CONTENTS OF THE SOLAR SYSTEM DATABASE

THE INFORMATION AVAILABLE TO STUDENTS ABOUT THE PLANETS IN OUR SOLAR SYSTEM

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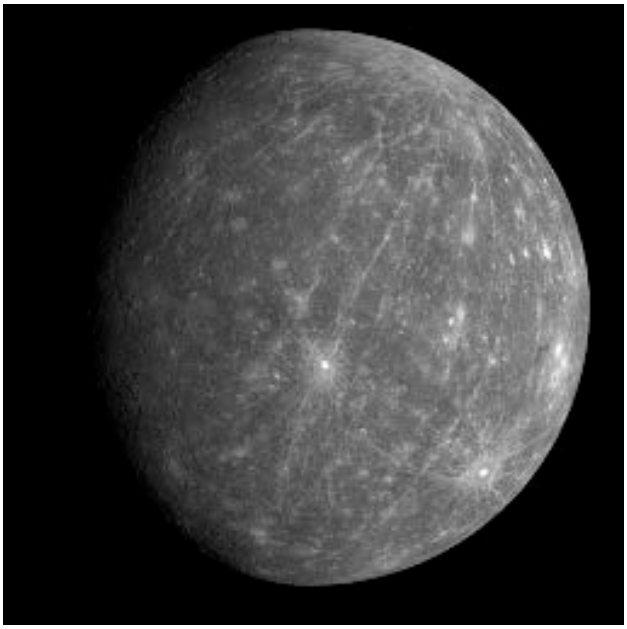
MERCURY

Mercury is the planet closest to the Sun. It is slightly larger than Earth’s moon, and looks very much like the Moon, with ancient impact craters scarring its rocky surface. Mercury flies along in its orbit at an average speed of 48 kilometers (29 miles) per second. That’s faster than any other planet, and about one and a half times faster than

Earth. Mercury has no moons, perhaps because it is too close to the Sun to hold on to one.



Because Mercury is so close to the Sun and because it moves so quickly, it has a very short year. It takes Mercury only 88 Earth days to travel around the Sun. Its year may be short, but a day on Mercury is very long. Remember that a day is the time it takes for a planet to rotate on its axis one time. It takes Mercury 59 Earth days to rotate once. This means that a day on Mercury is almost two of our months long. It also means that a year on Mercury is only one and a half Mercury days long.

Being so close to the Sun, you would think that Mercury would be very hot. However, only half of Mercury – the half turned toward the Sun – is very hot. Temperatures on the side of Mercury facing the Sun soar to 420 (NASA JPL) degrees Celsius. As you know, water boils at 100 degrees Celsius, so you can imagine how hot this is. However, the dark side of Mercury is very different. Mercury has almost no atmosphere, so it has no way to hold in the heat. Temperatures on the dark side of Mercury fall as low as 185 degrees below zero Celsius. Since Mercury's day is so long, this means that a spot on Mercury would bake in these high temperatures for almost 30 Earth days. Then, as Mercury rotates, the same spot would be turned from the Sun, where it would spend another 30 days at temperatures far below freezing.

In 1991, astronomers found that despite the heat, Mercury may have small ice caps at its north and south poles. The ice exists inside deep craters. The floors of these craters remain in perpetual shadow, so the Sun cannot melt the ice.

Mercury is a dense, rocky planet. Its core probably consists of iron and nickel. As Mercury spins on its axis, the iron in its core may generate a weak magnetic field that surrounds the planet.

Mercury's surface is hard and rocky, pitted with craters, and probably is covered with a thin layer of fine dust. Hugh cliffs tower as much as two miles above the surrounding landscape. The surface may be rich in metals.

If Earth were the size of a baseball, Mercury would be the size of a golf ball. Because of this, Mercury has a much lower level of gravity than Earth. Mercury's gravity if 0.38 of Earth's.

Mariner 10 made three passes near the planet in 1974 and ‘75. It photographed half of the planet’s surface, measured temperatures, and discovered a weak magnetic field. American and European space agencies are drafting plans for future missions to Mercury.

Although there may be a few trace gases left, Mercury's atmosphere has long since escaped into space because of the heat of the nearby Sun. There is no air, no water (only ice -frozen water- was observed), and nothing can grow on the planet’s surface. Astronauts who travel to Mercury will need strong shielding to protect them from the heat and the Sun’s harsh radiation.

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VENUS

The second planet from our Sun is Venus.
Like Mercury, Venus has no moons.
Venus is the hottest world in the solar system. It is blanketed by a thick atmosphere that heats its surface like the inside of a greenhouse. But with an average surface temperature of almost 462 (NASA JPL) degrees Celsius, this place is no garden!

Other than its atmosphere, Venus is so similar to Earth that it is sometimes called Earth’s sister planet. Its diameter and mass are almost identical to Earth’s. If Venus is so similar to Earth, why is it so much hotter?

The “greenhouse effect” on Venus is caused by its atmosphere. Energy from the Sun passes through the atmosphere to the planet’s surface, where it is absorbed and radiated back at longer wavelengths (as heat). Venus’ atmosphere traps these longer wavelengths so they cannot escape into space. The trapped heat builds up, so the planet grows hotter and hotter. The same thing happens in an automobile on a hot day. Sunlight comes through the windows and warms the inside of the car, but the heat is trapped.

Even though Venus' orbit brings it closer to Earth than any other planet, its blanket of clouds kept much of Venus a mystery. But space probes sent by the Soviet Union and the United States, as well as studies with ground-based radar, have allowed astronomers to "see" the surface of Venus for the first time. The first exploration of Venus by radar was in 1962.

Space probes have revealed that the atmospheric pressure at the surface of Venus is 90 times that of Earth's. The atmosphere consists mainly of carbon dioxide - the same gas that humans breathe out. Since Venus has a lack of oxygen in the upper atmosphere, humans would not be able to breathe this atmosphere. In addition, the clouds of Venus contain drops of sulfuric acid, a chemical poisonous to living things on Earth. The thick atmosphere on Venus makes it difficult to see objects very far away. Despite this high atmospheric pressure, the gravity on Venus is 0.90 times that of Earth.

Venus takes 225 Earth days to travel around the Sun, making its year a little more than half as long as ours. However, like Mercury, it rotates very slowly. It takes 243 Earth days for Venus to turn on its axis one time.

