Summary

25.1 Exploring the Solar System

There have been two major models of the solar system: the geocentric model and the heliocentric model. In the geocentric model, Earth is in the center and the sun and the other planets circle around it. Ptolemy developed a complex version of this model around 140 A.D. The geocentric model was widely accepted until the early 1500s. In the heliocentric model, the sun is in the center and all the planets circle around it. Nicolaus Copernicus supported this model in the early 1500s. Scientists later proved that the heliocentric model is correct.

In 1600, Johannes Kepler discovered that the orbits of planets are ellipses, not circles. An ellipse has an oval shape. Isaac Newton discovered that the forces of gravity and inertia keep the planets in orbit. Inertia alone would cause the planets to fly into space. Gravity alone would cause them to fall into the sun. The two forces together keep the planets orbiting around the sun.

The solar system consists of the sun, the planets, their moons, and some smaller objects. Only the sun produces its own light. We can see planets and moons because they reflect sunlight. The first four planets are Mercury, Venus, Earth, and Mars. They are closest to the sun. The outer planets are Jupiter, Saturn, Uranus, and Neptune. They are much farther from the sun. Except for Mercury and Venus, all the planets have moons. A moon is a small natural body that revolves around a planet.

Distances between objects in space are very great. As a result, astronomers often use astronomical units to measure distances. One astronomical unit (AU) equals the distance from Earth to the sun, or about 150 million kilometers.

Modern technology has allowed scientists to explore the solar system in new ways. Starting in the 1960s, astronauts could use spacecraft to orbit Earth and visit the moon in order to learn about the solar system. Today, scientists mainly use space probes and telescopes to learn about the solar system. Space probes are spacecraft without people on board. The probes carry scientific instruments and cameras into space and send data back to Earth. Space probes have photographed most of the planets and moons of the solar system. Telescopes, such as the Hubble Space Telescope, have provided new views of the solar system.

25.2 The Earth-Moon System

The moon is Earth's nearest neighbor in space. The moon is much smaller than Earth. It also has much less mass. As a result, the force of gravity on the moon is far less than the force of gravity on Earth. The moon's gravity is too weak even to hold onto gas molecules. Therefore, the moon has no atmosphere. Without an atmosphere, the moon's surface temperature varies greatly. When the surface is sunny, it is extremely hot. When the surface is dark, it is extremely cold.

The major features on the surface of the moon are maria, highlands, and craters.

- Maria are low, flat plains. They were formed by ancient volcanoes.
- Highlands are rough, mountainous regions. They cover most of the moon's surface.
- Craters are round dents in the surface caused by meteoroids hitting the moon. Meteoroids are chunks of rock that move through the solar system.

Scientists think that the moon formed from Earth about 4.6 billion years ago. They think that a huge object slammed

into Earth and broke off chunks of the planet. The chunks gradually came together to form the moon.

Recall that the moon does not produce its own light. You can see the moon because it reflects light from the sun. The different shapes of the moon visible from Earth are called phases. The moon's phases are caused by changes in the relative positions of the moon, Earth, and sun. The moon revolves around Earth.

Sunlight illuminates half of the moon. The phase of the moon depends on how much of the sunlit portion of the moon is facing Earth. During a full moon phase, you can see the entire sunlit half, so the moon looks like a circle. During other phases, you can see less of the sunlit half, so the moon takes different shapes, such as a half circle or a crescent.

The moon takes almost 30 days to complete one full revolution around Earth. In this time, the moon goes through a full cycle of phases.

An eclipse occurs when an object in space, such as the moon, casts a shadow on another object in space, such as Earth. Eclipses in the Earth-moon system can occur only when the sun, moon, and Earth are in a straight line. There are two different types of eclipses in the Earth-moon system: solar eclipses and lunar eclipses.

- A solar eclipse occurs when the moon casts a shadow on Earth. All or part of the sun disappears for a short time as the moon's shadow passes over Earth.
- A lunar eclipse occurs when Earth casts a shadow on the moon. All or part of the moon disappears for a short time as the moon passes through Earth's shadow.

Tides are the regular rise and fall of ocean waters. Tides are caused mainly by differences in the moon's gravitational pull on Earth. The moon's gravity affects the liquid oceans more than it does solid Earth. The pull of the moon causes the oceans to bulge at places closest to and farthest from the moon. High tides occur when an area moves through either of these two bulges. Low tides occur halfway between high tides. Most coastal areas have two high tides and two low tides each day. The sun's gravity also influences the tides. However, the sun's gravity has less influence than the moon's gravity, because the sun is so much farther away from Earth.

25.3 The Inner Solar System

Mercury, Venus, Earth, and Mars are called the terrestrial planets. All the terrestrial planets are similar in structure to Earth. All are relatively small and dense, and all have rocky surfaces. All of them also have a crust, mantle, and iron core. The terrestrial planets are much warmer on average than the outer planets. This is because they are closer to the sun. Unlike the outer planets, the terrestrial planets have few, if any, moons.

Mercury is the smallest planet and the planet closest to the sun. Mercury also has the shortest year of any planet. Mercury is a dense planet with a very large iron core. Its surface has many craters. Mercury is geologically dead. This means that volcanism and other geological forces no longer act on the planet. Mercury has no water and virtually no atmosphere. Without an atmosphere, Mercury's surface temperature ranges between extremely hot and extremely cold. Mercury also has no moons.

