

What Are Conditions Like on the Outer Planets?

Lesson Objectives

- Describe main features of the outer planets and their moons.
- Compare the outer planets to each other and to Earth.

Introduction

Jupiter, Saturn, Uranus, and Neptune are the outer planets of our solar system. These are the four planets farthest from the Sun. The outer planets are much larger than the inner planets. Since they are mostly made of gases, they are also called gas giants.

The gas giants are mostly made of hydrogen and helium. These are the same elements that make up most of the Sun. Astronomers think that most of the nebula was hydrogen and helium. The inner planets lost these very light gases. In the inner solar system the gases were too hot for the gravity of the inner planets to keep them. In the outer solar system it was cold enough for the gravity of the planets to keep the colder slower moving hydrogen and helium gas.

All of the outer planets have numerous moons. They also have planetary rings made of ice. Only the rings of Saturn can be easily seen from Earth.

Section 1: Jupiter

Jupiter is the largest planet in our solar system.

Jupiter, shown in the figure on the next page, is the largest planet in our solar system. Jupiter is named for the king of the gods in Roman mythology.

Jupiter is truly a giant! The planet has 318 times the mass of Earth, and about 1400 times Earth's volume. So Jupiter is much less dense than Earth. Because Jupiter is so large, it reflects a lot of sunlight. When it is visible, it is the brightest object in the night sky besides the Sun. Jupiter is quite far from the Earth. The planet is more than five times as far from the Sun as Earth. It takes Jupiter about 12 Earth years to orbit once around the Sun.

Terms to know

- Galilean moons
- gas giants
- outer planets
- planetary rings

A Ball of Gas and Liquid

Since Jupiter is a gas giant, could a spacecraft land on its surface? The answer is no. There is no solid surface at all! Jupiter is made mostly of hydrogen, with some helium, and small amounts of other elements. The outer layers of the planet are gas. Deeper within the planet, the intense pressure condenses the gases into a liquid. Jupiter may have a small rocky core at its center.



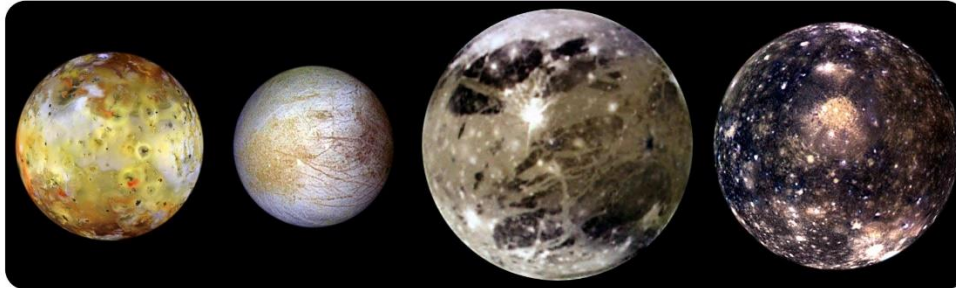
A Stormy Atmosphere

Jupiter's atmosphere is made mostly of hydrogen and helium gas. There are also small amounts of other gases that contain hydrogen, like methane, ammonia and water vapor. Astronomers think that clouds in the atmosphere are particles of water, ice and compounds made of ammonia. Alternating cloud bands rotate around the planet in opposite directions. Colors in these cloud bands may come from complex organic molecules. The Great Red Spot, shown in the Figure above, is Jupiter's most noticeable feature. The spot is an enormous, oval-shaped storm. It can expand to be more than two times as wide as the entire Earth! Clouds in the storm rotate counterclockwise. They make one complete turn every six days or so. The Great Red Spot has been on Jupiter for at least 300 years. It may have been observed as early as 1664. It is possible that this storm is a permanent feature on Jupiter. No one knows for sure.

Jupiter's Moons and Rings

Jupiter has lots of moons. As of 2012, we have discovered over 67 natural satellites of Jupiter. Four are big enough and bright enough to be seen from Earth using a pair of binoculars. These four moons were first discovered by Galileo in 1610. They are called the Galilean moons. The Figure below shows the four Galilean moons and their sizes relative to Jupiter's Great Red Spot. These moons are named Io, Europa, Ganymede, and Callisto. The Galilean moons are larger than even the

biggest dwarf planets, Pluto and Eris. Ganymede is the biggest moon in the solar system. It is even larger than the planet Mercury!