Another interesting fact about Venus is that it spins backward on its axis. If you could stand on the surface of Venus and see the Sun through the cloud cover, it would rise in the west and set in the east – the opposite of Earth. Daytime on Venus is about as bright as a cloudy day on Earth, and the winds on the ground are gentle. Gravel and flattened boulders are scattered over the plains. Because of the heat and pressure on Venus, no probe landing there has ever survived for more than an hour.

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EARTH

Photo of Earth

The world we call home is the third planet from our Sun. Of all the planets in our solar system, Earth is the only one that can support human life. No other planet has oceans of water, an oxygen-rich atmosphere, and intelligent life.

Earth has one moon, which we normally refer to simply as “the Moon.” Until Galileo discovered four of the moons of Jupiter, we thought the Moon was the only moon in the solar system. Now we know it is merely one of more than 60 moons. The Moon is our companion in the solar system, traveling around the Sun with us. It takes 365 days for our world and its Moon to make this journey around the Sun. It is this revolution around the Sun that determines the length of our year.

In many ways, Earth is just an average planet. It is bigger than four planets in the solar system and smaller than the other four. Two planets, Venus and Mercury, are closer to the Sun, while the other six are farther away.

We assign Earth a gravity of 1.00, and use that figure to compare its gravity to other worlds. For example, the gravity of our Moon is .16, meaning that our moon has about one-sixth the gravity of Earth. Mercury, Venus, Mars, and Pluto have less gravity than Earth, while Jupiter, Saturn, Uranus, and Neptune have more gravity.

Earth formed about 4.5 billion years ago, and it is still evolving. Earthquakes and volcanoes are violent proof of Earth’s shifting crust. Beneath this thin crust of rock - which averages about four miles (7 km) thick under the oceans and up to 25 miles (40 km) beneath the continents - lies a 1770 km layer of denser rock called the mantle.

Beneath the mantle is Earth’s core, made mostly of nickel and iron. The inner part of the core is solid, but the outer part is liquid. From its edge to its center, the core measures about 2160 miles. This metal core is part of the reason why Earth has a magnetic field.

Earth is the largest body in the solar system with a solid surface. This solid surface locks in the heat of the core. This heat can build up until it is strong enough to force its way out. This can push on the surface of the Earth, causing it to shift. The result of this shifting is earthquakes. Sometimes, the heat trapped beneath the surface builds up to the point where it explodes out of the ground, causing volcanoes. Earth is the only planet that has ongoing plate tectonics (movement of the rigid plates that make up the surface), though some moons may have similar dynamics.

Above Earth's solid surface lies its atmosphere. The atmosphere has more oxygen today than it did when Earth formed. While the early atmosphere was mostly carbon dioxide, more than three-quarters of Earth's atmosphere is now nitrogen, and most of the rest of it is oxygen. Chemical reactions locked much of the early carbon dioxide inside rocks, while plants produced the oxygen in our present-day atmosphere. Earth's atmosphere is extremely important. In addition to containing the gases plants and animals need to live and grow, our atmosphere protects us from the harmful ultraviolet radiation of the Sun.

The temperatures on Earth vary with location and season. Temperatures have ranged on the Celsius scale from as low as 88 degrees below zero to 58 degrees above zero. The average temperature at Earth's surface is 17 degrees Celsius.

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EARTH'S MOON

Photo of Earth's Moon

Compared to the other moons in our solar system, our own Moon is something of an oddity. Except for tiny Pluto, all the other planets are much larger than their moons. But Earth is only about four times wider than its Moon. Compared to huge planets like Jupiter and Saturn, which are 40 or 50 times larger than their biggest moons, Earth and its Moon could almost be considered twin planets.

But Earth and Moon don't look like twins. Unlike Earth, the Moon has no atmosphere. Instruments aboard the Clementine spacecraft hinted that some ice might hide inside craters at the Moon's poles (in 2008, Chandrayaan-1 spacecraft has confirmed the existence of surface water ice). And the lunar surface is covered with craters, the scars from countless comets and asteroids that struck it over billions of years. Some of these objects were bigger than mountains.

When a meteor strikes Earth, it makes a crater, just as it would on the Moon. But on Earth, wind, rain, and the motions of the crust erase or fill in these craters. Since the Moon has no atmosphere, there is no rain or wind to erode the craters. And because the Moon's interior is no longer hot and active like Earth's, there are no active volcanoes on the Moon. So craters formed by meteorites on the Moon last a long time.

There are many theories about how the Moon was formed. The most popular theory today says that very early in the history of the solar system a large object - perhaps several times the mass of Mars - slammed into Earth. A geyser of molten material spewed into space, and entered orbit around Earth. Some of this material fell back to Earth, but much of it came together to form the Moon. Recent research suggests this process - from impact to fully formed Moon - may have required a thousand years or less.

The Moon has almost no atmosphere. When the Apollo astronauts went to the Moon, they had to carry their own air to the lunar surface. They also needed to wear spacesuits to protect them from the Sun's intense radiation, because there was no

atmosphere to block its harmful rays. Because the Moon has no atmosphere, the sky is black, even during the day.

The gravity on the Moon is only 0.16 of what it is on Earth. If you were to take a walk on the Moon, you would find that you feel much lighter than you do on Earth. You would be able to jump higher and farther, and you would find it much easier to carry heavy objects.

The Moon is locked in a synchronous orbit with the Earth. This means that one side of the Moon always faces the Earth, while the other side is always turned away. Until we sent spacecraft to orbit the Moon, we had no idea what the far side of the Moon looked like. If you landed on the hemisphere that faces Earth, our home planet would hang in the sky, appearing almost four times wider than the full Moon appears in Earth's sky. Earth would stand in almost the same position in the sky, never rising or setting. The Sun, on the other hand, would appear to move slowly across the sky, rising only once every month. Then you would have two weeks of light followed by two weeks of night.

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MARS

Photo of Mars

The fourth planet in our solar system is Mars. Perhaps because of its reddish color, Mars was named for the Roman god of war. Mars has two small moons which were named for the sons of the Greek god of war: Phobos (Fear) and Deimos (Terror). Neither of these moons is round. In fact, they are shaped a little like potatoes. It takes Mars and its moons 687 Earth days to travel around the Sun. This means that the Martian year is little less than two of our years.

Although Mars is smaller and colder than Earth, it is still quite similar to our planet. It has a thin atmosphere and polar ice caps, and dry riverbeds crisscross its surface. Mars' axis is tipped, just like Earth's, meaning that Mars has seasons, too. Frozen water may exist beneath the red Martian soil - perhaps providing a home for living organisms. But it is not the planet described in science-fiction books and movies. There are no signs of civilizations on its surface - past or present.

