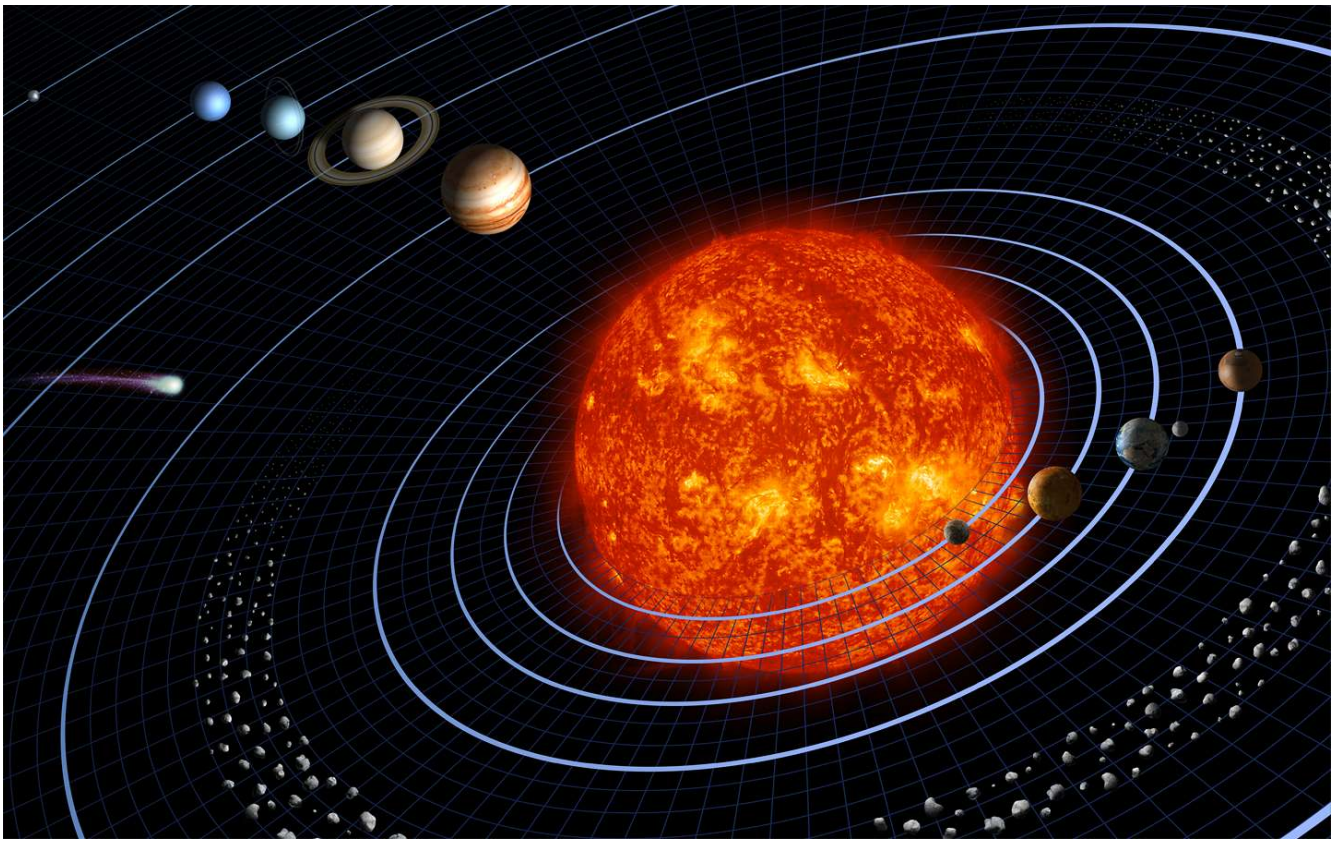
Wikijunior

Solar System



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Introduction

General Introduction

This is a project of Wikijunior, a collection of free books written especially for kids to learn about science and nature. Many people have been involved with writing this book. This project is hosted on Wikibooks, and you are encouraged to help participate with writing and editing these books.

What This Book Will Cover

There are several short articles that will cover each of the planets and many other bodies of the Solar System. Information that will be interesting to kids will be discussed. In addition, some general topics will be added that aren't specifically about an individual planet or moon of the Solar System.

Solar System

People have been watching the sky for thousands of years and wondered exactly what is out there. With advances in telescopes as well as spaceships which have physically traveled to various planets, a considerable amount of knowledge has been obtained to better understand the universe near to us.

The name of our system comes from the old *latin* word for the Sun: *Sol*. Because the Sun is the largest object in the system and all the other bodies orbit around it, it became known as the *Solar* system.

What is the Solar System?

At the center of the Solar System is the Sun. This is but one of billions of stars in the sky, but is important to us as it gives us warmth and energy for us to use. There are many worlds that are near the Sun, each of them are as different as you can possibly imagine. All of these worlds that either orbit the Sun or orbit a planet going around the Sun make up what we call the Solar System. As you read each of the sections about these different worlds, we will explore the differences between all of these worlds, and hopefully you will understand how unique and special the Earth is as well.

There are a total of nine planets in our system. The inner-most planet is called Mercury. This is followed by Venus and then our Earth. Beyond Earth is an orange-hued planet called Mars. In the outer part of the system are four giant planets called Jupiter, Saturn, Uranus, and Neptune. The outermost planet is a small world named Pluto.

Our system also includes many other bodies. The moons are small worlds that orbit the planets, in much the same way as the planets orbit the Sun. There are also a lot of much smaller objects called asteroids. These are big chunks of rock or metal that are mostly found orbiting the Sun between Mars and Jupiter. We also get visitors from the cold outer edge of our system that are called comets. These are big lumps of ice and dust. Comets can form immense tails when they come close to the Sun and start to melt.

The solar wind is a hot gas that erupts from the sun and flies away into space. This gas travels past the planets into outer space. The place where this gas reaches the very thin gas between the stars is at the edge of the solar system. This bubble of gas is about 100 times as far from us as the Earth is from the Sun. Beyond that is a lot of empty space. The nearest star to the Sun is thousands of times further away than the size of the entire Solar System. It's a very, very big universe out there.

Who discovered it?

Prior to 1781, there were only seven known bodies in our solar system, besides the Earth. These seven were the Sun, our Moon, Mercury, Venus, Mars, Jupiter, and Saturn. These had been known since humans first began to observe the sky at night. There were also visitors called comets that would appeared in the sky for a time, then fade away.

The Babylonians believed that each of these objects was related to a different deity, and their calendar used a seven-day week. The practice of naming the seven visible objects of the solar system still continues to this day. Each of the English words for the day of the week comes from an old name for a god or goddess. In English this is a mixture of both Norse and Roman gods, but in other languages the connection to the Roman names of the planets is more apparent.

Weekday	Object	Related Norse Diety	Spanish equivalent
Sunday	Sun		Domingo
Monday	Moon		Lunes
Tuesday	Mars	Tyr	Martes
Wednesday	Mercury	Woden (also Odin)	Miércoles
Thursday	Jupiter	Thor	Jueves
Friday	Venus	Frige (also Freyr)	Viernes
Saturday	Saturn		Sábado

Galileo Galilei first turned a telescope on the sky and began to write down what he saw. Among the things he saw were four moons orbiting Jupiter. As time passed and the telescope was improved, more objects were found. In 1655, Christiaan Huygens discovered the moon Titan orbiting Saturn. In 1781 Sir William Herschel discovered the planet Uranus. In 1801, Giuseppe Piazzi discovered the first asteroid. Many more asteroids were later discovered by astronomers.

The discovery of the planet Neptune did not come by chance, but was found using math. Astronomers had made tables of where each body should appear in the future. But Uranus did not match the predictions. So a model was made to account for the difference. This model predicted that the gravity from an unknown planet was pulling on Uranus. The model also predicted about where the mystery planet would be found. This planet was then found in 1846.

The last planet Pluto was later found in 1930 using the same method.

How was it formed?

Our Solar System is part of a much larger system called the Milky Way. This is a vast mix of dust, gas, stars, and other objects that is called a galaxy. Our galaxy rotates about the center, and if you could see it from a long, long way off it would look like a wispy pin-wheel.

Within our Milky Way galaxy are clouds of dust and gas where stars are born. Our Solar System was created in just such a cloud. A part of this cloud began to collapse under the pull of its own gravity. As it got smaller, it formed a big, spinning disk of gas and tiny particles of dust. This disk was thickest at the middle, and this part slowly collapsed to form the early Sun.

The remainder of the disk continued to rotate about the Sun in the center. The tiny particles of dust were now close enough so that they would often collide, and some of these would stick together. The bits of dust would slowly collect to form grains. These would in turn join to form lumps the size of gravel, then pebbles.

As the objects grew in size, a few grew larger than the rest and began to pull on the other rocks with their gravity. The rocks grew ever bigger, reaching the size of mountains which crashed together with powerful force. In the end there were only a few massive bodies left, which swept up the rest of the disk to form the planets, moons, and asteroids.

While this was going on, the Sun began to glow from the huge energy released by its own collapse. The temperature at the center of the Sun reached a million degrees, and it turned into a furnace that could create more energy by smashing tiny atoms together. This energy rose up to the surface and was emitted as light, heat, and other forms.

This energy being emitted by the Sun swept away any surviving tiny particles and gas from the inner Solar System, leaving behind only the larger objects.

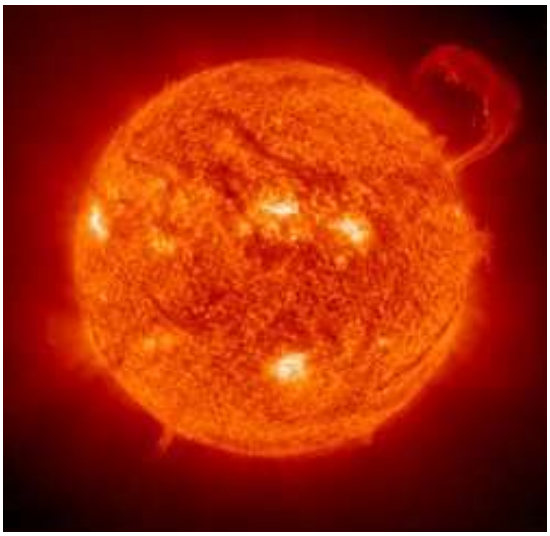
What will happen to it?

About four thousand million years from now, the Sun will have used up most of fuel. It will begin to enter the final stages of its life. It will expand into a huge star called a *Supergiant*. The size of this star will be so big that several of its planets will be inside, including the Earth. These planets will be burnt to a crisp inside the very hot atmosphere.

Eventually the sun will begin to throw off its outer atmosphere, forming an immense sphere of faintly glowing gas that astronomers call a *planetary nebula*. The sun will then shrink down into a small star called a *white dwarf*. This will be about 100 times as small as the current sun we see. It will then slowly begin to cool and grow ever fainter over time.

The Sun

The Sun is a large ball of very hot gas, mostly hydrogen and helium. It is the power house of the Solar System. It's our nearest **star**. Scientists can tell what is going on inside a star from its color. Without the sun there would be no life on Earth. We depend on the sun for **energy**.



This picture was taken with a special filter that shows the complex magnetic fields generated by the sun. The loops of gas extending out from the sun are called prominences.

Sun Facts:

- The Sun is really a star.
- If the Sun blew up, it would take about 8 minutes before anyone noticed.
- It produces light and heat energy needed for life.
- Every second, over 4 million tons of material is converted into energy through nuclear fusion.
- The equator of the sun rotates much faster than areas closer to the solar "poles".
- **Never look directly at the sun without filters**. A passing glance will cause temporary blindness, and looking at the sun without special filters in a telescope will cause permanent blindness in your eyes.

How big is the sun?

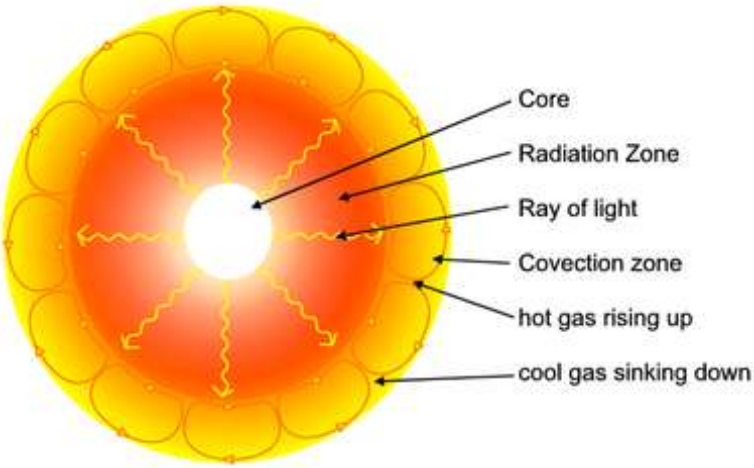
The Sun is very big - much, MUCH bigger than the Earth! It is 1,392,000 km or 109 Earths across and contains more than 99.9% of the solar system's mass. If you could somehow stand on the surface of the Sun, you would weigh 28 times as much. A grown person would weigh as much as a car.

More than a million Earths could fit into the volume of the sun! It doesn't look that big from where we stand, though. That's because the sun is about 150,000,000 km away. At that distance, it takes light from the sun over eight minutes to reach the Earth. Compared to other stars, the sun is about average-sized.

What happens inside the sun?

The sun is the main source of energy for the earth. This energy is released deep within the sun in a process called atomic fusion. Four hydrogen atoms are fused

together to make one helium atom. The helium atom has slightly less mass than the four hydrogen atoms; the extra mass is converted to energy. This is the same way energy is released in a nuclear bomb called a hydrogen bomb. The diagram below shows what scientists think is going on inside the Sun. The colours are to show the different regions.

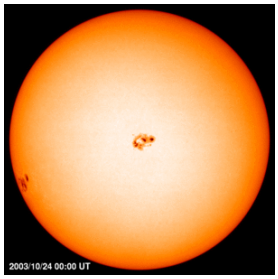


Core: The center of the Sun is very dense. It's about 12 times as dense as lead. It's also very hot - about 15 million °C. This region is where most of the nuclear reactions are taking place.

Radiation Zone: In this zone the light, heat, and X-rays produced in the core fight their way out towards the surface. The gases that make up the zone are still very dense and keep absorbing and emitting the rays. Have you ever tried to run through water? That's what it's like for light waves in this region of the sun. It can take a single ray of light a million years to make its way out of this zone.

Convection zone: Have you ever seen the air shimmer above a fire? Perhaps you've been told it's because "heat rises"? Well actually heat doesn't rise all by itself. It is the hot air that is rising. Hot gases tend to rise, cold gases tend to sink. In this outer region of the sun the gases are less dense and so behave more like ordinary gases that we see on Earth. At the bottom of the convection zone the gas gets heated up by the energy that is coming through the radiation zone from the core. This gas rises up to the surface of the sun where it gives up its heat and cools down. The now cold gas then sinks back down. The plumes of rising hot gas and sinking cool gas together form huge ribbons of circulating gas known as "convection cells".

What are sunspots?



The dark areas are called sunspots.

Sunspots are slightly cooler areas on the surface of the sun that appear as dark areas. They only appear dark against the brightness of the rest of the surface of the sun. Despite their appearance, they are still extremely bright — brighter than an electric arc. The number of sunspots seen rises and falls over an 11 year cycle.

Sunspots appear when the Sun's magnetic field is concentrated, impeding the flow of energy. A typical sunspot

consists of a dark region, called the Umbra, surrounded by a lighter region, called the Penumbra. The Umbra is about 2000 °C (3600 °F) cooler than the photosphere and only looks dark in relation to its surroundings. Spots usually form in groups which are carried across the solar disk by the Sun's rotation.

Over a period of about 11 years, sunspot numbers increase before decreasing slowly. This sunspot cycle happens at about the same time as the increase and decrease in the Sun's overall activity.

The most complex sunspots are hubs of intense magnetic fields. These active regions can suddenly erupt as flares that are short-lived, extremely bright areas that release large amounts of charged particles and radiation. Flares are more prevalent during peaks in solar activity.

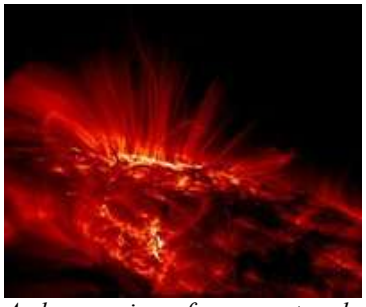
What is the solar atmosphere like?

The part of the sun that you see in the sky is called the **photosphere**. This is where the pressure from the gases inside the sun is low enough that they no longer glow so bright, and is generally considered the "surface" of the sun. Everything that is below the photosphere gives off light. The photosphere is also the very top of the convective zone of the sun. It is on the photosphere that you see sunspots.

While you can say that the atmosphere of the sun begins at the photosphere, in reality the entire sun is one very large ball of gases, where there is no definite beginning or end to the gases from the Sun. Because the Sun is so hot, gases from the sun are constantly streaming outward and form various parts of the solar atmosphere, which extends beyond even the orbit of Pluto. These gases near the Earth are very thin, with so little in the way of gas pressure that you can basically call it a vacuum, but it still is enough that it pushes away gases from other stars in our galaxy. It is only until you get to the **heliopause** that you can say that the influence of the Sun's atmosphere ends.

