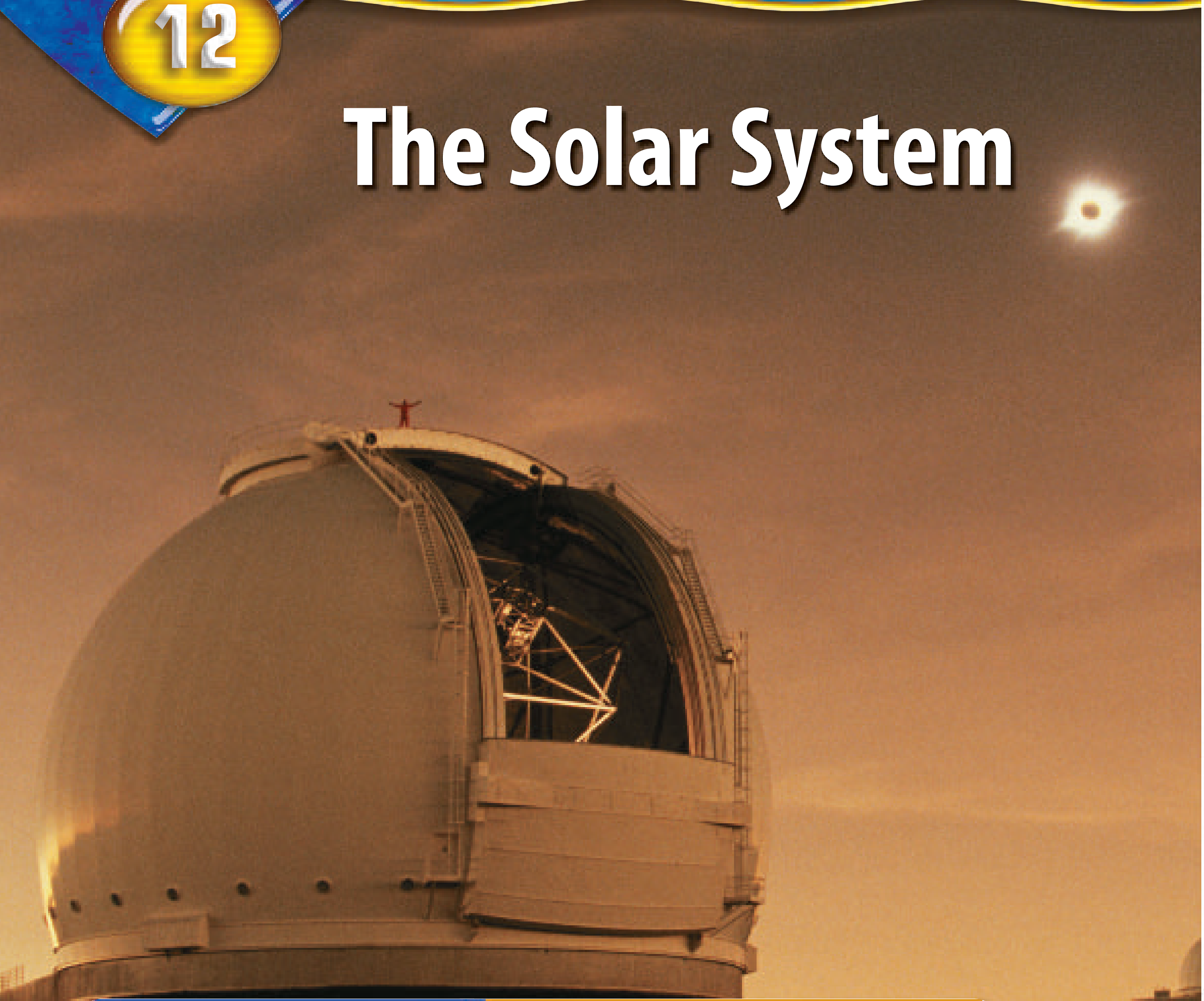
chapter 12

The Solar System



chapter preview

How is space explored?

You've seen the Sun and the Moon. You also might have observed some of the planets. But to get a really good look at the solar system from Earth, telescopes are needed. The optical telescope at the Keck Observatory in Hawaii allows scientists a close-up view.

Science Journal If you could command the Keck telescope, what would you view? Describe what you would see.

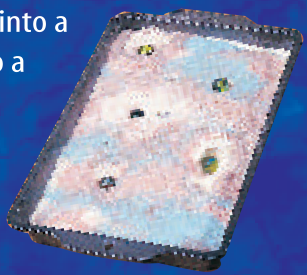
Roger Ressmeyer/CORBIS

Start-Up Activities

Launch LAB

Model Crater Formation

Some objects in the solar system have many craters. The Moon is covered with them. The planet Mercury also has a cratered landscape. Even Earth has some craters. All of these craters formed when rocks from space hit the surface of the planet or moon. In this lab, you'll explore crater formation.



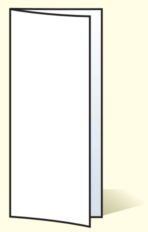
1. Place white flour into a metal cake pan to a depth of 3 cm.
2. Cover the flour with 1 cm of colored powdered drink mix or different colors of gelatin powder.
3. From different heights, ranging from 10 cm to 25 cm, drop various-sized marbles into the pan.
4. **Think Critically** Make drawings in your Science Journal that show what happened to the surface of the powder when marbles were dropped from different heights.

Science Online — Preview this chapter's content and activities at blue.msscience.com

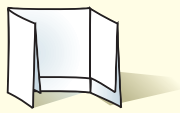
FOLDABLES™ Study Organizer

The Solar System Make the following Foldable to help you identify what you already know, what you want to know, and what you learned about the solar system.

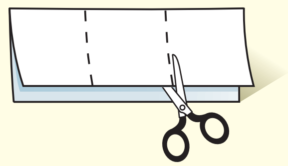
STEP 1 **Fold** a vertical sheet of paper from side to side. Make the front edge about 1.25 cm shorter than the back edge.



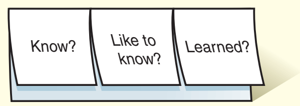
STEP 2 **Turn** lengthwise and **fold** into thirds.



STEP 3 **Unfold and cut** only the top layer along both folds to make three tabs.



STEP 4 **Label** each tab.



Identify Questions Before you read the chapter, write what you already know about the solar system under the left tab of your Foldable. Write questions about what you'd like to know under the center tab. After you read the chapter, list what you learned under the right tab.

Roger Ressmeyer/CORBIS, (inset)Matt Meadows

section 1

The Solar System

as you read

What You'll Learn

- **Compare** models of the solar system.
- **Explain** that gravity holds planets in orbits around the Sun.

Why It's Important

New technology has come from exploring the solar system.

Review Vocabulary

system: a portion of the universe and all of its components, processes, and interactions

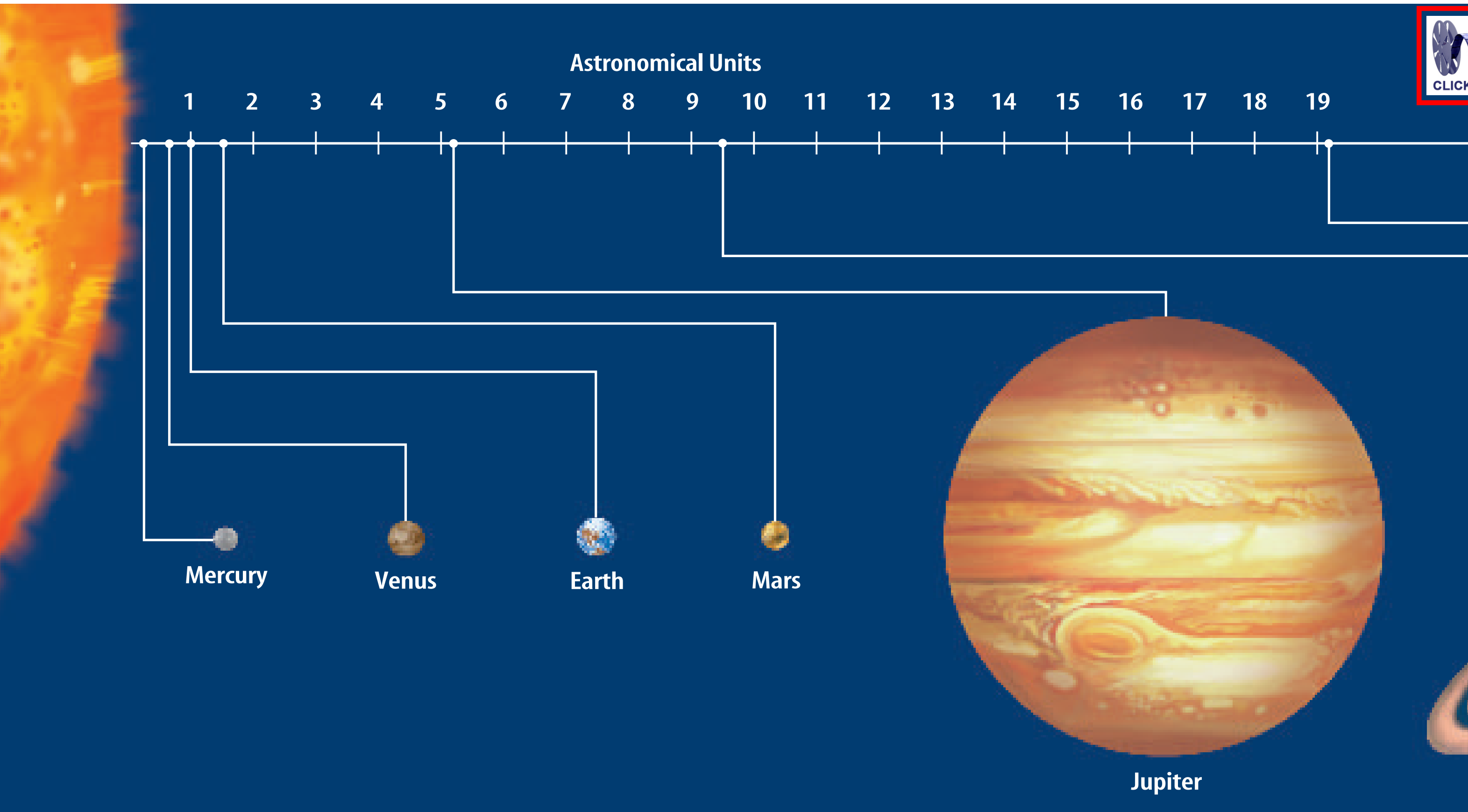
New Vocabulary

- solar system

Ideas About the Solar System

People have been looking at the night sky for thousands of years. Early observers noted the changing positions of the planets and developed ideas about the solar system based on their observations and beliefs. Today, people know that objects in the solar system orbit the Sun. People also know that the Sun's gravity holds the solar system together, just as Earth's gravity holds the Moon in its orbit around Earth. This wasn't always accepted as fact.

Earth-Centered Model Many early Greek scientists thought the planets, the Sun, and the Moon were fixed in separate spheres that rotated around Earth. The stars were thought to be in another sphere that also rotated around Earth. This is called the Earth-centered model of the solar system. It included Earth, the Moon, the Sun, five planets—Mercury, Venus, Mars, Jupiter, and Saturn—and the sphere of stars.



Sun-Centered Model People believed the idea of an Earth-centered solar system for centuries. Then in 1543, Nicholas Copernicus published a different view. Copernicus stated that the Moon revolved around Earth and that Earth and the other planets revolved around the Sun. He also stated that the daily movement of the planets and the stars was caused by Earth's rotation. This is the Sun-centered model of the solar system.

Using his telescope, Galileo Galilei observed that Venus went through a full cycle of phases like the Moon's. He also observed that the apparent diameter of Venus was smallest when the phase was near full. This only could be explained if Venus were orbiting the Sun. Galileo concluded that the Sun is the center of the solar system.

Modern View of the Solar System We now know that the **solar system** is made up of nine planets, including Earth, and many smaller objects that orbit the Sun. The nine planets and the Sun are shown in **Figure 1.** Notice how small Earth is compared with some of the other planets and the Sun.

The solar system includes a huge volume of space that stretches in all directions from the Sun. Because the Sun contains 99.86 percent of the mass of the solar system, its gravity is immense. The Sun's gravity holds the planets and other objects in the solar system in their orbits.

Science Online

Topic: Solar System
Visit blue.msscience.com for Web links to information about the solar system.

Activity Make a list of objects in the solar system. Write a one-sentence description of each object on your list.

