The Solar System: The Sun and the Planets

8.3

The Solar System consists of the Sun, the eight planets and their moons, and billions of other smaller celestial objects. All of these celestial objects orbit the Sun (Figure 1).

Some planets are relatively close to the Sun. Mercury is just 58 million km away. Other objects are much farther away. Neptune is almost 4 billion km from the Sun! It would take a spacecraft travelling at 28 000 km/h almost 50 years to cross the Solar System.

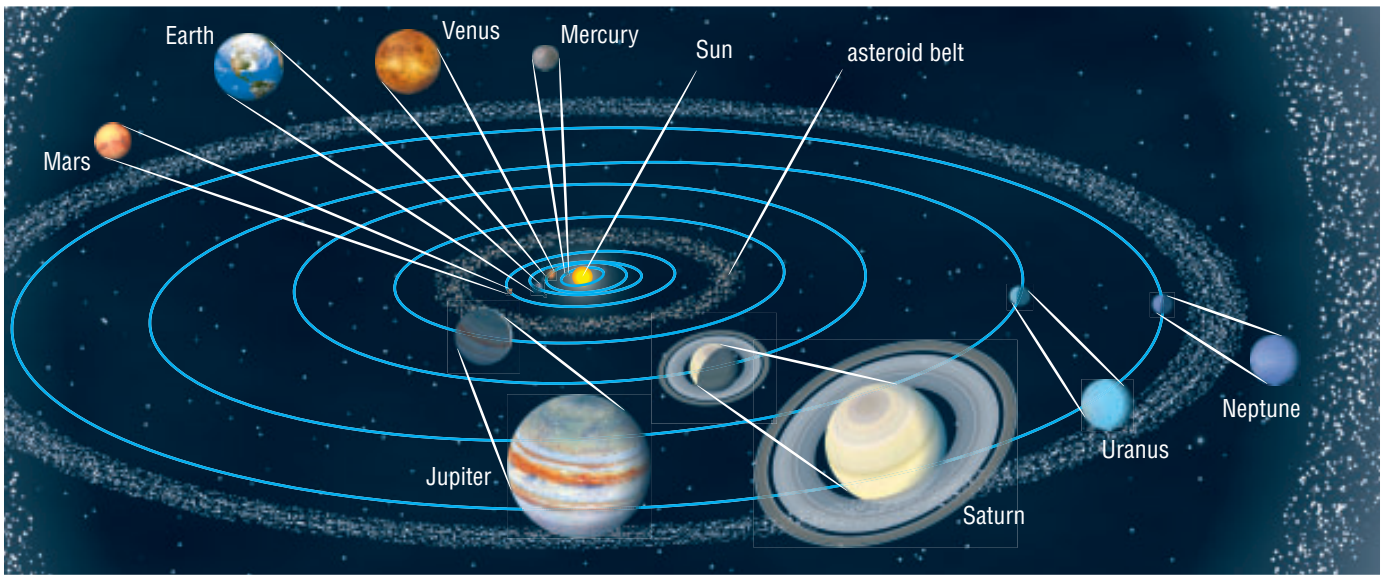

Figure 1 This drawing shows the Solar System, but does not illustrate true relative distances or sizes. For example, the Sun is about 100 times larger than Earth.

Measuring Distances in the Solar System

Distances in the Solar System are so great that astronomers must use a more convenient unit than the kilometre to measure them. The **astronomical unit**, or AU, is the average distance between the Sun and Earth—approximately 150 000 000 km. The AU provides a more manageable way to measure astronomical distances. For example, the planet Jupiter is 780 million km from the Sun. This equals 5.2 AU, which is more than five times farther from the Sun than Earth!

astronomical unit approximately 150 million kilometres; the average distance from Earth to the Sun

Planets Big and Small

The Sun is the largest object in the Solar System. The next largest objects in the Solar System are the planets. On a clear night, you can sometimes see planets such as incredibly hot Venus, desert-like Mars, and monster-sized Jupiter. In the night sky, the planets appear as only bright points of light because they are so far away.

The four planets nearest the Sun are Mercury, Venus, Earth, and Mars. These small, rocky planets are considered part of the inner Solar System. The four planets beyond Mars are Jupiter, Saturn, Uranus, and Neptune. These planets lie in the outer Solar System and are known as the gas giant planets. As their name implies, they are all big. Each of the eight planets has unique properties that make it different from the others.

TRY THIS REPRESENT THE SIZES OF THE PLANETS

SKILLS: Planning, Performing, Observing

SKILLS HANDBOOK 3.B.