Various parts of the solar atmosphere are as follows:

Prominences and Solar Flares



A closeup view of a sunspot and prominences from the TRACE spacecraft

When you look at the sun through a telescope (with special filters so you eyes don't get damaged!), at the sides of the photosphere there appear to be large eruptions of gases like it was from a volcano. Each of these is called a prominence. There have been several kinds of prominences, but all of them are very large. Ones you can see are hundreds of kilometers long, and the largest was almost 400,000 kilometers. That is almost twice as far as the moon is from the Earth. These prominences are related to sunspots,

because they are often seen as coming from a sunspot. The largest of these prominences sometimes become so large that they leave the sun entirely, and that is when they become a **solar flare**.

Chromosphere

When early astronomers viewed the sun during an eclipse, they noticed that there was a brief flash of light immediately before and after the eclipse. Instead of being a steady white light, it seemed to be a rainbow spectrum of all of the colors you can see, which is what gives the chromosphere its name. It is not as bright as the photosphere, which is why you normally don't see it during the day, but only during an eclipse.

Corona

Solar Corona during an eclipse in 1999

Even more faint than the photosphere or chromosphere is the corona. This is a region extending from the chromosphere and gradually becoming a part of the solar wind throughout the rest of the solar system. The reason why the corona glows is because the gases in the corona are actually hotter than the surface of the Sun! The reason why this happens is still a mystery to scientists, but there are several theories for what is happening. The corona will shift and change, sometimes very rapidly over minutes or hours, due to changes from the sun itself. Because the photosphere is so bright, it is difficult to observe the corona except during an eclipse even with advanced scientific instruments. Some telescopes in space are making it easier to observe the corona, but it is still something that scientists are trying to understand.

Solar Wind

As the corona gets further from the sun, it is still "blowing" against all of the planets in the solar system. This is called the **solar wind**. While the gas pressure is very low, it still is enough that some very light objects and other gases are pushed away with the solar wind. For other astronomical object, this is visible with the two comet "tails", where one "tail" is mainly rocks and dust, with the other "tail" composed of gases. This second tail is being pushed by the solar wind and causes its effect.

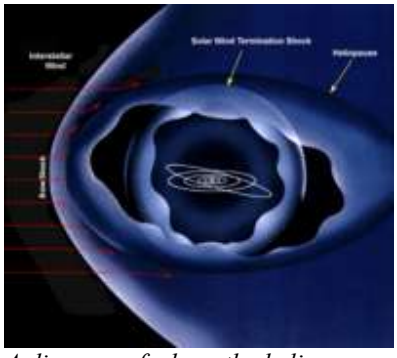
In 1960, the Satellite Echo I entered orbit and was one of the largest satellites ever put into space, in terms of volume. Basically it was a large ballon that was inflated by a small amount of gases inside. Because it was so light but also very large, its orbit was substantially affected by the solar wind and other solar pressures. Even more compact satellites still have to take solar wind into account when planning orbits and how long a satellite will stay in orbit.

In the future, **solar sails** will use the solar wind and **light pressure** in order to travel between planets, where spaceships use sails instead of just using rocket engines.

Zodiacial Light

Zodiacial Light with an Aurora

If you travel to a place very far away from any cities and look up at the night sky, a very faint glow will come from a band across the sky in roughly the same part of the sky that you see the other planets. This is not the Milky Way, which is also visible, but even more faint than that. This is actually sunlight which is reflected off of dust and meteoroids that are found throughout the **ecliptic plane**. This dust is the remains of comets and asteroids colliding with each other and eventually falls into the sun over millions of years.



A diagram of where the heliopause is located

Heliopause

The Heliopause is what can largely be considered the edge of the solar system. This is where the solar wind slows down and stops (or "pauses") due to the "solar wind" coming from other stars in the galaxy. There is a region just inside the heliopause where the solar wind slows down from supersonic speeds (literally, faster than sound) to subsonic speeds. This creates a slight jolt in the electrical systems of spaceships that was detected by the Voyager I spaceship in May 2005, which was the first man-made object to ever travel this far from the Sun. Since this is so far from the Sun, this is a part of astronomy that scientists are still trying to study and there is much more that needs to be learned about this part of the solar system.

What is solar weather?

Solar weather is a new science, but something that has a huge impact on a number of things here on the Earth. When a solar flare is produced on the sun, it includes a large amount of **plasma**, or very hot gases. If this flare then heads toward the Earth, it will cause a number of problems, including blackouts on electrical power systems in large cities, communications disruptions with radio transmitters and satellites, and potentially even death if an astronaut is caught unprotected when a large **solar storm** comes from that flare. Normally the Earth's atmosphere protects you and I from direct effects of these flares.

These solar flares also cause something called an aurora. This is also known as the "Northern Lights" or "Southern Lights" (depending if you are closer to the

north or the south pole) where the plasma interacts with the atmosphere of the Earth and the Earth's magnetic field. Normally you can only see this event when you are close to one of the poles, but sometimes a very powerful solar flare will produce an aurora that can be seen as far south as Mexico, or as far north as Southern Brazil, or South Africa.

The aurora is not unique to the Earth either. Aurora have been seen on all of the planets except for Mercury and Pluto by telescopes and space probes. The aurora on Pluto have not been seen because it is so far away and no space probes have ever been there, and Mercury doesn't have an atmosphere (that is substantial).

Just like there are weather forecasts for weather on the Earth, there are weather forecasters that study solar weather and try to predict when solar storms will come. Not only do they study just what will happen near the Earth, but they also try to predict what is going to happen in other parts of the solar system as well. As more space missions go into other parts of the solar system, this will become even more important. To help make the predictions, they also study the sun itself, and try to determine in advance when a solar flare will occur.

Mercury

Mercury from Mariner 10

Mercury is the closest planet to the sun. It is a **terrestrial planet** and the second smallest planet after Pluto. Only one spacecraft has flown by Mercury, Mariner 10, which was launched by the U.S. on November 3, 1973. Much of what we know about this planet came from this mission.

Mercury Facts:

- Mercury orbits the sun faster than any other planet.
- Mercury's surface temperature can vary from -300° F (-180° C) to 800° F (430°C).
- Radar observations suggest that there is frozen water on Mercury's north pole.

How big is Mercury?

Comparison of the size of Mercury to the Earth

Mercury is about 4879 km in diameter, which makes it a little over a third as big as the Earth is across. It's small enough that eighteen balls of modeling clay the size of Mercury could be rolled together to make one the size of Earth. In fact, the diameter of Mercury is only about one and a half times the diameter of our moon. It is the second smallest planet in the Solar System, just larger than Pluto. The small size and how close it is to the Sun sometimes make it difficult to observe Mercury in the sky, especially without a telescope or binoculars.

What is its surface like?

View of the surface of Mercury

Mercury has craters like those on the Earth's moon. They were made when **asteroids** or **comets** crashed into the surface. The largest crater we've seen on Mercury is the *Caloris Basin*. It is about 1350 km in diameter and was caused when a huge asteroid, probably about 100 km wide, hit Mercury about 4 billion years ago.

The surface also has big cliffs called **scarps**. They were made long ago when Mercury cooled down and shrank. This shrinking caused the surface to get wrinkled in some places, which created the scarps.

There are also **plains**. Some of them may have been made by **lava** flows long ago. There may also be water ice on both of Mercury's poles. The poles, like Earth's, get very little warmth from the Sun, so the ice doesn't melt or evaporate.

It gets very hot during the day and very cold at night on Mercury. It's so hot during the day (430°C, hot enough to melt tin!) because Mercury is so close to the sun. At night, however, it gets down to -180°C, much colder than Antarctica in winter. It loses almost all of its heat during the night because Mercury has very little **atmosphere**, which would normally help to keep in the warmth.

What is its moon like?

Mercury does not have a moon. Mercury's rotation is so slow that if Mercury had a moon, it would crash into Mercury or get broken up. This would happen because the moon's gravity would cause tidal effects on Mercury. There would

be two bulges called tidal bulges on Mercury. One would bulge toward the moon, with the other bulge being on the opposite side of Mercury. The moon's motion in its orbit would be faster than Mercury's rotation because Mercury's rotation is very slow. That would cause the moon to be ahead of the tidal bulge all the time. The gravity from the bulge would pull back on the moon. This would cause the moon to become closer to Mercury and Mercury's rotation to speed up. This would continue to happen over millions of years until the moon got broken up by Mercury's gravity or crashed onto Mercury. Mercury had existed for billions of years, so if it had any moon, it is long gone.

How long is a day on this planet?

Mercury **rotates** much slower than Earth. Its day is 58.6 Earth days long.

How long is a year on this planet?

Mercury is the planet with the shortest year in the solar system. It is about 88 Earth days long, roughly one quarter of an Earth year. This means that an eight-year-old person would be 32 years old on Mercury. One interesting thing about Mercury is that there are three Mercury days for every two Mercury years.

What is it made of?

Mercury has a large iron **core** for a planet of its size. The planet contains a larger portion of iron than any other planet in the solar system. The outer layer of the planet is made of **silicates**, which are ordinary rocks.

How much would Mercury's gravity pull on me?

If you were on Mercury, it would pull you down with a force about one third as strong as the force of Earth's gravity.

Who is it named after?

Artistic depiction of Mercury

In Roman mythology, Mercury was the messenger of the gods. He wore a hat and sandles with wings on them, allowing him to travel around the world extremely quickly. The planet Mercury was named after him because it orbits around the sun faster than any other planet in the Solar System, traveling nearly 50 km *every second*!

Mythology

Not only was Mercury the messenger of the gods, he was also the god of buying and selling. His name probably comes from the Latin word *mercator*, which means "merchant."

Mercury had his own day of the week, *dies mercuri*, or "Mercury's Day". In France it is mercredi. In English we named this day after a Norse god, *Woden*, making it "Woden's Day", or Wednesday.

Venus

Venus (in the visual spectrum)

Venus Facts:

- Venera 7, the first space probe to land on Venus, was put out of action by the hostile conditions on Venus after only 23 minutes.
- With a few exceptions, the surface features on Venus are all named after women.
- A day on Venus is longer than a year there.

Venus is the second closest planet to the sun, and was named after the Roman goddess called Venus. It is in a category called **terrestrial planets**, this means that it is very similar in size and was created close to the same way as our planet Earth. In fact, sometimes it is called Earth's "sister planet" as they are somewhat alike in both size and roughly a similar distance from the Sun.

How big is the planet?

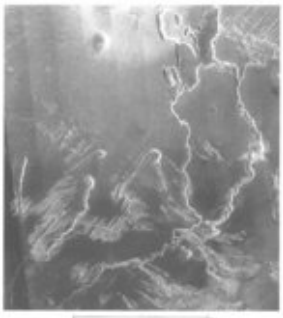
Venus is very close in size to earth and with a diameter of about 12,100 km or almost 95% of the size of the Earth. This is one of the reasons why Venus is often considered to be the "twin" to the Earth. It is also made up of very similar minerals to those found on the Earth.

Earth and Venus Comparison

What is its surface like?

Picture from the Russian Spacecraft Venera 13 on the Surface of Venus

Venus has a very interesting surface. It is very, very dry and also hot enough to melt lead on its surface. We could not survive on the planet because of this. Anyone attempting to walk on the surface of Venus would boil to death, be squashed flat by the air pressure, and then have their remains eaten away by the corrosive atmosphere. Dispite all of this, there are some features on the surface of Venus that are surprisingly similar to features on the Earth.



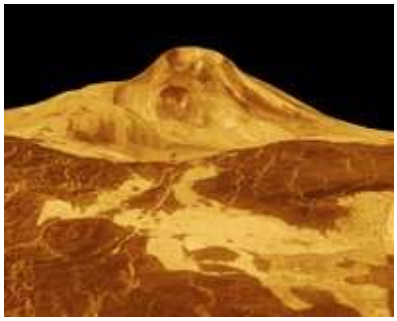
Channels on the surface of Venus bearing resembelance to a river channel on the Earth

River-like channels have been formed on Venus. It is believed that these channels are formed from erupting lava that takes a long time to cool down, and flows down into the lower elevation areas of Venus. Similar rivers of lava have been seen in Hawaii and other volcanoes on the Earth, but the longest of these lava channels on Venus is over 7,000 km long and sometimes as wide as one to two km. That is by far longer than any river on the Earth, including the Nile, Amazon, or Mississippi rivers!

An Arachnoid volcano on the surface of Venus

One of the more unusual features to Venus that seems to be unique only to Venus so far is what are called **arachnoid volcanoes**, or simply arachnoids. When scientists first saw images of these features, it reminded them of pictures of spiders or ticks, although these features were hundreds of kilometers across. These are volcanoes that due to the environmental conditions on Venus have formed very differently from other known volcanoes throughout the rest of the Solar System. The exact process that formed these is still not completely known and an area of future exploration on Venus.

Other more normal volcanoes have been found on Venus as well, and the interior of Venus appears to be almost as active as the interior of the Earth. Almost 90% of Venus's surface is made up of recently-solidified **basalt lava**, meaning that Venus has experienced a lot of **volcanic** activity from time to time. The oldest parts on Venus are thought to be only around 800 million years old.



Maat Mons on the Surface of Venus, by radar imaging

Parts of the surface of Venus appear to be structurally similar to continents on the Earth, with the largest of these called **Istar Terra**, named after the Babalonian equivalent of Venus. Deep basins like the ocean basins on the Earth have also been discovered, except that they are totally empty of water. Features like mountain ranges and Meteor craters have also been found on Venus. One of its highest mountains, named the Maxwell Montes, is roughly 2 km taller than Mount Everest. Because Venus has a very thick **atmosphere**, **meteors** slow down as they fall toward it's surface, so no craters that are smaller than about 3.2 km round can form, according to current theories, and none have been discovered.

Is there life on Venus?

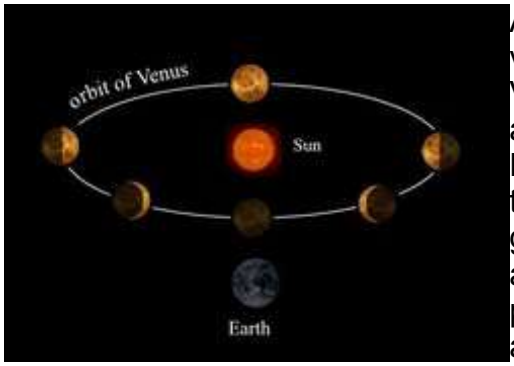
The Venera 13 Lander, which made scientific measurements and pictures from the surface of Venus

When astronomers first tried to make observations of Venus, they thought that Venus would have a very Earth-like environment, although slightly warmer than the Earth. Venus is almost the same size as the Earth, and covered with clouds, and it was assumed that these might be water clouds like are found here on the Earth.

Many stories written during this time described Venus as having a swamp-like environment, but still something that people could go and visit someday, and even live on. Sometimes exotic aliens were thought to live on Venus, just like people thought the same thing about Mars.

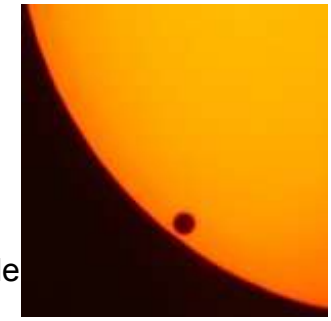
The debate on whether there were living things on Venus continued until robotic spacecraft traveled to the surface of Venus and directly measured the thickness of the atmosphere, what chemicals it contained, and the temperature. The environment on Venus is deadly to almost any living thing on Earth, and it is unlikely that manned exploration of its surface will ever happen. Spaceships that land on Venus must be very strong in order to work with the very high atmospheric pressures on its surface, and to withstand the acids in the atmosphere. One of the gases found on the surface is Sulfuric Acid, which is the same chemical that is used in car batteries, and very toxic if you eat or breathe it. There are many other chemicals that are just as deadly if you were to breathe them in.

Phases of Venus



After telescopes were invented, one of the very first places that they tried to study was Venus. Even with a modest telescope this is a fairly easy feature to identify. Just like the Earth's Moon has **phases** during different times of the month, Venus also appears to go through similar kinds of phases where it appears in a **crecent** shape during some parts of its orbit around the Sun. This visual appearance is caused because Venus is closer to the Sun than the Earth, and we are looking at the night sky of Venus, or the part of Venus that is facing away from the Sun.

This is slightly different than the phases of the Earth's Moon, because the distance between the Earth and Venus varies quite a bit. When Venus is at its closest point to the Earth, it appears as a thin crecent or even can't be seen at all. Only when Venus is almost at a location furthest from the Earth can a full disk be seen through a telescope.



Sometimes on rare occasions, Venus actually crosses directly between the Sun and the Earth. This is called a **transit**, which is very similar to a solar eclipse by the Earth's Moon. Many early details about Venus were discovered this way, including approximately how large Venus was, and the fact that it had an atmosphere due to how "fuzzy" the outline of Venus was against the Sun. During a transit of the Sun, Venus appears as a small circle going across the Sun's photosphere.

What is its moon like?

Early in history Venus was once thought to have a moon, named Neith after the mysterious goddess of Sais. The moon was first seen by Giovanni Domenico Cassini in 1672. **Astronomers** saw this moon from time to time until 1892, until they found out their sightings were mostly faint stars that were in the right place at the right time. Venus is now known to be moonless.

Venus's rotation is so slow that if Venus had a moon, it would crash into the planet or get broken up. This would happen because the moon's gravity would cause tidal effects on Venus, which would create two bulges called tidal bulges on Venus. One would bulge toward the moon, with the other bulge being on the opposite side of Venus. The moon's motion in its orbit would be faster than Venus's very slow rotation. That would cause the moon to be ahead of the tidal bulge all the time. The gravity from the bulge would pull back on the moon. This

would pull the moon closer to Venus and make Venus's rotation speed up. This would continue to happen over millions of years until the moon got broken up by Venus's gravity or crashed onto Venus. Venus has existed for billions of years, so if it had any moon, it is long gone.