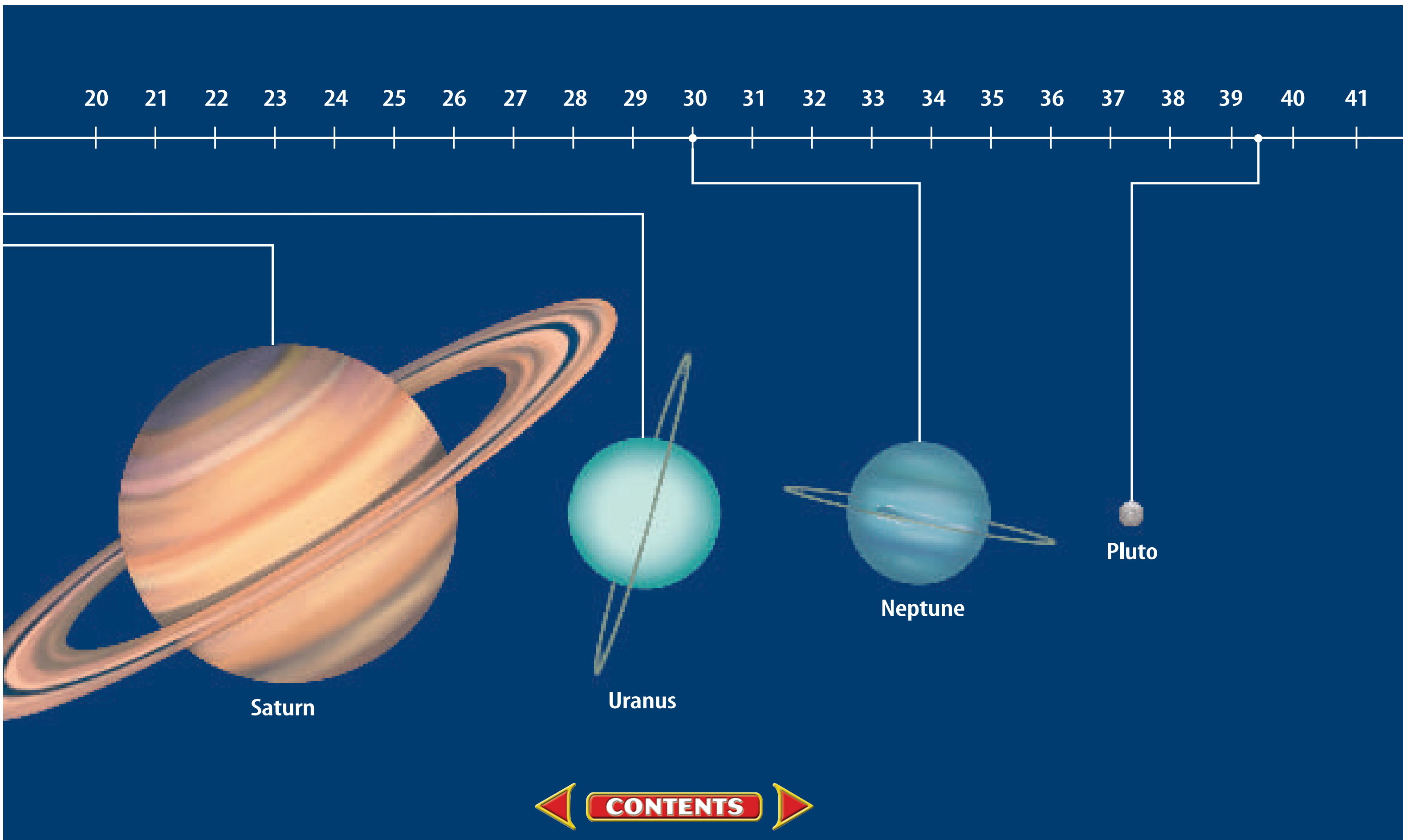


Figure 1 Each of the nine planets in the solar system is unique. The distances between the planets and the Sun are shown on the scale. One astronomical unit (AU) is the average distance between Earth and the Sun.

INTEGRATE Physics

Rotational Motion You might have noticed that when a twirling ice skater pulls in her arms, she spins faster. The same thing occurs when a cloud of gas, ice, and dust in a nebula contracts. As mass moves toward the center of the cloud, the cloud rotates faster.

How the Solar System Formed

Scientists hypothesize that the solar system formed from part of a nebula of gas, ice, and dust, like the one shown in **Figure 2.** Follow the steps shown in **Figures 3A** through **3D** to learn how this might have happened. A nearby star might have exploded or nearby O- or B-type stars formed, and the shock waves produced by these events could have caused the cloud to start contracting. As it contracted, the nebula likely fragmented into smaller and smaller pieces. The density in the cloud fragments became greater, and the attraction of gravity pulled more gas and dust toward several centers of contraction. This in turn caused them to flatten into disks with dense centers. As the cloud fragments continued to contract, they began to rotate faster and faster.

As each cloud fragment contracted, its temperature increased. Eventually, the temperature in the core of one of these cloud fragments reached about 10 million degrees Celsius and nuclear fusion began. A star was born—the beginning of the Sun.

It is unlikely that the Sun formed alone. A cluster of stars like the Sun, or smaller, likely formed from fragments of the original cloud. The Sun probably escaped from this cluster and has since revolved around the galaxy about 20 times.

Reading Check ***What is nuclear fusion?***

Planet Formation Not all of the nearby gas, ice, and dust was drawn into the core of the cloud fragment. The matter that did not get pulled into the center collided and stuck together to form the planets and asteroids. Close to the Sun, the temperature was hot, and the easily vaporized elements could not condense into solids. This is why lighter elements are scarcer in the planets near the Sun than in planets farther out in the solar system.

The inner planets of the solar system—Mercury, Venus, Earth, and Mars—are small, rocky planets with iron cores. The outer planets are Jupiter, Saturn, Uranus, Neptune, and Pluto. Pluto, a small planet, is the only outer planet made mostly of rock and ice. The other outer planets are much larger and are made mostly of lighter substances such as hydrogen, helium, methane, and ammonia.

Figure 2 Systems of planets, such as the solar system, form in areas of space like this, called a nebula.

European Southern Observatory/Photo Researchers

VISUALIZING THE SOLAR SYSTEM'S FORMATION

Figure 3

Through careful observations, astronomers have found clues that help explain how the solar system may have formed. A More than 4.6 billion years ago, the solar system was a cloud fragment of gas, ice, and dust. B Gradually, this cloud fragment contracted into a large, tightly packed, spinning disk. The disk's center was so hot and dense that nuclear fusion reactions began to occur, and the Sun was born. C Eventually, the rest of the material in the disk cooled enough to clump into scattered solids. D Finally, these clumps collided and combined to become the nine planets that make up the solar system today.

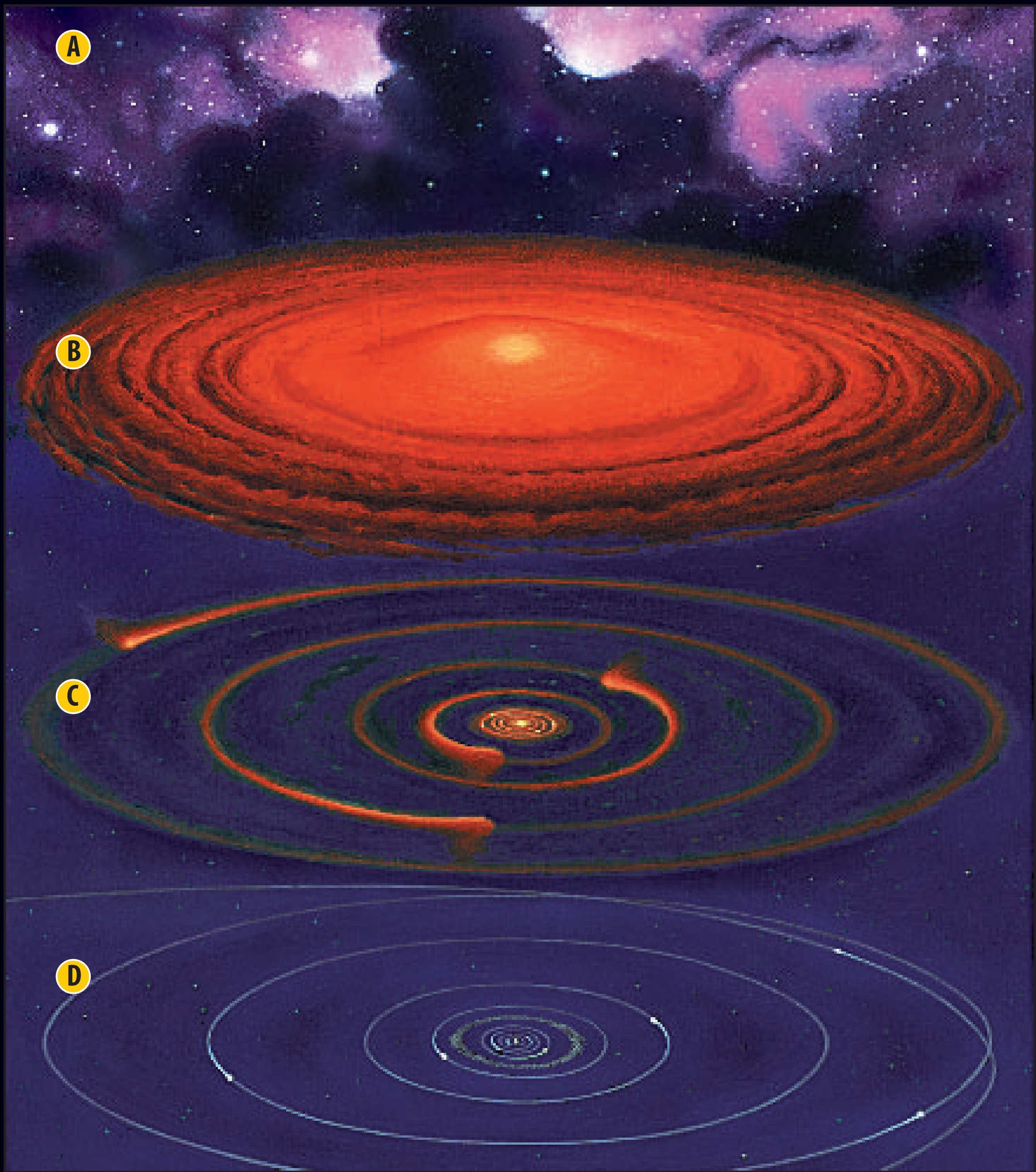
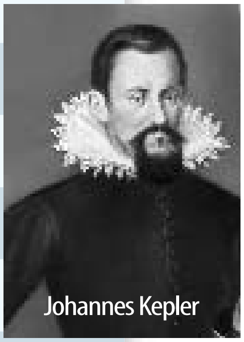


Table 1 Average Orbital Speed

Planet	Average Orbital Speed (km/s)
Mercury	48
Venus	35
Earth	30
Mars	24
Jupiter	13
Saturn	9.7
Uranus	6.8
Neptune	5.4
Pluto	4.7


Johannes Kepler

Motions of the Planets

INTEGRATE Physics

When Nicholas Copernicus developed his Sun-centered model of the solar system, he thought that the planets orbited the Sun in circles. In the early 1600s, German mathematician Johannes Kepler began studying the orbits of the planets. He discovered that the shapes of the orbits are not circular. They are oval shaped, or elliptical. His calculations further showed that the Sun is not at the center of the orbits but is slightly offset.

Kepler also discovered that the planets travel at different speeds in their orbits around the Sun, as shown in **Table 1.** You can see that the planets closer to the Sun travel faster than planets farther away from the Sun. Because of their slower speeds and the longer distances they must travel, the outer planets take much longer to orbit the Sun than the inner planets do.

Copernicus's ideas, considered radical at the time, led to the birth of modern astronomy. Early scientists didn't have technology such as space probes to learn about the planets. Nevertheless, they developed theories about the solar system that still are used today.

section 1 review

Summary

Ideas About the Solar System

- The planets in the solar system revolve around the Sun.
- The Sun's immense gravity holds the planets in their orbits.

How the Solar System Formed

- The solar system formed from a piece of a nebula of gas, ice, and dust.
- As the piece of nebula contracted, nuclear fusion began at its center and the Sun was born.

Motion of the Planets

- The planets' orbits are elliptical.
- Planets that are closer to the Sun revolve faster than those that are farther away from the Sun.

Self Check

1. **Describe** the Sun-centered model of the solar system. What holds the solar system together?
2. **Explain** how the planets in the solar system formed.
3. **Infer** why life is unlikely on the outer planets in spite of the presence of water, methane, and ammonia—materials needed for life to develop.
4. **List** two reasons why the outer planets take longer to orbit the Sun than the inner planets do.
5. **Think Critically** Would a year on the planet Neptune be longer or shorter than an earth year? Explain.

Applying Skills

6. **Concept Map** Make a concept map that compares and contrasts the Earth-centered model with the Sun-centered model of the solar system.

Science Online blue.msscience.com/self_check_quiz

CONTENTS

LAB

Planetary Orbits

Planets travel around the Sun along paths called orbits. As you construct a model of a planetary orbit, you will observe that the shape of planetary orbits is an ellipse.

Real-World Question

How can you model planetary orbits?

Goals

- **Model** planetary orbits.
- **Calculate** the eccentricity of ellipses.