Long ago, Mars may have been much more similar to Earth than it is today. Scientists believe that Mars may once have had a thick atmosphere containing lots of water vapor. During those times, Mars might have had rain showers like we do on Earth. Much of this water may still be on Mars, trapped in a layer of permafrost beneath the surface. Permafrost is permanently frozen water that is below the surface of a world, and it can be found in very cold regions of Earth as well.

Water may also have once flowed in rivers, lakes, and perhaps small seas on Mars. The surface of Mars shows signs that flooding occurred in the distant past. Also, there are many channels cut into the surface of Mars. These look like river systems on Earth and scientists believe that they may be the dried-up river beds of ancient rivers. Although no water flows over the Martian surface today, frost covers the north and south poles. These polar ice caps are made mostly of frozen carbon dioxide (dry ice), although the north polar cap contains a fair amount of water ice.

The atmosphere of Mars today is very different from Earth's. It is very thin, and it is made mostly of carbon dioxide, though there are other gases present as well. This thin atmosphere cannot protect Mars from the harmful radiation of the Sun. It also cannot hold the heat of the sun in. Temperatures on Mars rarely climb above freezing, and

they can plummet to 87 (NASA JPL) degrees below zero Celsius (-220 degrees Fahrenheit). A few thin clouds can be seen in the Martian sky.

Scientists believe that much of the atmosphere that Mars had in the past escaped into space. However, some of it may be frozen in the surface layer.

Mars is often called the Red Planet. Mars looks red because it has a great deal of iron in its surface soil. This iron reacted long ago with the tiny amount of oxygen found in the atmosphere of Mars. Iron and oxygen form rust, which gives Mars its reddish color.

The largest volcano that we know of in the solar system is on Mars. It is names Olympus Mons, and it is only a little smaller than the state of Texas. Pictures of Mars taken by spacecraft show hundreds of volcanoes. Scientists do not know if any of these volcanoes are still active.

Volcanoes on Mars can be much taller than those on Earth. This is because Mars has only 0.4 the level of gravity of Earth.

Mars also has a “grand canyon” which is much larger than the one found in the western United States. In fact, it’s as long as the United States is wide. It is named the Mariner Valley, and it is so large that it can be seen from Earth. There is an important difference between the Mariner Valley and the Grand Canyon. The Grand Canyon was formed by water which flowed through it over millions of years. The Mariner Valley was probably formed when forces inside Mars caused the surface to crack.

In August 1996, though, scientists announced the discovery of signs of possible ancient microscopic life in a meteorite from Mars. The meteorite was blasted into space when a huge boulder slammed into Mars. The meteorite eventually landed in Antarctica. Trace elements inside the meteorite prove that it came from Mars.

Evidence in the rock suggests that microscopic organisms a thousand times smaller than a human hair may have lived on Mars 3.6 billion years ago, when the planet was much warmer and wetter than it is today. The finding is disputed by many scientists, and additional tests are underway to try to confirm or refute the report.

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PHOBOS

Photo of Phobos

Many scientists believe that Phobos and Deimos are asteroids that wandered close to Mars billions of years ago. They were caught by Mars' gravity. The Martian atmosphere may have been thick enough to act as a brake, slowing the small bodies enough to trap them in orbit.

But other scientists say that the moons formed at the same time as Mars, or that they're the remnants of a larger moon that was shattered by a collision with a large meteor.

Phobos is the larger of the two moons of Mars. It is so close to Mars that it can travel around Mars three times (NASA JPL) every day. Even though Phobos is very small compared to our moon, it would look about half as big as the full Moon does on Earth.

Phobos is slowly moving closer to Mars. In another 60 to 100 million years, it will crash into Mars.

Phobos is only 28 kilometers wide, far too small to have any atmosphere at all. The gravity of Phobos is just 0.0008 of Earth's.

Phobos is small, dark, and airless. And it's one of the driest bodies in the solar system. That doesn't mean that Phobos is dull, though. Quite the contrary, Phobos survived a powerful impact that may have fractured its interior. The impact gouged a large crater into the moon.

If the meteor that created the crater had been a bit larger, it might have destroyed Phobos. Instead, many scientists think the impact cracked the moon's interior. The cracks could contain water ice. If so, Phobos could serve as a refueling station for manned Mars-exploration missions. But observations by several spacecraft indicate that there's less water at the surface of Phobos than in almost any other body in the solar system.

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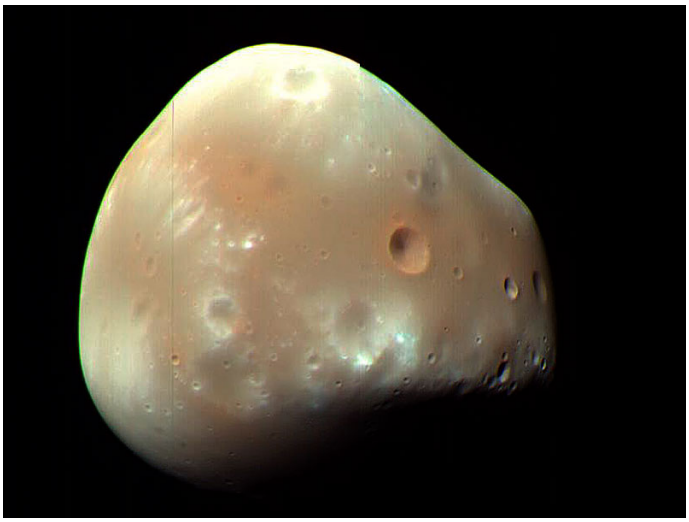
DEIMOS

Photo of Deimos



Deimos is farther away from Mars than Phobos is, and it moves slowly from east to west. Deimos would look like a small dot of light in the sky. Like Phobos and most small moons, Deimos does not have an atmosphere. Its gravity is only 0.0003 times the amount of Earth's gravity.

Deimos is covered by a powdery dust that could be several hundred feet deep. The tips of giant boulders peek above the dust like icebergs floating in a dark sea. The dust formed as the result of billions of years of meteorite impacts, which pulverized the tiny moon's surface.