How long is a day on this planet?

Venus **rotates** even more slowly than Mercury. One **siderial** day on Venus is about 243 Earth days long. This is the time it takes for a distant star to go from being directly overhead to being above you again. One **solar** day on Venus is about 117 Earth days long, or the time it takes for the sun to be over one spot on Venus to returning to that same position. The reason for this difference is that Venus is also going around the Sun at the same time it is turning. There is a difference between **sideral** and **solar** days on the Earth as well, but because the Earth is spinning so quickly compared to Venus it is only a difference of a few minutes each day instead of over a hundred days like it is on Venus.

It also rotates the opposite direction from most of the planets in the Solar System. This is called **retrograde motion**, where the Sun rises in the west and sets in the east, from the viewpoint of somebody standing on the surface of Venus.

This rotation period is also rather unusual because of an interesting coincidence with this orbital period and the Earth. Venus always seems to have the same side of its planet facing the Earth as it passes close to the Earth, almost as if Venus had a **tidal lock** on the Earth like the Earth's Moon. From the perspective of somebody standing on Venus, Earth would always be in the same spot in the sky year after year. What causes this behavior from Venus is totally unknown, and may be a pure luck, but many scientists often discover new ideas by studying a coincidence like this.

How long is a year on this planet?

One Venus year is 224.7 Earth days long. So, one Venus day is longer than one Venus year. There is an interesting coincidence with this period of time as well, because from one **conjunction** between the Earth and Venus to the next one (when the Earth and Venus are closest together and on the same side of the sun) is 584 days. What is unusual about this number is that it happens five times every eight years on the Earth, in a pattern that is very close to the same orbital time period of the Earth around the Sun.

> 25 x 117 (Earth days in a Venus solar day) = 2925 days
> 5 x 584 (Earth days between conjunction of Earth and Venus) = 2920 days
> 8 x 365 (Earth days in an Earth year) = 2920 days

This was known to ancient astronomers and played an important part in the

design of many ancient calendars, including some eight year cycles where the pattern that Venus followed in the sky was watched very closely. There is no current scientific theory to explain this coincidence other than it just happened to be like this.

What is it made of?

Like Earth, Venus appears to have have a **crust** and **mantle** made of **silicates** and an iron **core**. There are a number of features on the surface of Venus that resemble features found on the Earth, so it is likely that many of the internal characteristics of both the Earth and Venus are the same.

How much would Venus's gravity pull on me?

If you were on Venus, it would pull you down with a force about nine tenths as strong as the force of Earth's gravity. In terms of the effect of gravity when on the surface of Venus, it is almost identical to what happens to objects and people when they are on the Earth.

What is the future for exploring Venus?

An artists depiction of what a future mission to Venus may look like

Because Venus is so close to the Earth, and reveals many clues regarding how the Earth works, it is going to be studied even closer in the future. There are several proposals to have spacecraft travel to Venus and then deploy a **balloon** that would allow scientific intruments to travel in the atmosphere. In fact, two of these have already been sent to Venus, called **Vega 1** and **Vega 2**. These Russian spacecraft measured the composition of the atmosphere of Venus and relayed other important scientific information. There are plans now for even more advanced spacecraft, with perhaps even a motor on the balloon that would turn the spacecraft into an **airship**. In some very far reaching proposals there is a suggestion that perhaps a high-altitude balloon could even have people on board. Scientists studying Venus could live high in the clouds where the atmosphere isn't nearly so hazardous to people, with research being performed in a manner similar to how scientific research is currently conducted in Antarctica right now.

Can Venus be Terraformed?

An interesting debate is occuring right now about the possibility of Venus being changed into conditions similar to what the Earth is like right now. That is called **Terraformation**, or the formation of Earth-like worlds. While in theory it could be done, it would require incredible financial resources in order to accomplish, and there are some people who even question if it should even be done at all. While the concept is largely something science fiction authors talk about, it is a topic that is now beginning to enter into discussions with scientists who study this planet, at least in terms of speculating just how such a task might be accomplished. It is also argued by some scientists that we on the Earth are doing the opposite and **Venusforming** the Earth with pollution and the release of greenhouse gasses, turning the environment of the Earth to be more like Venus. Certainly the ideas that would be gained from trying to figure out how to increase the absorbtion of greenhouse gasses that make Venus so hot and inhospitable to life can have long term positive benefits for people here on the Earth.

Who is it named after?

Venus is named after the Roman goddess of love. It looked bright in the sky sometimes, so it was named after the beautiful goddess. The planet Venus is also associated with the Greek goddess Aphrodite, as well as Frigg and Freya in Norse mythology. Indeed, almost every ancient culture associated the planet with a major deity, although not all of them were female. An example of the planet being named after a male diety is Tlahuizcalpantecuhtli, one of the Aztec gods, together with his brother Xolotl. In Aztec society the morning and evening stars were considered seperate dieties rather than the same object as Greek and Roman societies thought of them.

Artistic representation of Venus

Earth

The Earth seen from space

Earth Facts:

- The Earth is the only planet in the known universe which is capable of supporting life as we know it.
- Some of the heat in the Earth's mantle actually comes from the breakdown of radioactive material. The pieces of rock and metal that collected to make the Earth brought in the rest of the energy when they fell onto the planet.

Earth is the planet we live on. It is the only planet in the solar system with liquid water. It's also the only one known to have life.

How big is the Earth?

The Earth is 12,742 km in diameter. It's the largest **terrestrial planet** in the solar system. The Earth weighs 5,973,000,000,000,000,000,000,000 kg. (That's nearly 6 trillion trillion kilograms)

How old is the Earth?

Scientific evidence shows that the Earth is 4.6 billion years old.

What is its surface like?

Moraine Lake by Lake Louise Alberta, Canada

Earth's surface is made of **continents** and **oceans**. There are also islands in the oceans. The top layer of Earth is called the **crust**. It divided into pieces called **tectonic plates**. They move very slowly, carrying continents with them. The

places where they meet are called **fault lines**. On fault lines, **magma** can seep up through the cracks and create **volcanoes** (once on the surface it's called **lava**.) When fault lines move apart they create new land (these are called **constructive margins**) and where they move towards each other one of them goes underneath the other (these are called **destructive margins**.) When they slide past each other, great tension builds up due to **friction** - when this tension is released the plates move rapidly and sharply in one direction, creating **earthquakes**.

Anawhata beach, west of Auckland, New Zealand

Earth has many kinds of **environments**. It is cold and icy in places like Antarctica. There are hot, dry deserts in some parts of the world like Africa and Arabia, and cold, dry deserts in some others like Siberia. Rain forests grow where it is warm and wet, in **equatorial zones** (these are areas a few hundred miles around a very hot 'line' called the **equator**. Outside equatorial zones there are areas of very dry, mostly hot desert, which is where all the water making the rainforests wet comes from, causing these areas to be very dry. Other kinds of forests grow between the Equator and the Poles, like the massive **coniferous** forests of pine and other trees which keep their leaves all the time, and **deciduous** forests of oak, beech and other leaf-losing plants. Some places are very wet and are called swamps or marshes. There are grasslands, many hot, some called **savannahs**, with lots of grass and few trees. There are also mountains, caused by collision of **tectonic plates**. Some of them are high with snow and ice on their tops all year. Others are lower and more rounded.

Is there life on the Earth?

When this question is asked on other planets in the solar system, it is important to know where you might find living things here on the Earth. Almost every important feature of the surface of the earth is in some way affected by living things, including mineral deposits and even the content of the air that we breathe.

One of the critical ingredients that all living things seem to need is water. Wherever you find liquid water, you will almost always find living things, even if it is not a place where you would want to live as a person. Bacteria has been found inside gysers, where the water temperature can be over 300° C. These living things not only live there, but even seem to need those very high temperatures. Other living things have been found on the bottom of the ocean, living around "thermal vents" where the only energy they obtain is from lava heating up water. It is so deep in the ocean that no sunlight ever appears there. Finally, you can find living things in Antarctica where it is always covered with ice, or even at the

top of mountains in the form of lichens, growing where otherwise nothing else could live.

Galileo being deployed after being launched by the Space Shuttle Atlantis

Is the Earth unique because only this planet could have living things growing on it? It would seem unlikely that this is the only planet in the Universe that has living things like we know them, and it is suspected that there are many other places in the Solar System where life might be. If liquid water is discovered anywhere else in the Solar System, you might just find some living things there too. There are other worlds in the Solar System where liquid water indeed has been found, so many scientists continue to look for signs on life on other planets.

An interesting experiment was conducted in December, 1990, where the **Galileo** spacecraft, on a journey to Jupiter, went past the Earth after having gone on a orbit around the sun earlier. In this situation, the scientists who were running the space probe decided to test the equipment to see if they could detect signs of life on the Earth. In addition to simply taking pictures of the Earth, it also detected signs of water, oxygen, and other elements and chemicals that are necessary for life. This information was then used to both see if these same instruments could detect life elsewhere, and to **calibrate** the instruments to make more accurate measurements when it arrived at Jupiter.

What are its moons like?

Earth has one permanent moon named Luna, or more commonly called the Moon. Earth also has a number of temporary natural satellites, the largest of which is the three-mile-wide body named Cruithne [pronounced 'KROOee-nyuh']. Discovered in 1986, Cruithne follows an eccentric horseshoe-shaped orbit that takes 770 years to complete.

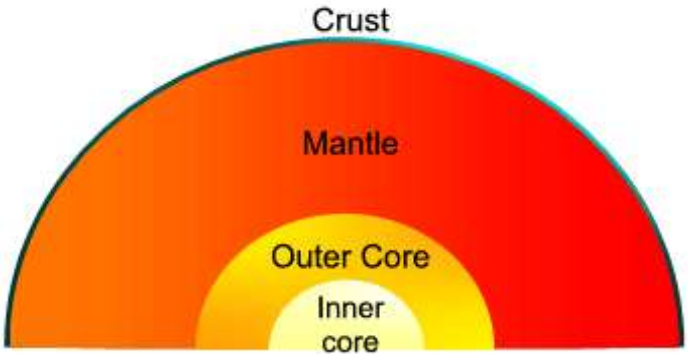
How long is a day on the Earth?

A day on Earth is 24 hours long (solar) and 23 hours 56 minutes (sidereal). It is how long it takes the Earth to spin once on its axis.

How long is a year on the Earth?

A year on Earth is 365 days long. It is how long it takes Earth to **orbit** the sun once.

What is it made of?



The Earth has a crust and mantle made of **silicates** and an inner and outer core. The **crust** is the surface layer. It is up to 5 km deep under the oceans and up to 35 km deep under the continents. Despite being so thin, scientists have not ever drilled all the way through the crust. The **mantle** extends from the bottom of the crust down to 2900 km under the surface. Under the mantle there is the liquid iron **outer core**. It extends from 2900 to 5100 km under the surface. At the center of Earth there is the solid **inner core**. It is made of iron and nickel.

How much would I weigh on Earth?

It's easy to find your weight on Earth by using a scale. You have weight because the Earth pulls you towards its center. (Normally, the ground or the floor get in the way, making you feel 'stuck' to them.) This force is known as **gravity**.

..... There are several kinds of scales:

1) Comparing of 2 masses (weights). You put the thing(s) you want to weigh on one pan (like some marbles), and then you put several "weights" on the other pan until the pointer shows that both pans have equal weights on them. Then you look at the pan with the known weights on it, and add them all up. The total is the mass of the thing(s) you want to weigh.

2) A spring balance usually has a hook on it, with a pan. You put the thing(s) you want to weigh on the pan, the spring is pulled, and the greater the weight, the further the spring is pulled. That distance, calibrated in pounds or kilogram (or whatever), is usually shown either on a dial or on a linear scale.

3) There are also electronic scales that give a properly calibrated reading—grocery stores, for example, use these.

NOTE: **gravity** varies slightly depending on the location where you want to get the weight; spring balances and some electronic scales can, in theory, read slightly different weights at different places because of that, but usually in practice that difference it too small to be noticed. But, because the balance type of scales work differently to the spring or electronic types, they will always read the true, correct mass. The would even give the same mass on the moon! (where gravity is much less than on Earth)

Did you know? that *Sir Isaac Newton* was the first person to realise that the force pulling you down to the ground was the same force that keeps the planets going around the sun? The story goes that he thought of this when he saw an apple fall from a tree.

Gravity is a very important force. As well as keeping you firmly stuck to the Earth, it keeps the Moon going round the Earth, The Earth going around the Sun and the Sun going around the center of the Milky Way **galaxy**. Gravity also makes stars and planets a nice round ball shape. In fact without gravity there wouldn't even *be* a sun, moon or earth. (The material that they are made of would just float away into space)

Who is it named after?

The word earth is used for both planet Earth and soil. Other names had been used for Earth such as Gaia and Tellus. Gaia is the Greek god of Earth. Tellus is the Roman name of the same god.

The Earth seen from the surface of the moon

Moon

The moon is our nearest neighbour in space.

The Moon is Earth's only permanent **natural satellite**. Twelve people landed and walked on it in the 1960s and 1970s. They collected and brought back rocks that were studied to find more about the Moon.

Moon Facts:

- Until Luna 3 sent back photos in in 1959, no one knew what was on the far side of the moon.
- The Moon is nearly twice as big as Pluto, the smallest planet.
- The "man in the moon" isn't always a man--the people of Mexico see a rabbit!
- The Moon and the Earth are sometimes refered to as a **binary planet system**, or as two different planets that orbit each other, because of how large the Moon is compared to the size of the Earth.

How big is the Moon?

The Moon is 3,476 km wide. This is just over a quarter of Earth's diameter. That makes the Moon a relatively large one. Most other planets are much larger than their moons. Because of this, Earth and the Moon had been called a double planet.

Astronaut Harrison Schmitt collecting lunar samples during Apollo XVII

What is its surface like?

The Moon does not have any air or liquid water. There is no life on the Moon. During the day it becomes very hot. At night it grows icy cold. A person going to the Moon needs an air supply and a special suit.

The Moon has many **craters**. The largest one is the *South Pole-Aitken Basin* that is on the far side and in the

south **hemisphere**. It is 2,240 km across. Some of the craters have bright rays around them. They were made by material thrown up by the impacts that made the craters. Those craters are the younger ones. The bright rays of older craters faded because of impacts of tiny meteors over millions of years.

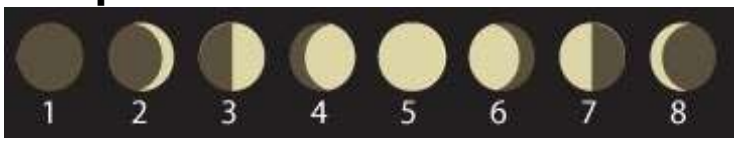
There are dark areas called maria. They are soldified **lava** flows that filled up large craters long ago. Most maria are on the near side and there are only a few on the far side. There are also lighter-colored highlands. The surface is covered by dust called regolith. It is thinner on the maria and thicker on the highlands. The Moon's regolith was made by pieces of rock that got thrown up by impacts.

There might be water ice in the floors of craters near the south pole. The bottoms of those craters are always dark because they are in the shadows of the crater rims. The ice came from **comets** that hit the Moon.

How long is a day and a year on the Moon?

It takes the Moon 27.3 Earth days to **rotate** once and to make one **orbit**. So, the Moon always keeps the same side faced towards Earth. That side is called the near side. It is the side with lots of maria. The other side is the far side. Nobody saw the far side until it was photographed in 1959 and first seen by astronauts in 1968.

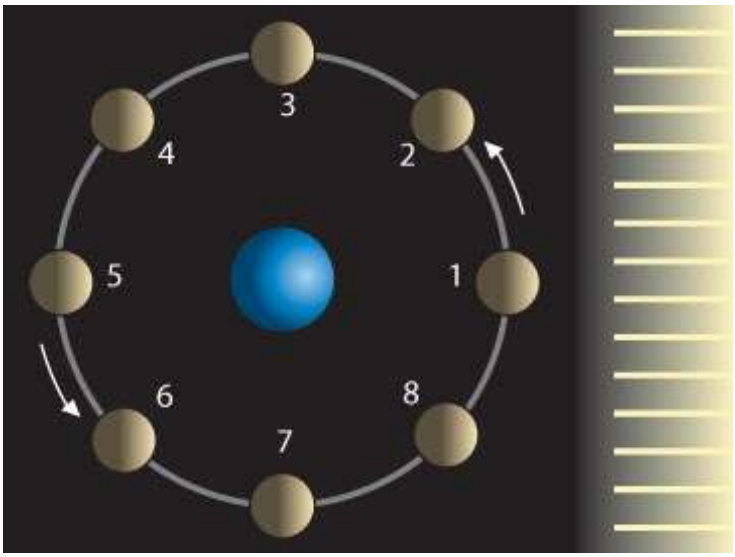
What are the phases of the Moon?



The Moon looks different at different times. This happens because the Sun lights up different parts of the Moon as the Moon moves in its orbit. This is called the phase of the Moon.

When the Moon is between Earth and the Sun, the side facing away from Earth is light up and the side we see is dark. This is called a new moon because people in many cultures used it to mark the beginning of a new month. When it is behind the Earth, the side we see is light up. This is called a full moon.