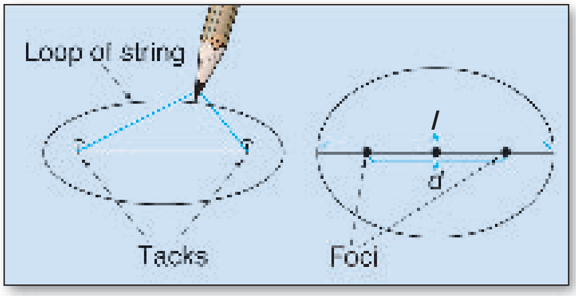
Materials

thumbtacks or pins (2)	metric ruler
cardboard (23 cm × 30 cm)	string (25 cm)
paper (21.5 cm × 28 cm)	pencil

Safety Precautions

Procedure

1. Place a blank sheet of paper on top of the cardboard and insert two thumbtacks or pins about 3 cm apart.
2. Tie the string into a circle with a circumference of 15 cm to 20 cm. Loop the string around the thumbtacks. With someone holding the tacks or pins, place your pencil inside the loop and pull it tight.
3. Moving the pencil around the tacks and keeping the string tight, mark a line until you have completed a smooth, closed curve.
4. Repeat steps 1 through 3 several times. First, vary the distance between the tacks, then vary the length of the string. However, change only one of these each time. Make a data table to record the changes in the sizes and shapes of the ellipses.
5. Orbits usually are described in terms of eccentricity, *e,* which is determined by dividing the distance, *d*, between the foci (fixed points—here, the tacks) by the length, *l*, of the major axis. See the diagram below.



6. **Calculate** and record the eccentricity of the ellipses that you constructed.
7. **Research** the eccentricities of planetary orbits. Construct an ellipse with the same eccentricity as Earth's orbit.

Conclude and Apply

1. **Analyze** the effect that a change in the length of the string or the distance between the tacks has on the shape of the ellipse.
2. **Hypothesize** what must be done to the string or placement of tacks to decrease the eccentricity of a constructed ellipse.
3. **Describe** the shape of Earth's orbit. Where is the Sun located within the orbit?

Communicating Your Data

Compare your results with those of other students. **For more help, refer to the Science Skill Handbook.**

section 2

The Inner Planets

as you read

What You'll Learn

- **List** the inner planets in order from the Sun.
- **Describe** each inner planet.
- **Compare and contrast** Venus and Earth.

Why It's Important

The planet that you live on is uniquely capable of sustaining life.

Review Vocabulary
space probe: an instrument that is sent to space to gather information and send it back to Earth

New Vocabulary
- Mercury
- Venus
- Earth
- Mars

Inner Planets

Today, people know more about the solar system than ever before. Better telescopes allow astronomers to observe the planets from Earth and space. In addition, space probes have explored much of the solar system. Prepare to take a tour of the solar system through the eyes of some space probes.

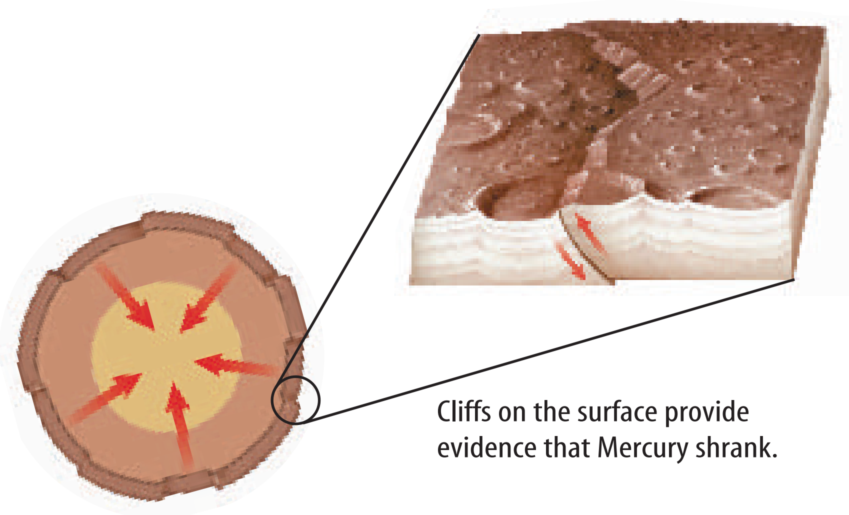
Mercury

The closest planet to the Sun is **Mercury.** The first American spacecraft mission to Mercury was in 1974–1975 by *Mariner 10.* The spacecraft flew by the planet and sent pictures back to Earth. *Mariner 10* photographed only 45 percent of Mercury's surface, so scientists don't know what the other 55 percent looks like. What they do know is that the surface of Mercury has many craters and looks much like Earth's Moon. It also has cliffs as high as 3 km on its surface. These cliffs might have formed at a time when Mercury shrank in diameter, as seen in **Figure 4.**

Why would Mercury have shrunk? *Mariner 10* detected a weak magnetic field around Mercury. This indicates that the planet has an iron core. Some scientists hypothesize that Mercury's crust solidified while the iron core was still hot and molten. As the core started to solidify, it contracted. The cliffs resulted from breaks in the crust caused by this contraction.

Figure 4 Large cliffs on Mercury might have formed when the crust of the planet broke as the planet contracted.

Mercury has many craters.

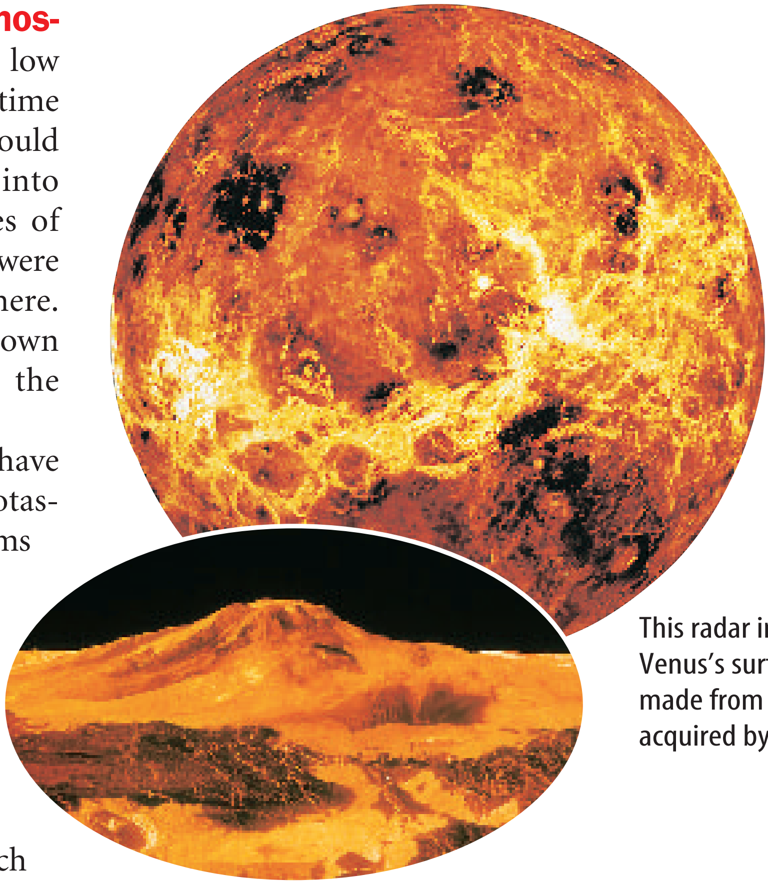


Cliffs on the surface provide evidence that Mercury shrank.

USGS/Science Photo Library/Photo Researchers

Does Mercury have an atmosphere? Because of Mercury's low gravitational pull and high daytime temperatures, most gases that could form an atmosphere escape into space. *Mariner 10* found traces of hydrogen and helium gas that were first thought to be an atmosphere. However, these gases are now known to be temporarily taken from the solar wind.

Earth-based observations have found traces of sodium and potassium around Mercury. These atoms probably come from rocks in the planet's crust. Therefore, Mercury has no true atmosphere. This lack of atmosphere and its nearness to the Sun cause Mercury to have great extremes in temperature. Mercury's temperature can reach 425°C during the day, and it can drop to −170°C at night.



This radar image of Venus's surface was made from data acquired by *Magellan.*

Maat Mons is the highest volcano on Venus. Lava flows extend for hundreds of kilometers across the plains.

Figure 5 Venus is the second planet from the Sun.

Venus

The second planet from the Sun is **Venus**, shown in **Figure 5.** Venus is sometimes called Earth's twin because its size and mass are similar to Earth's. In 1962, *Mariner 2* flew past Venus and sent back information about Venus's atmosphere and rotation. The former Soviet Union landed the first probe on the surface of Venus in 1970. *Venera 7,* however, stopped working in less than an hour because of the high temperature and pressure. Additional *Venera* probes photographed and mapped the surface of Venus. Between 1990 and 1994, the U.S. *Magellan* probe used its radar to make the most detailed maps yet of Venus's surface. It collected radar images of 98 percent of Venus's surface. Notice the huge volcano in **Figure 5.**

Clouds on Venus are so dense that only a small percentage of the sunlight that strikes the top of the clouds reaches the planet's surface. The sunlight that does get through warms Venus's surface, which then gives off heat to the atmosphere. Much of this heat is absorbed by carbon dioxide gas in Venus's atmosphere. This causes a greenhouse effect similar to, but more intense than, Earth's greenhouse effect. Due to this intense greenhouse effect, the temperature on the surface of Venus is between 450°C and 475°C.

Figure 6 More than 70 percent of Earth's surface is covered by liquid water.
Explain *how Earth is unique.*

Earth

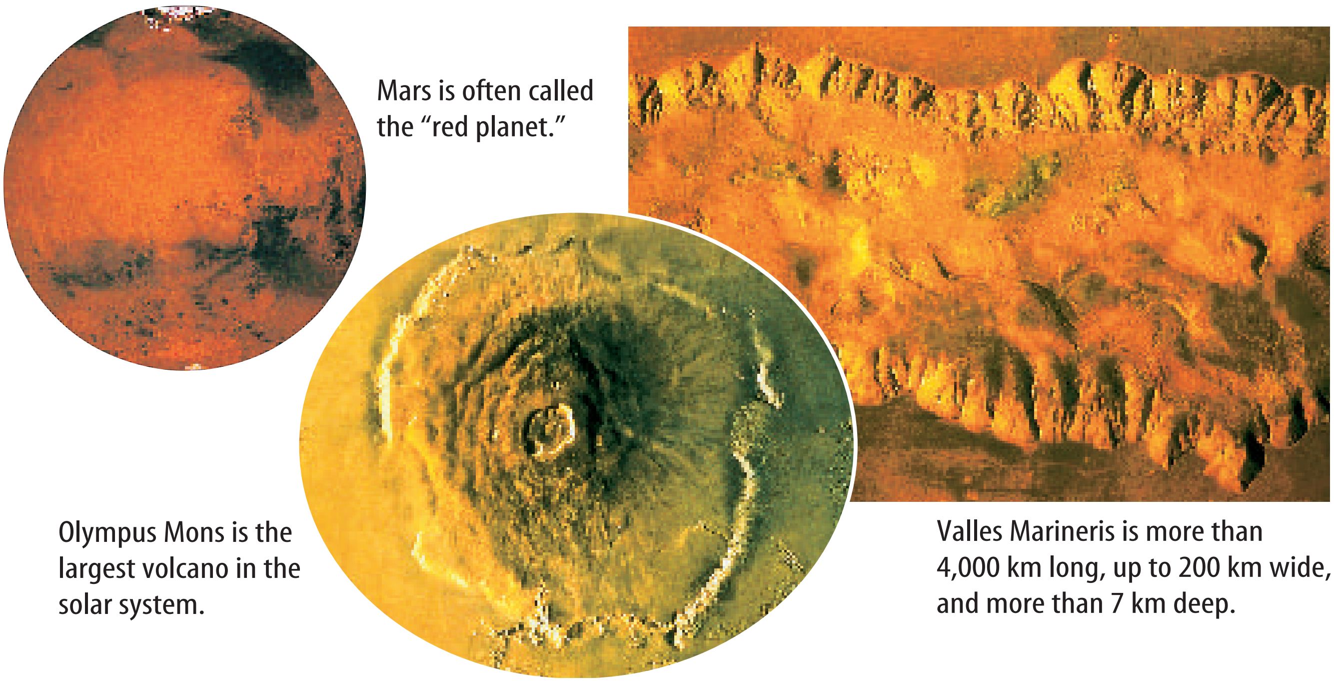
Figure 6 shows **Earth,** the third planet from the Sun. The average distance from Earth to the Sun is 150 million km, or one astronomical unit (AU). Unlike other planets, Earth has abundant liquid water and supports life. Earth's atmosphere causes most meteors to burn up before they reach the surface, and it protects life-forms from the effects of the Sun's intense radiation.

Mars

Look at **Figure 7.** Can you guess why **Mars,** the fourth planet from the Sun, is called the red planet? Iron oxide in soil on its surface gives it a reddish color. Other features visible from Earth are Mars's polar ice caps and changes in the coloring of the planet's surface. The ice caps are made of frozen water covered by a layer of frozen carbon dioxide.

Most of the information scientists have about Mars came from *Mariner 9,* the *Viking* probes, *Mars Pathfinder, Mars Global Surveyor,* and *Mars Odyssey. Mariner 9* orbited Mars in 1971 and 1972. It revealed long channels on the planet that might have been carved by flowing water. *Mariner 9* also discovered the largest volcano in the solar system, Olympus Mons, shown in **Figure 7.** Olympus Mons is probably extinct. Large rift valleys that formed in the Martian crust also were discovered. One such valley, Valles Marineris, is shown in **Figure 7.**

Figure 7 Many features on Mars are similar to those on Earth.



Mars is often called the "red planet."

Olympus Mons is the largest volcano in the solar system.

Valles Marineris is more than 4,000 km long, up to 200 km wide, and more than 7 km deep.