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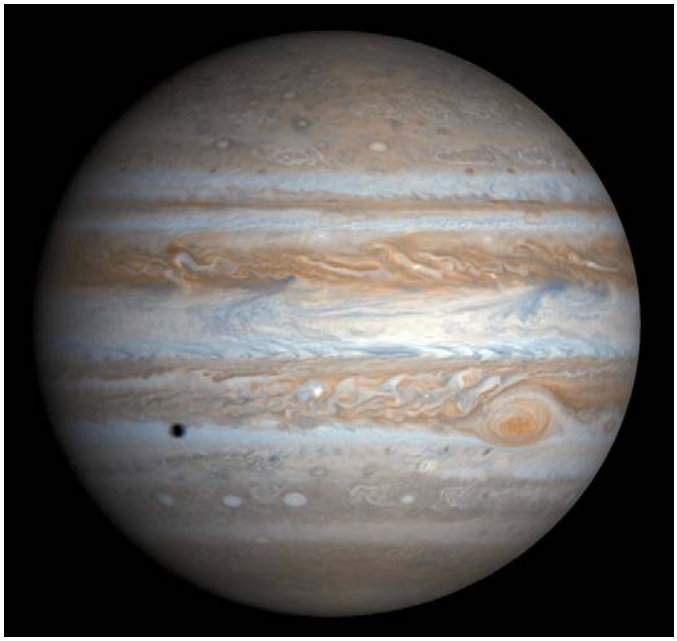
JUPITER

Photo of Jupiter



The fifth planet from our Sun is Jupiter. Jupiter is also the first of the gas giants, which are huge planets with deep atmospheres. As the largest planet in our solar system, it is fitting that it is named after the king of the Roman gods.

It takes Jupiter almost twelve of our years to go around the Sun. As it travels in its orbit, Jupiter pulls its moons and a set of asteroids along with it. Jupiter has sixty-three (NASA JPL) moons that we know about. Four of these moons, Io, Europa, Ganymede, and Callisto, were discovered by Galileo in 1610. For this reason, they are called the Galilean moons. They were the first moons discovered in our solar system that did not orbit the Earth.

If you were a visitor in our solar system, the first thing you would notice, after the Sun, is Jupiter. It is by far the largest planet in the solar system. In fact, if you put all the other planets and moons in our solar system together, they would still not be as massive as Jupiter.

Jupiter is so large that in some ways it acts like a small sun that never quite reached maturity. Its core may be as hot as 24,000 Celsius (NASA JPL). If Jupiter had been more massive, it might have collapsed and become a star.

Because Jupiter is so massive, the gravity is very strong (g = 2.54). If you were to visit Jupiter, you would have a hard time moving. As you fell through the atmosphere, the atmospheric pressure would grow so strong that it would eventually crush any human or machine. The Galileo probe, for example, survived for only about an hour as it parachuted through the atmosphere.

The core of Jupiter may be very hot, but its atmosphere is not. The cloud-top temperature is well below freezing (minus 120 degrees Celsius). Some parts of Jupiter are hotter than any place you would find on Earth, while other parts are colder than any place on Earth. The temperature on Jupiter varies widely depending on how deep below the top of the atmosphere you go.

All we can see of Jupiter are the clouds that swirl through its atmosphere. These clouds form bands of different colors, making Jupiter look like a striped beach ball

with a big red spot in its southern hemisphere. This Great Red Spot is actually a gigantic storm with winds that are much faster than any winds found on our planet. This hurricane-like storm is big enough to swallow two Earths. Unlike storms on Earth, this one doesn't seem to end. Scientists have watched the Great Red Spot whirl for over three hundred years.

Jupiter's atmosphere of hydrogen, helium, methane, and ammonia is poisonous to humans.

Scientists are not sure what lies beneath the clouds in Jupiter's atmosphere, but they think there may be a large ocean of liquid hydrogen. On Earth, hydrogen is usually a gas. However, if you squeeze its molecules closely together, hydrogen becomes a liquid. Jupiter's high gravity may be strong enough to squeeze hydrogen molecules close enough together to make a liquid.

At the core, the very center of Jupiter, gravity may actually hold hydrogen molecules so closely together that they become a solid. Solid hydrogen is actually a metal. This is very important to Jupiter, because when you spin a metal very fast, you make a magnet. As a result, Jupiter has a very strong magnetic field.

Dark, narrow rings circle Jupiter. These rings are made of rocks and boulders. They are held in orbit around Jupiter by gravity. However, they are much less impressive than the rings around Saturn.

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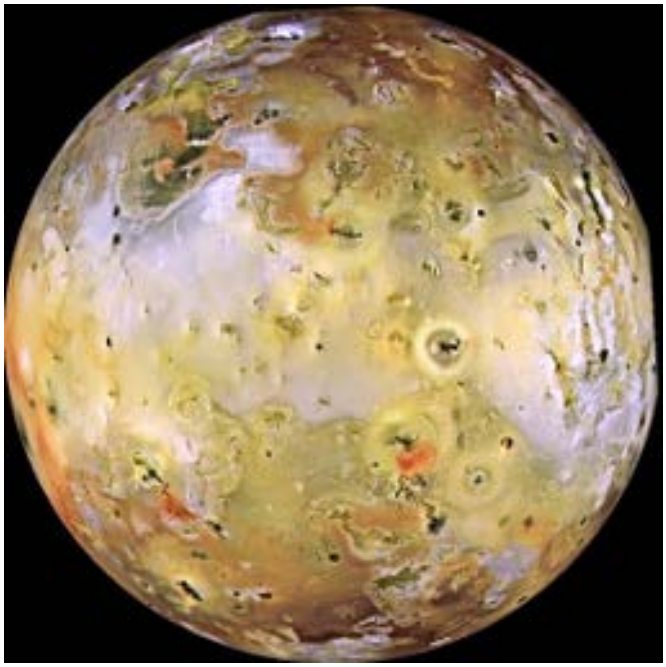
IO

Io is the most famous moon of Jupiter because active volcanoes dot its surface. They erupt frequently. The Voyager space probes observed up to nine major eruptions on Io at one time. Io is the only other world is our solar system where we have actually seen volcanoes explode. With so much volcanic activity, Io almost certainly has frequent quakes.



Io is a little bit bigger than our moon and has slightly more gravity (g = 0.19). It is almost as close to Jupiter as our Moon is to us. Jupiter's strong gravity pulls hard on Io. That makes rocks inside Io rub together and heat up. This heat melts the sulfur and other elements inside Io. Volcanoes form, and when they explode, sulfur compounds jet from the volcanoes. Much of this volcanic material falls to the surface of Io. The sulfur paints the surface of Io mostly orange and yellow, though you can also see black, white, and even blue stains.

