

CHAPTER 19 The Solar System

SECTION

2

The Inner and Outer Planets

KEY IDEAS

As you read this section, keep these questions in mind:

- How are the inner planets similar to one another?
- What are gas giants?
- What type of objects lie beyond the gas giants?

How Do Scientists Group and Compare the Planets?

There are eight planets in our solar system. Scientists classify the planets into two main groups: the inner planets and the outer planets. The inner planets are the four planets that are closest to the sun. The outer planets are farther away from the sun.

Inner planets	Outer planets
Mercury	Jupiter
Venus	Saturn
Earth	Uranus
Mars	Neptune

ASTRONOMICAL UNITS

Scientists typically describe distances in the solar system in terms of the average distance between Earth and the sun. The average distance between Earth and the sun is 150 million km, or one *astronomical unit* (AU). Planets closer to the sun than Earth are less than 1 AU from the sun. Planets farther from the sun than Earth are more than 1 AU from the sun.

DAYS AND YEARS

On Earth, a day is about 24 hours and a year is about 365 days. However, on other planets, days and years are not the same length as they are on Earth. For any planet, a *day* is the time it takes for the planet to rotate once on its axis. A *year* is the time it takes the planet to revolve once around the sun. We often describe the lengths of days and years on other planets by comparing them to days and years on Earth. ✓

READING TOOLBOX

Define As you read this section, underline words you don't know. When you figure out what they mean, write the words and their definitions in your notebook.

LOOKING CLOSER

1. Identify What are the four outer planets?

READING CHECK

2. Define What is a year?

SECTION 2 The Inner and Outer Planets *continued*

Talk About It

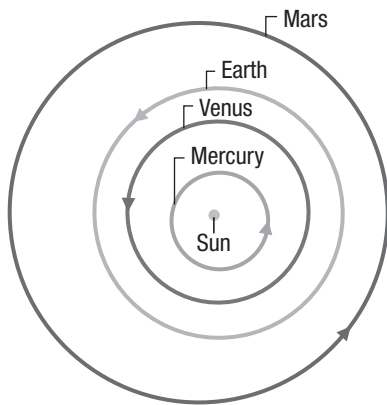
Define Look up the word *terrestrial* in a dictionary. With a partner, discuss why scientists use this word to describe the inner planets.

LOOKING CLOSER

3. Identify Which terrestrial planet is farther from the sun than Earth?

What Are the Inner Planets?

The inner planets have rocky surfaces and metallic cores. The inner planets are sometimes called the **terrestrial planets** because their compositions and surface features are similar to Earth's.



Gravity keeps the orbits of the inner planets in nearly circular paths.

MERCURY

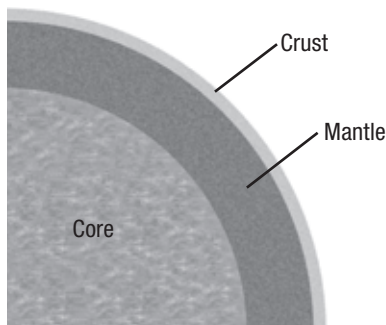
Mercury is the smallest planet and is the closest planet to the sun. The surface of Mercury is covered with craters. Because it has no atmosphere, Mercury's surface temperatures are extreme. During the day, Mercury can be as hot as 720 K. At night, it can be as cold as 103 K. ✓

READING CHECK

4. Explain Why are Mercury's surface temperatures so extreme?

Critical Thinking

5. Infer People have not been to any planet except Earth. How do you think scientists know about conditions on other planets?

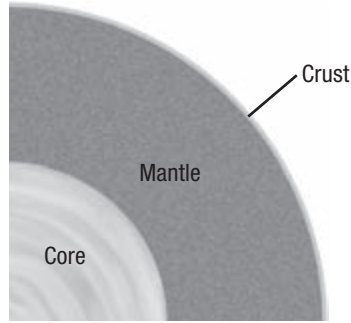


Mercury is the smallest planet in the solar system. It is a terrestrial planet.

VENUS

Venus can be seen from Earth, generally near sunrise and sunset. Thus, some people call Venus the *morning star* or *evening star*. Venus's surface has mountains and plains. The planet spins slowly on its axis in a direction opposite that of most other planets.

SECTION 2 The Inner and Outer Planets *continued*



We cannot see through Venus's atmosphere to its surface. The *Magellan* space probe used radar to produce the image of Venus's surface that is shown here.