(t)Science Photo Library/Photo Researchers, (bl)USGS/TSADO/Tom Stack & Assoc., (others)USGS/Tom Stack & Assoc.

The *Viking* Probes

The *Viking 1* and *2* probes arrived at Mars in 1976. Each spacecraft consisted of an orbiter and a lander. The *Viking 1* and *2* orbiters photographed the entire surface of Mars from their orbits, while the *Viking 1* and *2* landers touched down on the planet's surface. The landers carried equipment to detect possible life on Mars. Some of this equipment was designed to analyze gases given off by Martian soil. These experiments found no conclusive evidence of life on Mars.

Pathfinder, Global Surveyor, and *Odyssey*

The *Mars Pathfinder* carried a robot rover named Sojourner with equipment that allowed it to analyze samples of Martian rock and soil. Data from these tests indicated that iron in Mars's crust might have been leached out by groundwater. Cameras onboard *Global Surveyor* showed features that look like gullies formed by flowing water and deposits of sediment carried by the water flows. The features, shown in **Figure 8,** are young enough that scientists are considering the idea that liquid groundwater might exist on Mars and that it sometimes reaches the surface. It is also possible that volcanic activity might melt frost beneath the Martian surface. The features compare to those formed by flash floods on Earth, such as on Mount St. Helens.

More recently, instruments on another probe called *Mars Odyssey* detected frozen water on Mars. The water occurs as frost beneath a thin layer of soil. The frost is common in the far northern and far southern parts of Mars.

Reading Check *What evidence indicates that Mars has water?*

Mini LAB

Inferring Effects of Gravity

Procedure

1. Suppose you are a crane operator who is sent to Mars to help build a Mars colony.
2. You know that your crane can lift 44,500 N on Earth and Mars, but the gravity on Mars is only 40 percent of Earth's gravity.
3. Determine how much mass your crane could lift on Earth and Mars.

Analysis

1. How can what you have discovered be an advantage over construction on Earth?
2. How might construction advantages change the overall design of the Mars colony?

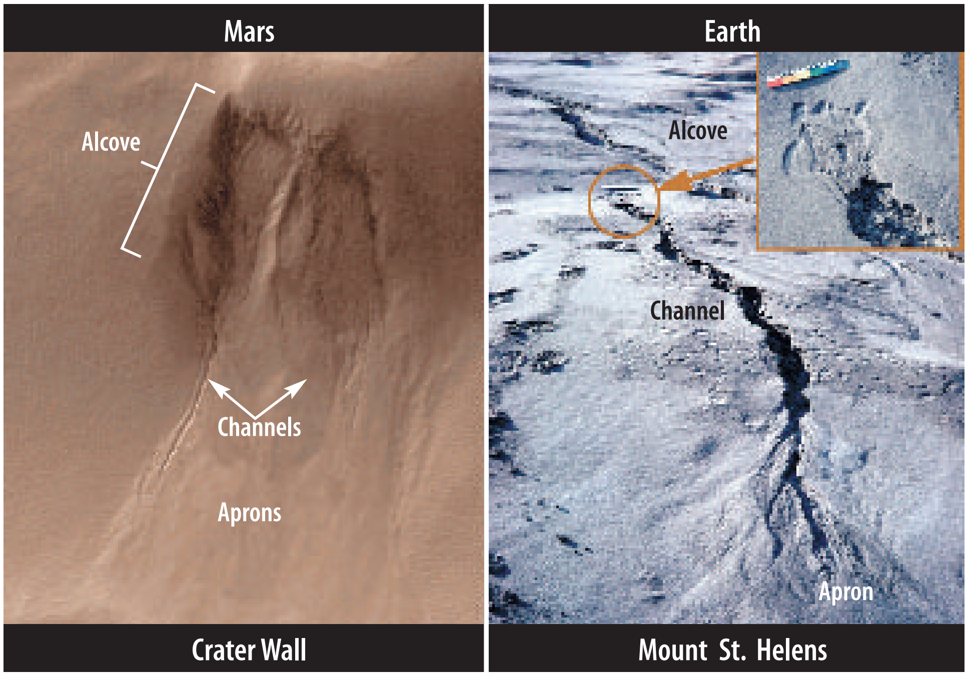


Figure 8 Compare the features found on Mars with those found on an area of Mount St. Helens in Washington state that experienced a flash flood.

NASA/JPL/Malin Space Science Systems

Science Online

Topic: Mars Exploration

Visit blue.msscience.com for Web links to information about future missions to Mars.

Activity Make a timeline that shows when each probe is scheduled to reach Mars. Include the mission objectives for each probe on your timeline.

Mars's Atmosphere The *Viking* and *Global Surveyor* probes analyzed gases in the Martian atmosphere and determined atmospheric pressure and temperature. They found that Mars's atmosphere is much thinner than Earth's. It is composed mostly of carbon dioxide, with some nitrogen and argon. Surface temperatures range from −125°C to 35°C. The temperature difference between day and night results in strong winds on the planet, which can cause global dust storms during certain seasons. This information will help in planning possible human exploration of Mars in the future.

Martian Seasons Mars's axis of rotation is tilted 25°, which is close to Earth's tilt of 23.5°. Because of this, Mars goes through seasons as it orbits the Sun, just like Earth does. The polar ice caps on Mars change with the season. During winter, carbon dioxide ice accumulates and makes the ice cap larger. During summer, carbon dioxide ice changes to carbon dioxide gas and the ice cap shrinks. As one ice cap gets larger, the other ice cap gets smaller. The color of the ice caps and other areas on Mars also changes with the season. The movement of dust and sand during dust storms causes the changing colors.

Applying Math — Use Percentages

DIAMETER OF MARS The diameter of Earth is 12,756 km. The diameter of Mars is 53.3 percent of the diameter of Earth. Calculate the diameter of Mars.

Solution

1. *This is what you know:*
   - diameter of Earth: 12,756 km
   - percent of Earth's diameter: 53.3%
   - decimal equivalent: 0.533 (53.3% ÷ 100)
2. *This is what you need to find:* diameter of Mars
3. *This is the procedure you need to use:* Multiply the diameter of Earth by the decimal equivalent.
   $(12{,}756 \text{ km}) \times (0.533) = 6{,}799 \text{ km}$

Practice Problems

1. Use the same procedure to calculate the diameter of Venus. Its diameter is 94.9 percent of the diameter of Earth.
2. Calculate the diameter of Mercury. Its diameter is 38.2 percent of the diameter of Earth.

Science Online — For more practice, visit blue.msscience.com/math_practice

Martian Moons Mars has two small, irregularly shaped moons that are heavily cratered. Phobos, shown in **Figure 9,** is about 25 km in length, and Deimos is about 13 km in length. Deimos orbits Mars once every 31 h, while Phobos speeds around Mars once every 7 h.

Phobos has many interesting surface features. Grooves and chains of smaller craters seem to radiate out from the large Stickney Crater. Some of the grooves are 700 m across and 90 m deep. These features probably are the result of the large impact that formed the Stickney Crater.

Deimos is the outer of Mars's two moons. It is among the smallest known moons in the solar system. Its surface is smoother in appearance than that of Phobos because some of its craters have partially filled with soil and rock.

As you toured the inner planets through the eyes of the space probes, you saw how each planet is unique. Refer to **Table 3** following Section 3 for a summary of the planets. Mercury, Venus, Earth, and Mars are different from the outer planets, which you'll explore in the next section.

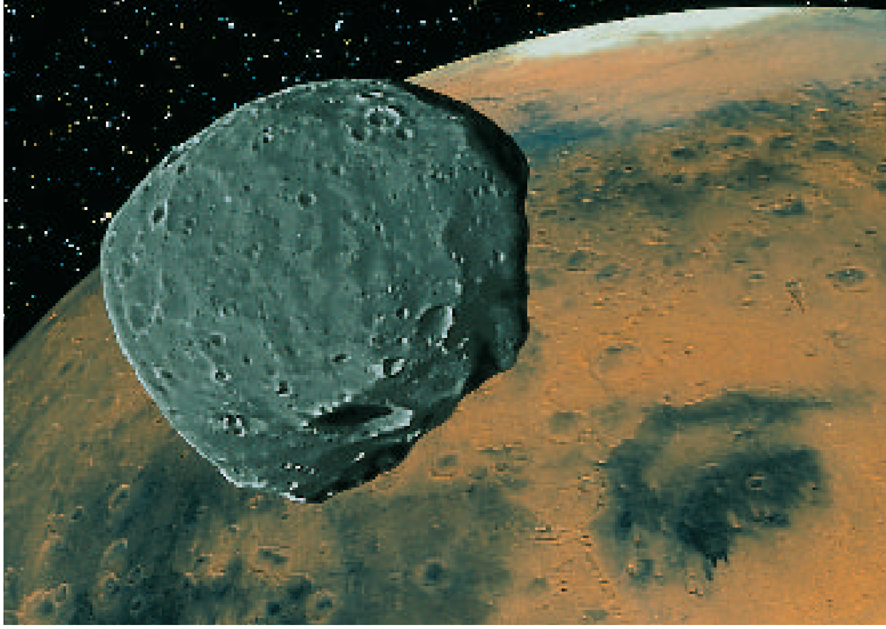


Figure 9 Phobos orbits Mars once every 7 h.
Infer *why Phobos has so many craters.*

section 2 review

Summary

Mercury
- Mercury is extremely hot during the day and extremely cold at night.
- Its surface has many craters.

Venus
- Venus's size and mass are similar to Earth's.
- Temperatures on Venus are between 450°C and 475°C.

Earth
- Earth is the only planet known to support life.

Mars
- Mars has polar ice caps, channels that might have been carved by water, and the largest volcano in the solar system, Olympus Mons.

Self Check

1. **Explain** why Mercury's surface temperature varies so much from day to night.
2. **List** important characteristics for each inner planet.
3. **Infer** why life is unlikely on Venus.
4. **Identify** the inner planet that is farthest from the Sun. Identify the one that is closest to the Sun.
5. **Think Critically** Aside from Earth, which inner planet could humans visit most easily? Explain.

Applying Math

6. **Use Statistics** The inner planets have the following average densities: Mercury, 5.43 g/cm^3; Venus, 5.24 g/cm^3; Earth, 5.52 g/cm^3; and Mars, 3.94 g/cm^3. Which planet has the highest density? Which has the lowest? Calculate the range of these data.

section 3

The Outer Planets

as you read

What You'll Learn

- **Describe** the characteristics of Jupiter, Saturn, Uranus, and Neptune.
- **Explain** how Pluto differs from the other outer planets.

Why It's Important

Studying the outer planets will help scientists understand Earth.

Review Vocabulary

moon: a natural satellite of a planet that is held in its orbit around the planet by the planet's gravitational pull

New Vocabulary

- Jupiter
- Great Red Spot
- Saturn
- Uranus
- Neptune
- Pluto

Outer Planets

You might have heard about *Voyager, Galileo,* and *Cassini.* They were not the first probes to the outer planets, but they gathered a lot of new information about them. Follow the spacecrafts as you read about their journeys to the outer planets.

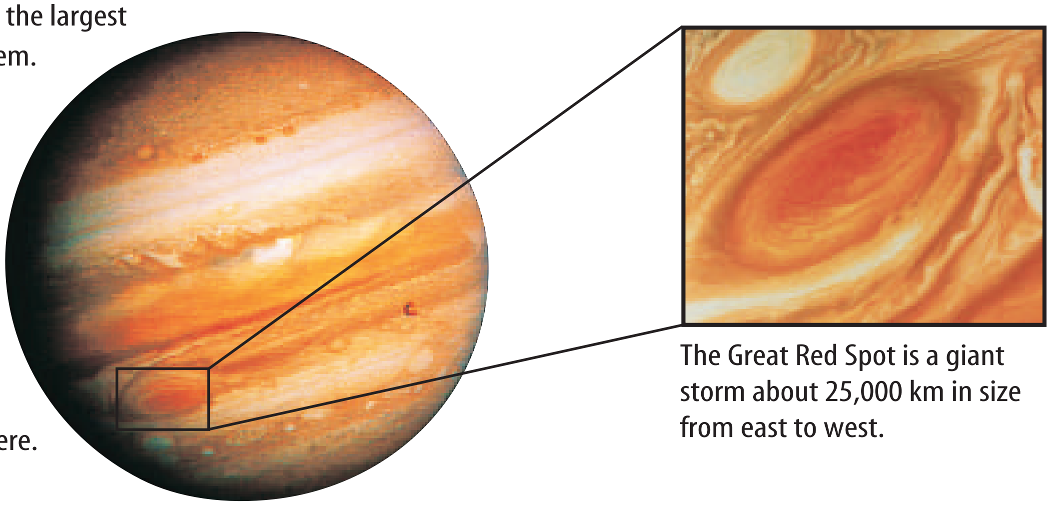
Jupiter

In 1979, *Voyager 1* and *Voyager 2* flew past **Jupiter,** the fifth planet from the Sun. *Galileo* reached Jupiter in 1995, and *Cassini* flew past Jupiter on its way to Saturn in 2000. The spacecrafts gathered new information about Jupiter. The *Voyager* probes revealed that Jupiter has faint dust rings around it and that one of its moons has active volcanoes on it.

