section 13 The Solar System

PS 1.1c The Sun and the planets that revolve around it are the major bodies in the solar system. Other members include comets, moons, and asteroids. Earth’s orbit is nearly circular. 1.1d Gravity is the force that keeps planets in orbit around the Sun and the Moon in orbit around the Earth.

• Before You Read

Name the planets in the solar system that you already know.

• Read to Learn

Ideas About the Solar System

Based on their observations, early humans believed the Sun and planets moved around Earth. Today, people understand that Earth and the other planets and objects in the solar system orbit, or move around, the Sun.

Earth-Centered Model Early Greek scientists thought the planets, the Sun, the Moon, and the stars 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 stars.

Sun-Centered Model In 1543, Nicholas Copernicus published his model of the solar system. He stated that Earth and the other planets revolved around the Sun and that the Moon revolved around Earth. He explained that the Sun and the planets only looked like they were moving around Earth because Earth rotates. This is the Sun-centered model of the solar system.

Galileo Galilei used his telescope to observe that Venus went through a full cycle of phases like the Moon’s. Also, Venus looked smaller when its phase was near full. This could only be explained if Venus were orbiting the Sun, not Earth. Galileo concluded that the Sun is the center of the solar system.

What You’ll Learn

- Past and present ideas about the solar system
- How the solar system formed
- How the Sun’s gravity holds planets in orbit

Ask Questions As you read, write down your questions. Use the questions to find out more about topics that are not clear, or topics that are particularly interesting.

Foldables

A Find Main Ideas Make the following two-tab Foldable to help you identify the main ideas about past and present views on the solar system.
What is the modern view of the solar system?

Today, we know that the solar system is made up of eight planets, including Earth, and many smaller objects that orbit the Sun. The Sun and the position of the eight planets relative to the Sun are shown in the figure on this page and the next page. The solar system also includes a huge amount of space that stretches out in all directions from the Sun.

The Sun contains 99.86 percent of the mass in the solar system. Therefore, the Sun has a lot of gravity. The Sun's gravity is strong enough to hold the planets and other objects in their orbits.

How the Solar System Formed

Scientists hypothesize that the solar system formed more than 4.6 billion years ago. They have found clues that it may have formed from a cloud of gas, ice, and dust. Over time, this cloud pulled together to form a large, tightly packed, spinning disk. The center of the disk heated up to about 10 million degrees Celsius, and the reaction known as nuclear fusion began. That is how the star, the Sun, formed at the center of the solar system.

How did the planets form?

Not all of the gas, ice, and dust was pulled into the center of the spinning disk to form the Sun. Some matter collided and stuck together to form planets and asteroids. The eight planets of the solar system are divided into two groups, the inner planets and the outer planets.
What are the eight planets?

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, and Neptune. The outer planets are much larger than the inner planets. They are made up mostly of lighter substances, including hydrogen, helium, methane, and ammonia.

These light substances are not found in great quantities in the inner planets. The high temperatures closer to the Sun turned these substances to gas. They could not cool enough to form solids.

Motions of the Planets

When Nicholas Copernicus developed his Sun-centered model of the solar system, he thought the orbits of the planets were circles. In the early 1600s, Johannes Kepler discovered that the orbits of the planets are oval shaped, or elliptical. He also found that the Sun's position in the orbits is slightly off-center.

Kepler discovered that the planets orbit the Sun at different speeds. Planets closer to the Sun travel faster than planets farther away from the Sun. The outer planets also have longer distances to travel and take much longer to orbit the Sun than the inner planets.

3. Identify

Name the inner planets.

4. Infer

Which planet takes longer to orbit the Sun—Mars or Neptune?
After You Read

Mini Glossary

solar system: system of eight planets, including Earth, and many smaller objects that orbit the Sun

1. Review the term and its definition in the Mini Glossary. On the lines below, write something you have learned about the solar system.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

2. Complete the chart that shows how the solar system may have formed.

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1. The solar system formed from a cloud of ________, ________, and ________.</td>
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<tr>
<td>2. The cloud condensed to form a(n) ________.</td>
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<tr>
<td>3. ________ formed first. It was at the center of the new solar system.</td>
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<tr>
<td>4. The other material in the solar system collided and formed ________ planets.</td>
<td></td>
</tr>
<tr>
<td>5. The inner planets are ________, ________, and ________.</td>
<td></td>
</tr>
<tr>
<td>The outer planets are ________, ________, and ________.</td>
<td></td>
</tr>
</tbody>
</table>

3. Review the questions you wrote as you read this section. What resources could you use to find answers to your questions? Did the questions you write help you understand the information?