Sometimes material blasted from the volcanoes soars as much as 300 kilometers (180 miles) high. It escapes the gravity of Io entirely and goes out into space. For example, sulfur from Io has landed on its neighboring moon Amalthea and colored it bright red.

Because there are so many active volcanoes, the surface of Io is constantly changing. The material that explodes out of the volcanoes covers the ground, covering up craters and other surface features. When the Galileo spacecraft scanned Io in early 1996, it found that much of the moon's surface had been repaved by volcanic eruptions since the Voyager probes visited in the late 1970s.

Io also has a thin atmosphere which is made of the gases that escape from the volcanoes. Scientists think these volcanic gases include sodium and sulfur dioxide. The atmosphere is thicker above active volcanoes and patches of evaporating ice. The outer region of the atmosphere is gradually escaping into space.

Parts of Io may be over 500 degrees Celsius, but most of it is much colder, well below freezing. The same side of Io always faces Jupiter, but the other moons of Jupiter pull on Io also. This causes Io to wobble a little. As seen from Jupiter, Io looks like it is shaking its head "no."

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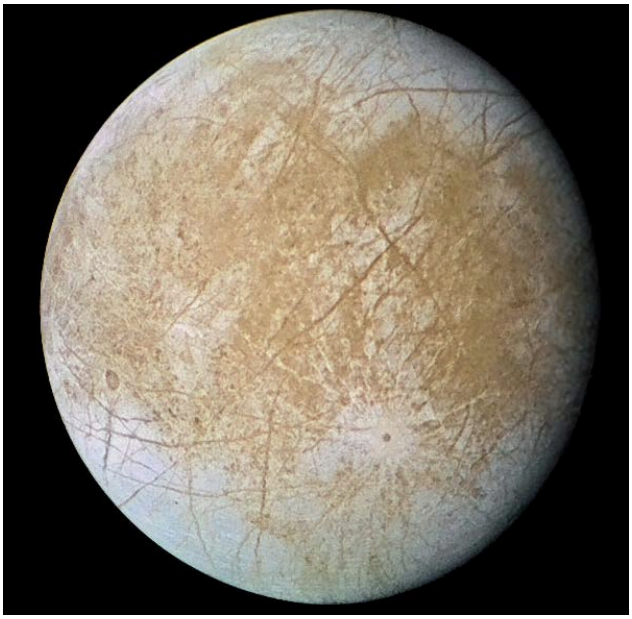
EUROPA



Of all the icy bodies in our solar system, Europa may be the most intriguing. Its surface looks like a cracked egg, with jagged grooves radiating across a smooth, white shell. Europa is covered by a thick layer of ice. Surface temperatures are around 130 degrees below zero Celsius. The Galileo spacecraft found dark cracks on Europa's surface, suggesting that oceans of liquid water may lie beneath the surface of ice.

One hemisphere of Europa always faces Jupiter, just as the same side of the Moon always faces Earth. But the gravity of Jupiter's other large moons tries to turn Europa around, so it gets pulled and twisted. This gravitational battle generates heat in Europa's core – perhaps enough to melt some of its ice.

One good sign that there is liquid water on Europa is that there are relatively few impact craters on its surface. Early in the history of our solar system, all worlds were hit by meteors, which left craters on their surfaces. On worlds without atmospheres or bodies of water, like our Moon, the craters have lasted for billions of years. However, if a world has liquid water, the water would fill in the crater created by the meteor. Europa's surface shows few craters – a good sign that the ice is floating atop liquid water.

Some scientists and fiction writers have speculated that exotic organisms might live in these oceans, but no one will know for sure until probes can dive into the frigid waters. Someday, a robotic submarine may glide through that ocean, looking for simple bacteria, or even odd sea creatures.

Europa is the smallest of the four Galilean moons, and the only one smaller than our own Moon. The surface gravity on Europa is about 0.14 of Earth's.

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GANYMEDE

Ganymede is the solar system's largest moon – one and a half times the size of our own Moon. In fact, Ganymede is larger than the planets Mercury and Pluto. Ganymede consists of about half water ice and half rock and metal. Its surface gravity is 0.15 of Earth's.

When Galileo flew past Ganymede, it took pictures of great fault lines, deep canyons, and smooth plains. These were created by the movement of the crust of Ganymede, meaning that at some time in the past, Ganymede had earthquakes. This means that Ganymede had a strong internal heat source which would cause shifting of the crust. This shifting caused ice on the surface to melt and flow, filling in many of the craters created when the solar system was young. Ganymede has fewer craters than its neighbor Callisto.

Parallel grooves called Sulci cover more than half of Ganymede's surface. Scientists aren't sure yet how the Sulci formed; maybe pieces of Ganymede's crust pulled apart or bumped together, creating wrinkles.

The Galileo probe discovered other interesting characteristics of Ganymede. It detected hints of a thin, cold atmosphere. It also appears that Ganymede has its own magnetic field. The field indicates that Galileo's core might consist of molten iron - like Earth's core. As Ganymede rotates on its axis, the iron core would act like an electric motor, generating a magnetic field around the moon.

The surface of Ganymede has light and dark markings. Scientists can tell how old these areas are by counting the number of craters on them. Many craters indicate that the area has not changed much over time. Few craters mean that the ground has shifted to fill in the craters left by meteors. The dark areas of Ganymede are probably the oldest parts of its surface, and have not changed since early in its history. The

lighter areas have undergone more change. The bright spots are recent impact craters made of water ice.

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CALLISTO

Callisto, the Galilean satellite farthest from Jupiter, is an icy, rocky moon covered with craters. Callisto is almost as big as the planet Mercury. However, it has a much lower surface gravity, only 0.13 of Earth's.

Callisto's interior probably consists of a rocky core surrounded by ice mixed with rock and dirt. But Callisto's most interesting feature is its surface. It's more heavily cratered than any other planet or moon in the solar system. That means that not much has happened to Callisto over the last four billion years.

The other large solid bodies in the solar system underwent the same pounding - including Earth. But on the other worlds, many of the craters were erased by wind, rain, ice, volcanoes, or other forces. Giant lava flows even paved over some of the craters on our own Moon. But Callisto has preserved its ancient craters with little or no change.

