

## Lesson 3

# The Outer PLANETS

### ESSENTIAL QUESTIONS



How are the outer planets similar?



What are the outer planets made of?

### Vocabulary

Galilean moons p. 69

## Inquiry Launch Lab

15 minutes

### How do we see distant objects in the solar system?

Some of the outer planets were discovered hundreds of years ago. Why weren't all planets discovered?

#### Procedure

- 1 Read and complete a lab safety form.
- 2 Use a **meterstick**, **masking tape**, and the **data table** to mark and label the position of each object on the tape on the floor along a straight line.
- 3 Shine a **flashlight** from "the Sun" horizontally along the tape.
- 4 Have a partner hold a page of this **book** in the flashlight beam at each planet location. Record your observations below.

Object	Distance from Sun (cm)
Sun	0
Jupiter	39
Saturn	71
Uranus	143
Neptune	295



### Florida NGSSS

**LA.8.2.2.3** The student will organize information to show understanding or relationships among facts, ideas, and events (e.g., representing key points within text through charting, mapping, paraphrasing, summarizing, or comparing/contrasting);

**MA.6.A.3.6** Construct and analyze tables, graphs, and equations to describe linear functions and other simple relations using both common language and algebraic notation.

**SC.8.E.5.3** Distinguish the hierarchical relationships between planets and other astronomical bodies relative to solar system, galaxy, and universe, including distance, size, and composition.

**SC.8.E.5.4** Explore the Law of Universal Gravitation by explaining the role that gravity plays in the formation of planets, stars, and solar systems and in determining their motions.

**SC.8.E.5.7** Compare and contrast the properties of objects in the Solar System including the Sun, planets, and moons to those of Earth, such as gravitational force, distance from the Sun, speed, movement, temperature, and atmospheric conditions.

### Data and Observations

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### Think About This

1. What happens to the image of the page as you move away from the flashlight?  

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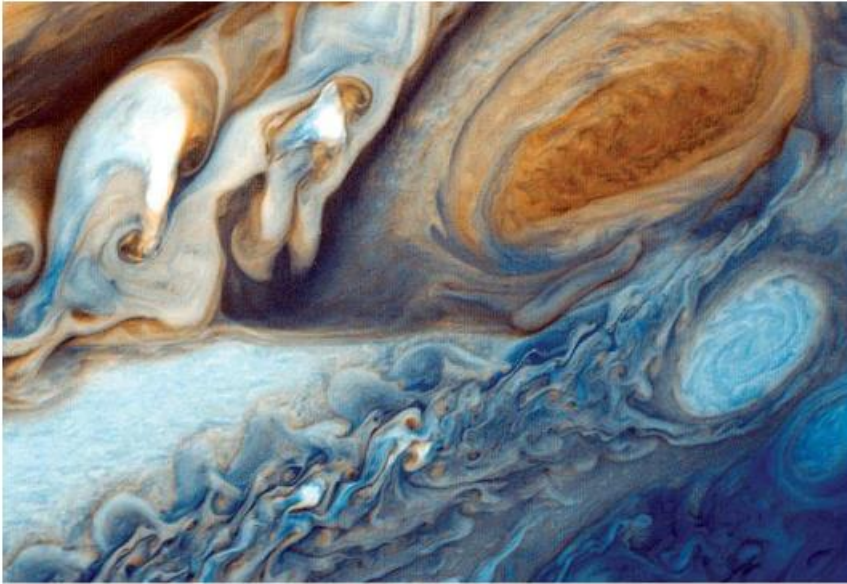
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2.  **Key Concept** Why do you think it is more difficult to observe the outer planets than the inner planets?  

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**Inquiry** What's below?

1. Clouds often prevent airplane pilots from seeing the ground below. Similarly, clouds block the view of Jupiter's surface. What do you think is below Jupiter's colorful cloud layer?

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## The Gas Giants

Have you ever seen water drops on the outside of a glass of ice? They form because water vapor in the air changes to a liquid on the cold glass. Gases also change to liquids at high pressures. These properties of gases affect the outer planets.

The outer planets, shown in **Figure 12**, are called the gas giants because they are primarily made of hydrogen and helium. These elements are usually gases on Earth.

The outer planets have strong gravitational forces because of their huge sizes. These forces apply tremendous pressure to the atmosphere of each planet and change gases to liquids. Thus, the outer planets mainly have liquid interiors. In general, an outer planet has a thick gas and liquid layer covering a small solid core.