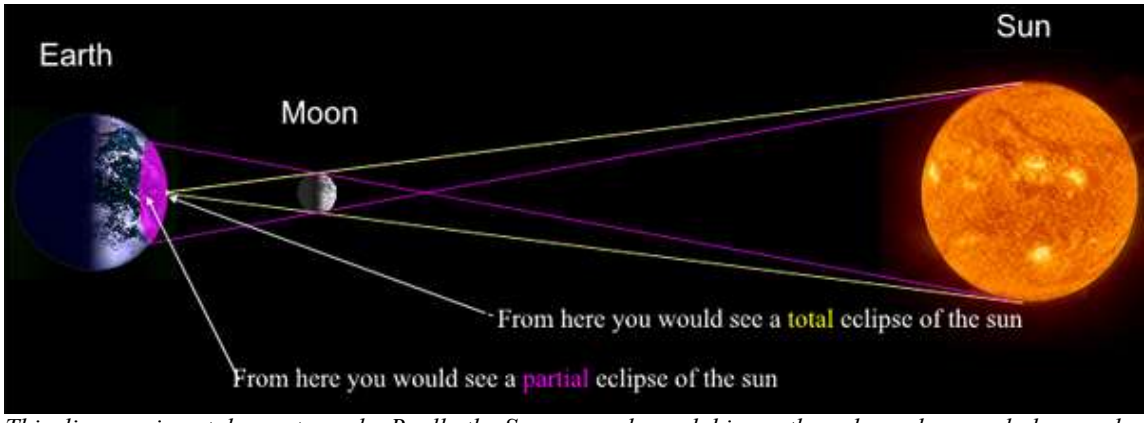
When the Moon is halfway between new moon and full moon, we see one quarter of the Moon. This phase is called the first quarter. When the Moon is halfway between full moon and new moon, we see a quarter of the Moon again, but the opposite quarter from what we see at first quarter. This phase is called the third quarter because the Moon had gone three quarters the way around its orbit from the new moon position.



When the Moon is between either one of the quarter phases and new moon, it is in a crescent phase. It is shaped like a banana or a cow's horns. When the Moon is between either one of the quarter phases and full moon, it is in a gibbous phase. The unlit part as seen from Earth is crescent shaped.

The cycle of phases does not match the Moon's 27.3 Earth day orbit. This is because the Moon makes one orbit in 27.3 days if you use the faraway stars to keep track of the Moon's position. The Earth is moving in its orbit around the Sun. While the Moon makes its orbit, the Earth moves ahead of it. The Moon needs extra time to catch up with the Earth and complete the cycle of phases. The complete cycle of phases takes 29.5 days. This is why we use 30 days, not 27 days, as the average length of the month.

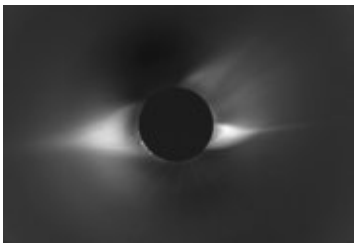
An interesting thing happens sometimes when the moon is a crescent phase. The Earth can reflect enough sunlight to the Moon to make the noramlly unlit part be dimly light. This is called earthshine. If that dim lighting cannot be seen, it could be viewed by letting a camera collect enough light to make the dim part look brighter in the picture.



This diagram is not drawn to scale. Really the Sun us much much bigger than shown here and also much much further away. But it should give you an idea of how solar eclipses occur. Imagine a person standing on the yellow spot. Their view of the sun is completely blocked by the moon and so they experience a total eclipse. A person standing in the purple region will have part of their view of the sun blocked by the moon. They will see a partial eclipse.

What are eclipses?

Why can we see the full moon if it is behind the Earth as seen from the Sun? Why can we get sunlight at new moon if it is between the Sun and the Earth? The Moon doesn't always get blocked out by Earth's shadow at full moon and it doesn't always block the Sun at new moon because the orbit of the Moon is tilted. This tilt usually makes the Moon be above or below the Sun at new moon or the Earth's shadow at full moon.



Solar Eclipse - November 3rd, 1994 - High Altitude Observatory

But sometimes when things are lined up right, eclipses happen. There are two main kinds of eclipses. When the Moon does block the Sun, it is called a solar eclipse. They can be viewed with special filters to keep people from hurting their eyes. Unfortunately, when a solar eclipse occurs, only a few people can view a total eclipse, as the part of the Earth that is dark from the eclipse is only in a small area of the world.

One of the unique things about the Earth's Moon is that the apparent size (how big you see something when you look up into the sky) of both the Moon and the Sun are almost identical. This results in some very spectacular views when this occurs, especially when you are in the part of the world where the eclipse is total. In addition to seeing eruptions of gases from the sun called **prominences**, you can also see the **corona** of the sun. This is a region of very hot gasses that are escaping from the sun and form the **solar wind**. This particularly interesting because normally the **photosphere** of the Sun keeps you from being able to see the corona, and many astronomers try to do scientific measurements of the corona during an eclipse.

When the Moon does go through the Earth's shadow, it is called a lunar eclipse

Lunar Eclipse - September 11th, 2003

and it can be viewed with the eyes. Because the Earth is so much larger than the Moon, a lunar eclipse can usually be viewed by just about half of the people on the Earth when they occur, and happen about twice a year. Before and after the moon enters the shadow of the Earth, it turns to a reddish color. This is due to the fact that the blue colors of sunlight are scattered in the atmosphere and the red light is able to go through much more air. This is exactly the same as what you see during a sunset or sunrise, except on the moon this is light that is going through the Earth's atmosphere.

Other planets with moons can have eclipses too. Shadows of moons have been seen on the surface of other planets, and those moons go into the shadow of those planets as well. When a planet goes between us and the Sun, it is called a **transit**. These usually are not noticed by anybody due to sunlight dimming (unlike an eclipse of the Moon), but can be seen with telescopes that have special filters to keep the sunlight from hurting your eyes.

How does the Moon cause tides?

In this diagram the Earth has an exagerated, deep ocean covering the whole of the surface

The ocean tides are caused by gravity. The closer you are to the Moon, the stronger the pull of gravity. The ocean facing the Moon is closer than the middle of the Earth. It is pulled more strongly by gravity. The ocean is pulled into a bulge called a **tide**. The places where the ocean bulges is a high tide. In between is the low tide.

When you bring along a moon. The gravity of the moon gets weaker and weaker as you go further from it. This causes the ocean to bulge.

The other side of the world feels the weakest pull from the Moon. Here the Earth is pulled more strongly than the ocean. The Earth moves away from the water. This makes the ocean bulge out on this side as well. In between these two bulges, the oceans of the world are lower.

Both the Moon and the Sun cause tides, but the moon's is much stronger. This is because the Moon is much closer to the Earth, so it's gravity changes more quickly from strong to weak on the opposite sides of the Earth. The Sun, being much further away, has a less variable gravity strength. As the Earth turns, the tides always point toward the Moon and Sun.

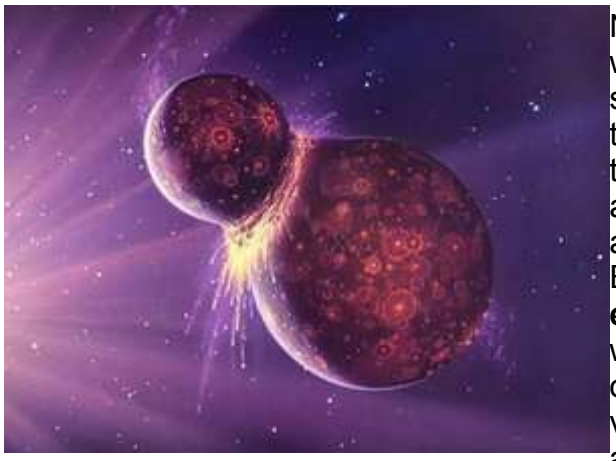
The biggest tides happen when the Earth, Moon, and Sun line up. These are called **spring tides**. They occur at the new moon and the full moon. In between the tides are lower. The weakest tides are called **neap tides**. Here the pulls of the Moon and the Sun cancel each other out.

A spring tide (Note the Sun, Earth and moon are not to scale)

A neap tide. The Moon still tries to pull the ocean but the sun also causes a weak tide of it's own. This partially cancels out the moons effors and so weakens the tide

What is it made of?

The **silicate crust** is about 60 km thick on the near side and 100 km thick on the far side. It is thinner under the maria and thicker under the highlands. It is thought that the near side has more maria than the far side because the thinner crust made it easier for lava to flood craters. There is a silicate **mantle** and a small **core** 600 to 850 km across.



No one knows exactly how the Moon was made, although scientists have several theories. Some scientists think that the Moon was made very early in the life of Earth (when the earth was about 50 million years old). A planet about as big as Mars hit the young Earth. The collision had so much **energy** that the Mars-sized planet was completly destroyed. Also much of the earth's crust and mantle was vaporised. Some of the debris formed a ring around the earth and eventually was pulled together by gravity to form the moon. The rest of the colliding planet and young Earth merged to became the modern Earth.

All this happend billions of years ago. The idea was suggested by things like the small size of the Moon's core and comparisons of what the Moon and Earth are made.

How much would the Moon's gravity pull on me?

If you were on the Moon, it would pull you down with a force about one sixth as strong as the force of Earth's gravity. This allowed the people who visited the Moon to lift rocks that they could not lift as easily if they were on Earth.

Who is it named after?

The goddess Diane, also known as the moon goddess in Roman Mythology

Moon and Month both come from the same old Greek word Mene for the moon. Monday follows Sunday as the Moon follows the Sun. Interestingly the Latin name Lunar is used in many languages so Lundi is french for Monday.

Other names had been used for the Moon such as Selene and Luna. Selene is the Greek goddess of the Moon. Luna is the Roman name of the same Goddess. Diana is also usually associated with the moon.

Mars

Valles Marineris on Mars

Mars Facts:

- Mars is red because of rust.
- A volcano on Mars called Olympus Mons is the highest mountain in our solar system.
- Mars has polar ice caps just like Earth.
- Mars has ancient river beds where scientists think liquid water flowed millions or billions of years ago.

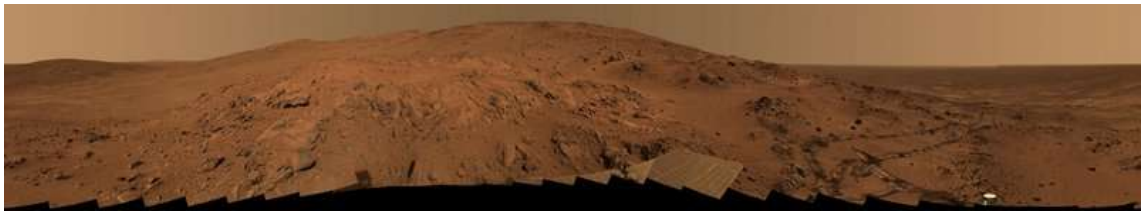
Mars is the fourth planet from the sun. It is a **terrestrial planet**, because it is very similar to the Earth in terms of atmosphere and surface features.

How big is the planet?

Comparison of the size of Mars and the Earth

Mars is 6,804.9 km or 0.533 Earths in diameter. That makes it a little more than half of Earth's dameter, so its volume is around 15% that of the Earth.

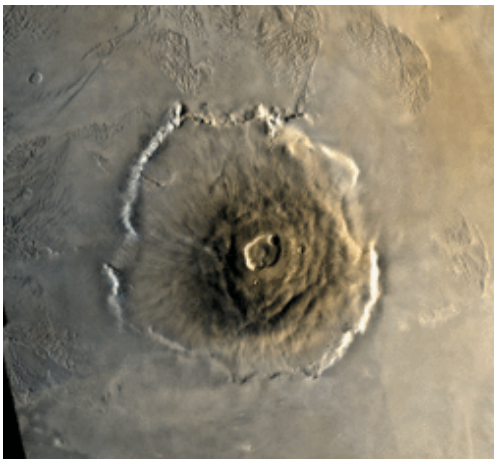
What is its surface like?



Panorama from the Mars Rover "Spirit"

The surface of Mars is dry and dusty. The highlands of the southern **hemisphere** have more craters than the lower areas in the northern hemisphere. One of the craters is the huge *Hellas Planitia*. It is 2100 km across.

There is an area called the *Tharsis Bulge* that has four huge volcanos. These volcanos have not erupted for millions of years. The largest one is *Olympus Mons*. It is 27 km tall, making it the highest mountain in the solar system and much higher than Mount Everest on Earth. It is 540 km across, making it too big to see the whole thing from the surface of Mars.


Olympus Mons

Mars has a huge **canyon** called *Valles Marineris* that is much bigger than the Grand Canyon on Earth. It is 4000 km long, up to 7 km deep and up to 200 km wide. It it thought that *Valles Marineris* was made when the surface cracked when the Tharsis Bulge formed.

There are also two ice caps at the poles. They are made of **carbon dioxide** and water ices. The northern one is large and the southern one is small.

In some places, there are **channels** that look like they were made by water **erosion**. Mars may have once been a wet planet like Earth.

If you got in a spaceship and landed on the surface of Mars, you would notice that there is air and an atmosphere, but it is very thin. When you are standing at the bottom of Valles Marineris, there is almost the same air pressure as you would find on the top of the tallest mountain on Earth, Mount Everest. Even then, you would not want to breathe it because it has very little oxygen, and much more carbon dioxide than on the Earth. Carbon dioxide is the gas that you send out from your lungs when you are breathing. Even with these problems, someday people will travel to Mars and walk on its surface.

Is there life on Mars?

This is a question that many scientists have been asking for a very long time. When telescopes were first became powerful enough to study Mars in detail, the Italian astronomer Giovanni Schiaparelli spotted lines on the surface of Mars that he believed to be like rivers. Unfortunately this word in Italian, when translated into English was also the same word for canals, and that sparked the imaginations of many people to believe that there was not only living things on Mars, but an advanced civilization of people that built cities and structures that could be seen on the Earth, like the Great Wall of China is visible from space as the sign advanced tool making.

Popular fiction took advantage of this interest, and the notion of Martians invading the Earth is a common idea in stories like this. Perhaps the most famous story using this idea is the novel "The War of the Worlds", by H.G. Wells, which includes some scientific opinions of what astronomers thought might be on

Mars when that book was written. This story has since been made into a movie on several occasions, theatrical stage productions, and even radio dramas.

Most astronomers and space scientists no longer believe that there is an advanced civilization on Mars. The question is now if anything, even small plants and animals ever lived on Mars in the past or are still living there. This question is still unanswered, but there have been some attempts to find out.


Model of Viking Lander

In 1976, robot spacecraft from Earth called **Viking landers** went to Mars to find out. When it landed, the pictures of Mars that came back to Earth made Mars look very much like a desert, with very little water. Some experiements that were done to Martian soil seemed to indicate there was no life on Mars, although one experiment did indicate that there might be something alive in the soil. Even that experiment, however, was not convincing.

Shortly after the Viking space missions, a rock was discovered in Antarctica that was believed to have come from Mars. When scientists examined the inside of that rock, they discovered that there might be an ancient fossil of some bacteria.

Another robotic spacecraft called **Mars Observer** has been orbiting Mars for several years now, and it has taken photos of riverbeds and other features on the surface that suggest that Mars had liquid water flowing on the surface. If this is true, it seems likely that at least some very simple form of life may have lived on Mars as well.

In spite of all the scientific research to search for life on Mars, the question still hasn't been completely answered, and this is something that is debated by scientists even today.

What are its moons like?

It is believed that these moons did not originally orbit Mars, but were instead a part of the Asteroid belt. When these pieces of the Solar System came close to Mars, they were captured by the gravity of Mars and went into relatively stable orbits around Mars. Like the Earth's moon, these moons are in a **tidal lock**, always keeping the same face towards Mars while they are in orbit.

The Moons of Mars

Mars has two natural satellites:

Phobos

In Roman mythology both Phobos and Deimos were the sons of the Roman god Mars. Phobos means "fear" or "fright". Phobos also orbits closer to Mars than any other moon to any other major planet in the solar system. In a few million years Phobos will eventually crash into the surface of Mars due to **orbital decay**, where it goes closer to the surface of Mars every year.

Deimos

Deimos means "panic" or "dread" as the son of Mars. Deimos is one of the smallest moons of any planet in the Solar System (so far).

How long is a day on this planet?

One day on Mars is only a little longer than an Earth day at 1.025 Earth days. A year is 1 Earth year and 322 Earth days long.

What is it made of?

It is thought that Mars has an iron and **sulfur core** and a **mantle** and **crust** made of **silicate**.

How much would Mars's gravity pull on me?

If you were on Mars, it would pull you down with a force about two fifths as strong as the force of Earth's gravity. This would make somebody living on the surface of Mars to experience something significantly different. You could lift objects that weigh almost three times as much compared to similar objects here on the Earth. You could jump up almost three time higher, but it would take much more time in order to fall to the ground from the same height.

Even though it appears as though you would be like a comic-book hero on Mars, you would still have to worry about the mass of an object. A large object that is moving forward would still crush you if you got in its way, just like it would be a problem here on the Earth, and a bullet from a gun would do just as much damage on Mars as it does on the Earth.

Who is it named after?

Due to its red appearence in the sky, Mars is named after the Roman god of war.

Mars/Phobos

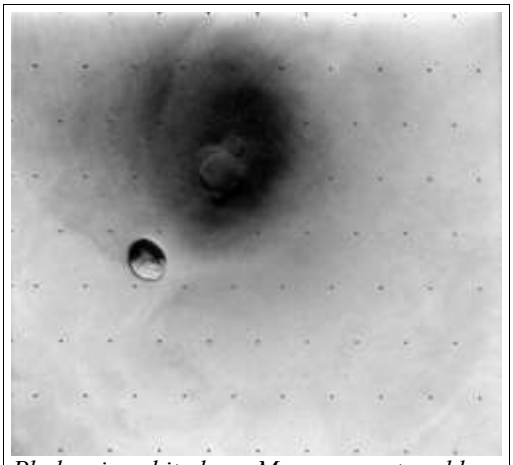
Phobos as seen by the Viking-1 Orbiter

Phobos Facts:

- Phobos orbits Mars closer than any other moon to the planet that it orbits.
- Tidal forces make gravity toward Phobos almost twice as strong near the middle than on the ends that face Mars and are away from Mars.