________________________________________________________________________

________________________________________________________________________
The Solar System

section 2 The Inner Planets

PS 1.1c The Sun and the planets that revolve around it are the major bodies in the solar system. Other members include comets, moons, and asteroids. Earth's orbit is nearly circular. Also covered: PS 1.1d, 1.1e, 2.1a

Before You Read

What do you know about Mercury and Venus? What would you like to know about these inner planets?

Read to Learn

Inner Planets

Today, people know a great deal about the solar system. Scientists use telescopes to study the planets both from Earth and from space. They also use space probes to study the solar system. Much of the information you will read in this section was gathered by space probes.

Mercury

Mercury is the planet closest to the Sun. The spacecraft Mariner 10 sent pictures of Mercury to Earth in 1974 and 1975. Scientists learned that Mercury, like Earth's Moon, has many craters. But unlike the Moon, Mercury has cliffs as high as 3 km on its surface. These cliffs might have formed when the crust of the planet broke as the core of the planet was cooling and shrinking.

Scientists learned that Mercury has a weak magnetic field. This shows that Mercury has an iron core, the same as Earth. Some scientists think that Mercury's crust solidified while the iron core was still hot and liquid. As the core became more solid, it became smaller. The cliffs resulted from breaks in Mercury's crust caused by the shrinking of the core.

What You'll Learn

- facts about the inner planets
- what each inner planet is like
- compare and contrast Venus and Earth

Make Flash Cards Make four flash cards to help you study this section. On one side of the card, write the name of an inner planet. On the other side, write facts about that planet.

Compare and Contrast Make the following Foldable to understand how the inner planets are similar and different.

Mercury

Venus

Earth

Mars
Does Mercury have an atmosphere?

Mercury has no true atmosphere. This is because Mercury has a low gravitational pull and high temperatures during the day. Most gases that could form an atmosphere escape into space. Earth-based observations have found traces of sodium and potassium around the planet. However, these atoms probably come from rocks in Mercury'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 as high as 425°C during the day, and it can fall to as low as −170°C at night. A picture of Mercury and some facts about the planet are shown below.

Venus

Venus is the second planet from the Sun. Venus is sometimes called Earth's twin because its size and mass are similar to Earth's. When Mariner 2 flew past Venus in 1962, the satellite sent back information about Venus's atmosphere and rotation. From 1990 to 1994, the U.S. Magellan probe used radar to make detailed maps of Venus's surface. A picture of Venus and some facts about the planet are shown below.
How hot is it on Venus?

The thick clouds on Venus block most of the Sun's light from reaching the planet's surface. The clouds and carbon dioxide gas in the atmosphere trap heat from the Sun. Temperatures on the surface of Venus range from 450°C to 475°C.

Earth

Earth is the third planet from the Sun. It is about 150 million km from the Sun, or one astronomical unit (AU). Earth is the only planet in the solar system that has large amounts of liquid water. More than 70 percent of Earth's surface is covered by liquid water. Earth is also the only planet that supports life. Earth's atmosphere protects life forms from the Sun's harmful radiation. The atmosphere also causes most meteors to burn up before they reach the surface of the planet. A picture of Earth and some facts about the planet are shown below.

Mars

Mars is the fourth planet from the Sun. It is called the red planet. Its red color is caused by iron oxide in the soil. Polar ice caps on Mars can be seen through telescopes from Earth. The ice caps are made of frozen water covered by a layer of frozen carbon dioxide. A picture of Mars and some facts about the planet are shown below.
What have scientists learned from missions to Mars?

Several spacecraft have made missions to Mars. From these missions, scientists have learned that there are long channels on the planet that might have been carved by flowing water. The largest known volcano in the solar system is on Mars. It is called Olympus Mons. It is probably not an active volcano. There are also large valleys in the Martian crust.

What did the Viking probes do?

The Viking 1 and 2 probes arrived at Mars in 1976. Each probe had two parts—an orbiter and a lander. The orbiters remained in space. They took photographs of the entire surface of Mars. The landers touched down on the surface of Mars. They carried equipment to search for signs of life on the planet. No conclusive evidence of life was found on Mars.

How were Pathfinder, Global Surveyor, and Odyssey used?