**2. NGSSS Check Compare** How are the outer planets similar? **SC.8.E.5.7**

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**Figure 12** The outer planets are primarily made of gases and liquids.

**Active Reading** **3. Identify** the largest outer planet.



Active Reading

FOLDABLES

LA.8.2.2.3

Make a four-door book. Label each door with the name of an outer planet. Use the book to organize your notes on the outer planets.



# Jupiter

The largest planet in the solar system, Jupiter, is shown in Figure 13. Its diameter is more than 11 times larger than the diameter of Earth. Its mass is more than twice the mass of all the other planets combined. One way to understand just how big Jupiter is is to realize that more than 1,000 Earths would fit within this gaseous planet's volume.

Jupiter takes almost 12 Earth years to complete one orbit. Yet, it spins faster than any other planet. Its period of rotation is less than 10 hours. Like all the outer planets, Jupiter has a ring system.

## Jupiter's Atmosphere

The atmosphere on Jupiter is about 90 percent hydrogen and 10 percent helium and is about 1,000 km deep. Within the atmosphere are layers of dense, colorful clouds. Because Jupiter rotates so quickly, these clouds stretch into colorful, swirling bands. The Great Red Spot on the planet's surface is a storm of swirling gases.

**Figure 13** Jupiter is mainly hydrogen and helium. Throughout most of the planet, the pressure is high enough to change the hydrogen gas into a liquid.

Active Reading **5. Explain**

Why is Jupiter's period of revolution so much longer than the inner planets' periods of revolution?

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## Jupiter's Structure

Overall, Jupiter is about 80 percent hydrogen and 20 percent helium with small amounts of other materials. The planet is a ball of gas swirling around a thick liquid layer that conceals a solid core. About 1,000 km below the outer edge of the cloud layer, the pressure is so great that the hydrogen gas changes to liquid. This thick layer of liquid hydrogen covers Jupiter's core. Scientists do not know for sure what makes up the core. They suspect that the core is made of rock and iron. The core might be as large as Earth and could have 10 times more mass.

**4. NGSSS Check List** What makes up each of Jupiter's three distinct layers? **SC.8.E.5.3**

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SUBMIT SHOW ANSWERS CLEAR

Atmosphere

Core

Liquid hydrogen

The Great Red Spot is a giant storm that is twice as wide as Earth.

Jupiter's atmosphere is about 1,000 km thick and contains several layers of clouds. The average temperature at the top of the cloud layers is about -150°C.

Jupiter Data	
<b>Mass:</b>	318 Earth masses
<b>Diameter:</b>	11.2 times Earth's diameter
<b>Average distance from Sun:</b>	5.20 AU
<b>Period of rotation:</b>	9.9 hours
<b>Period of revolution:</b>	11.9 years
<b>Number of moons:</b>	63

Jupiter has a faint ring system. This image of Jupiter's rings was taken by *Voyager 2*.

## The Moons of Jupiter

Jupiter has at least 63 moons, more than any other planet. Jupiter's four largest moons were first spotted by Galileo Galilei in 1610. *The four largest moons of Jupiter—Io, Europa, Ganymede, and Callisto—are known as the Galilean moons.* The Galilean moons all are made of rock and ice. The moons Ganymede, Callisto, and Io are larger than Earth's Moon. Collisions between Jupiter's moons and meteorites likely resulted in the particles that make up the planet's faint rings.

## Saturn

Saturn is the sixth planet from the Sun. Like Jupiter, Saturn rotates rapidly and has horizontal bands of clouds. Saturn is about 90 percent hydrogen and 10 percent helium. It is the least-dense planet. Its density is less than that of water.