How Big is Phobos?

Phobos is actually quite tiny compared to most other moons in the Solar System. It is not a round sphere-like object, but irregularly shaped, so its size is not always the same across. At the largest extreme, it is 26 km across, and the smallest is about 18 km across. Basically about the size of a large city here on the Earth.



Phobos in orbit above Mars, as captured by the Viking-2 orbiter, above the Martian volcano Ascraeus Mons

What is Its Surface Like?

A photo closeup of Phobos by the Viking-1 Orbiter

From the basic appearance, it is very much like it would look on the Earth's Moon, except that the surface features are exaggerated. Just like the Earth's Moon, Phobos has no atmosphere. Also like the Earth's moon to the Earth, Phobos has one face that constantly points the same direction toward Mars, and is called **tidally locked**.

One big difference you would notice is that there is almost no gravity at all on Phobos. Just by jumping with your own legs, you would be able to put yourself into "orbit" and "fly" around Phobos. The gravity is only 1/1000th as strong as it is on the Earth. This also affects "mountains" on Phobos, as there would appear to be huge cliff and other features

where on even the Earth's Moon they would have collapsed due to gravity pulling them down.

One of the most prominent features on Phobos is a giant crater named **Stickney**. The impact from this crater has a significant effect on the structure of the entire moon, and lines or "grooves" are along the surface of Phobos that were formed as a result of this impact.

If you were standing on Phobos, Mars would be a significant feature in the sky, taking up almost 1/4 of the sky.

How Long Is a Day on Phobos?

A day on Phobos is the same as its orbit around Mars, because it is tidally locked. This is about 7 hours 40 minutes.

How Long Is an Orbit Around Mars?

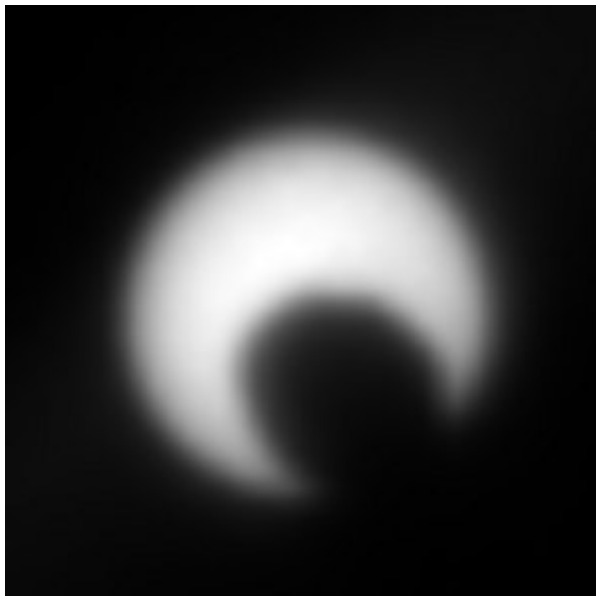
Phobos is very close to the surface of Mars. In fact, it is closer than any other moon in the Solar System that has been discovered so far from the surface of the planet that it orbits.

The time it takes to go around Mars is about 7 hours and 40 minutes. This produces a very interesting experience to somebody on Mars, where Phobos rises from the west and sets in the east, as it travels faster than the sun on a Martian day.

Solar Eclipse by Phobos

Just like on the Earth by the Earth's Moon, Phobos does eclipse the Sun on Mars. This is also called a **transit**, and produces many of the same effects that you see from a solar eclipse. If you were to see such an eclipse on Mars, it would significantly darken the Sun, but it would not go into totality like the Earth's Moon does on the Earth. Also, because the orbit of Phobos is so fast, the eclipse would happen very quickly, in just a few seconds instead of the several minutes you see an eclipse on the Earth.

One other thing to keep in mind is that because Phobos orbits Mars so closely, an "eclipse" near the Martian equator will be much more noticable than an eclipse further away, because Phobos is usually quite a bit closer to an observer at the equator.



Solar eclipse by Phobos on Mars

The future of Phobos

Because Phobos is so close to Mars, and because of the very low gravity, Phobos may be a place where people and supplies are transfered before going to the surface of Mars and then going to the Earth, almost like a space station in orbit around the Earth. It is very likely that if people go to Mars as astronauts, they will be vising Phobos as well. Phobos also has water ice that could be useful to astronauts on Mars as drinking water and for oxygen.

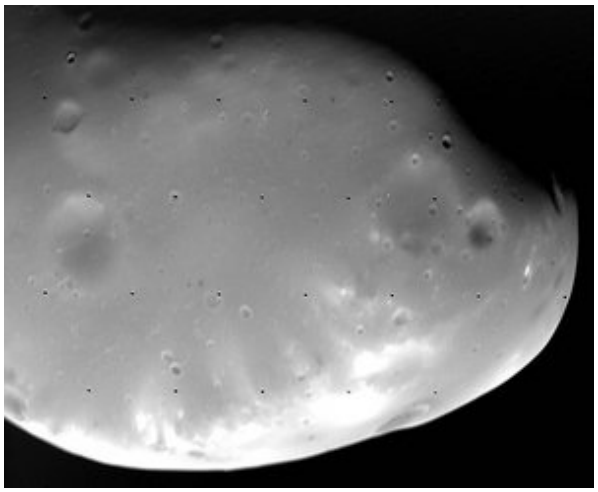
Who is it Named After?

Phobos was named after the son of Mars, who in mythology was the god of "fear" or "fright", and one of the servants of Mars.

How was it discovered?

Asaph Hall was an astronomer with the **United States Naval Observatory**, where he studied many of the planets and objects in the Solar System. In 1877 he discovered both Phobos and Deimos, and identified them as moons of Mars. The name for Phobos was suggested by Henry Madan, based on the book **Iliad**, a classical Greek book about mythology.

Mars/Deimos



Deimos as seen by the Viking-2 Orbiter

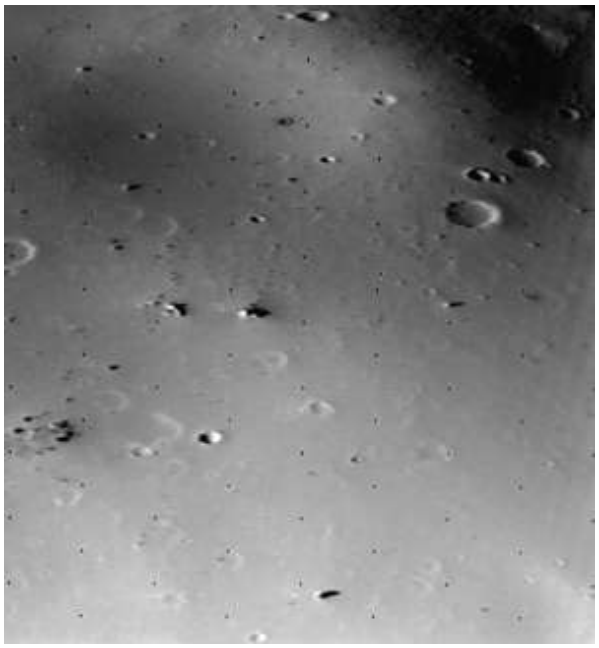
Phobos Facts:

- Deimos is one of the smallest moons in the Solar System.

How Big is Deimos?

Deimos is one of the smallest moons in the solar system at only 12 km in diameter, or about 1/2 the diameter of Phobos. Surprisingly, however, Deimos was spotted and identified as a moon before Phobos, partly because of its greater distance from Mars. The surface area of Deimos is roughly the size of a medium-sized city on the Earth. It is also very irregular in shape, due to is small size.

From the viewpoint of somebody standing on Mars, Phobos would appear almost as just a very bright star, and you would not be able to identify any surface features without a telescope.



A view of the surface of Deimos from only 30km away

What is Its Surface Like?

The surface of Deimos has no atmosphere of any kind, and it is full of craters from meteors hitting the surface, just like the Earth's Moon. The surface of Deimos is made up of black rocks called **carbonaceous chondrite**, which is made up of the

element carbon. There is also water ice on the surface of Deimos, as well as most of the interior.

Because Deimos is so small, one thing that you notice is that the gravity on Deimos is almost not even there. It is about 1/2500th of the force of gravity here on the Earth. This is so little gravity that it would be very dangerous for people to walk on the surface without a **tether** or some other restraint to keep them from pushing themselves completely away from Deimos. If there were a structure on Deimos built for humans, it would resemble an orbital space station inside.

Because Deimos is **tidally locked** to Mars, it always keeps one side facing Mars during its entire orbit. This means that if you were on the side facing Mars, you would always see Mars in the same part of the sky all of the time. The other size would never see Mars in the sky. On the side facing Mars, the view of Mars itself takes up almost one eleventh of the sky, so Mars itself would be a rather significant object to look at.

One of the reasons why scientists are interested in exploring Deimos is because it is believed to be an asteroid that was captured by Mars many millions of years ago. By studying Deimos and its brother moon Phobos, scientists hope to get a very close view of what other asteroids of a very similar size also look like elsewhere in the solar system.

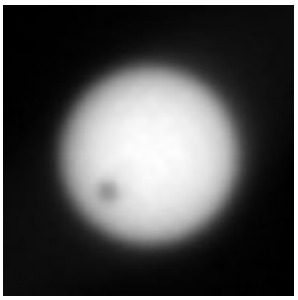
How Long Is a Day on Deimos?

A "day" on Deimos last about 30.5 hours. It is **tidally locked** to Mars, so a day on Deimos is precisely the same as the time it takes to orbit Mars.

How Long Is an Orbit Around Mars?

It takes about 30.5 hours for Deimos to orbit completely around Mars. This creates a very unusual situation because it is close to the rotation period of Mars. From the surface of Mars, Deimos still appears to rise from the east and set in the west like the Sun, Planets, and everything else in the sky (except Phobos), but it lingers in the sky for a very long time, taking almost 3 sols (Martian days) to finally set in the western sky.

Solar Eclipse by Deimos



Eclipse of the Sun by Deimos as seen by the Mars Rover Opportunity

Just like how the Earth's Moon can come between the Earth and the Sun, Deimos occasionally comes between Mars and the Sun. This is also called a **transit**, and in this case perhaps transit is a more appropriate term than eclipse.

Because Deimos is so tiny and relatively far away from Mars as well, the portion of the Sun that is covered by Deimos during an eclipse is very small, and from the perspective of somebody standing on the ground on Mars would hardly even be noticed.

Who is it Named After?

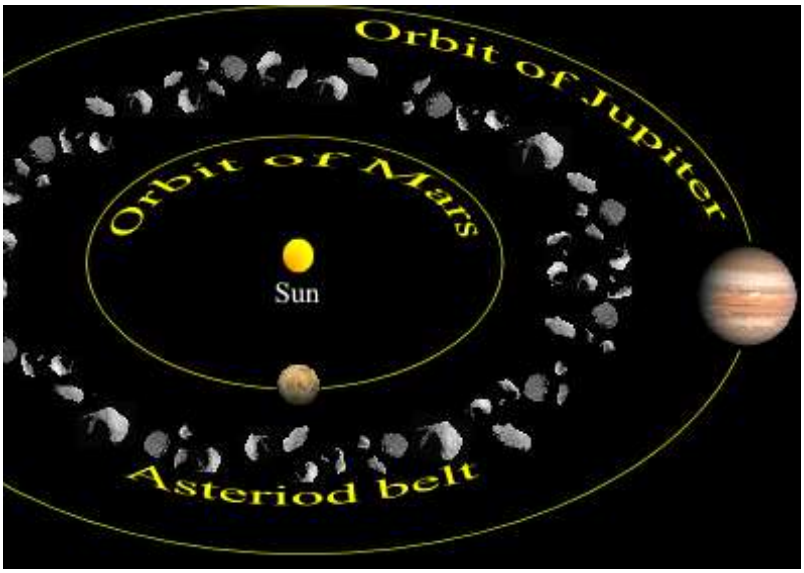
Deimos is named after the Greek son of Ares (the Greek name for Mars), who is also called "panic" or even "dread". Deimos, together with Phobos and others, would in mythology often accompany Ares into battle with gods.

How was it discovered?

Asaph Hall, the discoverer of Phobos

Asaph Hall was an astronomer with the **United States Naval Observatory**, where he studied many of the planets and objects in the Solar System. In 1877 he discovered both Phobos and Deimos, and identified them as moons of Mars. The name for Deimos was suggested by Henry Madan, based on the book **Iliad**, a classical Greek book about mythology.

Asteroid belt



Asteroid Ida and its moon

The asteroid belt lies between Mars and Jupiter. It contains lumps of rock much smaller than planets. These lumps are called asteroids or minor planets. They are not visible from Earth with the naked eye, but many may be seen through binoculars or small telescopes.

How big are the asteroids?

The largest asteroid is Ceres, which is 1032 kilometers across. The next largest, which is called Pallas, is 588 kilometers across. Asteroids less than a kilometer across have also been seen. Unofficially the limit has been set at 50 meters, and anything smaller than that is going to be simply called a meteoroid. With advances in telescopes and particularly for objects that travel close to the Earth, some objects have been seen that are indeed smaller than 50 meters that merely pass nearby the Earth.

How many are there?

There are probably several million asteroids in the solar system. Over 96,000 asteroids have been given numbers. Almost 12,000 of them have names. But even though there are a lot of asteroids, the asteroid belt is mostly empty space. Traveling through the asteroid belt in a space ship would not be very much like what you see in a science fiction film.

What are they named after?

The first asteroids were named after mythical heroes and gods much like the major planets. The first to be discovered was named Ceres after the Roman goddess of growing plants (particularly grain) and of motherly love. The second asteroid discovered was called Pallas named after one of the Greek gods of wisdom. Asteroids are also given a number in the order of their discovery, so Ceres is 1, Pallas is 2, and so forth. As the number of know asteroids increased the supply of mythical names was exhausted so a names from other sources were used.

Some asteroids were named after countries. For example asteroid number 136 is named Austria. Others were named after plants, for example 978 Petunia. 1620 Geographos was named after the National Geographic Society, in recognition to their efforts at sharing knowledge about the Solar System. Many are named after people both alive and dead. In a couple of cases, like 2309 Mr. Spock, asteroids were named after the discover's pet cat. This naming has been discouraged, but it still happens occasionally. Even fictional characters have been used.

Today, names for asteroids can be suggested by the people who discover them. The names become official after a group of people reviews them to make sure they are not offensive or too much like another name. Due to some automated asteroid scanning observatories and a systematic exploration of the Solar System for near Earth asteroids, almost all new asteroid discoveries are not even getting a name at all, but rather a numerical designation, and it is not anticipated that they will ever be given a formal name, at least in this century.

What are they made of?

Most asteroids (3 out of 4) are made of carbon-based rock. The rest are made of the metals iron and nickel. About half of these are pure iron and nickel; the rest are mixed with silica compounds. Each of the larger metal asteroids contains more iron than has been mined in the entire history of human kind.

Scientists are very interested in what asteroids are made of because it can help them learn how the solar system was formed. Several spacecraft have visited asteroids to learn more about them.

Are there asteroids outside of the asteroid belt?

Most asteroids are found in the asteroid belt, but not all. Some asteroids orbit closer to the Sun. Asteroids that closely approach Earth are called Near-Earth Asteroids. Sometimes they strike the Earth, burning in the atmosphere as a meteor. If they are large enough, they might actually hit the surface and become meteorites.

There are also some asteroids in the outer solar system that are called Centaurs, although it is hard to determine whether a particular Centaur is an asteroid, comet, or Kuiper Belt object. For example, the first Centaur to be discovered was Chiron. But some scientists think it is a comet, not an asteroid. Officially it is both the asteroid 2060 Chiron and the comet 95P/Chiron!

Some asteroids are also found at the stable points 60° behind and ahead of the orbits of Jupiter and other planets. The points are called Lagrange points and the asteroids found there are called Trojans. Many of the small moons of some planets may have once been asteroids that were captured by the planet's gravity when they came too close.

Jupiter

Jupiter (Note the red spot)

Jupiter Facts:

- Due to its magnetic field trapping particles from the Sun, Jupiter is surrounded by very powerful radiation belts which would kill anyone who entered them.
- Jupiter's moon Europa is thought to have a giant ocean below its surface.

Jupiter is by far the largest planet within our solar system: two and a half times larger than all of the other planets put together. It is the fifth planet from the Sun and one of the brightest planets. Jupiter is sometimes called a "gas giant" because most of this planet is made up of liquid and gas.

- Jupiter's magnetic field is the largest single thing in the solar system. It is 26 million kilometers across, making it about 20 times bigger than the Sun. It has a tail that extends past Saturn's orbit. If it could be seen from Earth, it would appear to be five times the size of the full moon.

Jupiter as seen by the space probe "Cassini". This is the most detailed color portrait of Jupiter ever assembled.

How big is the planet?

Jupiter is 142,984 km or 11.209 Earths in diameter at the **equator**. That makes it about one tenth as big as the sun. About one thousand four hundred Earths could fit into the volume of Jupiter. It is 133,709 km or 10.517 Earths in diameter from pole to pole. Jupiter's rapid **rotation** makes it bulge out at the equator.