LOOKING CLOSER

6. Explain Why was it necessary to use radar to produce an image of Venus's surface?

Life as we know it could not exist on Venus. The atmosphere is so thick that atmospheric pressure on Venus's surface is more than 90 times the pressure on Earth. Venus's atmosphere is made up mainly of carbon dioxide and sulfuric acid. The carbon dioxide traps radiation from the sun, causing heat to build up. In fact, surface temperatures on Venus may rise above 700 K. ✓

EARTH

Earth, our home, is the third planet from the sun. It is the only planet that has liquid water on its surface. Life as we know it cannot survive without liquid water. Earth is the only planet we know that can support life.

Compared to the other planets, temperatures on Earth's surface do not vary very much. This is mainly because Earth contains so much water. All the water on Earth's surface is called the **hydrosphere**. Water can absorb a lot of heat. Because of this, the hydrosphere helps keep temperatures on Earth from rising too high or falling too low.

Earth's atmosphere also helps keep surface temperatures from rising too high or falling too low for life to exist. The atmosphere contains about 78% nitrogen and 21% oxygen. The other 1% is made up of argon, carbon dioxide, and other gases. The atmosphere absorbs radiation from the sun and traps it as heat. This is known as the *greenhouse effect*. Without the greenhouse effect, Earth would be too cold for life to survive. ✓

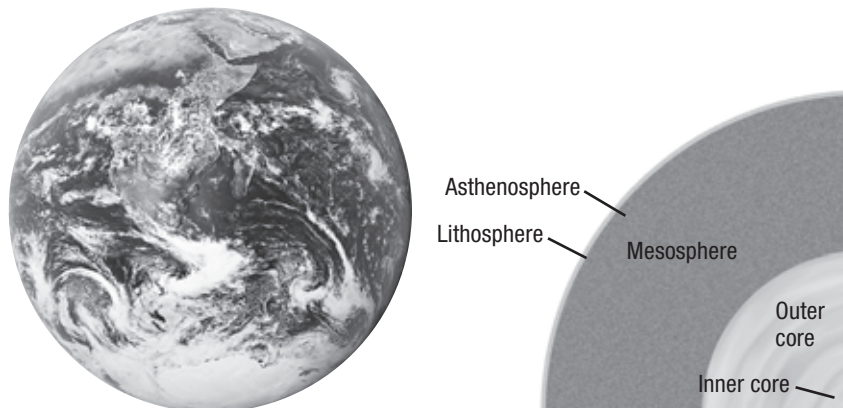
READING CHECK

7. Identify Give two reasons that life as we know it cannot exist on Venus.

READING CHECK

8. Describe Which two gases make up 99% of Earth's atmosphere?

SECTION 2 The Inner and Outer Planets *continued*



LOOKING CLOSER

9. Identify On the photograph of Earth, label part of the hydrosphere.

Earth is the only planet that we know contains life.

Critical Thinking

10. Apply Concepts More objects from space strike the surface of Mercury than strike Earth's surface. What do you think is the reason for this?

Earth's atmosphere also protects life on Earth in other ways. The upper atmosphere blocks most harmful ultraviolet radiation before it can reach Earth's surface and harm living things. The atmosphere also keeps many objects, such as human-made satellites and rocks from space, from hitting Earth's surface. The atmosphere causes these objects to break apart before they hit the planet's surface. Only relatively large objects can survive a trip through Earth's atmosphere.

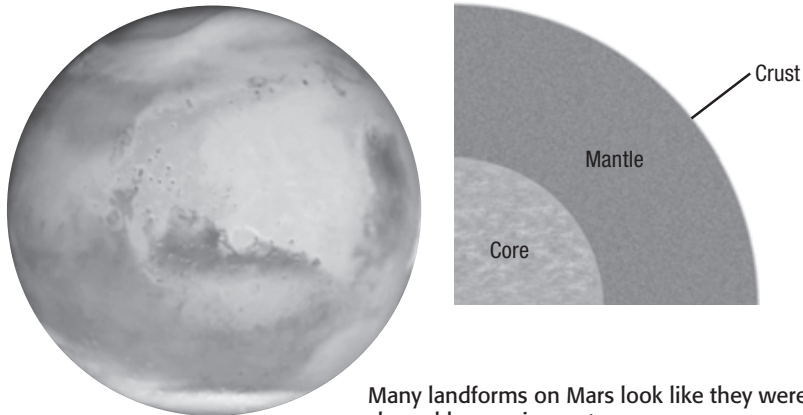
Earth's atmosphere has not always been the same as it is now. Early in Earth's history, the atmosphere contained much more carbon dioxide, methane, and ammonia than it does now. However, it did not contain much oxygen at all. As organisms such as microbes and plants evolved, they produced oxygen during photosynthesis. Most of the oxygen in the atmosphere today was produced by such organisms many millions of years ago.