Jupiter's Atmosphere Jupiter is composed mostly of hydrogen and helium, with some ammonia, methane, and water vapor. Scientists hypothesize that the atmosphere of hydrogen and helium changes to an ocean of liquid hydrogen and helium toward the middle of the planet. Below this liquid layer might be a rocky core. The extreme pressure and temperature, however, would make the core different from any rock on Earth.

You've probably seen pictures from the probes of Jupiter's colorful clouds. In **Figure 10,** you can see bands of white, red, tan, and brown clouds in its atmosphere. Continuous storms of swirling, high-pressure gas have been observed on Jupiter. The **Great Red Spot** is the most spectacular of these storms.

Figure 10 Jupiter is the largest planet in the solar system.

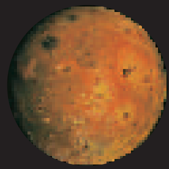
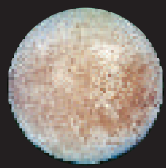
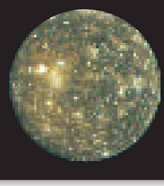


Notice the colorful bands of clouds in Jupiter's atmosphere.

The Great Red Spot is a giant storm about 25,000 km in size from east to west.

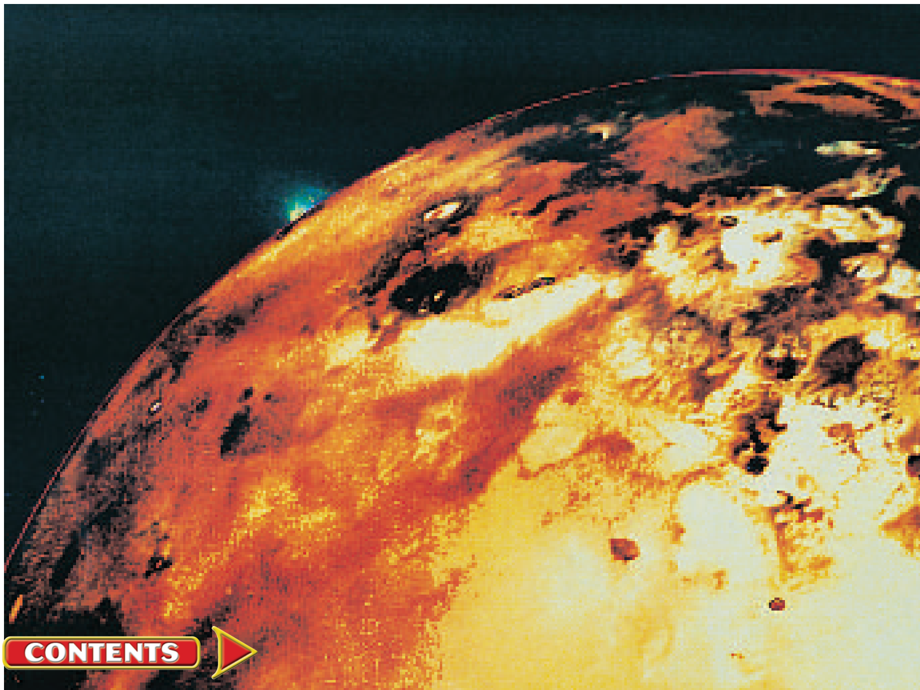
(t to b)USGS/TSADO/Tom Stack & Assoc., NASA/JPL/Photo Researchers, NASA/TSADO/Tom Stack & Assoc., JPL, NASA

Table 2 Large Moons of Jupiter

Io The most volcanically active object in the solar system; sulfurous compounds give it its distinctive reddish and orange colors; has a thin oxygen, sulfur, and sulfur dioxide atmosphere.	
Europa Rocky interior is covered by a 100-km-thick crust of ice, which has a network of cracks; an ocean might exist under the ice crust; has a thin oxygen atmosphere.	
Ganymede Has a crust of ice about 500 km thick, covered with grooves; crust might surround an ocean of water or slushy ice; has a rocky core and a thin oxygen atmosphere.	
Callisto Has a heavily cratered crust of ice and rock several hundred kilometers thick; crust might surround a salty ocean around a rock core; has a thin atmosphere of carbon dioxide.	

Moons of Jupiter At least 61 moons orbit Jupiter. In 1610, the astronomer Galileo Galilei was the first person to see Jupiter's four largest moons, shown in **Table 2.** Io (I oh) is the closest large moon to Jupiter. Jupiter's tremendous gravitational force and the gravity of Europa, Jupiter's next large moon, pull on Io. This force heats up Io, causing it to be the most volcanically active object in the solar system. You can see a volcano erupting on Io in **Figure 11.** Europa is composed mostly of rock with a thick, smooth crust of ice. Under the ice might be an ocean as deep as 200 km. If this ocean of water exists, it will be the only place in the solar system, other than Earth and possibly Ganymede and Callisto, where liquid water exists in large quantities. Next is Ganymede, the largest moon in the solar system—larger even than the planet Mercury. Callisto, the last of Jupiter's large moons, is composed mostly of ice and rock. Studying these moons adds to knowledge about the origin of Earth and the rest of the solar system.

Figure 11 *Voyager 2* photographed the eruption of this volcano on Io in July 1979.



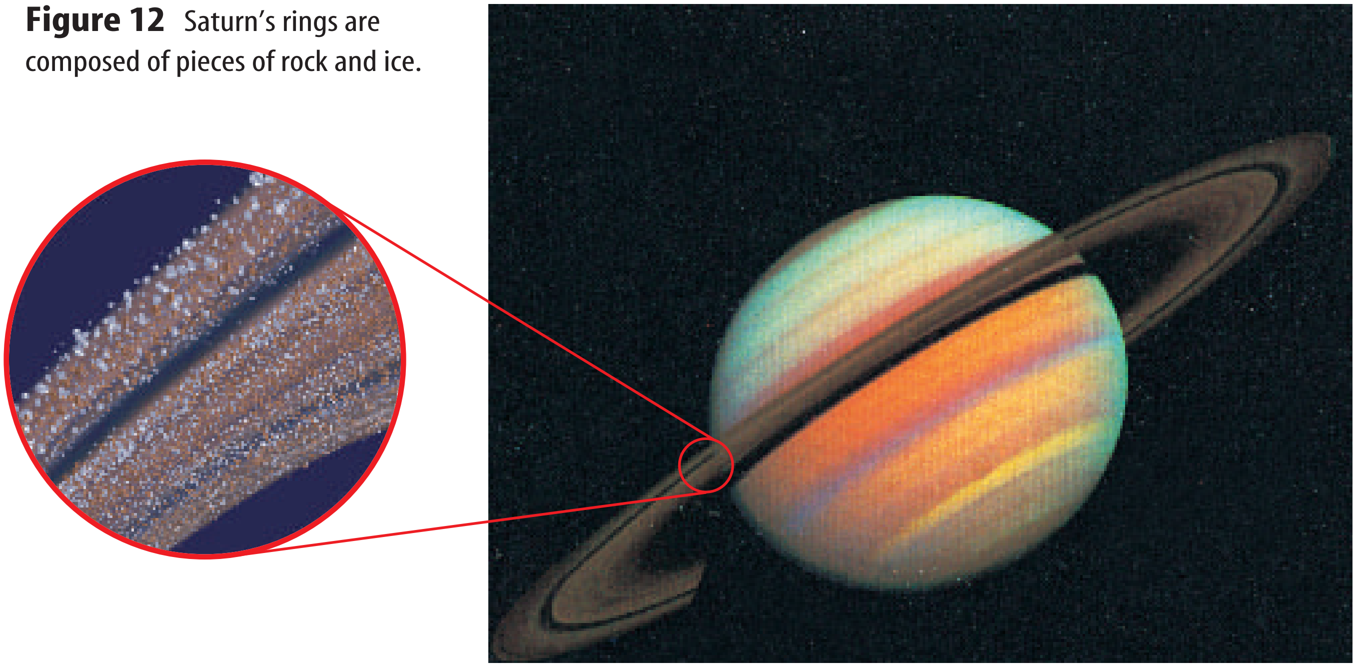


Figure 12 Saturn's rings are composed of pieces of rock and ice.

Saturn

The *Voyager* probes next surveyed Saturn in 1980 and 1981. *Cassini* is scheduled to reach Saturn on July 1, 2004. **Saturn** is the sixth planet from the Sun. It is the second-largest planet in the solar system, but it has the lowest density.

Saturn's Atmosphere Similar to Jupiter, Saturn is a large, gaseous planet. It has a thick outer atmosphere composed mostly of hydrogen and helium. Saturn's atmosphere also contains ammonia, methane, and water vapor. As you go deeper into Saturn's atmosphere, the gases gradually change to liquid hydrogen and helium. Below its atmosphere and liquid layer, Saturn might have a small, rocky core.

Rings and Moons The *Voyager* probes gathered new information about Saturn's ring system. The probes showed that Saturn has several broad rings. Each large ring is composed of thousands of thin ringlets. **Figure 12** shows that Saturn's rings are composed of countless ice and rock particles. These particles range in size from a speck of dust to tens of meters across. Saturn's ring system is the most complex one in the solar system.

At least 31 moons orbit Saturn. Saturn's gravity holds these moons in their orbits around Saturn, just like the Sun's gravity holds the planets in their orbits around the Sun. The largest of Saturn's moons, Titan, is larger than the planet Mercury. It has an atmosphere of nitrogen, argon, and methane. Thick clouds make it difficult for scientists to study the surface of Titan.

Mini LAB

Modeling Planets

Procedure

1. Research the planets to determine how the sizes of the planets in the solar system compare with each other.
2. Select a scale for the diameter of Earth.
3. Make a model by drawing a circle with this diameter on **paper.**
4. Using Earth's diameter as 1.0 unit, draw each of the other planets to scale.

Analysis

1. Which planet is largest? Which is smallest?
2. Which scale diameter did you select for Earth? Was this a good choice? Why or why not?

Try at Home

JPL

Uranus

Beyond Saturn, *Voyager 2* flew by Uranus in 1986. **Uranus** (YOOR uh nus) is the seventh planet from the Sun and was discovered in 1781. It is a large, gaseous planet with at least 21 moons and a system of thin, dark rings. Uranus's largest moon, Titania, has many craters and deep valleys. The valleys on this moon indicate that some process reshaped its surface after it formed. Uranus's 11 rings surround the planet's equator.

Figure 13 The atmosphere of Uranus gives the planet its distinct bluish-green color.

Uranus's Characteristics The atmosphere of Uranus is composed of hydrogen, helium, and some methane. Methane gives the planet the bluish-green color that you see in **Figure 13.** Methane absorbs the red and yellow light, and the clouds reflect the green and blue. Few cloud bands and storm systems can be seen on Uranus. Evidence suggests that under its atmosphere, Uranus has a mantle of liquid water, methane, and ammonia surrounding a rocky core.

Figure 14 shows one of the most unusual features of Uranus. Its axis of rotation is tilted on its side compared with the other planets. The axes of rotation of the other planets, except Pluto, are nearly perpendicular to the planes of their orbits. However, Uranus's axis of rotation is nearly parallel to the plane of its orbit. Some scientists believe a collision with another object tipped Uranus on its side.

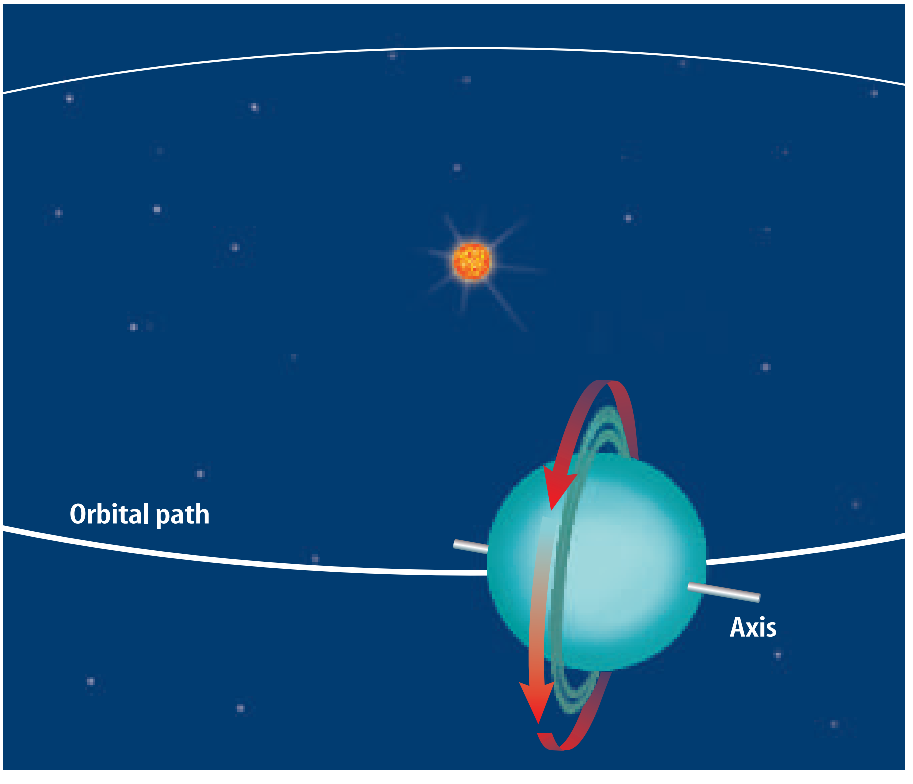


Figure 14 Uranus's axis of rotation is nearly parallel to the plane of its orbit. During its revolution around the Sun, each pole, at different times, points almost directly at the Sun.