Venus is called the "evening star" or the "morning star." Except for the moon, Venus is the brightest object in Earth's night sky. Venus is almost as large as Earth. It has a very thick atmosphere, which contains mostly carbon dioxide. The carbon dioxide absorbs heat and raises the planet's temperature. Venus is

too hot to have liquid water on its surface. The atmosphere of Venus also contains sulfur, probably from volcanoes. Some volcanoes may still be active. Venus has no moons.

Earth is unique among the terrestrial planets in several ways. One of the most important ways is that liquid water can exist on Earth's surface. Earth has a suitable atmosphere and temperature range for water to remain in liquid form. Water makes it possible for life to survive on Earth. Living things use carbon dioxide. As a result, Earth's atmosphere contains relatively little carbon dioxide. Without much carbon dioxide, the atmosphere does not overheat the planet. Water on Earth also causes erosion. This has shaped Earth's land surface in many ways. Earth has one moon.

Mars is the planet that is most like Earth. Mars looks red because of rusty iron in the rocks on the surface. The surface of Mars also has huge volcanoes, but they are no longer active. Mars has a very thin atmosphere, which contains mostly carbon dioxide. It is very cold on Mars because of the thin atmosphere and relatively great distance from the sun. Mars may have had liquid water on its surface at one time. It still has water frozen in ice caps at the poles. Like Earth, Mars has a tilted axis. This causes Mars to have seasons. The changing seasons cause dust storms on Mars.

Beyond Mars is a belt of asteroids that orbit the sun. Asteroids are small, rocky bodies. They range in diameter from about 1 kilometer to 500 kilometers. Scientists think that asteroids are parts of the early solar system that never came together to form a planet.

25.4 The Outer Solar System

The outer solar system consists of the rest of the planets: Jupiter, Saturn, Uranus, and Neptune. All of these planets are called gas giants. The gas giants are very different from the terrestrial planets. The gas giants are much colder because they are farther from the sun. They are also much larger and more massive. In addition, the gas giants have a different composition from terrestrial planets. The gas giants consist mainly of liquid hydrogen and helium, with small dense cores of metal and rock. They do not have solid surfaces. Also unlike the terrestrial planets, the gas giants have many moons.

Jupiter is the largest and most massive planet in the solar system. Its surface is covered with colorful clouds. Huge storms on Jupiter's surface may last for hundreds of years. Jupiter has more than 50 moons.

Saturn is the second-largest planet in the solar system. It is best known for its rings. The rings are made of particles of ice and rock. Most of the particles are the size of snowballs. Saturn has the thickest atmosphere in the solar system. It contains mostly hydrogen and helium. Saturn has more than 30 moons.

Uranus is the third-largest planet in the solar system. The atmosphere of Uranus also contains mostly hydrogen and helium, but it contains some methane gas as well. The methane gas makes Uranus look blue-green from Earth. Uranus has rings, but they are not as visible as Saturn's. The most unusual characteristic of Uranus is its tilt. Its axis is tilted nearly into the plane of the planet's orbit. Uranus has at least 20 moons.

Neptune is slightly smaller than Uranus. It has clearly visible clouds in its atmosphere. The clouds are made of methane ice crystals. The methane crystals make Neptune look blue from Earth. Neptune has huge storms in its atmosphere. It also has rings, similar to the rings of Uranus. Neptune has at least eight moons.

The dwarf planet Pluto is much smaller and denser than the outer planets. Pluto's orbit is also unusual. It is very elliptical. Sometimes Pluto is closer

to the sun than Neptune. At other times, Pluto is much farther from the sun than Neptune. Like Uranus, Pluto has a very tilted axis. Pluto has three moons.

In addition to the planets, the dwarf planets, and their moons, other objects move through the solar system. These objects include comets and meteoroids.

- A comet is a piece of ice and rock. Some of the comet vaporizes when the comet passes close to the sun. The gas and dust from the comet stream out behind the comet to form a tail.
- A meteoroid is a piece of rock that travels through the solar system. Most meteoroids are no bigger than grains of sand. Some meteoroids are as old as the solar system itself.

The solar system does not end with Neptune and Pluto. Beyond Neptune, thousands of pieces of ice, dust, and rock orbit the sun in a region called the Kuiper belt. Beyond the Kuiper belt is a huge area of comets called the Oort Cloud. These comets are thought to circle the solar system.

25.5 The Origin of the Solar System

Scientists have developed a theory about how the solar system formed. It is called the nebular theory. It is accepted by most astronomers.

The nebular theory states that the solar system formed from a rotating cloud of dust and gas, called a nebula. The dust and gas may have come from previous stars. The explosion of a nearby star may have started the nebula rotating. The gravitational attraction among particles made the nebula shrink. As the nebula got smaller, it rotated faster. Eventually, the nebula began to flatten out like a disk. The disk was thicker in the middle than at the edges. The sun developed from the middle part of the disk. The sun formed when heat and pressure increased and began to cause nuclear reactions. The planets developed from the edge of the disk. The planets gradually formed as particles of dust and gas collided and combined into larger objects.

The nebular theory also helps explain some of the differences between the terrestrial planets and the gas giants. When the solar system formed, it was very hot near the sun. Rock-forming materials such as iron were able to condense at high temperatures. These materials formed the terrestrial planets. In the outer solar system, it was much cooler. It was cool enough for ice-forming materials such as methane and ammonia to condense. Therefore, these materials formed the gas giants. Much more material was available for planet formation in the outer solar system. This allowed the gas giants to become much larger than the terrestrial planets. Large size gave the gas giants strong gravity. The gravity attracted hydrogen and helium gas from space to form the atmospheres of the gas giants.