The Galileo spacecraft focused on one of the largest craters, known as Valhalla. It consists of a bright central region almost 400 miles across, surrounded by rings that span almost 2,000 miles. These rings are concentric, meaning that they look like the ripples that result when you throw a stone into water. The crater probably formed when a large asteroid or comet slammed into Callisto several billion years ago. If the impact had been much more powerful, it might have shattered the big moon.

Scientists recently discovered evidence that Callisto has an atmosphere made of oxygen. This was probably created when water ice on the surface was broken down into hydrogen and oxygen. Hydrogen is a very light element, so it floated off into space. Oxygen is heavier, so Callisto's gravity was strong enough to hold onto it. Callisto's surface temperature is estimated to be about 135 degrees below zero (Moore et al. 2004: Callisto) on the Celsius scale.

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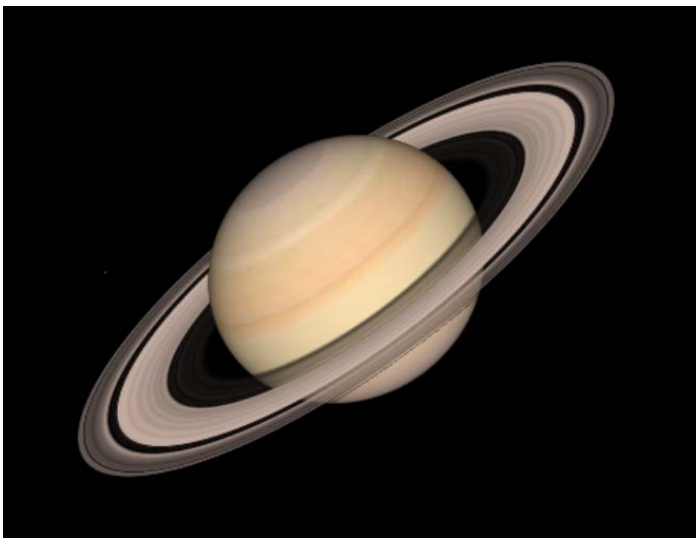
SATURN



Saturn is the famous "ringed planet." Although Saturn is the sixth planet from the Sun, it is clearly visible to the unaided eye as a bright golden "star." Its rings are visible through a small telescope.

Saturn has more moons than any other planet in the solar system – at least 60 (NASA JPL), though there may be others we have not yet discovered. The largest moon of Saturn is Titan, which is larger than the planet Mercury. The remainder of Saturn's moons are much smaller. They probably do not have atmospheres, and their gravity is low. The medium-sized moons include Rhea, Iapetus, Dione, Tethys, Enceladus, and Mimas. It takes Saturn and its moons 29.5 Earth years to travel around the Sun.

Saturn is the second of the four gas giants, and the second largest planet in our solar system. Even though it is 95 times more massive than Earth, its surface gravity is only slightly higher: 1.07 times Earth's gravity. Why? Saturn is much less dense, or tightly packed, than Earth. At the surface of Saturn you are still far from the core of the planet.

Saturn has a very thick atmosphere made mostly of hydrogen, with some helium, water vapor, methane, and ammonia. If you could get through Saturn's clouds and survive the crushing atmospheric pressure, you would find a world without any solid land. An ocean of liquid hydrogen, thousands of miles deep, completely covers the

planet's solid core. As you dropped deeper into the atmosphere, clouds would blot out the view of the Sun and Saturn's beautiful rings.

All of the gas giants have rings, though none are as spectacular as those of Saturn. For a long time people thought that Saturn had just one large ring. Then scientists began to discover gaps and realized that there were actually several rings. It was not until the Voyager probes reached Saturn in 1979 that we realized that Saturn actually has thousands of narrow rings rather than a few large ones.

Saturn's rings are made of ice and rock. They are not solid, but consist of small bits of frozen material. The rings may have formed with Saturn itself, or they may have formed much later, when a small moon or even a large comet passed too near Saturn and was pulled apart by the planet's powerful gravity. Measured from edge to edge, Saturn's rings span about 600,000 miles (one million km), or two and a half times the distance from Earth to the Moon.

Saturn's day is 10 hours and 40 minutes long. Like all the gas giants, this means that it spins very quickly on its axis. However, a strange thing about Saturn is that the area over its equator spins faster than the area around its poles. How is this possible? Remember that Saturn is made of gases. Gases move differently from solids, so it is possible for one area to move faster than another.

From a distance, Saturn's weather looks calm compared to Jupiter's. However this may be because its clouds are thicker and it's more difficult to see its storms. Winds at Saturn's equator may reach speeds of 1,100 miles (1,770 km) per hour. That's strong enough to tear apart any living thing.

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TITAN

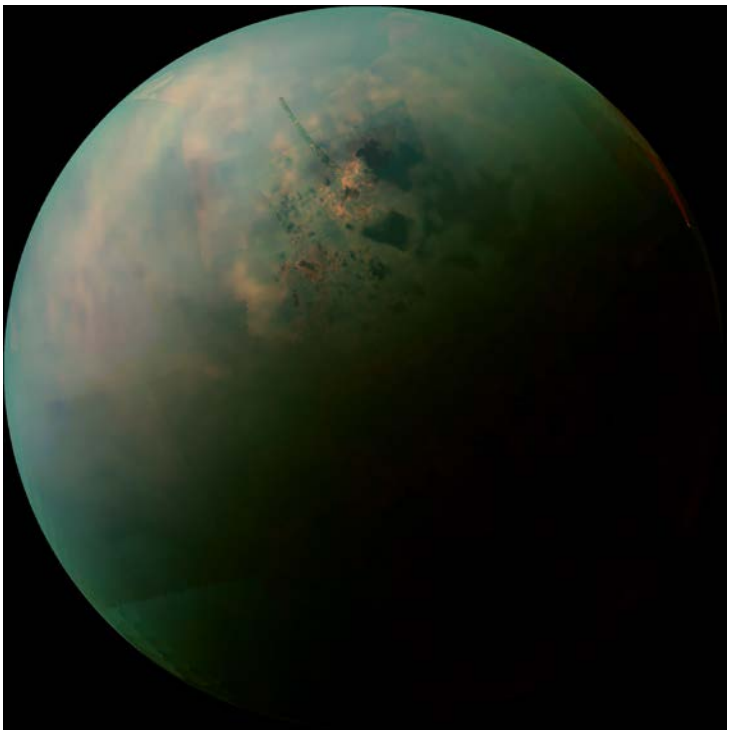

Photo of Titan

Titan is Saturn's largest and most interesting moon. What makes it so interesting is that Titan is the only moon known to have a thick atmosphere. This atmosphere looks like a thick layer of orange "smog". It is made mostly of nitrogen with some methane (a compound made of carbon and hydrogen) and other substances.