The Galilean moons are as large as small planets.

Scientists think that Europa is a good place to look for extraterrestrial life. Europa is the smallest of the Galilean moons. The moon's surface is a smooth layer of ice. Scientists think that the ice may sit on top of an ocean of liquid water. How could Europa have liquid water when it is so far from the Sun? Europa is heated by differences in Jupiter's gravity as Europa's distance changes during an orbit. These tidal forces are so great that they stretch and squash its moon. This could produce enough heat for there to be liquid water. Various missions have been discussed to explore Europa, including the idea to have a probe melt deep down through the ice into the ocean. However, no such mission has yet been attempted.

In 1979, two spacecrafts, Voyager 1 and Voyager 2, visited Jupiter and its moons. Photos from the Voyager missions showed that Jupiter has a ring system. This ring system is very faint, so it is very difficult to observe from Earth.

Section 2: Saturn

Saturn, shown in the figure below, is famous for its beautiful rings. Saturn is the second largest planet in the solar system. Saturn's mass is about 95 times Earth's mass. The gas giant is 755 times Earth's volume. Despite its large size, Saturn is the least dense planet in our solar system. Saturn is actually less dense than water. This means that if there were a bathtub big enough, Saturn would float! In Roman

mythology, Saturn was the father of Jupiter. Saturn orbits the Sun once about every 30 Earth years.

Saturn is the least dense planet in our solar system.



Saturn's composition is similar to Jupiter's. The planet is made mostly of hydrogen and helium. These elements are gases in the outer layers and liquids in the deeper layers. Saturn may also have a small solid core. Saturn's upper atmosphere has clouds in bands of different colors. These clouds rotate rapidly around the planet. But Saturn has fewer storms than Jupiter.

Saturn's Rings

Saturn's rings were first observed by Galileo in 1610. He didn't know they were rings and thought that they were two large moons. One moon was on either side of the planet. In 1659, the Dutch astronomer Christiaan Huygens realized that they were rings circling Saturn's equator. The rings appear tilted. This is because Saturn's rotation axis is tilted about 27 degrees from a line perpendicular to its orbit.

The Voyager 1 spacecraft visited Saturn in 1980. Voyager 2 followed in 1981. These probes sent back detailed pictures of Saturn, its rings, and some of its moons. The Cassini spacecraft has been in orbit around Saturn since 2004. From the Voyager and Cassini data, we learned that Saturn's rings are made of mostly ice particles of different sizes with a little bit of dust. There are several gaps in the rings. The gaps result from gravitational interactions between the ring particles and Saturn's moons that orbit outside the ring or by a small moon orbiting within the gap.

Saturn's Moons

As of 2012, over 62 moons have been identified around Saturn. Only seven of Saturn's moons are round. All but one is smaller than Earth's moon. Some of the very small moons are found within the rings. All the

particles in the rings are like little moons, because they orbit around Saturn.

Saturn's largest moon, Titan, is about one and a half times the diameter of Earth's moon. Titan is even larger than the planet Mercury. Scientists are very interested in Titan. The moon has an atmosphere that is thought to be like Earth's first atmosphere. This atmosphere was around before life developed on Earth. Like Jupiter's moon, Europa, Titan may have a layer of liquid water under a layer of ice. Scientists now think that there are lakes on Titan's surface. Don't take a dip, though. These lakes contain liquid methane and ethane instead of water! Methane and ethane are compounds found in natural gas.

Section 3: Uranus



Uranus is the 7th planet out from the Sun. Uranus' rings are almost perpendicular to the planet.

Uranus, shown in the figure above, is named for the Greek god of the sky, the father of Saturn. Astronomers pronounce the name "YOOR-uh-nuhs." Uranus was not known to ancient observers. The planet was first discovered with a telescope by the astronomer William Herschel in 1781.

Uranus is faint because it is very far away. Its distance from the Sun is 2.8 billion kilometers (1.8 billion miles). A photon from the Sun takes about 2 hours and 40 minutes to reach Uranus. Uranus orbits the Sun once about every 84 Earth years.