MARS

Mars is a very cold planet. It has a relatively thin atmosphere made up mostly of carbon dioxide. Surface temperatures on Mars range from 144 K to 300 K. Mars has polar icecaps made of frozen carbon dioxide. The icecaps also contain small amounts of frozen water. Other surface features on Mars suggest that the planet once had liquid water on its surface.

READING CHECK

11. Infer Why do some scientists think there may once have been liquid water on Mars's surface?

SECTION 2 The Inner and Outer Planets *continued*

Mars has many unusual landforms. The Martian volcano Olympus Mons is the largest volcano in the solar system. It is almost three times taller than Mount Everest. Mars's thin atmosphere cannot cause objects that enter it to break apart. Therefore, many objects hit, or impact, Mars's surface, making craters. ✓

The surface of Mars looks red. This is because the soil contains iron oxide. Mars has frequent dust storms, which form large, red dunes on the planet's surface.

Comparison of the Inner Planets				
	Mercury	Venus	Earth	Mars
Distance from sun	0.4 AU	0.7 AU	1 AU	1.5 AU
Diameter	38% of Earth's	95% of Earth's	12,756 km	53% of Earth's
Density	98% of Earth's	89% of Earth's	5.515 g/cm ³	71% of Earth's
Surface gravity	38 % of Earth's	91% of Earth's	9.8 m/s ²	38% of Earth's
Length of a day	59 Earth days	243 Earth days	24 hours	24.7 Earth hours
Length of a year	88 Earth days	225 Earth days	365 days	1.9 Earth years

What Is the Asteroid Belt?

Hundreds of small, rocky objects are located between Mars and Jupiter. These objects, which range in diameter from 3 km to 700 km, are called **asteroids**. The region in which asteroids are found is called the *asteroid belt*. Most asteroids stay in orbit between Mars and Jupiter, but some leave the region and may cross Earth's orbit. However, there is only a very small chance that an asteroid will hit Earth in the near future.

Talk About It

Discuss What kinds of features may suggest that Mars's surface once had liquid water on it? In a small group, talk about different features on Earth that are formed by running water. Then, try to find out if scientists have observed similar features on Mars.

✓ READING CHECK

12. Identify What is the largest volcano in the solar system?

LOOKING CLOSER

13. Compare Which terrestrial planet is most similar to Earth in terms of diameter and surface gravity?

SECTION 2 The Inner and Outer Planets *continued*

LOOKING CLOSER

14. Infer Where is Ida probably located?



This asteroid, which scientists call Ida, is about 58 km long.

Ceres is the largest object in the asteroid belt. Scientists once considered Ceres a planet because of its size and location. However, scientists now classify Ceres as an asteroid.

Ceres is also considered a dwarf planet. Like a planet, a **dwarf planet** is an object that orbits the sun and is round because of its own gravity. However, unlike a planet, the gravity of a dwarf planet has not cleared other objects from the path of its orbit. ✓

READING CHECK

15. Compare How is a dwarf planet different from a planet?

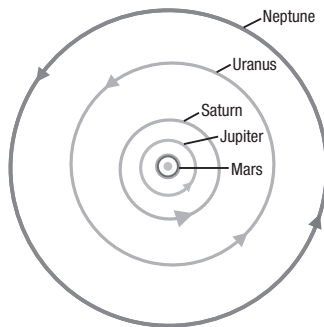
What Are the Gas Giants?

The outer planets are much larger than the inner planets. Because they have thick, gaseous atmospheres, the outer planets are also called the **gas giants**.

All of the gas giants have rings around them. Most of the rings are thin and difficult to detect. In addition to rings, all of the gas giants have many satellites. Remember that a *satellite* is an object that orbits a planet. Some of the gas giants have more than 40 satellites.

LOOKING CLOSER

16. Identify Which outer planet is closest to the sun?

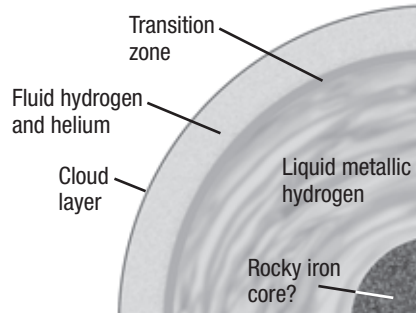


Jupiter, Saturn, Uranus, and Neptune are the four outer planets.

JUPITER

Jupiter is the largest planet in our solar system. It is about 1,300 times the size of Earth. Jupiter's atmosphere contains hydrogen, helium, methane, and ammonia.

SECTION 2 The Inner and Outer Planets *continued*



Scientists think that Jupiter may have a small, rocky core.