The only moon in our solar system larger than Titan is Ganymede, a moon of Jupiter. Titan is almost twice as large as our own Moon. Its gravity is 0.14 of Earth's.

At the top of its clouds, Titan's temperature is 180 degrees below zero Celsius. However, we know very little about Titan's surface. The Cassini-Huygens mission flew by Titan and detected hydrocarbon seas of methane and ethane near the poles. The Huygens probe landed near the equator and took pictures for several hours. It didn't find the seas, but found a muddy surface with water ice with a layer of methane scattered about the surface (NASA press releases).

With binoculars, you can just make out Titan as a tiny star-like point of light near bright golden Saturn.

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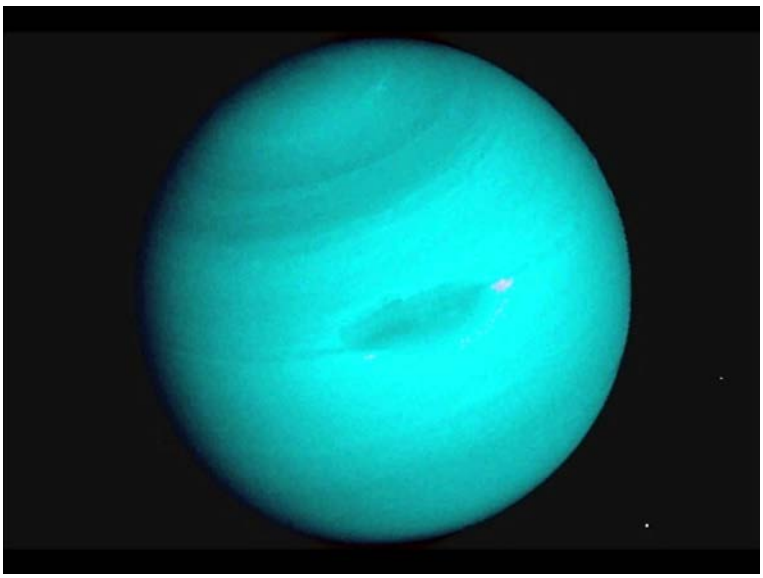
URANUS

The seventh planet from our Sun is Uranus. The planet was named after the father of Saturn in Roman mythology.



Uranus has 27 (NASA JPL) moons that we know about, though there may be more. None of these moons is very large. In fact, only five of them had been discovered before Voyager 2 visited Uranus in 1986. Uranus and its moons take more than 84 Earth years to travel around our Sun. Its orbit is more than 19 times as far from the Sun as our own. From Uranus the Sun looks like a small bright star rather than the blazing ball we see from Earth.

Ancient people knew about the existence of five planets besides Earth: Mercury, Venus, Mars, Jupiter, and Saturn. It is one of the great surprises of astronomy that they did not also know about Uranus. Uranus is bright enough to be seen with the unaided eye – when the conditions are just right. Yet no one realized that it was a planet until 1781, when William Herschel "discovered" Uranus.

Like Jupiter and Saturn, Uranus is a gas giant. Its cloudy atmosphere is made mostly of hydrogen and helium with some methane. The other gas giants have atmospheres that are striped with colorful bands and storms have been seen on them. In contrast, Uranus has a solid green/blue color. Methane high in the planet's atmosphere gives Uranus its blue color, and thick clouds hide everything below this layer.

We do not know for certain what lies beneath the thick atmosphere of Uranus. Scientists think that Uranus may have a rocky core. Above that may lie oceans made of water, ammonia, and methane. At the top of its clouds the temperature of Uranus is well below freezing – 200 degrees below zero on the Celsius scale. However, Uranus is probably much warmer deeper in its atmosphere.

Uranus is the third largest planet in our solar system – about four times larger than Earth. However, it is less dense, so its surface gravity is only 0.89 of the surface gravity of Earth.

The most peculiar thing about Uranus is that it looks like it has been tipped over on its side. On all the other planets, the north and south poles are never turned to face directly into the Sun. Uranus is different. Because it seems to orbit the Sun on its side,

both its north and south poles face the Sun directly for part of its year. It may be that, long ago, Uranus was hit by some large object that knocked the huge planet on its side.

Day and night on Uranus are very different from what we experience on Earth. At the north or south pole, “winter” would last for 42 years, and the Sun would not be visible at all during that time. The Sun becomes visible again at the “spring” equinox and remains in the sky for another 42 years.

Uranus is encircled by very thin, dark rings, similar to those around Jupiter. The Hubble Space Telescope has been able to take photographs of the rings of Uranus, but the only way to see them from Earth’s surface is to watch as stars pass behind Uranus; as the star passes behind the rings, it fades in and out of view. Voyager 2 photographed the rings of Uranus and Neptune, making it clear that all the gas giants have rings around them - not just Saturn.

Like all the gas giants, Uranus has many moons –27 (NASA JPL) at least. Unlike Uranus, they are all rich in surface features. However, they are very small. Our own moon is 20 times larger than Titania – the largest moon of Uranus.

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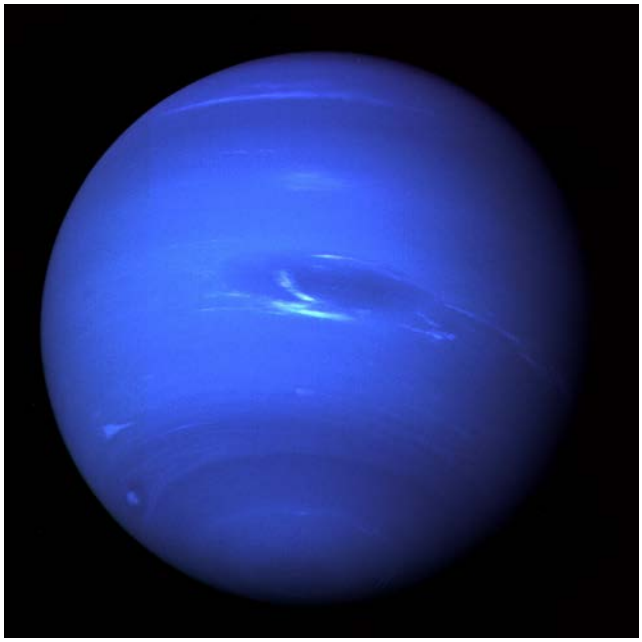
NEPTUNE

Neptune is the eighth planet from our Sun and the smallest of the gas giants. It was named for the god of the sea in Roman mythology.