An Icy Blue-Green Ball

Uranus is a lot like Jupiter and Saturn. The planet is composed mainly of hydrogen and helium, but Uranus has a higher percentage of “ices” than Jupiter and Saturn. These “ices” include water, ammonia, and methane. Uranus is also different because of its blue-green color. Methane gas absorbs red light so the reflected light gives Uranus a blue-green color. The atmosphere of Uranus has bands of clouds. These clouds are hard to see in normal light. The result is that the planet looks like a plain blue ball.

Uranus is the least massive outer planet. Its mass is only about 14 times the mass of Earth. Like all of the outer planets, Uranus is much less dense than Earth. Gravity is actually weaker than on Earth's surface. If you were at the top of the clouds on Uranus, you would weigh about 10 percent less than what you weigh on Earth.

The Sideways Planet

All of the planets rotate on their axes in the same direction that they move around the Sun except for Venus and Uranus. While Venus rotates in the opposite direction, Uranus is tilted on its side. Its axis is almost parallel to its orbit. How did Uranus get this way? One possibility is that the planet was struck by a large planet-sized object as it was forming during the early days of the solar system.

Rings and Moons of Uranus

Uranus has a faint system of rings, as shown in the Figure below. The rings circle the planet's equator. However, Uranus is tilted on its side. So the rings are almost perpendicular to the planet's orbit.

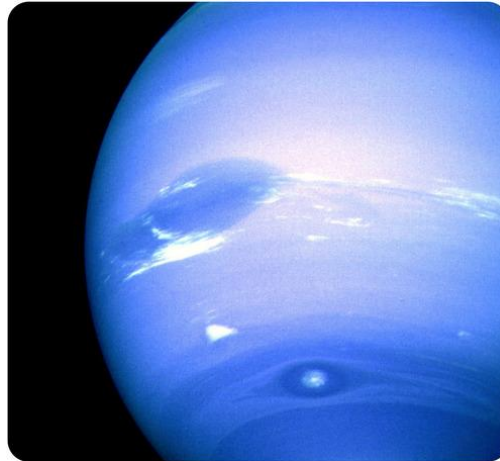


We have discovered 27 moons around Uranus. All but a few are named for characters from the plays of William Shakespeare.

Section 4: Neptune

Neptune is shown in the Figure below. It is the eighth planet from the Sun. Neptune is so far away you need a telescope to see it from Earth. Neptune is the most distant planet in our solar system. It is nearly 4.5 billion kilometers (2.8 billion miles) from the Sun. One orbit around the Sun takes Neptune 165 Earth years.

Neptune has a great dark spot at the center left and a small dark spot at the bottom center.



Scientists guessed Neptune's existence before it was discovered. Uranus did not always appear exactly where it should. They said this was because a planet beyond Uranus was pulling on it. This gravitational pull was affecting its orbit. Neptune was discovered in 1846. It was just where scientists predicted it would be! The planet was named Neptune for the Roman god of the sea.

Uranus and Neptune are often considered “sister planets.” They are very similar to each other. Neptune has slightly more mass than Uranus, but it is slightly smaller in size.

Extremes of Cold and Wind

Like Uranus, Neptune is blue. The blue color is mostly caused by the absorption of red light by methane in Neptune's atmosphere. Neptune is not a smooth looking ball like Uranus. The planet has a few darker and lighter spots. When Voyager 2 visited Neptune in 1986, there was a large dark-blue spot south of the equator. This spot was called the Great Dark Spot. When the Hubble Space Telescope photographed

Neptune in 1994, the Great Dark Spot had disappeared. Another dark spot had appeared north of the equator. Neptune's appearance changes due to its turbulent atmosphere. Winds are stronger than on any other planet in the solar system. Wind speeds can reach 1,100 km/h (700 mph). This is close to the speed of sound! The rapid winds surprised astronomers. This is because Neptune receives little energy from the Sun to power weather systems. It is not surprising that Neptune is one of the coldest places in the solar system. Temperatures at the top of the clouds are about -218°C (-360°F).

Neptune's Rings and Moons

Like the other outer planets, Neptune has rings of ice and dust. These rings are much thinner and fainter than Saturn's. Neptune's rings may be unstable. They may change or disappear in a relatively short time.

Neptune has 13 known moons. Only Triton, shown in the Figure below, has enough mass to be round. Triton orbits in the direction opposite to Neptune's orbit. Because of this, scientists think Triton did not form around Neptune. The satellite may have been captured by Neptune's gravity as it passed very close to Neptune.

Neptune's moon
Triton.