LOOKING CLOSER

17. Describe What material may make up much of Jupiter's interior?

Huge storms occur in Jupiter's atmosphere. One storm, called the Great Red Spot, is a huge circular storm that is more than twice the diameter of Earth. The Great Red Spot has existed for hundreds of years. ✓

Jupiter has more than 60 satellites. The four largest, Ganymede, Callisto, Io, and Europa, were discovered by Galileo in 1610. You can see these satellites with binoculars or a small telescope. Io has a thin atmosphere. Scientists think there may be liquid water on Europa.

READING CHECK

18. Identify What is the Great Red Spot?

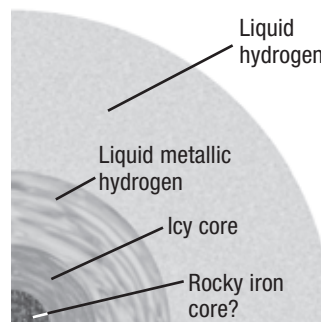
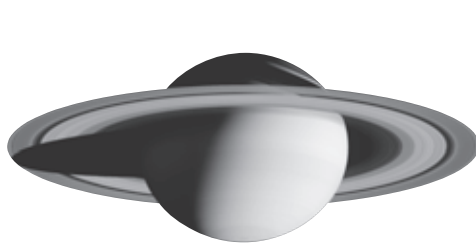
SATURN

All the gas giants have rings, but the rings of Saturn are probably the most well known. The rings are bands made up of particles of dust, rock, and ice. The particles range in size from a few millimeters to several meters. Most, however, are the size of a large snowball. ✓

How do the particles stay in rings around the planet? Gravitational forces from the planet act in one direction and those from Saturn's many satellites act in another. These competing forces hold the particles in rings around the planet.

READING CHECK

19. Describe What makes up Saturn's rings?



Scientists are not sure where the material in Saturn's rings came from.

LOOKING CLOSER

20. Compare Name one way that Saturn's interior is similar to Jupiter's interior.

SECTION 2 The Inner and Outer Planets *continued*

URANUS AND NEPTUNE

Uranus and Neptune are similar to each other in size and color. Both are smaller than Saturn and Jupiter, but like the other gas giants, they have thick, gaseous atmospheres. Their atmospheres are made up mainly of hydrogen, helium, and methane. Methane gives both planets a bluish color. ✓

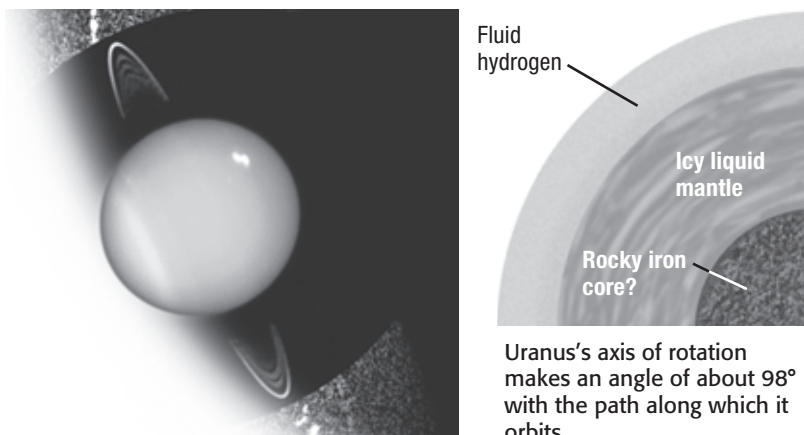
READING CHECK

21. Explain What gives Uranus and Neptune their bluish color?

Uranus is a very cold planet. Temperatures in its upper atmosphere are about 58 K. Uranus is tilted on its side at a 98° angle. This tilt is greater than the tilt of any other planet's axis. It gives Uranus the most extreme seasons in the solar system.

LOOKING CLOSER

22. Compare Give one way that Uranus is different from the other planets in the solar system.

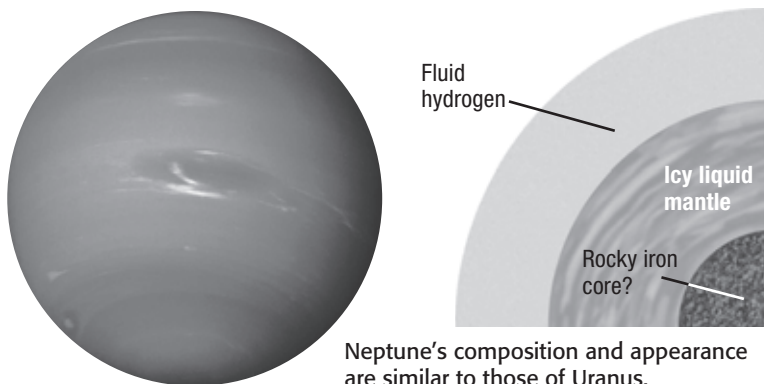


After Uranus was discovered, astronomers used what they knew about gravity in their search for other planets. Based on variations in Uranus's orbit, they predicted that another planet must exist that is farther from the sun than Uranus. Using this information, Johann Galle discovered Neptune in 1846.