### Saturn's Structure

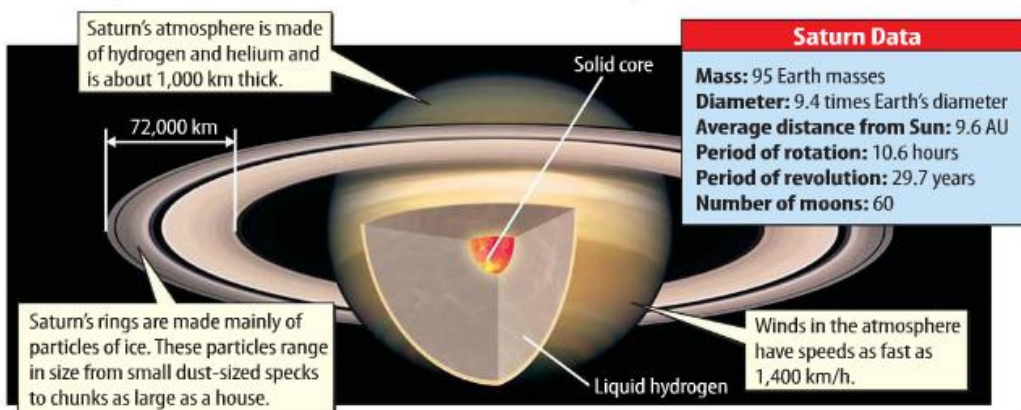
Saturn is made mostly of hydrogen and helium with small amounts of other materials. As shown in **Figure 14**, Saturn's structure is similar to Jupiter's structure—an outer gas layer, a thick layer of liquid hydrogen, and a solid core.

The ring system around the planet is the largest and most complex in the solar system. Saturn has seven bands of rings, each containing thousands of narrower ringlets. The main ring

system is over 70,000 km wide, but it is likely less than 30 m thick. The ice particles in the rings are possibly from a moon that was shattered in a collision with another icy object.

**7. NGSSS Check Describe** **Circle** what makes up Saturn and its ring system. **SC.8.E.5.3**

**Figure 14** Like Jupiter, Saturn is mainly hydrogen and helium. Saturn's rings are one of the most noticeable features of the solar system.



## Math Skills

MA.6.A.3.6

### Ratios

A ratio is a quotient—it is one quantity divided by another. Ratios can be used to compare distances. For example, Jupiter is 5.20 AU from the Sun, and Neptune is 30.05 from the Sun. Divide the larger distance by the smaller distance:

$$\frac{30.05}{5.20} = 5.78$$

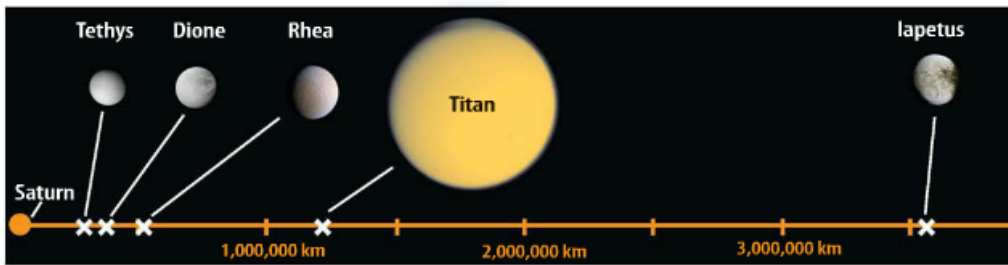
Neptune is 5.78 times farther from the Sun than Jupiter.

### 6. Practice

How many times farther from the Sun is Uranus (distance = 19.20 AU) than Saturn (distance = 9.58 AU)?

Click below.

abc



**Figure 15** The five largest moons of Saturn are shown above drawn to scale.

**Active Reading** 8. **Recognize** Circle the largest moon of Saturn.

Click below.

abc

### Saturn's Moons

Saturn has at least 60 moons. The five largest moons, Titan, Rhea, Dione, Iapetus, and Tethys, are shown in **Figure 15**. Most of Saturn's moons are chunks of ice less than 10 km in diameter. However, Titan is larger than the planet Mercury. Titan is the only moon in the solar system with a dense atmosphere. In 2005, the *Cassini* orbiter released the *Huygens* (HOY guns) **probe** that landed on Titan's surface.

### WORD ORIGIN

#### probe

from Medieval Latin *proba*, means "examination"

### Uranus

Uranus, shown in **Figure 16**, is the seventh planet from the Sun. It has a system of narrow, dark rings and a diameter about four times that of Earth. *Voyager 2* is the only space probe to explore Uranus. The probe flew by the planet in 1986.