Neptune has a distinctive bluish-green color.

The pinkish hue of Neptune's largest moon, Triton, is thought to come from an evaporating layer of nitrogen and methane ice.

Figure 15 Neptune is the eighth planet from the Sun.

Neptune

Passing Uranus, *Voyager 2* traveled to Neptune, another large, gaseous planet. Discovered in 1846, **Neptune** is usually the eighth planet from the Sun. However, Pluto's orbit crosses inside Neptune's during part of its voyage around the Sun. Between 1979 and 1999, Pluto was closer to the Sun than was Neptune.

Neptune's Characteristics Neptune's atmosphere is similar to Uranus's atmosphere. The methane content gives Neptune, shown in **Figure 15,** its distinctive bluish-green color, just as it does for Uranus.

Reading Check *What gives Neptune its bluish-green color?*

Neptune has dark-colored storms in its atmosphere that are similar to the Great Red Spot on Jupiter. One discovered by *Voyager 2* in 1989 was called the Great Dark Spot. It was about the size of Earth. However, observations by the *Hubble Space Telescope* in 1994 showed that the Great Dark Spot had disappeared. Bright clouds also form and then disappear. This shows that Neptune's atmosphere is active and changes rapidly.

Under its atmosphere, Neptune is thought to have a layer of liquid water, methane, and ammonia that might change to solid ice. Neptune probably has a rocky core.

Neptune has at least 11 moons and several rings. Triton, shown in **Figure 15,** is Neptune's largest moon. It has a thin atmosphere composed mostly of nitrogen. Neptune's rings are young and probably won't last very long.

INTEGRATE Language Arts

Names of Planets The names of most of the planets in the solar system come from Roman or Greek mythology. For example, Neptune was the Roman god of the sea, and Pluto was the Greek god of the underworld. Research to learn about the names of the other planets. Write a paragraph in your Science Journal that summarizes what you learn.

Pluto

The smallest planet in the solar system, and the one scientists know the least about, is **Pluto**. During part of its 248-year orbit, Pluto is closer to the Sun than Neptune. However, because Pluto is farther from the Sun than Neptune during most of its orbit, it is considered to be the ninth planet from the Sun. Pluto is vastly different from the other outer planets. It's surrounded by only a thin atmosphere, and it's the only outer planet with a solid, icy-rock surface.

Figure 16 The *Hubble Space Telescope* gave astronomers their first clear view of Pluto and Charon as distinct objects.

Pluto's Moon Pluto's single moon, Charon, has a diameter about half the size of Pluto's. It was discovered in 1978 when a bulge was noticed on a photograph of the planet. Later photographs, taken with improved telescopes, showed that the bulge was a moon. Pluto and Charon are shown in **Figure 16.** Because of their close size and orbit, some scientists consider them to be a double planet.

Data from the *Hubble Space Telescope* indicate the presence of a vast disk of icy objects called the Kuiper Belt beyond Neptune's orbit. Some of the objects are hundreds of kilometers in diameter. One found in 2002 is about 1,300 km in diameter. Many astronomers think that Pluto and Charon are members of the Kuiper Belt.

section 3 review

Summary

Jupiter

- Jupiter is the largest planet in the solar system.
- The Great Red Spot is a huge storm on Jupiter.

Saturn

- Saturn has a complex system of rings.

Uranus

- Uranus has a bluish-green color caused by methane in its atmosphere.

Neptune

- Like Uranus, Neptune has a bluish-green color.
- Neptune's atmosphere has storms and can change rapidly.

Pluto

- Pluto is a small, ice-rock planet.
- Its moon, Charon, is about half as large as Pluto.

Self Check

1. **Describe** the differences between the outer planets and the inner planets.
2. **Describe** what Saturn's rings are made from.
3. **Explain** how Pluto is a unique outer planet.
4. **Explain** how Uranus's axis of rotation differs from those of most other planets.
5. **Think Critically** What would seasons be like on Uranus? Explain.

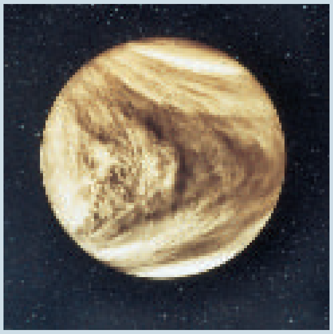
Applying Skills

6. **Identify a Question** Pluto has never been visited by a space probe, so many questions are unanswered. Think of a question about Pluto that you'd like to have answered. Then, explain how the answer to your question could be discovered.

Science Online blue.msscience.com/self_check_quiz

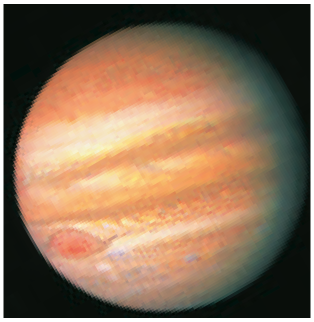
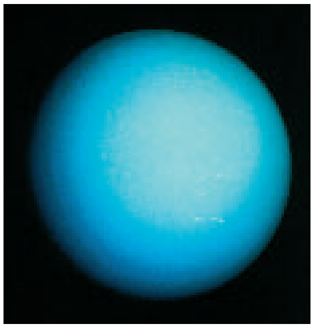
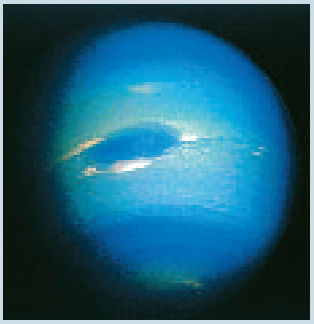
CONTENTS

Table 3 Planets

Mercury		■ closest to the Sun ■ second-smallest planet ■ surface has many craters and high cliffs ■ no atmosphere ■ temperatures range from 425°C during the day to −170°C at night ■ has no moons
Venus		■ similar to Earth in size and mass ■ thick atmosphere made mostly of carbon dioxide ■ droplets of sulfuric acid in atmosphere give clouds a yellowish color ■ surface has craters, faultlike cracks, and volcanoes ■ greenhouse effect causes surface temperatures of 450°C to 475°C ■ has no moons
Earth		■ atmosphere protects life ■ surface temperatures allow water to exist as solid, liquid, and gas ■ only planet where life is known to exist ■ has one large moon
Mars		■ surface appears reddish-yellow because of iron oxide in soil ■ ice caps are made of frozen carbon dioxide and water ■ channels indicate that water had flowed on the surface; has large volcanoes and valleys ■ has a thin atmosphere composed mostly of carbon dioxide ■ surface temperatures range from −125°C to 35°C ■ huge dust storms often blanket the planet ■ has two small moons

CONTENTS

Table 3 Planets

Jupiter		■ largest planet ■ has faint rings ■ atmosphere is mostly hydrogen and helium; continuous storms swirl on the planet—the largest is the Great Red Spot ■ has four large moons and at least 57 smaller moons; one of its moons, Io, has active volcanoes
Saturn		■ second-largest planet ■ thick atmosphere is mostly hydrogen and helium ■ has a complex ring system ■ has at least 31 moons—the largest, Titan, is larger than Mercury
Uranus		■ large, gaseous planet with thin, dark rings ■ atmosphere is hydrogen, helium, and methane ■ axis of rotation is nearly parallel to plane of orbit ■ has at least 21 moons
Neptune		■ large, gaseous planet with rings that vary in thickness ■ is sometimes farther from the Sun than Pluto is ■ methane atmosphere causes its bluish-green color ■ has dark-colored storms in atmosphere ■ has at least 11 moons
Pluto		■ small, icy-rock planet with thin atmosphere ■ single moon, Charon, is half the diameter of the planet

CONTENTS

section 4

Other Objects in the Solar System

as you read

What You'll Learn

- **Describe** how comets change when they approach the Sun.
- **Distinguish** among comets, meteoroids, and asteroids.
- **Explain** that objects from space sometimes impact Earth.

Why It's Important

Comets, asteroids, and most meteorites are very old. Scientists can learn about the early solar system by studying them.

Review Vocabulary

crater: a nearly circular depression in a planet, moon, or asteroid that formed when an object from space hit its surface

New Vocabulary

- comet
- meteor
- meteorite
- asteroid

Comets

The planets and their moons are the most noticeable members of the Sun's family, but many other objects also orbit the Sun. Comets, meteoroids, and asteroids are other important objects in the solar system.

You might have heard of Halley's comet. A **comet** is composed of dust and rock particles mixed with frozen water, methane, and ammonia. Halley's comet was last seen from Earth in 1986. English astronomer Edmund Halley realized that comet sightings that had taken place about every 76 years were really sightings of the same comet. This comet, which takes about 76 years to orbit the Sun, was named after him.

Oort Cloud Astronomer Jan Oort proposed the idea that billions of comets surround the solar system. This cloud of comets, called the Oort Cloud, is located beyond the orbit of Pluto. Oort suggested that the gravities of the Sun and nearby stars interact with comets in the Oort Cloud. Comets either escape from the solar system or get captured into smaller orbits.

Comet Hale-Bopp On July 23, 1995, two amateur astronomers made an exciting discovery. A new comet, Comet Hale-Bopp, was headed toward the Sun. Larger than most that approach the Sun, it was the brightest comet visible from Earth in 20 years. Shown in **Figure 17,** Comet Hale-Bopp was at its brightest in March and April 1997.

Figure 17 Comet Hale-Bopp was most visible in March and April 1997.

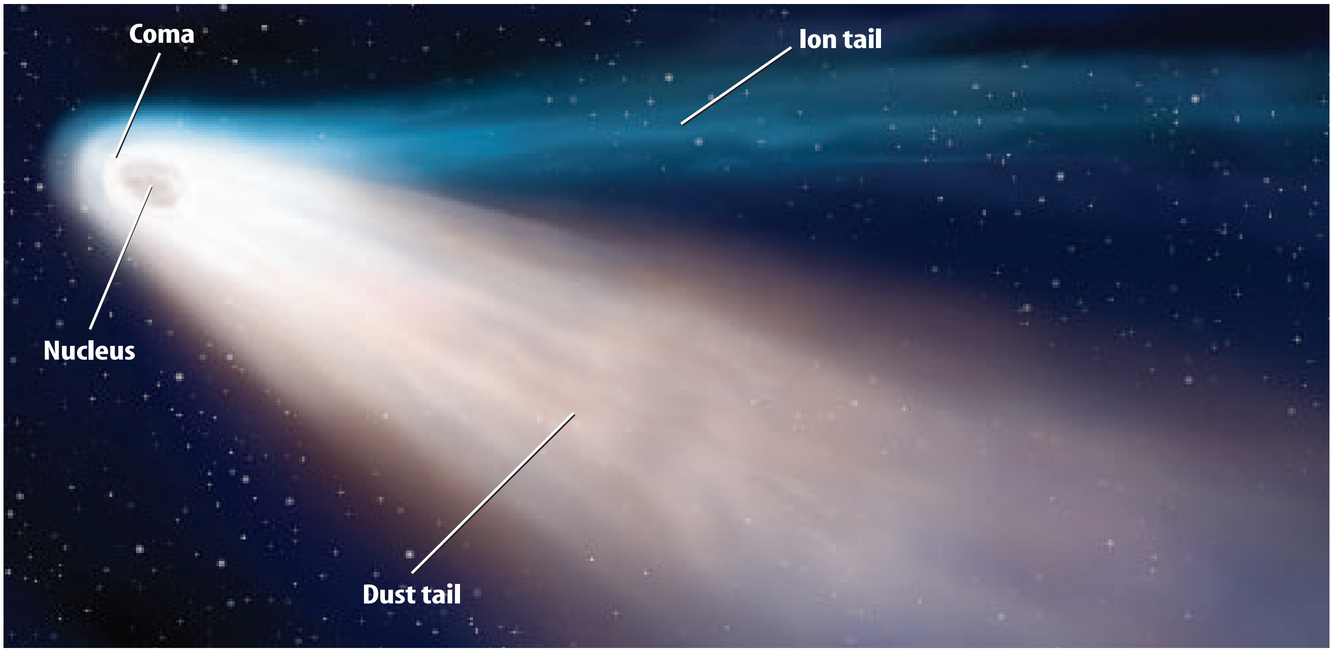


Figure 18 A comet consists of a nucleus, a coma, a dust tail, and an ion tail.

Structure of Comets The *Hubble Space Telescope* and spacecrafts such as the *International Cometary Explorer* have gathered information about comets. In 2006, a spacecraft called *Stardust* will return a capsule to Earth containing samples of dust from a comet's tail. Notice the structure of a comet shown in **Figure 18.** It is a mass of frozen ice and rock similar to a large, dirty snowball.

As a comet approaches the Sun, it changes. Ices of water, methane, and ammonia vaporize because of the heat from the Sun, releasing dust and bits of rock. The gases and released dust form a bright cloud called a coma around the nucleus, or solid part, of the comet. The solar wind pushes on the gases and dust in the coma, causing the particles to form separate tails that point away from the Sun.