The temperature of the gases in Neptune's upper atmosphere is about 58 K. Like Jupiter, Neptune has many storms. Winds on Neptune may reach 1,100 km/h.

Critical Thinking

23. Describe How are Neptune and Jupiter similar? Give two ways.



SECTION 2 The Inner and Outer Planets *continued*

Comparison of the Outer Planets				
	Jupiter	Saturn	Uranus	Neptune
Distance from sun	5 AU	9.54 AU	19 AU	30 AU
Diameter	11 times Earth's	9.4 times Earth's	4 times Earth's	3.9 times Earth
Density	24% of Earth's	13% of Earth's	24% of Earth's	32% of Earth's
Surface gravity	2.54 times Earth's	1.07 times Earth's	91% of Earth's	1.2 times Earth's
Length of a day	less than 10 Earth hours	10.7 Earth hours	17.25 Earth hours	16 Earth hours
Length of a year	12 Earth years	29 Earth years	84 Earth years	165 Earth years

LOOKING CLOSER

24. Compare Which two gas giants are most similar in terms of density?

25. Compare Which two gas giants are most similar in terms of diameter?

What Is the Kuiper Belt?

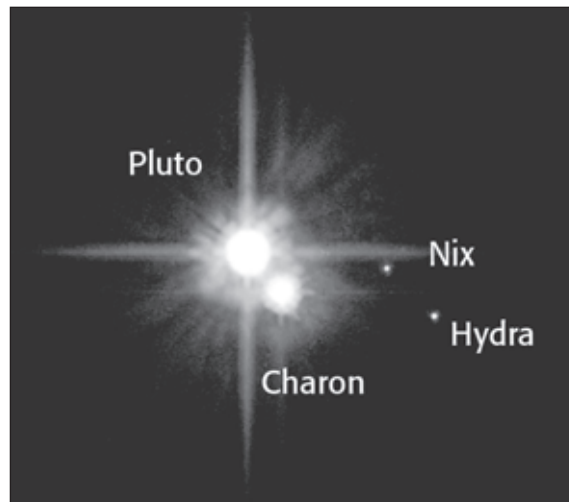
Beyond Neptune's orbit lies the Kuiper Belt. Many small objects made of rock and ice are found in this region. Scientists think these objects are left over from material that formed the solar system. ✓

One of the most well-known objects in the Kuiper Belt is a dwarf planet called Pluto. Pluto has a thin, gaseous atmosphere and a solid, icy surface. Scientists have also found another object, named Eris, that is even larger than Pluto. This object is also considered a dwarf planet.

READING CHECK

26. Identify What do scientists think was the origin of the objects in the Kuiper Belt?

Pluto's main satellite, Charon, is about half the size of Pluto. Two smaller satellites of Pluto, Hydra and Nix, were discovered in 2005.



LOOKING CLOSER

27. Identify What are three satellites of Pluto?

Scientists once classified Pluto as a planet. However, *planet* did not have a clear scientific definition until 2006. In that year, the International Astronomical Union (IAU) voted on a definition of planet. Because Pluto has not cleared other objects out of its orbital path, it is now considered a dwarf planet.

Section 2 Review

SECTION VOCABULARY

asteroid a small, rocky object that orbits the sun; most asteroids are located in the band between the orbits of Mars and Jupiter

dwarf planet a celestial body that orbits the sun, is round because of its own gravity, but has not cleared its orbital path

gas giant a planet that has a deep, massive atmosphere, such as Jupiter, Saturn, or Neptune

hydrosphere the portion of Earth that is water

terrestrial planet one of the highly dense planets nearest to the sun; Mercury, Venus, Earth, and Mars

1. Identify What unit is used to describe distances within the solar system? What is this unit based on?

2. Compare Give two similarities between a dwarf planet and a planet.

3. List Give three ways the gas giants differ from the terrestrial planets.

4. Describe Give two ways Earth's atmosphere helps makes life on Earth possible.

5. Infer Some scientists think that life may be possible on Jupiter's moon, Europa. Why?

6. Infer Is it possible for the length of a day on a planet to be longer than the length of a year? Explain your answer.