In this activity, you will create scale models of the planets to help you visualize the size differences between them.

Equipment and Materials: metre stick; calculator; ruler; modelling clay; balloons; masking tape

1. Your teacher will draw a circle on the board, measuring 1.0 m in diameter. This represents a scale model of the Sun, with a diameter 100 times that of Earth.
2. Look at the equatorial diameter values in Table 1. These values represent the diameter of each planet in relation to Earth's diameter. For example, Mars has a value of 0.53, which means that its diameter is about half that of Earth.
3. Use modelling clay to create a model of Earth with a diameter of 1 cm. Compare the size of your model Earth with the Sun on the board and note your observations in your notebook.
4. Use the equatorial diameter data in Table 1 to create scale models of the other planets. Choose modelling clay or balloons as appropriate.
5. Use masking tape to label each planet.

A. Compare the size of Jupiter with the size of the Sun. Estimate how many Jupiters would fit across the diameter of the Sun. Write the answer in your notebook. Then measure to see whether your estimate was correct. T/I

B. The largest known star is VY Canis Majoris, which is 2100 times the size of the Sun. How big would its diameter be at the scale of this activity? T/I

C. Using the equatorial diameter data from Table 1, create a bar graph with the planet names on the *x*-axis and diameters on the *y*-axis. C

Table 1 Properties of Planets in the Solar System

Properties	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
equatorial diameter (Earth diameters)	0.382	0.949	1.0	0.53	11.21	9.44	4.01	3.88

Dwarf Planets

As our knowledge of the Universe grows, so do our ideas about the planets, stars, and other celestial objects. At the end of the 19th century, the word "planet" only applied to celestial objects in the Solar System. Over time, however, astronomers began to discover other celestial objects. These discoveries led to a change in the definition of "planet" in 2006. To be considered a "planet" a celestial object must

- be in orbit around a star (such as the Sun)
- have enough mass to be pulled into a stable sphere shape by gravity
- dominate its orbit (i.e., its mass must be greater than anything else that crosses its orbit)

dwarf planet a celestial object that orbits the Sun and has a spherical shape but does not dominate its orbit

From its discovery in 1930 until 2006, Pluto was considered the ninth planet in the Solar System. However, the new definition of planet excluded Pluto and added it to the category of "dwarf planet." **Dwarf planets** orbit the Sun and have a spherical shape. However, they do not dominate their orbits (Figure 2).

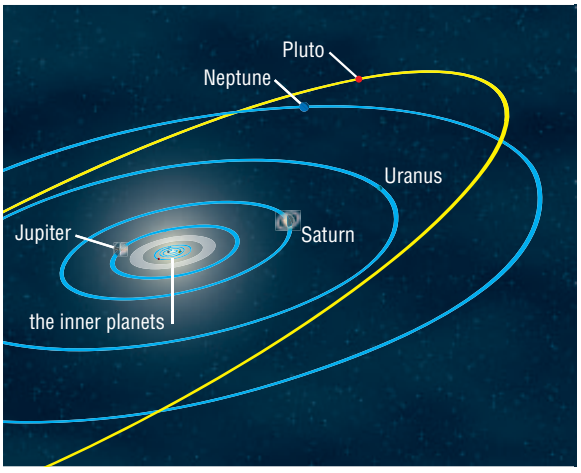

Figure 2 Pluto does not meet the criteria for a planet because its tilted orbit crosses Neptune's orbit.

Currently, there are five recognized dwarf planets—Ceres, Pluto, Haumea, Makemake, and Eris. However, only two of these—Ceres and Pluto—have been observed in enough detail to demonstrate that they fit the definition. Most of the dwarf planets discovered to date lie beyond the orbit of Neptune. Astronomers suspect that up to 2000 dwarf planets exist, with as many as 200 of these located within a region of the outer Solar System known as the Kuiper belt.

Smaller Members of the Solar System

In addition to the Sun and planets, the Solar System contains billions of smaller celestial objects. Some are made of rock and metal; others are composed of ice.

Asteroid Belt

Asteroids are small celestial objects in the Solar System composed of rock and metal (Figure 3). Although they also orbit the Sun, they are too small to be considered planets. The vast majority of asteroids lie in an area known as the asteroid belt, located between the orbits of Mars and Jupiter. Asteroids vary in size and can have a diameter of up to 950 km. The largest asteroids are round, but most are irregularly shaped.

Figure 3 At least 40 000 asteroids, approximately 800 m across or larger, make up the asteroid belt.