After many trips around the Sun, most of the ice in a comet's nucleus has vaporized. All that's left are dust and rock, which are spread throughout the orbit of the original comet.

Meteoroids, Meteors, and Meteorites

You learned that comets vaporize and break up after they have passed close to the Sun many times. The small pieces from the comet's nucleus spread out into a loose group within the original orbit of the comet. These pieces of dust and rock, along with those derived from other sources, are called meteoroids.

Sometimes the path of a meteoroid crosses the position of Earth, and it enters Earth's atmosphere at speeds of 15 km/s to 70 km/s. Most meteoroids are so small that they completely burn up in Earth's atmosphere. A meteoroid that burns up in Earth's atmosphere is called a **meteor**, shown in **Figure 19.**

Figure 19 A meteoroid that burns up in Earth's atmosphere is called a meteor.

Pekka Parviainen/Science Photo Library/Photo Researchers

Figure 20 Meteorites occasionally strike Earth's surface. A large meteorite struck Arizona, forming a crater about 1.2 km in diameter and about 200 m deep.

Meteor Showers Each time Earth passes through the loose group of particles within the old orbit of a comet, many small particles of rock and dust enter the atmosphere. Because more meteors than usual are seen, the event is called a meteor shower.

When a meteoroid is large enough, it might not burn up completely in the atmosphere. If it strikes Earth, it is called a **meteorite.** Barringer Crater in Arizona, shown in **Figure 20,** was formed when a large meteorite struck Earth about 50,000 years ago. Most meteorites are probably debris from asteroid collisions or broken-up comets, but some originate from the Moon and Mars.

Reading Check *What is a meteorite?*

Asteroids

An **asteroid** is a piece of rock similar to the material that formed into the planets. Most asteroids are located in an area between the orbits of Mars and Jupiter called the asteroid belt. Find the asteroid belt in **Figure 21.** Why are they located there? The gravity of Jupiter might have kept a planet from forming in the area where the asteroid belt is located now.

Other asteroids are scattered throughout the solar system. They might have been thrown out of the belt by Jupiter's gravity. Some of these asteroids have orbits that cross Earth's orbit. Scientists monitor the positions of these asteroids. However, it is unlikely that an asteroid will hit Earth in the near future.

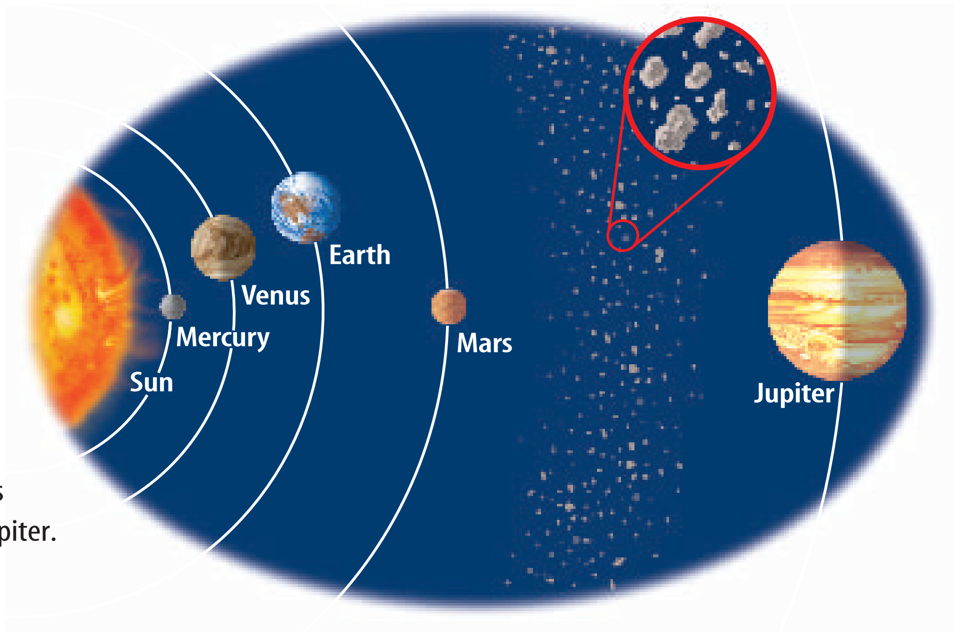


Figure 21 The asteroid belt lies between the orbits of Mars and Jupiter.

Georg Gerster/Photo Researchers

Exploring Asteroids The sizes of the asteroids in the asteroid belt range from tiny particles to objects 940 km in diameter. Ceres is the largest and the first one discovered. The next three in order of size are Vesta (530 km), Pallas (522 km), and 10 Hygiea (430 km). The asteroid Gaspra, shown in **Figure 22,** was photographed by *Galileo* on its way to Jupiter.

Figure 22 The asteroid Gaspra is about 20 km long.

NEAR On February 14, 2000, the *Near Earth Asteroid Rendezvous (NEAR)* spacecraft went into orbit around the asteroid 433 Eros and successfully began its one-year mission of data gathering. Data from the spacecraft show that Eros's surface has a large number of craters. Other data indicate that Eros might be similar to the most common type of meteorite that strikes Earth. On February 12, 2001, *NEAR* ended its mission by becoming the first spacecraft to land softly on an asteroid.

Comets, asteroids, and most meteorites formed early in the history of the solar system. Scientists study these space objects to learn what the solar system might have been like long ago. Understanding this could help scientists better understand how Earth formed.

section 4 review

Summary

Comets

- Comets consist of dust, rock, and different types of ice.
- Billions of comets surround the solar system in the Oort Cloud.

Meteoroids, Meteors, Meteorites

- When meteoroids burn up in the atmosphere, they are called meteors.
- Meteor showers occur when Earth crosses the orbital path of a comet.

Asteroids

- Many asteroids occur between the orbits of Mars and Jupiter. This region is called the asteroid belt.

Self Check

1. **Describe** how a comet changes when it comes close to the Sun.
2. **Explain** how craters form.
3. **Summarize** the differences between comets and asteroids.
4. **Describe** the mission of the *NEAR* spacecraft.
5. **Think Critically** A meteorite found in Antarctica is thought to have come from Mars. How could a rock from Mars get to Earth?

Applying Math

6. **Use Proportions** During the 2001 Leonid Meteor Shower, some people saw 20 meteors each minute. Assuming a constant rate, how many meteors did these people see in one hour?

JPL/TSADO/Tom Stack & Assoc.

LAB Model and Invent

Solar System Distance Model

Goals

- **Design** a table of scale distances and model the distances between and among the Sun and the planets.

Possible Materials

meterstick
scissors
pencil
string (several meters)
notebook paper (several sheets)

Safety Precautions

Use care when handling scissors.

Real-World Question

Distances between the Sun and the planets of the solar system are large. These large distances can be difficult to visualize. Can you design and create a model that will demonstrate the distances in the solar system?

Make a Model

1. **List** the steps that you need to take to make your model. Describe exactly what you will do at each step.
2. **List** the materials that you will need to complete your model.
3. **Describe** the calculations that you will use to get scale distances from the Sun for all nine planets.
4. **Make** a table of scale distances that you will use in your model. Show your calculations in your table.
5. **Write** a description of how you will build your model. Explain how it will demonstrate relative distances between and among the Sun and planets of the solar system.

Planetary Distances

Planet	Distance to Sun (km)	Distance to Sun (AU)	Scale Distance (1 AU = 10 cm)	Scale Distance (1 AU = 2 cm)
Mercury	5.97×10^7	0.39		
Venus	1.08×10^8	0.72		
Earth	1.50×10^8	1.00		
Mars	2.28×10^8	1.52		
Jupiter	7.78×10^8	5.20		Do not write in this book.
Saturn	1.43×10^9	9.54		
Uranus	2.87×10^9	19.19		
Neptune	4.50×10^9	30.07		
Pluto	5.92×10^9	39.48		

Test Your Model

1. **Compare** your scale distances with those of other students. Discuss why each of you chose the scale that you did.
2. Make sure your teacher approves your plan before you start.
3. **Construct** the model using your scale distances.
4. While constructing the model, write any observations that you or other members of your group make, and complete the data table in your Science Journal. Calculate the scale distances that would be used in your model if 1 AU = 2 m.

Analyze Your Data

1. **Explain** how a scale distance is determined.
2. Was it possible to work with your scale? Explain why or why not.
3. How much string would be required to construct a model with a scale distance of 1 AU = 2 m?
4. Proxima Centauri, the closest star to the Sun, is about 270,000 AU from the Sun. Based on your scale, how much string would you need to place this star on your model?

Conclude and Apply

1. **Summarize** your observations about distances in the solar system. How are distances between the inner planets different from distances between the outer planets?
2. Using your scale distances, determine which planet orbits closest to Earth. Which planet's orbit is second closest?

Communicating Your Data

Compare your scale model with those of other students. Discuss any differences. **For more help, refer to the Science Skill Handbook.**

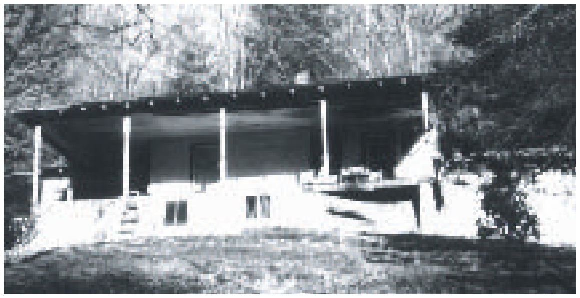
Bettmann/CORBIS

IT CAME FROM OUTER SPACE!

On September 4, 1990, Frances Pegg was unloading bags of groceries in her kitchen in Burnwell, Kentucky. Suddenly, she heard a loud crashing sound. Her husband Arthur heard the same sound. The sound frightened the couple's goat and horse. The noise had come from an object that had crashed through the Pegg's roof, their ceiling, and the floor of their porch. They couldn't see what the object was, but the noise sounded like a gunshot, and pieces of wood from their home flew everywhere. The next day the couple looked under their front porch and found the culprit—a chunk of rock from outer space. It was a meteorite.

For seven years, the Peggs kept their "space rock" at home, making them local celebrities. The rock appeared on TV, and the couple was interviewed by newspaper reporters. In 1997, the Peggs sold the meteorite to the National Museum of Natural History in Washington, D.C., which has a collection of more than 9,000 meteorites. Scientists there study meteorites to learn more about the solar system. One astronomer explained, "Meteorites formed at about the same time as the solar system, about 4.6 billion years ago, though some are younger."

Scientists especially are interested in the Burnwell meteorite because its chemical make up is different from other meteorites previously studied. The Burnwell meteorite is richer in metallic iron and nickel than other known meteorites and is less rich in some metals such as cobalt. Scientists are comparing the rare Burnwell rock with other data to find out if there are more meteorites like the one that fell on the Peggs' roof. But so far, it seems the Peggs' visitor from outer space is one-of-a-kind.



The Burnwell meteorite crashed into the Peggs' home and landed in their basement on the right.

Research Do research to learn more about meteorites. How do they give clues to how our solar system formed? Report to the class.

Science Online
For more information, visit blue.msscience.com/oops

Reviewing Main Ideas

Section 1 The Solar System

1. Early Greek scientists thought that Earth was at the center of the solar system. They thought that the planets and stars circled Earth.
2. Today, people know that objects in the solar system revolve around the Sun.

Section 2 The Inner Planets

1. The inner planets are Mercury, Venus, Earth, and Mars.
2. The inner planets are small, rocky planets.

Section 3 The Outer Planets

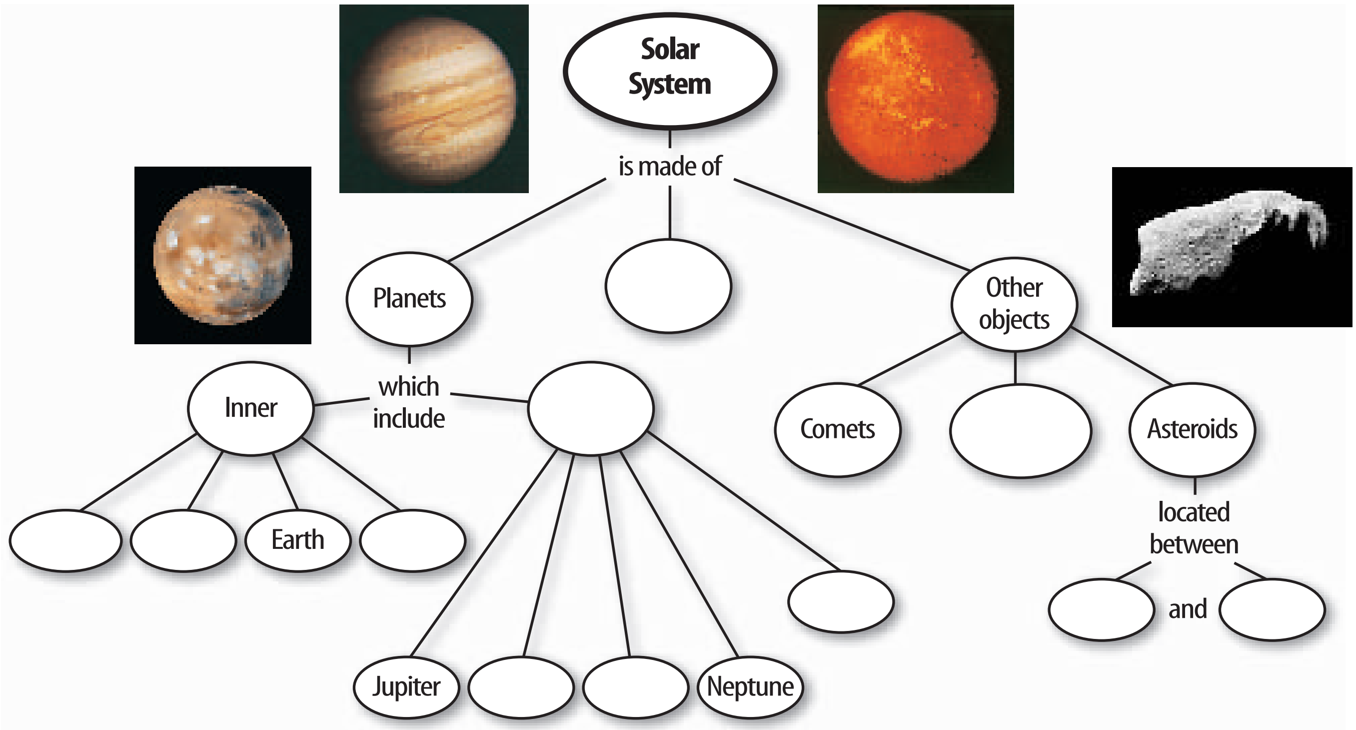
1. The outer planets are Jupiter, Saturn, Uranus, Neptune, and Pluto.
2. Pluto is a small icy planet. The other outer planets are large, gaseous planets.