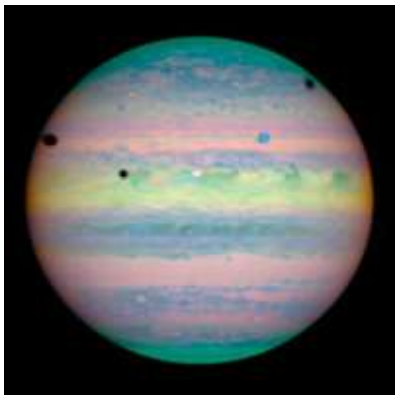
What is its surface like?

Jupiter does not have a solid surface. This enormous planet has a relatively small solid and rocky core. Liquids and gases surround this core and blend with the atmosphere.

Jupiter is a cloudy, windy and stormy planet. It is always covered by a layer of clouds, and wind speeds of 600 km/h are not uncommon. The storms are visible as swirls, bands and spots. A particularly violent storm, about three times Earth's diameter, is known as the Great Red Spot. This storm has been in existance for nearly 300 years!

The Great Red Spot

The layer of clouds is divided into several bands. The lighter colored bands are called **zones** and the darker bands are called **belts**. The colors are caused by small changes in the temperature and chemistry. Each band rotates in the opposite direction from its neighbors. Along the edges where the bands meet, these winds collide and create swirling patterns.



Jupiter Eclipses

The stormy atmosphere of Jupiter has flashes of lightning just like on Earth. However these can be up to 100 times more powerful. The lightning is made by water near the tops of the clouds.

What are its rings like?

Jupiter's rings are dark and hard to see. They are made of tiny particles that meteors knocked off Jupiter's small inner moons.

What are its moons like?

Jupiter has 63 known moons. There are four major moons that were discovered by Galileo in 1610. Those moons are Io, Europa, Ganymede and Callisto. They are called the Galilean moons. There are often **eclipses** on Jupiter's cloud tops by the Galilean moons.

Amalthea Group

There are four small moons **orbiting** inside Io's orbit. That group is called the Amalthea group because Amalthea is the largest one. They are all small and potato shaped. Amalthea is very red. The material of Jupiter's rings came from meteors knocking it off of those moons.

Io

Io is Jupiter's closest major moon. It is 3643.2 km across, slightly larger than Earth's Moon. It has **volcanos** and molten **sulfur** lakes. There are not very many **craters** if there are any at all because the volcanic activity would cover them up. Io has an **iron** and maybe iron sulfide **core** at least 1800 km across. It is surrounded by a **silicate** shell. There is little water on Io. Maybe it was because when Jupiter was forming, it was hot enough to dry out Io, but not the other major moons. In Roman mythology Io was a beautiful young woman that Jupiter loved.

Europa

Europa is 3,121.6 km across, about ten percent smaller than Earth's Moon. It is made of silicates and has a layer of smooth water ice 10 to 30 km thick. The ice has long cracks in it and very few craters. It looks like the sea ice on Earth. The ice had slid around at the cracks. There is liquid water under the ice up to 100 km below the surface. There are also some large spots on the surface. In Roman mythology Europa was courted by Jupiter in the form of a bull.

Ganymede

Ganymede is 5262.4 km across, making it 380 km bigger than Mercury. It is Jupiter's largest moon and the largest moon in the solar system. It had **plate tectonics** like Earth. There are older darker regions and newer areas with grooves where the plates moved. Newer craters have bright rays around them from material thrown up by impacts. Older craters look flat and faded because the icy surface does not hold the shape of the crater as well as rock does over long periods of time. Ganymede may have an iron and sulfur core with a silicate **mantle** and an icy shell. It may be like an Io with a layer of ice on it. In Roman mythology Ganymede was a beautiful young man who Jupiter kidnapped and made cupbearer to the gods on Mt. Olympus.

Callisto

Callisto is 4820.6 km across, about the same size as Mercury. It has many craters. Like craters on Ganymede, the older craters had faded. The largest crater is *Valhalla*. It has a bright center 600 km across with rings around it up to 3000 km across. Callisto is made of silicates and ice. There is a 200 km thick icy **crust** with a liquid water sea under it. In Roman mythology Callisto was turned into a bear by Jupiter's jealous wife Juno. Later Jupiter placed her in the stars as The Great Bear.

Other moons

The other moons are tiny ones in several groups outside the orbits of the major moons, there is a small moon, Themisto and four groups of little moons that orbit very far from Jupiter.

How long is a day on this planet?

One Jupiter day is about 10 Earth hours long.

How long is a year on this planet?

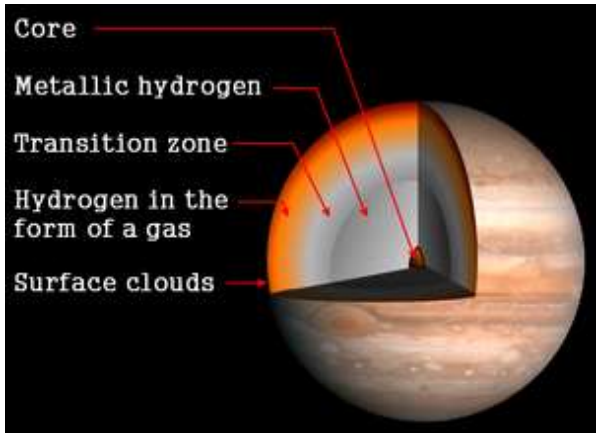
One year on Jupiter is 4,335 Earth days or 11.87 Earth years long.

A Jupiter year is about equal to four-tenths (or two-fifths) of a Saturn year. Thus after every two Saturn years, Jupiter has completed five full orbits about the Sun. So after 59 years, Saturn and Jupiter will be back in nearly the same position. When the orbits of two planets are simple ratios of each other like this, it is called a **resonance**.

What is it made of?

Jupiter has a rocky **core**. Around the core, there is metallic **hydrogen**. On top of that is liquid and then gaseous hydrogen. There is no place where the hydrogen suddenly turns from a gas to a liquid.

The gaseous hydrogen is part of Jupiter's **atmosphere**. Other gases there include **helium,**, methane, water, and ammonia!



The interior of Jupiter contains a small rocky core, surrounded by hydrogen that is under such intense pressure it forms a metal. During the transition zone the hydrogen gradually changes from metal to liquid and finally gas.

How much would Jupiter's gravity pull on me?

If you were floating close to the cloud tops of Jupiter, it would pull you down with a force about two and a half times as strong as the force of Earth's gravity.

Jupiter's rapid rotation causes the equator to bulge out. This would also cancel out about 10 percent of gravity's force on you if you were at the equator. The amount of this counteraction becomes lower the closer you get to the poles.

Who is it named after?

Statue of Zeus (Jupiter) in Olympia, Greece

Jupiter is named after the chief of the Roman gods, also called Zeus in ancient Greece. It was so named because of the planet's enormous size, which dominates all the others.

Jupiter/Amalthea

Amalthea is the third moon of Jupiter.

Amalthea Facts:

- Amalthea is the reddest object in the solar system, even redder than Mars.

How Big is Amalthea?

Amalthea has is irregularly shaped. It has an average diameter of 172 km.

What is Its Surface Like?

The surface of Amalthea has many craters. The largest crater, called Pan, is 100 km across and 8 km deep. Another crater, called Gaea, is 80 km across and twice as deep as Pan.

There are two mountains on Amalthea. They are called Mons Lyctas and Mons Ida.

How Long Is a Day on Amalthea?

One day on Amalthea is equal to 11 hours, 57 minutes, and 23 seconds

Who is it Named After?

Amalthea is named after a nymph who nursed Zeus with goat's milk.

How was it discovered?

Amalthea was discovered on September 22, 1892 by Edward Emerson Barnard, using the 36 inch (91 cm) **refractor telescope** at Lick Observatory .

Jupiter/Io

Io Facts:

- Io is the most volcanically active body in the Solar System.

How Big is Io?

Io is 3642.6 km, or 0.28 Earths wide.

What is Its Surface Like?

Unlike most moons, Io has a "young" surface. Because there is so much volcanic activity, the surface is almost free of craters.

In addition to volcanoes, Io also has many mountains, lakes of molten sulfur, **calderas**, and flows of molten sulfur or silicate hundreds of kilometers long. The colour of the surface is due to sulfur and its various compounds.

How Long Is a Day on Io?

Io takes about 1 and three-quarters of a day to complete one rotation.

Who is it Named After?

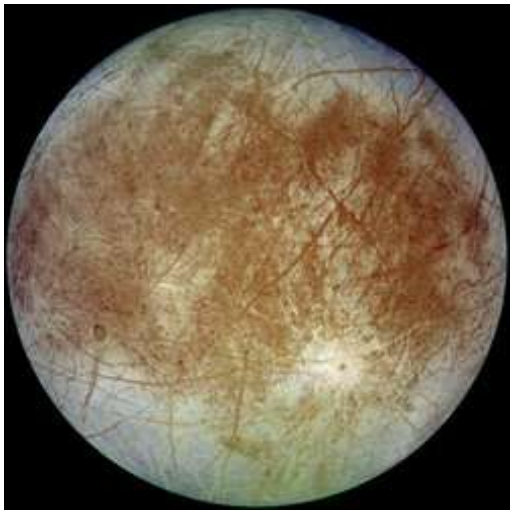
Io is named after one of Zeus' many lovers.

How was it discovered?

Io was discovered by both Simon Marius and Galileo Galilei. It was found on Janurary 7, 1610.

Jupiter/Europa

Europa is one of the moons of Jupiter. Europa has an icy surface. Europa is special to scientists as they beleive there is an ocean under the ice. Life may live in the ocean.



Europa Facts:

- Europa may have an ocean under its icy surface
- Some scientists think that extraterrestrial life may live in Europa's oceans

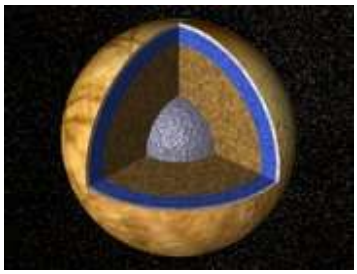
How Big is Europa?

Europa is 3,121.6km (.246 earths) across. It would take 125 Europa's to equal the weight of one Earth, and almost 67 Europa's could be fit into the volume that Earth occupies.

What is Its Surface Like?

Picture of the surface of Europa taken by the Galilleo spacecraft

The Europan surface is extremely smooth; few features more than a few hundred meters high have been seen. There are very few craters on Europa, and only three are more than 5 km wide. This would seem to indicate a young and active surface; based on estimates of the frequency of cometary bombardment Europa probably endures, the surface must be no more than 30 million years old. The smoothness and visible markings strongly resemble that of sea ice on Earth, and it is thought that under the surface there is a layer of liquid water kept warm by tidally generated heat. The temperature on the surface of Europa is far below freezing, even at the equator, so water ice is as hard as rock. The largest craters appear to be filled with flat, fresh ice; based on this and on the calculated amount of heat generated by Europan tides it is predicted that the outer crust of solid ice is approximately 10-30 kilometers thick, which could mean that the liquid ocean underneath may be as deep as 90 kilometers.



Cutaway of what we think the interior of Europa could look like

Europa's most striking surface feature is a series of dark streaks crisscrossing the entire globe. These streaks strongly resemble the cracks that form in sea ice on Earth, and close examination shows that the edges of Europa's crust on either side of the cracks have moved relative to each other. The larger bands are roughly 20 km across with a central band of lighter material that is thought to have been produced by a series of volcanic water eruptions or geysers as the Europan crust spread open to expose warmer layers beneath. The effect is similar to that seen in the Earth's oceanic ridges. These various fractures are thought to have been caused in large part by the tidal stresses exerted by Jupiter; Europa's surface is thought to rise and fall up to 30 meters between high and low tides. Since Europa is tidally locked to Jupiter- the same side always faces towards Jupiter - the stress patterns should form a distinctive and predictable pattern. However, only the youngest of Europa's fractures conform to the predicted pattern; other fractures appear to have occurred at increasingly different orientations the older they are. This can be explained if Europa's surface rotates slightly faster than its interior, which is possible due to the subsurface ocean seperating the moon's surface from its rocky mantle.

It has been suggested that life may exist in this under-ice ocean. Scientists who suggest this point out that life can thrive in similarly harsh conditions on Earth: around deep-ocean hydrothermal vents or in the Antarctic Lake Vostok, which is also under a thick sheet of ice. There is currently no supporting evidence that life exists on Europa, but efforts have nevertheless been made to avoid any possibility of contamination. The Galileo mission was concluded by crashing the spacecraft into Jupiter—if simply abandoned, the unsterilized craft might have eventually crashed into Europa and contaminated it with microorganisms from Earth. This would have made it impossible to determine if Europa ever had its own native life, and could even destroy native organisms if they exist.

How Long Is a Day on Europa?

Europa rotates just as fast as it goes around Jupiter so that the surface of Europa always faces the same way towards Jupiter. This means that there is no day and night on Europa, but rather a light and dark side, just like with the Moon.

How Long Is an Orbit Around Jupiter?

Europa takes a little more than three and a half days to go around Jupiter.

Who is it Named After?

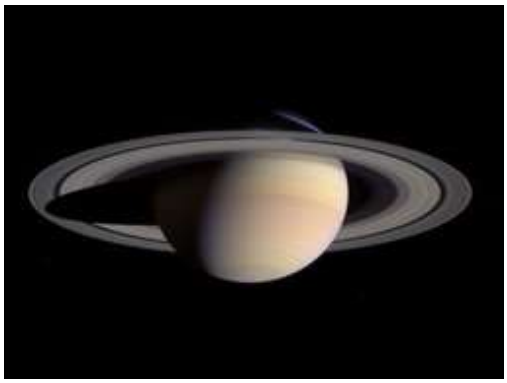
Europa is nammed after one of Zeus' love interests.

How was it discovered?

Europa was discovered by two people: Simon Marius and Galileo Galilei. Galileo discovered it on Janurary 7, 1610. Marius also observed it around the same time.

Europa and Zeus in the form of a white bull

Saturn



Saturn casts a shadow on its rings

Saturn Facts:

- If you could find a bathtub big enough, Saturn would float in it.
- Some of Saturn's moons control the width of its rings.
- add description.

How big is the planet?

Saturn is 120,536 km or 9.449 Earths in diameter at the **equator**. It is only 108,728 km or 8.552 Earths in diameter from pole to pole. It is bigger at the equator because it spins fast enough to budge out.

What is its surface like?

Saturn has no surface that you could stand on without going deep into its **atmosphere**. The atmosphere has bands, but they're not as colorful as Jupiter's.

What are its rings like?

Saturn's rings are composed of silica rock, iron oxide, and ice particles ranging in size from specks of dust to the size of a small automobile.

Saturn with some of its moons

What are its moons like?

Saturn has at least 48 moons. The exact number of Saturn's moons will never be known because of the similar sizes of the moons and the chunks of ice in Saturn's rings.

Shepherd moons

There are small potato shaped moons in or near Saturn's rings. They control the ring particles with their gravity. That is why they are called shepherd moons. Six of them are known and there may be

more.

Mimas

Mimas is made mostly of water ice with a little rock. It has a large **crater** for its size called *Herschel*. It is 130 km across, making it about a third as big as Mimas.

Enceladus

Enceladus is made of ice. It has smooth areas, cracks and some craters. The smooth areas are younger. Craters there got erased within the past 100 million years.

Tethys

Tethys is an icy moon that has many craters, including the huge *Odysseus*. It is 400 km across, a quarter as big as Tethys. The crater had become flattened because the icy material doesn't hold its shape as well as rock would. There is also a large valley called *Ithaca Chasma*. It is 3 to 5 km deep, 100 km wide and 2000 km long, three fourth of the way around Tethys. There are two moons, Telesto and Calypso, that share Tethys's orbit. Telesto is ahead of Tethys and Calypso is behind it..

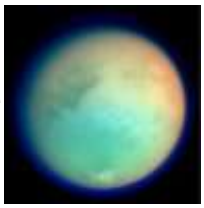
Dione

Dione is made of lots of ice and maybe some rock in the **core**. It has lots of craters. The craters are flattened because the ice doesn't hold their shape as well as rock. One side has bright white lines that are cliffs made of ice. There is one moon, Helene, that is ahead of Dione in its orbit.

Rhea

Rhea is an icy moon similar to Dione with some rock in the core. It has many craters on one side and the other side has some bright white icy areas.

Titan



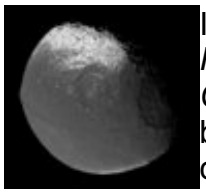
Titan is the largest moon of Saturn and the second largest one in the solar system. It is the only moon in the solar system that has a thick **atmosphere**. The atmosphere is made of **nitrogen**, **methane** and various **organic compounds**. Its surface has light and dark areas and few craters. However, the Cassini probe discovered a huge crater, 440 km across, with its **radar**. The Huygens probe

was carried by Cassini. It got released from Cassini and landed on Titan. It sent back pictures of Titan's surface. Titan has a gigantic atmosphere, extending hundreds of kilometers above the surface.

Hyperion

Hyperion is made of water ice with a little rock. It is potato shaped. It wobbles instead of rotating in the same way other moons do.

Iapetus



Iapetus it made of ice with a little rock. It has a light area, *Roncevaux Terra* with craters. There is a big dark area called *Cassini Regio* that covers half of Iapetus. The dark material may be made of organic compounds. Some of it is on the bottom of craters. Some huge craters and a ridge had been discovered in *Cassini Regio* by the Cassini probe. The ridge stretches 1300 km along the **equator** It is up to 20 km high, which is over 20 times higher than Mount Everest.

Phoebe

Phoebe is made of ice and rock, but looks dark because it has a layer dark material on the outside. It also looks rough.