Meteoroids

A meteoroid is a piece of metal or rock in the Solar System that is smaller than an asteroid. Most meteoroids are the size of dust particles, but some can be as large as a car or building. Meteoroids sometimes get pulled in by Earth's gravity. As they are pulled down into Earth's atmosphere, friction causes them to burn up, creating a bright streak of light across the sky, known as a meteor. This phenomena is commonly referred to as a "shooting star." Meteors enter Earth's atmosphere at speeds of more than 1.5×10^5 km/h. On rare occasions, larger meteors do not burn up completely in the atmosphere and their remains, which we call meteorites, crash to the ground (Figure 4).

Several large meteorites have been known to create craters on impact. Lake Cheko, for example, is believed to have been formed by an impact crater during the Tunguska Event mentioned at the beginning of this chapter.

Canada is home to more than two dozen identified impact craters. The Manicouagan Crater, in northern Quebec, was formed from the impact of a meteorite with a 5 km diameter approximately 212 million years ago. The resulting crater is 100 km wide (Figure 5). The Sudbury Basin, located in northern Ontario, was formed from a 10 km meteorite impact that occurred 1.85 billion years ago. It is the second largest impact crater in the world, measuring 62 km long by 30 km wide. Much of the nickel mined in the Sudbury area originated from this meteorite.

DID YOU KNOW?

Meteoroids

About 100 tonnes of meteoroids as small as dust particles fall to the surface of Earth every day.

DID YOU KNOW?

Impact Event

A leading theory on the extinction of dinosaurs suggests that a 10 km meteorite impact is what caused the extinction of these animals 65 million years ago.

Figure 4 On November 20, 2008, a meteor flashed across the Prairie provinces. A few days later, this meteorite was found on a frozen pond at Lone Rock, Saskatchewan.

Figure 5 This satellite image shows the Manicouagan Crater, in northern Quebec. The crater is now filled with water, forming the ring-shaped Lake Manicouagan.

Figure 6 To observe a meteor shower, you need to watch from a dark location, outside city limits.

comet a chunk of ice and dust that travels in a very long orbit around the Sun

DID YOU **KNOW?**

Naming Comets

Most comets are named after their discoverers. For example, Comet Hale-Bopp was named after Alan Hale and Thomas Bopp, both amateur astronomers in the United States who discovered the comet in 1995.

METEOR SHOWERS

On a clear night there is, on average, one meteor flash in the sky every 15 minutes. However, on certain dates during the year, a number of meteors can be seen radiating from one point in the sky. We call this a meteor shower. For example, the Leonid meteor shower occurs every year around November 17th. Meteor showers mainly occur when clouds of particles left behind by comets enter the atmosphere of a planet, such as Earth (Figure 6).

Comets

Comets are large chunks of ice, dust, and rock that orbit the Sun. They range in size from less than 100 m to more than 40 km across. Some comets take a few years to travel around the Sun, whereas others take hundreds of thousands of years.

Comets are classified as either short- or long-period comets. Short-period comets originate from a region just beyond the orbit of Neptune and travel around the Sun in less than 200 years. Halley's Comet is the most famous example of a short-period comet, taking 75 to 76 years to make one trip around the Sun. The last visit of Halley's Comet was in 1986; it will return in 2061. Long-period comets originate from a spherical cloud of debris much farther away than Pluto and take more than 200 years to orbit the Sun. Comet Hale-Bopp is one of the most recent long-period comets to be observed from Earth. It takes about 2380 years for Hale-Bopp to make one trip around the Sun.

When a comet gets close enough to the Sun, its outer surface begins to sublimate—changing state from a solid to a gas—and its icy nucleus heats up. As this occurs, gases and dust escape. These gases and dust form a gaseous cloud around the nucleus called a coma, which can be thousands of kilometres wide (Figure 7).

As a comet approaches the Sun, radiation and solar wind from the Sun exert a force on the coma, which causes a gaseous tail to form, pointing directly away from the Sun. In addition, a dust tail forms in the direction from which the comet originated (Figure 8).