The Mars Pathfinder analyzed Martian rock and soil. These data indicated that iron might have reached the surface of Mars from underground. Global Surveyor took pictures that showed features like gullies that could have been formed by flowing water. Mars Odyssey had instruments that detected frozen water. The water forms a layer of frost under a thin layer of soil. It is possible that volcanic activity might melt frost beneath the Martian surface. The features look similar to those formed by flash floods on Earth, such as on Mount St. Helens. You can see how they compare in the figure below.
What makes up Mars’s atmosphere?
Mars’s atmosphere is much thinner than Earth’s atmosphere. It is made up mostly of carbon dioxide with some nitrogen and argon. Temperatures on the surface of Mars can be as high as 35°C and as low as −125°C. The change in temperature between day and night causes strong winds, which in turn cause global dust storms. This information is important if humans ever explore Mars.

Are there seasons on Mars?
Mars’s axis is tilted 25°, which is close to Earth’s tilt of 23.5°. So, Mars has seasons as it orbits the Sun. The polar ice caps on Mars change with the season. During winter, carbon dioxide freezes at the poles. The polar ice caps get larger. During summer, the carbon dioxide ice changes to gas. The ice caps get smaller. It is winter at one pole when it is summer at the other pole. The color of the ice caps and other areas on Mars also changes with the seasons. This is due to the movement of dust and sand during dust storms.

Does Mars have moons?
Mars has two small moons—Phobos and Deimos. Phobos orbits Mars once every 7 hours. It has a large crater and chains of smaller craters. Deimos orbits Mars once every 31 hours. It is farther away from Mars’s surface. Its surface looks smoother than that of Phobos. Its craters have partially filled with soil and rock.
After You Read

Mini Glossary

Earth: third planet from the Sun; has plenty of liquid water and an atmosphere that protects life

Mars: fourth planet from the Sun; has polar ice caps and a reddish appearance caused by iron oxide in the soil

Mercury: planet closest to the Sun; does not have a true atmosphere; has a surface with many craters and high cliffs

Venus: second planet from the Sun; similar to Earth in mass and size; has thick clouds

1. Review the terms and their definitions in the Mini Glossary. Write something interesting you learned about Mars, Venus, or Mercury.

2. Complete the table to organize the information from this section.

<table>
<thead>
<tr>
<th>THE INNER PLANETS</th>
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<tbody>
<tr>
<td>ORDER FROM SUN</td>
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<td>MERCURY</td>
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3. Review the flash cards you made. How did this help you learn the content of the section? How could you use the flash cards to prepare for a test on the inner planets?

End of Section

ScienceOnline Visit glencoe.com to access your textbook, interactive games, and projects to help you learn more about the inner planets.
The Solar System

section 2 The Outer Planets

PS 1.1c The Sun and the planets that revolve around it are the major bodies in the solar system. Other members include comets, moons, and asteroids. Earth’s orbit is nearly circular.

Before You Read

What do you know about the outer planets Jupiter, Uranus, Saturn, or Neptune? What would you like to learn?

Read to Learn

Outer Planets

Voyager, Galileo, and Cassini were not the first space probes to explore the outer planets. However, much new information about the outer planets has come from these probes.

Jupiter

Jupiter is the fifth planet from the Sun. It is the largest planet in the solar system. Data from space probes show that Jupiter has faint rings around it made of dust. Io, one of Jupiter’s moons, has active volcanoes.

What is Jupiter’s atmosphere made of?

Jupiter is made up mostly of hydrogen and helium with some ammonia, methane, and water vapor. Scientists hypothesize that the atmosphere of hydrogen and helium gas changes to liquid hydrogen and helium toward the middle of the planet. Below this liquid layer may be a rocky core that is probably different from any rock on Earth.

Jupiter’s atmosphere has bands of white, red, brown, and tan clouds. Storms of swirling gas have been observed on the planet. The Great Red Spot is the most spectacular of these storms.

What You’ll Learn

- facts about the outer planets: Jupiter, Uranus, Saturn, and Neptune
- which are the dwarf planets

Study Coach

Make Flash Cards Make five flash cards to help you study this section. On one side of each card, write the name of one of the outer planets. On the other side, write facts about that planet.

Foldables

Compare and Contrast Make the following Foldable to help you understand how the outer planets are similar and different.

- Jupiter
- Saturn
- Uranus
- Neptune
How many moons orbit Jupiter?
At least 61 moons orbit Jupiter. In 1610, the astronomer Galileo Galilei was the first person to see the four largest moons. Io (I oh) is the large moon closest to Jupiter.