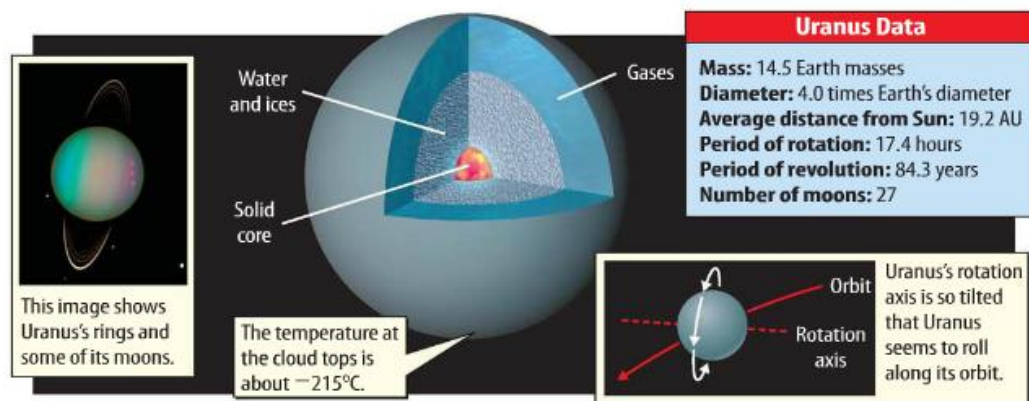
**Figure 16** Uranus is mainly gas and liquid with a small, solid core. Methane gas in the atmosphere gives Uranus a bluish color.

**Active Reading** 9. **Explain** What is different about Uranus's rotation axis?

Uranus has a deep atmosphere composed mostly of hydrogen and helium. The atmosphere also contains a small amount of methane. Beneath the atmosphere is a thick, slushy layer of water, ammonia, and other materials. Uranus might also have a solid, rocky core.

**10. NGSSS Check Identify** What are the substances that make up the atmosphere and the thick slushy layer on Uranus? **SC.8.E.5.7**

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## Uranus's Axis and Moons

**Figure 16** shows that Uranus has a tilted axis of rotation. In fact, it is so tilted that the planet moves around the Sun like a rolling ball. This sideways tilt might have been caused by a collision with an Earth-sized object.

Uranus has at least 27 moons. The two largest moons, Titania and Oberon, are considerably smaller than Earth's moon. Titania has an icy cracked surface that once might have been covered by an ocean.

## Neptune

Neptune, shown in **Figure 17**, was discovered in 1846. Like Uranus, Neptune's atmosphere is mostly hydrogen and helium, with a trace of methane. Its interior also is similar to the interior of Uranus. Neptune's interior is partially frozen water and ammonia with a rock and iron core.

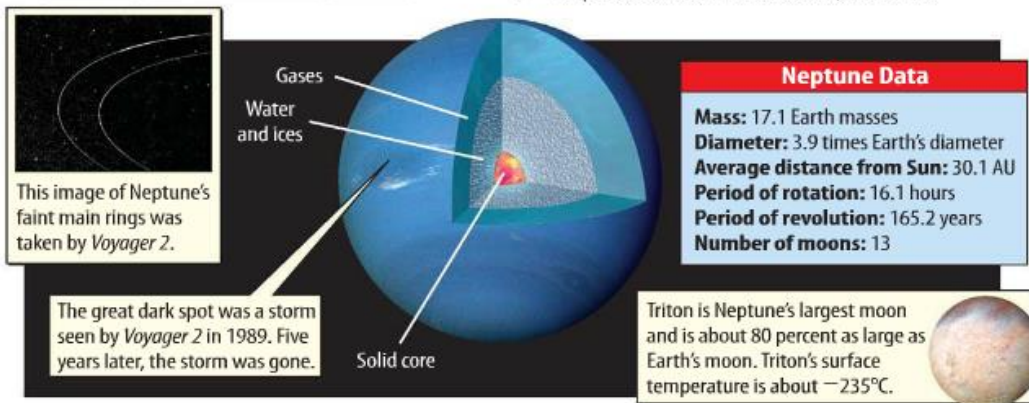
Neptune has at least 13 moons and a faint, dark ring system. Its largest moon, Triton, is made of rock with an icy outer layer. It has a surface of frozen nitrogen and geysers that erupt nitrogen gas.

 **11. NGSSS Check Contrast** How does the atmosphere and interior of Neptune compare with that of Uranus? **SC.8.E.5.7**

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This image of Neptune's faint main rings was taken by *Voyager 2*.

The great dark spot was a storm seen by *Voyager 2* in 1989. Five years later, the storm was gone.

Neptune Data	
<b>Mass:</b>	17.1 Earth masses
<b>Diameter:</b>	3.9 times Earth's diameter
<b>Average distance from Sun:</b>	30.1 AU
<b>Period of rotation:</b>	16.1 hours
<b>Period of revolution:</b>	165.2 years
<b>Number of moons:</b>	13

Triton is Neptune's largest moon and is about 80 percent as large as Earth's moon. Triton's surface temperature is about  $-235^{\circ}\text{C}$ .