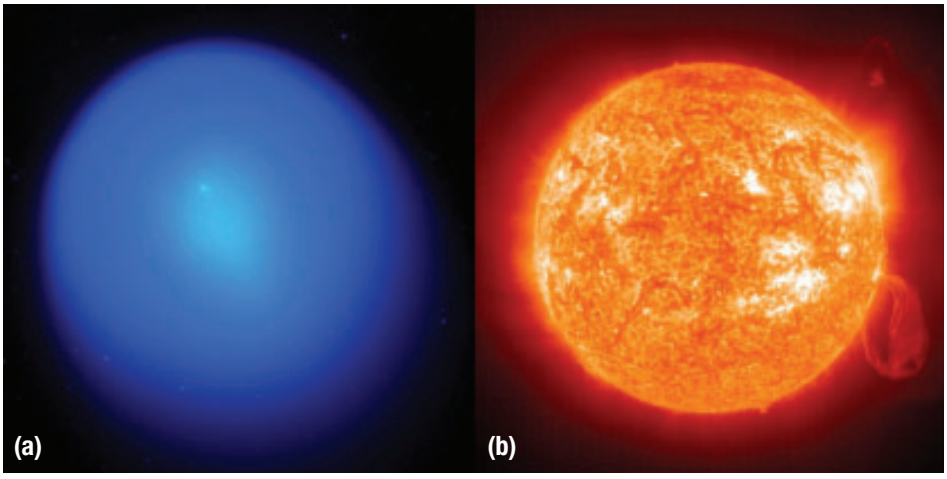

Figure 7 In 2007, Comet Holmes released large mounts of gas and dust, forming a coma (a) that expanded the diameter of the comet to be greater than that of the Sun (b).

Figure 8 Most comets have two tails—a gaseous tail and a dust tail.

If a comet ventures too close to a planet, it can be pulled in by the planet's gravity. This is what happened to Comet Shoemaker-Levy 9 when it crashed into Jupiter in July 1994 (Figure 9). Satellites that survey the Sun have even photographed some comets falling into the Sun.

UNIT TASK Bookmark

How can you apply what you learned about the planets and other members of the Solar System in this section to the Unit Task described on page 446?

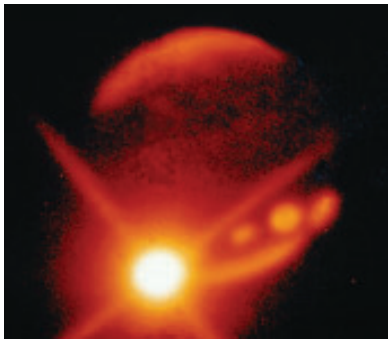

Figure 9 The fireball created when Comet Shoemaker-Levy 9 hit Jupiter on July 18, 1994 grew to over 20 000 km in diameter.

IN SUMMARY

- The average distance between the Sun and Earth is defined as one astronomical unit (AU).
- The four planets closest to the Sun are the terrestrial planets. These small, rocky planets are considered part of the inner solar system. The four planets farthest from the Sun are the gas giants. These large, gaseous planets are part of the outer Solar System.
- Pluto has been reclassified as a dwarf planet, based on its physical properties and motion.
- Besides the planets, there are smaller objects in the Solar System that orbit the Sun, such as asteroids, comets, and meteoroids.

CHECK YOUR LEARNING

1. Draw a picture of the Solar System from the "top" looking down onto the North Pole of Earth. Include and label the eight planets, plus Pluto, the asteroid belt, a comet, and a meteoroid. C K/U
2. Copy Table 2 into your notebook. Complete the table, naming the planets that are terrestrial and those that are gas giants. Then compare the two types under the remaining headings. K/U

Table 2

Names of planets	Large or small	Rock and metal or gas	Inner or outer Solar System

3. (a) Why do astronomers use astronomical units to measure distances in the Solar System? K/U
   (b) How many kilometres make up 1 AU? K/U
4. Why is Pluto no longer considered a planet in the Solar System? What kind of object is it considered to be now? K/U
5. Identify the errors in the following quotations by referring to the definitions of "meteoroid," "meteorite," and "meteor." Then rewrite them with the correct vocabulary. K/U C
   (a) "I saw a really bright meteorite flash across the sky!"
   (b) "The meteoroid made a huge hole in the ground when it crashed into Earth."
   (c) "Meteors sometimes hit spacecraft when they are travelling through deep space."
6. What evidence exists in the Canadian landscape to suggest that large meteorites have crashed into Earth? T/I
7. Describe what you think meteor showers look like and explain why they occur. You may use a diagram in your explanation. K/U C
8. Halley's Comet is one of the most famous objects in the Solar System, even though we have not seen it since 1986. K/U T/I
   (a) In what year will we next be able to see Halley's Comet?
   (b) In 1997, people could see Comet Hale-Bopp. In what year will this comet return?
9. Why do comets appear to have large tails flowing away from the Sun? K/U