Jupiter’s gravity and the gravity of the next large moon, Europa, pull on Io. This force heats up Io. The result is that Io has the most active volcanoes in the entire solar system.

Europa is made up mostly of rock. It has a thick crust of ice. Under the ice there might be a deep ocean. If this ocean does exist, it would be one of the few places in the solar system with large quantities of liquid water. The next moon is Ganymede. Ganymede is the largest moon in the solar system—larger than the planet Mercury. Callisto, the last of Jupiter’s large moons, is made up mostly of ice and rock. Callisto is another place in the solar system where there may be a large quantity of water. Pictures of Jupiter and Callisto, as well as some facts about Jupiter, are shown below.

Saturn
Saturn is the sixth planet from the Sun. It is the second-largest planet in the solar system. Saturn is the least dense planet in the solar system.

What is Saturn’s atmosphere like?
Saturn is similar to Jupiter. Both planets are large and made up mostly of gas. Saturn has a thick outer atmosphere made up mostly of hydrogen and helium. Deeper within the atmosphere the gases change to liquid. Below its atmosphere and liquid layers, Saturn might have a small, rocky core.
What are Saturn’s rings and moons like?
Each of Saturn’s large rings is made up of thousands of thin rings. These are made of ice and rock particles. Some particles are as tiny as a speck of dust, and some are tens of meters across. Saturn has the most complex ring system in the solar system.

At least 47 moons orbit Saturn. The planet’s gravity holds them in their orbits. Titan is the largest of Saturn’s moons. It is larger than the planet Mercury. A picture of Saturn and some facts about the planet are shown below.

![Saturn and Uranus images]

Uranus

Uranus (YOOR uh nus) is the seventh planet from the Sun. It is a large planet and also is made up mostly of gas. Thin, dark rings surround the equator. Scientists know that Uranus has at least 27 moons. Its largest moon, Titania, has many craters and deep valleys.

What are the characteristics of Uranus?
The atmosphere of Uranus is made up of hydrogen, helium, and some methane. Methane gives the planet a bluish-green color. A few clouds and storms can be seen on Uranus. There may be liquid water under its atmosphere.

Uranus has an unusual rotation. It is tilted on its side. The axes of rotation of the other planets are nearly perpendicular to the planes of their orbits. Uranus’s axis of rotation is nearly parallel to the plane of its orbit. Some scientists believe that a collision may have caused Uranus to tip over in this way. A picture of Uranus and some facts about the planet are shown above.

Think it Over

3. Compare and Contrast Describe two ways that Saturn and Uranus are different.

4. Recognize Cause and Effect What do scientists believe may have caused Uranus to tilt on its axis?
**Neptune**

Neptune is the eighth planet from the Sun. However, part of Pluto's orbit crosses inside Neptune's orbit. From 1979 until 1999, Pluto was closer to the Sun than Neptune was.

**What characteristics does Neptune have?**

Neptune's atmosphere is similar to Uranus's atmosphere. Methane gives the atmosphere of Neptune its bluish-green color, just as it does for Uranus. Neptune has dark-colored storms similar to the Great Red Spot on Jupiter. These storms and bright clouds form and disappear. This shows that Neptune's atmosphere is active and changes rapidly.

There may be a layer of liquid water under Neptune's atmosphere. The planet probably has a rocky core. Neptune has at least 11 moons and several rings. Neptune's largest moon, Triton, has a thin atmosphere made up mostly of nitrogen and methane.

**Dwarf Planets**

In August, 2006, the International Astronomical Union (IAU) defined the term *planet*. With that definition, Pluto, which became the ninth planet in 1930, was no longer a planet. It is now known as a dwarf planet. Besides Pluto there are two other dwarf planets, Ceres and Eris.

**What do we know about dwarf planets?**

Ceres was discovered in 1801. It is located in the asteroid belt and is the largest asteroid. Ceres orbits the Sun about once every 4.6 years.

Pluto has a thin atmosphere and a solid, icy-rock surface. Pluto has three moons, Nix, Hydra, and Charon. Pluto orbits the Sun once every 248 years.