**Inquiry**  
**LAB STATION**

**Try It!**

SC.8.N.1.1,  
LA.8.2.2.3

**Apply It!**

After you complete the lab, answer these questions.

**MiniLab** How do Saturn's moons affect its rings? at [connectED.mcgraw-hill.com](http://connectED.mcgraw-hill.com)

1. What planets have ring systems that would be affected by their moons?

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2. What is special about Saturn's largest moon?

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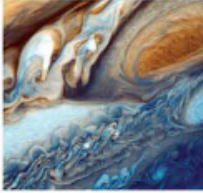
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**Figure 17**  The atmosphere of Neptune is similar to that of Uranus—mainly hydrogen and helium with a trace of methane. The dark circular areas on Neptune are swirling storms. Winds on Neptune sometimes exceed 1,000 km/h.

## Lesson Review 3

### Visual Summary



All of the outer planets are primarily made of materials that are gases on Earth. Colorful clouds of gas cover Saturn and Jupiter.



Jupiter is the largest outer planet. Its four largest moons are known as the Galilean moons.



Uranus has an unusual tilt, possibly due to a collision with a large object.

### Use Vocabulary

- 1 **Identify** What are the four Galilean moons of Jupiter? **SC.8.E.5.3**

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### Understand Key Concepts

- 2 **Contrast** How are the rings of Saturn different from the rings of Jupiter? **SC.8.E.5.3**

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- 3 Which planet's rings probably formed from a collision between an icy moon and another icy object?

- (A) Jupiter (B) Neptune (C) Saturn (D) Uranus

### Interpret Graphics

- 4 **Organize** List the outer planets.



### Critical Thinking

- 5 **Predict** what would happen to Jupiter's atmosphere if its gravitational force suddenly decreased. Explain.

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### Math Skills

**MA.6.A.3.6**

- 6 **Calculate** Mars is about 1.52 AU from the Sun, and Saturn is about 9.58 AU from the Sun. How many times farther from the Sun is Saturn than Mars?

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# Pluto

## What in the world is it?

Since Pluto's discovery in 1930, students have learned that the solar system has nine planets. But in 2006, the number of planets was changed to eight. What happened?

Neil deGrasse Tyson is an astrophysicist at the American Museum of Natural History in New York City. He and his fellow Museum scientists were among the first to question Pluto's classification as a planet. One reason was that Pluto is smaller than six moons in our solar system, including Earth's moon. Another reason was that Pluto's orbit is more oval-shaped, or elliptical, than the orbits of other planets. Also, Pluto has the most tilted orbit of all planets—17 degrees out of the plane of the solar system. Finally, unlike other planets, Pluto is mostly ice.

Tyson also questioned the definition of a planet—an object that orbits the Sun. Then shouldn't comets be planets? In addition, he noted that when Ceres, an object orbiting the Sun between Jupiter and Mars, was discovered in 1801, it was classified as a planet. But, as astronomers discovered more objects like Ceres, it was reclassified as an asteroid. Then, during the 1990s, many space

## Pluto TIME LINE

- 1930**  
Astronomer Clyde Tombaugh discovers a ninth planet, Pluto.
- 1992**  
The first object is discovered in the Kuiper belt.
- July 2005**  
Eris—a Pluto-sized object—is discovered in the Kuiper belt.
- January 2006**  
NASA launches *New Horizons* spacecraft, expected to reach Pluto in 2015.
- August 2006**

objects similar to Pluto were discovered. They orbit the Sun beyond Neptune's orbit in a region called the Kuiper belt.

These new discoveries led Tyson and others to conclude that Pluto should be reclassified. In 2006, the International Astronomical Union agreed. Pluto was reclassified as a dwarf planet—an object that is spherical in shape and orbits the Sun in a zone with other objects. Pluto lost its rank as smallest planet, but became "king of the Kuiper belt."

Neil deGrasse Tyson is director of the Hayden Planetarium at the American Museum of Natural History.



This illustration shows what Pluto might look like if you were standing on one of its moons.

### It's Your Turn

**RESEARCH** With a group, identify the different types of objects in our solar system. Consider size, composition, location, and whether the objects have moons. Propose at least two different ways to group the objects.