Other moons

There are two groups of small outer moons. Phoebe is part of the outermost group.

How long is a day on this planet?

One day on Saturn is about 10 hours and 40 minutes in Earth time.

How long is a year on this planet?

One year on Saturn is 29.45 or about 29 and a half Earth years long. That is 10,758 Earth days!

A Saturn year is almost exactly equal to two and half Jupiter years. Thus after every two Saturn years, Jupiter has completed five full orbits about the Sun. So after 59 years, Saturn and Jupiter will be back in nearly the same position. When the orbits of two planets are simple ratios of each other, it is called a **resonance**.

What is it made of?

Saturn has a rocky core. Around the core, there is liquid metallic **hydrogen**. On top of that is gaseous hydrogen. There is no place where the hydrogen suddenly turns from a gas to a liquid.

The gaseous hydrogen is part of Saturn's **atmosphere**. Other gases there include **helium** and some other gases. There may be rain made of helium falling through the hydrogen.

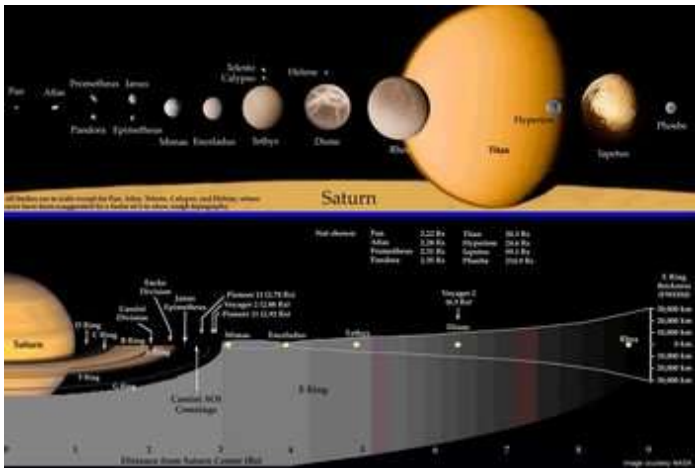
How much would Saturn's gravity pull on me?

If you were floating close to the cloud tops of Saturn, it would pull you down with a force only a little stronger than the force of Earth's gravity. The effects of Saturn's large radius and its mass almost cancel out, making the force only a little bigger.

Saturn's rapid rotation causes the equator to bulge out. This would also cancel out about 10 percent of gravity's force on you if you were at the equator. The amount of this counteraction becomes lower the closer you get to the poles.

Who is it named after?

Saturn is named after the Roman god of corn, nature and agriculture.



Map of the Saturn system (NASA)

Saturn/Mimas

Mimas is one of the moons of Saturn.

How Big is Mimas?

Mimas is 397.2 km wide.

What is its Surface Like?

The is covered with craters, the largest being Herschel, named after William Herschel. It spans about one-third of Minas' width. It is 5 km high, 10 km deep, and its peak is 6km above the crater floor.

Minas also has many **chasmata**(chasms), which are long, narrow, steep-sided depressions on the moon's surface.

How long is a Day on Mimas?

One day on Mimas is equal to 23 hours.

How Long is an Orbit Around Saturn?

Mimas takes 23 hours to make one orbit around Saturn. It has **syncoronous rotation**, meaning that it takes the same amount of time for Minas to complete one **orbit** as it does for one **rotation**

What is it Made of?

Mimas is made mostly of ice, with some rock.

How Much Would Minas' Gravity Pull on Me?

If you were on Minas, the gravity would be 0.008 times as much as earth's gravity.

Who is Minas Named After?

Minas is named after Minas, the son of the Greek goddess Gaia. The named was suggested by John Herschel, William Herschel's son. Minas is also called Saturn I.

Who Discovered Minas?

Minas was discovered in 1789 by William Herschel. It was the second moon of Saturn to be discovered by Herschel.

Saturn/Enceladus

Enceladus is a moon of Saturn.

How Big is Enceladus?

Enceladus measures 498.8km across.

What is its Surface Like?

The surface of Enceladus has a great deal of variety. Some areas are old and have lots of craters, while other areas are young and have smooth terrain. The younger areas are believed to have **cryovolcanoes**.

Saturn/Titan

Titan is the largest moon of the planet Saturn. It was discovered in 1655 by an astronomer from Holland named Christiaan Huygens. Titan is the only moon in the solar system to have a thick atmosphere.

How big is Titan?

The moon Titan is 5150 km wide. It is the second largest moon in the solar system. Only Ganymede, a moon of Jupiter, is larger. Titan is bigger than the entire planets of Mercury or Pluto.

How much would Titan's gravity pull on me?

If you were on Titan, it would pull you down with a force about one seventh as strong as the force of Earth's gravity.

Who is it named after?

Titan was named for a race of giants from Greek mythology.

Uranus

Uranus as seen from Voyager 2

Uranus Facts:

- Uranus's rings may look white in pictures, but they are actually made of asphalt-colored material.
- When it was first discovered Uranus was thought to be a star and was given the number 34 Tauri.
- Uranus is the only planet besides Pluto in our solar system that rotates on its side.

Uranus, the seventh planet from the sun, was discovered by William Herschel on March 13, 1781. It is a **gas giant** and the third largest planet in the Solar System.

How big is the planet?

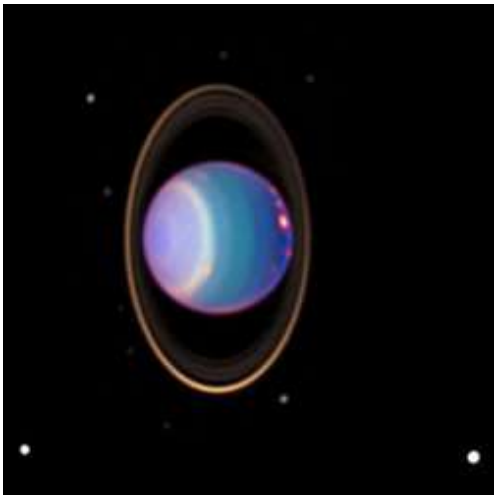
Uranus is 51,118 km or 4.007 Earths in diameter. This means that about four Earths placed in a line side by side would be as long as Uranus is across.

What is its surface like?

Uranus has no surface that you could stand on without going deep into the **atmosphere**.

What are its moons like?

Uranus has 27 discovered moons, which places it third in the solar system for number of moons! The five main ones are Miranda, Ariel, Umbriel, Titania and Oberon.



Uranus's rings and moons

Miranda

Miranda is the smallest and closest of Uranus's major moons. It is mainly made

of water ice, and **silicate** rocks. There are also some **methane** related **organic compounds**. Miranda also has **canyons** 20 km deep. Miranda was named after a character in "The Tempest", a play by Shakespeare. A color composite picture of Miranda was taken with by Voyager 2 on January 24, 1986, from a distance of 147,000 kilometres.

Ariel

Ariel is half water ice with the rest being silicate rocks and methane ice. Ariel doesn't have many craters and has big canyons. Ariel was named after the helpful sprite in "The Tempest" by Shakespeare.

Umbriel

Umbriel is made of lots of water ice and some silicate rocks and methane ice. It is also the darkest of Uranus's major moons. Umbriel was named after a character in the comic poem "The Rape of the Lock" by Alexander Pope.

Titania

Titania is the largest moon of Uranus. The majority of it is water ice, with quite a lot of silicate thrown in with some methane related organic compounds. Like Ariel, Titania also has some huge canyons. It was named after the Queen of the Fairies in " A Midsummer's Night Dream", a play by Shakespeare.

Oberon

Oberon is the outermost of the major moons of Uranus. It is very similar to Titania in what it is made of. It has many craters. Some of them have white rays around them and dark crater floors. The dark material may be made of organic compounds. It was named after the King of the Fairies in "A Midsummer's Night Dream".

Other moons

There are 13 tiny moons known to be **orbiting** Uranus inside Miranda's orbit. Nine more tiny moons are known to be in big orbits beyond Oberon's orbit.

How long is a day on this planet?

One day on Uranus is about 17 Earth hours long. Uranus spins on its side. Maybe it was because of a big impact early in the history of the solar system.

How long is a year on this planet?

One year on Uranus would be 30,708 days or 84 years on Earth.

What is it made of?

Unlike Jupiter and Saturn, Uranus is thought to be made mostly of rock and ices with only 15 percent of it being hydrogen. The gases in its **atmosphere** are mostly **hydrogen** and **helium**. Other gases found in smaller amounts are ammonia, water, and **methane**. The methane gives Uranus its blue-green color. Under the atmosphere, it is thought that there is an uniform mixture of rocky and icy materials rather than a seperate rocky core.

How much would Uranus's gravity pull on me?

If you were floating close to the cloud tops of Uranus, it would pull you down with a force about nine tenths as strong as the force of Earth's gravity. The effects of Uranus's large radius and its mass almost cancel out, making the force only a little bigger.

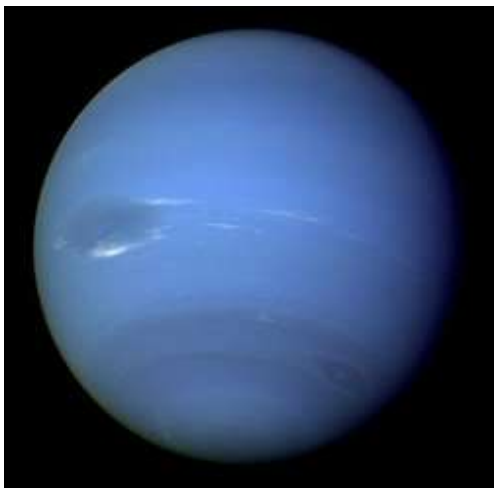
Uranus's rotation is not as rapid as that of Jupiter and Saturn. That means its equator does not bulge out as much. So, Uranus's rotation would not cancel out as much of its gravity's force.

Who is it named after?

Uranus was named after Ouranos, the Greek name for the sky. According to Greek mythology, Ouranos was the husband of Gaia, Mother Earth.

Neptune

Neptune is very similar to Uranus, but it is slightly smaller in diameter and more massive.



Neptune as seen from Voyager 2

Neptune Facts:

- Wind speeds on Neptune can reach 450 meters per second.
- Neptune was discovered because its gravitational field was affecting the orbit of Uranus.
- Neptune is sometimes the ninth planet from the Sun.

How big is the planet?

Neptune has a diameter of 49,528 km across at the **equator** and 48,681 km from pole to pole. It is almost as big as four Earths in a row. It bulges out a little at the equator because of its **rotation**, but not as much as Jupiter and Saturn.

What is its surface like?

Neptune is a gas giant so it does not have a surface that you can stand on without going deep into its **atmosphere**. The atmosphere looks blue-green. It has some dark blue spots. When the Voyager probe went by Neptune in 1989, there was a large one called the Great Dark Spot. Now it is gone and there are new spots. There are some high white clouds too. The winds of Neptune are very fast, blowing at up to 2000 km per hour. That is about ten times faster than the winds of some of Earth's strongest tornadoes.

What are its rings like?

Neptune has some faint rings that are dark and hard to see. There are clumps in some parts of the rings where the material is more dense. It could be because of the gravity of the nearby small inner moons of Neptune.

What are its moons like?

Neptune has 13 known moons. There could be more.

Inner moons

There are five small potato shaped moons **orbiting** close to Neptune.

Proteus

Proteus is a dark moon about 420 km across. It is irregularly shaped, but it is almost big enough for its gravity to pull it into a sphere. In Roman mythology Proteus was Neptune's herdman who could change into any shape he wanted.

Triton

Triton is the largest moon of Neptune. Scientists think that it is a lot like Pluto. It is 2700 km across. It is made of rock and some water ice. It has a surface temperature of −236 °C making it the coldest world visited by spacecraft. Triton has a very thin atmosphere made up nitrogen and a little methane.

There are volcanoes that have eruptions of liquid **nitrogen**, dust, or **methane** compounds. The eruptions happen because of the seasons. They make plumes up to 8 km high. There are few **craters** because the eruptions cover them up. There are ice caps of nitrogen and methane ice that change sizes with the seasons. There are also ridges and valleys. They may have formed because the changing seasons caused the material to repeatly freeze and warm up.

An interesting thing about Triton's orbit is that it goes around Neptune in the opposite direction from the direction of Neptune's rotation. Because of that, scientists think that Triton was captured by Neptune long ago. Its orbit is also very circular. Neptune's gravity made the orbit circular over a long time after the capture. The tidal effects involved in that may have heated Triton and kept ices melted for a billion years. In Roman mythology, Triton was the son of Neptune.

Nereid

Nereid is an irregularly shaped moon about 340 km across. Its orbit is very eccentric or noncircular. It may have been captured by Neptune or moved into the eccentric orbit by Triton's gravity when Triton got captured. In Roman mythology nereids were sea nymphs.

Outer moons

There are five other known moons. They are small potateo-shaped moons far

from Neptune. There could be more yet to be discovered.

How long is a day on this planet?

A day on Neptune lasts 16 hour and 7 minutes.

What is it made of?

Neptune is made of rock and metal in the **core**. The core is probably bigger than Uranus's because Neptune weighs more, but is the same size. Around the core is rock, water, **ammonia** and **methane**. The atmosphere makes up most of the planet and is made of **hydrogen** and **helium**. Lower down in the atmosphere, there is methane and ammonia too. The methane makes Neptune look blue-green.

How much would I weigh on Neptune?

If you were floating close to the cloud tops of Neptune, it would pull you down with a force only a little stronger than the force of Earth's gravity. The effects of Neptune's larger radius and its mass almost cancel out, making the force only a little bigger.

Neptune's rotation is not as rapid as that of Jupiter and Saturn. That means its equator does not bulge out as much. So, Neptune's rotation would not cancel out as much of its gravity's force.

Who is it named after?

Neptune is named after the Roman god of the seas, also known as Poseidon in ancient Greece.

Artistic impression of Neptune

Pluto

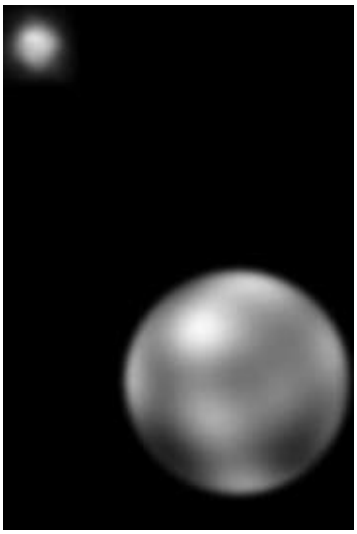
Pluto and its moon Charon

Pluto Facts:

- Pluto is the smallest planet
- Most often, it is farthest away from the sun, but sometimes Neptune is.
- Some astronomers believe that Pluto and its moon Charon are actually a "double planet", because Charon does not orbit around Pluto.

Pluto, the ninth planet in the Solar System, was accidentally discovered by the astronomer Clyde W. Tombaugh in Arizona on February 18, 1930.

How big is the planet?



Pluto and Charon from the Hubble Space Telescope

Pluto is the smallest of all of the planets in the Solar System, weighing only 13,200,000,000,000,000,000,000 kilograms. While this may seem large, it's only about 1/500th of the Earth's **mass**. If you were to cut Pluto in half and measure the length on the inside, you'd find that Pluto is 2390 kilometers across, and with a little math you could figure out that its **surface area** is about 17,950,000 square kilometers (or 1/30th of the Earth's) and that its **volume** is 7,150,000,000 (or 1/15th of the Earth's).

What is its surface like?

We don't really know for sure. No spacecraft has ever been there, and Pluto is so far away from Earth that even the best telescopes can't see any detail. It is certainly very cold, about -230°C. The surface of Pluto is covered with ice, but not the same kind of ice that is found on Earth. The ice that covers Pluto is believed to be made mostly of nitrogen. Pluto also has a very thin **atmosphere** of nitrogen and methane which may freeze out when Pluto moves further from the Sun.

Some powerful telescopes like the **Hubble Space Telescope** have observed some seasonal changes as Pluto moved closer to the Sun and then moved further away, due to the nature of its orbit around the Sun.

What is its moon like?

Pluto has one moon: Charon. Charon is about half the size of Pluto in length and, much like Pluto, is believed to be covered with ice. Unlike Pluto, however, the ice covering Charon is thought to be made of water rather than nitrogen. In Roman mythology Charon ferried the shades of the dead across the river Lethe to the land of the dead.

How long is a day on this planet?

One day on Pluto is about 6.387 Earth days long. Like Uranus, Pluto also spins on its side.

How long is a year on this planet?

One year on Pluto would be about 90,613 days or 248 years on earth!

What is it made of?

It is believed that Pluto is made mostly of rock and ice, although scientists will not be sure until more research is done on the planet. With the discovery of Charon, a good approximation of the average **density** of the planet can be determined, which can in turn suggest what Pluto is not made out of. If Pluto were made out of heavy minerals and iron like the planet Mercury, Pluto would have a very high density. Planets like Saturn are so thin and tenuous that their average density is less than even water. Pluto is somewhere in between, but more like some of the moons of the outer planets like Callisto or Triton, which are known to have quite a bit of water ice.

How much would Pluto's gravity pull on me?

If you were on Pluto, it would pull you down with a force less than one tenth as strong as Earth's gravity.

Who is it named after?

Pluto was named after the Roman god of the underworld.

Is Pluto really a planet?

Some scientists say that Pluto isn't really a planet. They say it is too small, and point out that Charon (Pluto's satelite) is not much smaller than it. Some consider

Pluto to be the largest known Kuiper belt object. Also, Pluto has a pattern of orbit around the sun that is different from other planets, and its orbit is affected somewhat by the gravitational pull of the nearby planet Neptune. Many Kuiper belt objects have orbits like that.