Eris, which is slightly larger than Pluto, was discovered in 2005 and originally named UB313. It has a moon named Dysnomia. Eris orbits the Sun once every 557 years.
After You Read

Mini Glossary

**Great Red Spot**: giant, high-pressure storm in Jupiter's atmosphere

**Jupiter**: largest planet, and fifth planet from the Sun; has an atmosphere made up mostly of hydrogen and helium

**Neptune**: usually the eighth planet from the Sun; is large, gaseous, and bluish-green in color

**Pluto**: dwarf planet, has a solid icy-rock surface and three single moons, Charon, Hydra, and Nix

**Saturn**: second-largest and sixth planet from the Sun; has a complex ring system, at least 47 moons, and a thick atmosphere made mostly of hydrogen and helium

**Uranus (YOR uh nus)**: seventh planet from the Sun; is large and gaseous, has a distinct bluish-green color.

1. Review the terms and their definitions in the Mini Glossary. Choose an outer planet and write a sentence that tells something you learned about it.

   ___________________________________________________________________________

   ___________________________________________________________________________

2. Complete the table below to organize the information from this section.

<table>
<thead>
<tr>
<th>THE OUTER PLANETS</th>
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<tbody>
<tr>
<td>ORDER FROM THE SUN</td>
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<tr>
<td>Jupiter</td>
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<tr>
<td>5th</td>
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<tr>
<td>Saturn</td>
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<tr>
<td>Uranus</td>
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<tr>
<td>Neptune</td>
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</table>
section 4 Other Objects in the Solar System

What You’ll Learn
- how comets change when they near the Sun
- the differences among comets, meteoroids, and asteroids

Before You Read
Look up into the sky on a clear night. There are many objects you can see in addition to the Moon. What do you think these objects are? What would you like to know about them?

Comets
Planets and moons are not the only objects in the solar system. Comets, meteoroids, and asteroids are other important objects that orbit the Sun.

You may have heard of Halley’s Comet. A comet is made up of dust and pieces of rock mixed with frozen water, methane, and ammonia. Halley’s Comet was last seen from Earth in 1986. It takes Halley’s Comet 76 years to orbit the Sun. Astronomer Jan Oort suggested that billions of comets surround the solar system. This cloud of comets, called the Oort Cloud, is located beyond the orbit of Pluto.

What is the structure of a comet?
A comet is a mass of frozen ice and rock similar to a large, dirty snowball. As a comet approaches the Sun, the Sun’s heat turns the ice to gas. This releases dust and bits of rock which form a bright cloud, or coma, around the nucleus, or solid part, of the comet. The solar wind pushes on the gas and dust to form tails that point away from the Sun.
Meteoroids, Meteors, and Meteorites

After many trips around the Sun, most of the ice in a comet’s nucleus has evaporated. The comet is now just rocks and dust, spread out within the original comet’s orbit. These objects are called meteoroids. A meteoroid that enters Earth’s atmosphere and burns up is called a meteor. Another term for a meteor is a shooting star.

Whenever Earth passes through the old orbit of a comet, small pieces of rock and dust enter Earth’s atmosphere. The event is called a meteor shower. A meteorite is a large meteoroid that does not burn up completely in Earth’s atmosphere and strikes Earth. Most meteorites are probably the remains from asteroid collisions or broken-up comets. Others come from the Moon and Mars. ✅

Asteroids

An asteroid is a piece of rock made up of material like that which formed the planets. Most asteroids are located in an area between the orbits of Mars and Jupiter called the asteroid belt as shown in the figure. Other asteroids are scattered throughout the solar system.

What else do we know about asteroids?

Some asteroids are tiny. Others measure hundreds of kilometers. The first asteroid ever discovered, Ceres, is the largest. It measures 940 km in diameter.

Comets, asteroids, and most meteorites were 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.
After You Read

Mini Glossary

asteroid: a piece of rock made up of material similar to that which formed the planets
comet: space object made of dust and rock particles mixed with frozen water, methane, and ammonia

meteor: a meteoroid that burns up in Earth's atmosphere
meteorite: a meteoroid that strikes Earth's surface

1. Review the terms and their definitions in the Mini Glossary. Write a sentence to tell what the Oort cloud is.

2. Complete the concept chart with the correct words from the Mini Glossary.

meteoroid that burns up in Earth's atmosphere
lies between the orbits of Mars and Jupiter
rock from space that strikes Earth's surface
space object made of dust and rock particles mixed with frozen water, methane, and ammonia

3. Reread the sentences you highlighted in the text. Did this strategy help you describe comets, meteors, and asteroids? Work with a partner and take turns describing space objects to each other.

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End of Section

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