Section 4 Other Objects in the Solar System

1. Comets are masses of ice and rock. When a comet approaches the Sun, some ice turns to gas and the comet glows brightly.
2. Meteors occur when small pieces of rock enter Earth's atmosphere and burn up.

Visualizing Main Ideas

Copy and complete the following concept map about the solar system.



(t)NASA, (bl)JPL/NASA, (br)file photo

chapter 12 Review

Using Vocabulary

asteroid p. 358	meteorite p. 358
comet p. 356	Neptune p. 352
Earth p. 344	Pluto p. 353
Great Red Spot p. 348	Saturn p. 350
Jupiter p. 348	solar system p. 337
Mars p. 344	Uranus p. 351
Mercury p. 342	Venus p. 343
meteor p. 357	

Fill in the blanks with the correct words.

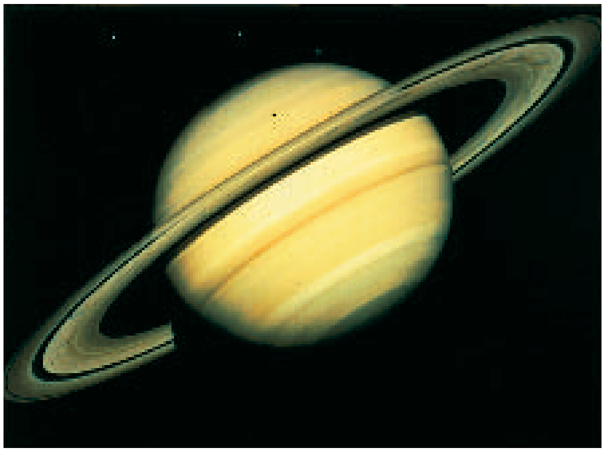
1. A meteoroid that burns up in Earth's atmosphere is called a(n) ________.
2. The Great Red Spot is a giant storm on ________.
3. ________ is the second largest planet.
4. The *Viking* landers tested for life on ________.
5. The ________ includes the Sun, planets, moons, and other objects.

Checking Concepts

Choose the word or phrase that best answers the question.

6. Who proposed a Sun-centered solar system?
   A) Ptolemy **C)** Galileo
   B) Copernicus **D)** Oort
7. What is the shape of planetary orbits?
   A) circles **C)** squares
   B) ellipses **D)** rectangles
8. Which planet has extreme temperatures because it has no atmosphere?
   A) Earth **C)** Saturn
   B) Jupiter **D)** Mercury
9. Where is the largest volcano in the solar system?
   A) Earth **C)** Mars
   B) Jupiter **D)** Uranus

Use the photo below to answer question 10.



10. Which planet has a complex ring system consisting of thousands of ringlets?
   A) Pluto **C)** Uranus
   B) Saturn **D)** Mars
11. What is a rock from space that strikes Earth's surface?
   A) asteroid **C)** meteorite
   B) meteoroid **D)** meteor
12. By what process does the Sun produce energy?
   A) magnetism
   B) nuclear fission
   C) nuclear fusion
   D) gravity
13. In what direction do comet tails point?
   A) toward the Sun
   B) away from the Sun
   C) toward Earth
   D) away from the Oort Cloud
14. Which planet has abundant surface water and is known to have life?
   A) Mars **C)** Earth
   B) Jupiter **D)** Pluto
15. Which planet has the highest temperatures because of the greenhouse effect?
   A) Mercury **C)** Saturn
   B) Venus **D)** Earth

NASA/Science Source/Photo Researchers

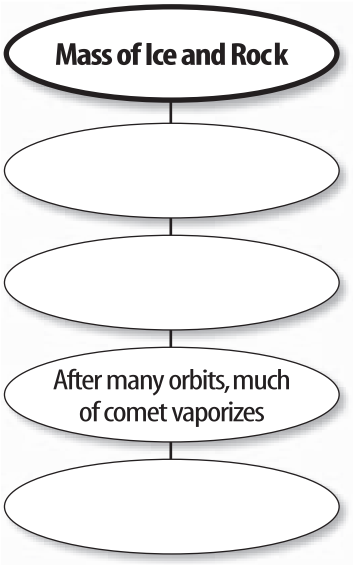
Science Online blue.msscience.com/vocabulary_puzzlemaker

CONTENTS

Thinking Critically

16. Infer Why are probe landings on Jupiter not possible?

17. Concept Map Copy and complete the concept map on this page to show how a comet changes as it travels through space.



18. Recognize Cause and Effect What evidence suggests that liquid water is or once was present on Mars?

19. Venn Diagram Create a Venn diagram for Earth and Venus. Create a second Venn diagram for Uranus and Neptune. Which two planets do you think are more similar?

20. Recognize Cause and Effect Mercury is closer to the Sun than Venus, yet Venus has higher temperatures. Explain.

21. Make Models Make a model that includes the Sun, Earth, and the Moon. Use your model to demonstrate how the Moon revolves around Earth and how Earth and the Moon revolve around the Sun.

22. Form Hypotheses Why do Mars's two moons look like asteroids?

Performance Activities

23. Display Mercury, Venus, Mars, Jupiter, and Saturn can be observed with the unaided eye. Research when and where in the sky these planets can be observed during the next year. Make a display illustrating your findings. Take some time to observe some of these planets.

24. Short Story Select one of the planets or a moon in the solar system. Write a short story from the planet's or moon's perspective. Include scientifically correct facts and concepts in your story.

Applying Math

25. Saturn's Atmosphere Saturn's atmosphere consists of 96.3% hydrogen and 3.25% helium. What percentage of Saturn's atmosphere is made up of other gases?

26. Length of Day on Pluto A day on Pluto lasts 6.39 times longer than a day on Earth. If an Earth day lasts 24 h, how many hours is a day on Pluto?

Use the graph below to answer question 27.

Weight on Several Planets

Planet	Proportion of Earth's Gravity	Melissa's Weight (lbs)
Mercury	0.378	
Venus	0.903	
Earth	1.000	70
Mars	0.379	
Jupiter	2.54	
Pluto	0.061	

27. Gravity and Weight Melissa weighs 70 lbs on Earth. Multiply Melissa's weight by the proportion of Earth's gravity for each planet to find out how much Melissa would weigh on each.

Standardized Test Practice

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the photo below to answer question 1.

1. What is shown in the photo above?
   A. asteroids **C.** meteors
   B. comets **D.** meteorites

2. Which is the ninth planet from the Sun?
   A. Earth **C.** Jupiter
   B. Mars **D.** Pluto

3. What is the name of Pluto's moon?
   A. Ganymede **C.** Charon
   B. Titan **D.** Phobos

4. Which object's gravity holds the planets in their orbits?
   A. Gaspra **C.** Mercury
   B. Earth **D.** the Sun

5. Which of the following occurs in a cycle?
   A. sunspot maxima and minima
   B. condensation of a nebula
   C. formation of a crater
   D. formation of a black hole

Test-Taking Tip

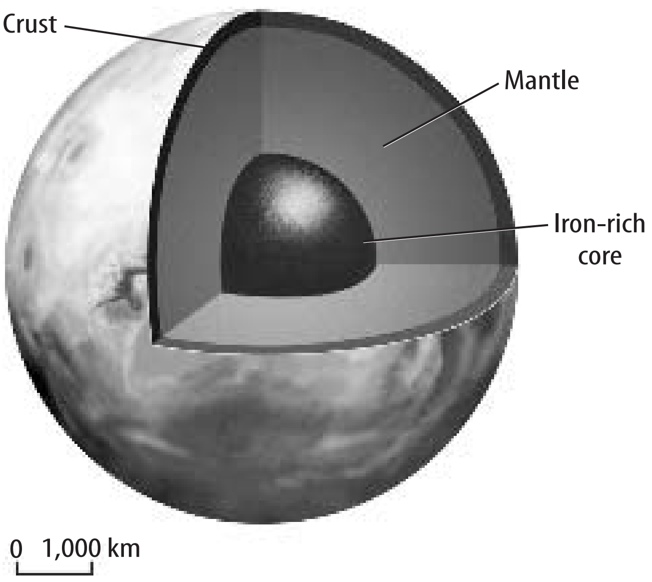
No Peeking During the test, keep your eyes on your own paper. If you need to rest them, close them or look up at the ceiling.

6. Which planet likely will be visited by humans in the future?
   A. Jupiter **C.** Mars
   B. Venus **D.** Neptune

7. Between which two planets' orbits does the asteroid belt occur?
   A. Mercury and Venus
   B. Earth and Mars
   C. Uranus and Neptune
   D. Mars and Jupiter

8. Who discovered that planets have elliptical orbits?
   A. Galileo Galilei
   B. Johannes Kepler
   C. Albert Einstein
   D. Nicholas Copernicus

Use the illustration below to answer question 9.



9. Which of the following answers is a good estimate for the diameter of Mars?
   A. 23,122 km **C.** 1,348 km
   B. 6,794 km **D.** 12,583 km

John R. Foster/Photo Researchers

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

10. Why does a moon remain in orbit around a planet?

11. Compare and contrast the inner planets and the outer planets.

12. Describe Pluto's surface. How is it different from the other outer planets?

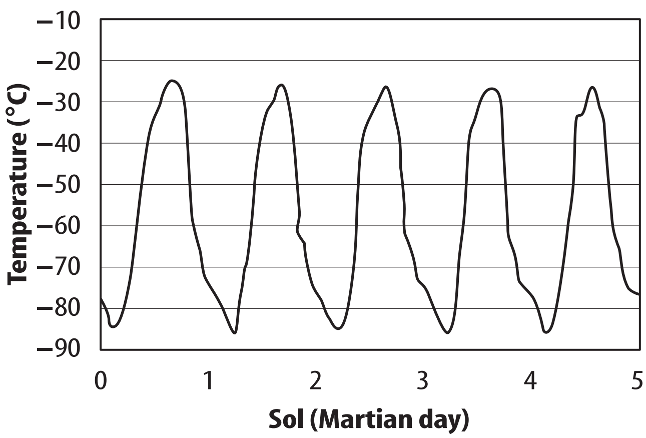
13. Describe Saturn's rings. What are they made of?

14. What is the Great Red Spot?

15. How is Earth different from the other planets in the solar system?

Use the graph below to answfer questions 16–19.

***Viking Lander 1* Temperature Data**



16. Why do the temperatures in the graph vary in a pattern?

17. Approximate the typical high temperature value measured by *Viking I.*

18. Approximate the typical low temperature value measured by *Viking I.*

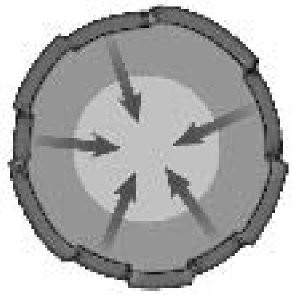
19. What is the range of these temperature values?

Part 3 Open Ended

Record your answers on a sheet of paper.

20. How might near-Earth-asteroids affect life on Earth? Why do astronomers search for them and monitor their positions?

Use the illustration below to answer question 21.



21. Explain how scientists hypothesize that the large cliffs on Mercury formed.

22. Describe the Sun-centered model of the solar system. How is it different from the Earth-centered model?

23. What is an astronomical unit? Why is it useful?

24. Compare and contrast the distances between the planets in the solar system. Which planets are relatively close together? Which planets are relatively far apart?

25. Summarize the current hypothesis about how the solar system formed.

26. Explain how Earth's gravity affects objects that are on or near Earth.

27. Describe the shape of planets' orbits. What is the name of this shape? Where is the Sun located?

28. Describe Jupiter's atmosphere. What characteristics can be observed in images acquired by space probes?