Neptune has thirteen moons that we know about. Six of them were discovered by Voyager 2 when it flew by Neptune in 1989 (NASA JPL). Most of these moons are very small. However, Neptune has one large moon: Triton. Triton is about three-fourths the size of our own Moon. Neptune and its moons take 165 Earth years to travel around the Sun. They are 30 times farther from the Sun than Earth is.

Neptune is the fourth-largest planet in the solar system, but it is so far from Earth that it was not discovered until 1846. Even then, it was discovered only through the work of mathematicians. Astronomers noticed that the orbit of Uranus was a little different than they expected. They realized that there must be some other planet that exerted a gravitational pull on Uranus. Through the use of mathematics, the location of this planet was determined. Astronomers looked for it and discovered it right where the mathematicians had predicted.

Neptune and Uranus are so similar that they are sometimes called twins. Neptune's atmosphere is also made of hydrogen, helium, and methane. It has slightly more methane in its atmosphere than Uranus does, so Neptune appears to be more blue. The temperature at the top of Neptune's clouds is more than 200 degrees below zero Celsius, though the temperature rises as you get deeper inside the planet.

Streaks of bright white clouds cross the blue atmosphere. Winds rip through Neptune's atmosphere at hundreds of miles per hour. You could not see the Sun, stars, or any of Neptune's moons through the thick atmosphere. Several large storm systems have been spotted on Neptune. One notable storm is called the Great Dark Spot. Once it did something very strange. It vanished from the southern hemisphere at about the same time that a similar storm appeared in the north.

Neptune's thick atmosphere may conceal a rocky core far below the visible clouds. This core is probably surrounded by an ocean of water, ammonia, and methane. Though Neptune is smaller than Uranus, it has a slightly higher level of gravity. At the surface of its atmosphere, Neptune has a gravity that is about 1.2 times the level of Earth's gravity.

Like all the gas giants, Neptune has a ring. Voyager 2 photographed several thin rings around Neptune when it flew past the planet in 1989. These rings are far less impressive than the rings of Saturn.

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TRITON

Photo of Triton

Triton is Neptune's largest moon. Still, the moon is so small and far away that even today's giant research telescopes can't see any details on its surface. But the Voyager 2 spacecraft, which flew past Triton in 1989, revealed quite a lot about the icy moon. Voyager 2 photographed giant cracks in the surface of Triton and geysers that blasted gas and dust up to five miles high.

Neptune's moons have no internal heat source to warm them, so they are extremely cold. Triton's surface is colder than any other planet or moon in the solar system that we know about. The average temperature is 235 degrees below zero Celsius. Its surface gravity is 0.08 (NASA JPL) of Earth's.

Voyager 2 also found that Triton has a thin atmosphere made of nitrogen and methane. Through Triton's thin atmosphere, the Sun would look more like a bright star than the large disk we see from Earth.

Triton orbits Neptune in the opposite direction from the way the planet rotates. It is the only large moon in the solar system that does this. Because of its strange orbit, astronomers think Triton may have been captured by Neptune instead of forming with the planet itself. Or, Triton may have been hit so hard by a comet or meteor that it changed the direction of its rotation. Many millions of years from now, Triton's orbit will carry it too close to Neptune, and the planet's gravity will pull the moon apart. Triton's remains will scatter along its orbital path, forming rings as bright as Saturn's.

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PLUTO

Pluto's orbit is 39 times further from the sun than Earth's. The Sun is so far away it would look like a bright dot in the sky-the brightest star visible.

Pluto has three known moons: Charon, Hydra, and Nix. (NASA JPL) Like most of the other worlds in our solar system, all of these names come from mythology. For example, Pluto was the Roman god of the underworld, where people went when they died, and Charon was the boatman who brought the dead across the river into the underworld. Pluto and Charon take 249 Earth years to orbit the sun.

Pluto is smaller even than our own Moon. Its surface gravity is only 0.07 (NASA JPL) of Earth's. Because it is so unlike the other worlds, scientists consider it to be a minor planet or dwarf planet. It probably formed by a different process from the other planets, and was pushed into its peculiar orbit by Neptune.

Pluto was actually discovered by mistake. Astronomers thought that the orbits of Uranus and Neptune were being affected by the gravity of another planet that had not yet been discovered. After many years of searching, Pluto was discovered in 1930. However, Pluto is too small to have any affect on Uranus and Neptune. Yet, if astronomers had not been looking for another planet, they would never have found Pluto.

Tiny Pluto is not always the farthest object from the Sun. Because of Pluto's unusual orbit, Neptune is sometimes farther from the Sun. Pluto's orbit is more elliptical, or stretched out, than the orbit of the major planets.

No probe has ever visited Pluto or its moon, so we have limited information about it. Astronomers have detected a very thin atmosphere of nitrogen, methane, and carbon monoxide. The atmosphere thickens when Pluto's orbit carries it closest to the Sun, and solar heat vaporizes some of the ice on its surface. As Pluto gets further from the

Sun, the gas in its atmosphere freezes again, adding a layer of bright, fresh frost to the frozen planet.

The surface of Pluto probably consists of rock and ice, but we cannot be sure. Scientists have estimated the temperature at the surface level to be 236 degrees below zero Celsius.

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CHARON

Charon is half the size of Pluto. Pluto and Charon are closer in size than any other planet-moon system in our solar system, and they are sometimes called a double planet. The surface gravity of Charon is unknown, though it is a small moon, so the gravity would be very low.

If you went to Pluto, you could see Charon from only one side of the planet, because the moon's orbit around Pluto takes just as long as one day on the planet. Thus, the moon always remains "over" the same spot on Pluto's surface, and the same side of the moon always faces Pluto.

Surface temperatures on Charon are probably similar to those on Pluto. As Pluto and Charon are in the part of their orbit that brings them closest to the Sun, they heat up slightly, perhaps to 200 degrees below zero Celsius. As they move farther away, their temperature drops to 220 degrees below zero Celsius. In 2007, the Gemini observatory found the presence of water crystals on the surface of Charon.

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