Pluto/Charon

Charon is the only moon of Pluto.

How Big is Charon?

Charon measures 1.172 km across, about half the size of Pluto. Because the size difference between Pluto and Charon is so small, they are sometimes considered to be **double planets**. They are also somtimes thought of as the first two **trans-Neptunian objects**.

What is its Surface Like?

The surface of Charon is covered in water ice.

How Long is a Day on Charon?

One day on Charon is equal to 6 days, 9 hours, and 18 minutes.

How Long is an Orbit Around Pluto?

Charon takes 6.387 days to orbit around Pluto, the same amount of time it takes for Pluto to complete one rotation.

Who is it Named After?

Charon is named after Charon. In Greek mythology, Charon ferried the dead across the river Acheron to Hades if they could pay him.

Who Discovered Charon?

Charon was discovered in 1978 by James Christy on June 22, 1978. He was examining highly magnified images of Pluto and noticed a small bulge sometimes appeared in the pictures. The bulge was later confirmed in older images and was given the temporary name of S/1978 P 1.

Comets

The Hale-Bopp comet

Comet Facts:

- Comets are often described as a giant "dirty snowball", because they are mostly made up of ice.
- Comets have two "tails", one made up of rocks and dust, the other made of gas.
- Comet tails always point *away* from the Sun, wheither they are approaching to or receeding from the Sun.

What is a comet?

A comet is a large piece of rocks and ice that occasionally gets close to the Sun. When it gets very close to the Sun, it "grows" a tail that can sometimes be seen at night without a telescope.

What is its surface like?

The surface of a comet is mainly chunks of ice mixed with rocks, usually about the size of a grain of sand or even smaller. When the comet is far away from the Sun it is cold and airless, and you would detect almost no gravity. If you were an astronaut standing on the surface of a comet, you could literally jump off the comet and fly into orbit around the sun using just the energy from your own muscles.

When a comet gets close to the Sun, however, things become a bit different. The ice begins to thaw and geysers form, which start to send out gasses, water vapor, and dust. These gasses can't be held by the gravity of the comet, so it drifts away from the comet. This is what causes the tail of a comet to form.

Halley's Comet, as seen from the Giotto spacecraft

How big is a comet?

As far as objects in our solar system are concerned, they are actually quite small, from a few kilometers in diameter to about 100 kilometers across. The tail of a comet, however, can be millions of kilometers long, sometimes stretching from the orbit of Mars to the orbit of the Earth.

Can I see a comet in the sky?

Not all comets are visible without a telescope. Comets that produce a spectacular tail are called a "great comet" and are quite unusual. Being able to see one of these comets only happens about once every century, which is why seeing a comet like that is considered a once in a lifetime experience. When a comet does come close to the Earth, it can take in a very large portion of the sky and is different from anything else you might see in the sky.

Other comets can be seen with a telescope, and these are more common. Sometimes a comet's orbit will change due to passing very close to some planets like Jupiter or the Earth, and then all of the ice can "boil off" by repeatedly coming close to the Sun. When this happens, a comet is considered to be "dead", although it is still an interesting thing to study. Often before this happens, a comet will break apart into hundreds of pieces or more.

When a comet breaks apart, it creates a trail of smaller rocks and pebbles in space that drift along in approximately the same orbit that the original comet traveled around the sun. These are the recurring **meteor showers** that happen from time to time, and most major meteor showers have now been identified either with an existing comet or the remains of a comet that was observed eariler, usually in previous centuries. When the Earth travels through this "swarm" of rocks left behind, you can see **shooting stars** or **meteorites** at night.

How many comets are there?

The exact number is hard to come up with, but there are thousands of comets in our solar system. Many of these comets simply burn up by falling into the Sun, or have orbits that cause them to leave the solar system. The spacecraft SOHO has been used to identify almost 1000 comets in just a few years. That is particularly significant because SOHO was not even designed to study comets, but instead was supposed to be strictly a tool to study activity on the Sun.

Of comets that orbit the sun and come close to the Earth on a regular basis, the number discovered so far is about 160 comets.

How is a comet named?

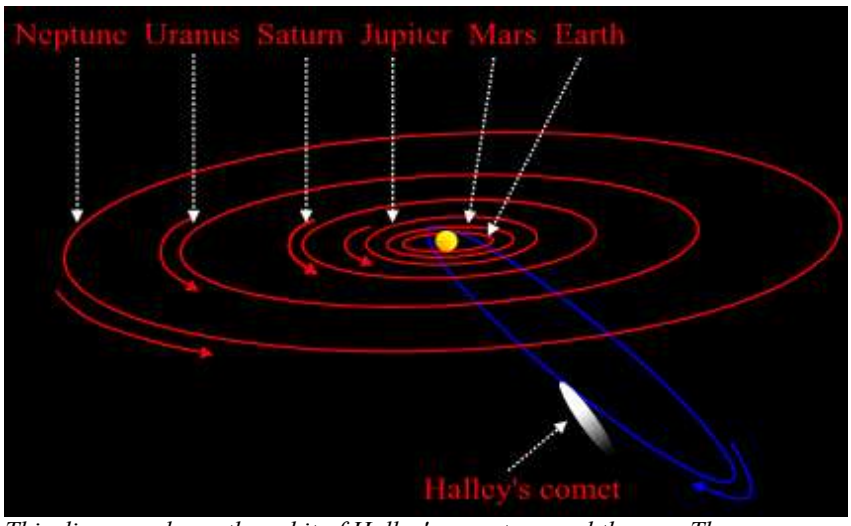
A comet is usually named after the astronomer who first discovered it. When several people are involved in its discovery, sometimes you will see multiple names on a comet, like Comet Hale-Bopp, or Comet Shoemaker-Levy. It is generally considered to be a great honor to have a comet named after you.

Photograph of Edmond Halley

Comets that were observed in the past weren't always named like this. Instead, they had names like "The Great September Comet

of 1882", where only the year that it was observed was mentioned in the name of the comet. This changed, however, when Edmond Halley was able to determine that comets which appeared in 1531, 1607, and 1682 were the same body and successfully predicted its return in 1759. This has become known as Halley's Comet.

What are some famous comets in history?



This diagram shows the orbit of Halley's comet around the sun. There are a few things to note about it:

- *It is much more elongated that a planet orbit.*
- *It is not in the same plane as the planets.*
- *It goes round it's orbit in the opposite direction. (This is called retrograde motion)*
- *The tail points directly away from the sun*

- Halley's Comet - Perhaps the most famous of all comets, and this was the first comet to be identified as a recurring comet.
- Comet Encke - The second comet to be identified as a recurring comet.
- Comet Shoemaker-Levy - This was the first comet to have been observed hitting another body in the solar system. In this case, it did a direct hit into the planet Jupiter, perhaps the most studied astronomical event in history.

Where do comets come from?

There are many theories about how comets form, but the current theory most widely accepted by astronomers is that they come from the Oort Cloud, a region of the solar system that is about as far as you can travel from the Sun but still be primarily affected by our sun and not other stars.

Do Comets bring bad luck?

In ancient times people didn't have a very good understanding of what Comets really were or where they came from. They were seen as very unusual objects in the sky, and very temporary in nature as well. In some societies it was often a sign of bad events in the future when a comet arrived, associated with the death of a king or a significant military defeat. In other countries Comets were considered to bring good luck, with increased fertility and more food. The ancient Chinese astronomers seem to have done the best job of actually recording when comets appeared in the sky, and left detailed descriptions of what they looked like and approximately where in the sky that each comet was seen.

Even as recently as the 1910 appearance of Halley's Comet there was widespread panic when it was discovered that the Earth might pass through the tail of that comet. The panic was over having the gasses from the comet flood the atmosphere of the Earth with poison. The reality was that there is so little gas in a comet tail that there is no measurable effect in the content of the Earth's atmosphere when an event like this occurs.

More recently popular media culture has produced news reports and motion pictures with the sensational idea of a comet striking the Earth and causing widespread destruction. This does have some basis of fact when historical and geological evidence suggests that in the past comet fragments or even whole comets may have struck the Earth. An explosion in a remote part of Siberia (eastern Russia) occurred in 1908 with effects very similar to a nuclear explosion in terms of damage to the environment. A substantially larger explosion called the K/T Event is thought to have caused the extinction of the dinosaurs. More recently astronomers were a witness to the impact of Comet Shoemaker-Levy into the planet Jupiter. Had that comet hit the Earth instead it would have destroyed almost all of the cities on the Earth.

Kuiper Belt

Kuiper Belt Facts:

- The Kuiper Belt is the most recently observed section of the solar system.

The Kuiper belt extends from Neptune's **orbit** to three billion kilometers beyond it. It contains lumps of icy material with **organic compounds**. That makes them like comets. These lumps are called Kuiper belt objects or minor planets. The Kuiper belt may have formed when the gravity of the young Jupiter sent the Kuiper belt objects out to where they are now.

How big are the Kuiper belt objects?

Scientists consider Pluto to be one of the largest Kuiper belt objects. It is 2390 km across. The next largest known Kuiper belt objects are Orcus, which is about 1600 km (1,000 miles) across, 2003 EL61 at 70 percent the size of Pluto and 2005 FY9 at 50 to 70 percent of Pluto's size.

In 2005, scientists said that they found an object, 2003 UB313, that is bigger than Pluto. It is somewhere between Pluto's size and 3200 km across. It is now almost 100 times further away from the Sun than Earth is. It can come about as close to the Sun as Pluto is. Its orbit is tilted almost 45 degress compared to Earth's orbit. Pluto's orbit is tilted by only 17 degrees. Some people are calling it the tenth planet. Others don't think that Pluto and 2003 UB313 should be considered planets.

Other large Kuiper belt objects about or over 1000 km across are Pluto's moon Charon, Quaoar, Varuna, Ixion, 1996 TL66, 2002 TX300, 2002 TC302, 2002 UX25 and 2002 AW197. Ceres, the largest asteroid, is about 950 km across.

There are many other Kuiper belt objects that are only a few kilometers or tens of kilometer across.

How many are there?

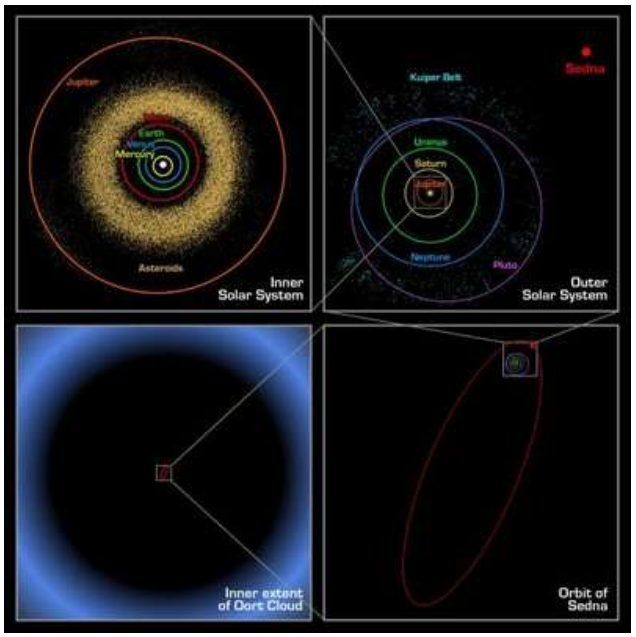
By the year 2004 over 800 Kuiper belt objects had been found. Scientists think that there are many more yet to be discovered, and some might be as big as Earth (though much colder).

What are they named after?

After the first object in the belt was spotted from the Mauna Kea Observatory in Hawaii, the belt was named after the astronomer Gerard Kuiper who in 1951 wrote that he thought it existed very long ago. Astronmomers including Frederick Leonard, Kenneth Edgeworth, and Julio Fernandez thought that the belt still existed; and some astronomers call it the Edgeworth-Kuiper belt.

Orcus, Charon, and Varuna were named after gods of the underworld, and Ixion a mythological person in the underworld. Quaoar was named after a creation god.

Oort Cloud



A Diagram showing approximately how far away the Oort Cloud might be in relation to the planets of the Solar System

Oort Cloud Facts:

- The Oort cloud is the farthest from the sun that you can go and still be in the solar system.
- It is believed that most comets originally were in the Oort Cloud before "falling" into the Sun.

What is an Oort cloud?

Scientists think that there is a group of rocks and ice that forms a cloud-like region surrounding our solar system. It is a collection of comet like objects **orbiting** far away from the sun. It is named after a Dutch astronomer Jan Oort who refined and popularized the theory.

Where is the Oort cloud?

The comets in the Oort cloud are at distances of 50 thousand to 100 thousand times the distance between Earth and the sun. That is a thousand times further away from the sun than Pluto is and about one fourth the distance to the nearest star. Light would take a year to travel that far.

How did the Oort cloud start?

The Oort Cloud objects may have formed closer to the sun during the solar system's formation. Then **gas giants** sent them far away with their gravity. They were sent in all directions, making the Oort Cloud ball shaped instead of disk shaped. The gravity of other stars made the objects' orbits more circular, making the objects stay far away from the sun. Maybe the gravity of other stars could

sometimes send the objects back toward the sun. We would see them as comets.

One object discovered so far is Sedna. It is 1180 to 1800 km across. Its **orbit** stretches from 76 to 928 times Earth's distance from the sun. Sedna takes about 11,250 Earth years to orbit the sun once. The last time Sedna was where it is now in its orbit, Earth's last Ice Age was ending! Some scientists consider it an inner Oort Cloud object. Others thinks that it should be included in the Kuiper Belt, making the belt bigger.

About gravity, mass, and weight

This is a myth-busting section to help you avoid getting confused about what it means to talk about your **mass**, or the more commonly used term for this, **weight**, on another planet. This will explain how these words, like many others we use, have different meanings when used in different contexts.

What are mass and gravity?

An object's mass can be thought of as the amount of material, matter or "stuff" the object is made of. The more "stuff" an object is made of, the more mass it has. All things with mass each have their own gravity. Gravity is the force that pulls on anything with mass. More massive objects have more gravity. Earth has more gravity than you do because it has much, much more mass than you do. So, when you jump, other people can see you fall back to Earth. Earth is also falling toward you. You have much less mass than Earth, so you do not pull Earth up as much as it pulls you down. That is why you do not notice Earth moving toward people who jump.

The more massive an object is, the harder it is to change its movement with forces. More massive objects also react more to gravitional fields. The reason why more massive objects do not fall faster than less massive objects is that the larger gravitional pull on more massive objects is canceled out by the greater difficultly gravity has making them fall.

A famous scientist named Galileo was the one who discovered that objects of different masses hit the ground at the same time after they are dropped. He used things like balls for his experiments because air would not slow them down as much as things like feathers. In 1971 Astronaut David Scott, who went to the Moon, dropped a feather and a hammer there at the same time. There was no air on the Moon to slow down the feather. Both the feather and the hammer hit the ground at the same time.

How much would I weigh on the Moon or another planet?

If you weighed 100 pounds or 100 kilograms on Earth, your weight on Planet X would be 100 of the same units. If you want to find out exactly how much you would weigh on Planet X, just take your weight from Earth, or the doctor's office, and multiply it by 1. Have you learned yet what happens when you multiply any number times one? It just stays the same, doesn't it?

Normal weight at the doctor's office

Weight on the Moon or other planets

Earth	Moon	Mercury	Venus	Mars	Pluto
110 lb	110 lb	110 lb	110 lb	110 lb	110 lb
50 kg	50 kg	50 kg	50 kg	50 kg	50 kg
7 st 12 lb	7 st 12 lb	7 st 12 lb	7 st 12 lb	7 st 12 lb	7 st 12 lb
Note that on the gas giants such as Jupiter, Saturn, Uranus, and Neptune you won't be able to find a place to set down your scale and weigh yourself on the cloudtops.					

But that's a pretty boring fact. So there must be something more to it—and there is! Maybe you have visited a science museum where one of the exhibits showed you that your weight would be different on some other planet.

Other meanings of *weight*

The word *weight* is something that we use with several different meanings. Most of the time we use it to measure how much stuff we have. That is the meaning we use when we say that a bag of sugar has a net weigh of two kilograms or of four pounds. That is also the meaning we use when we weigh ourselves at the doctor's office or at the gym, or when we calculate our Body Mass Index.

But we also sometimes use *weight* as a measure of how hard something is pressing downward because of gravity. Gravity is what pulls us towards the center of the Earth when we are on Earth, or, for example, towards the center of a planet Venus if we were on Venus.

Different units of measurement

Let's use the Moon for an example here.

If you want to find out exactly how much you would weigh on the Moon for this other meaning of weight, you need to learn and use different units from those you are accustomed to using to measure your weight in the meaning we normally use. You might just borrow the names of the units we normally use for this purpose, and use the same number here on earth with a new unit that we will call kilograms-force or pounds-force (which use the symbols kgf and lbf to distinguish them from kg and lb for the units of mass). If we do that, then on Earth the number of these units you weigh in this new meaning of the word *weight* is the same as the number of pounds and kilograms you weigh at the doctor's office. But if you go to a different planet or moon, then your weight in pounds or kilograms would stay the same, but your weight in pounds-force or kilograms-force would change. So it doesn't work so well to use the names that

are so much alike, if you are not on Earth. In order to keep track of the differences more easily, you can instead use a newer unit that was invented to help keep you from getting confused about these differences.

That modern international unit used for this purpose is something called a newton, but that does not mean that it is some "new" kind of "ton". Actually, it was named after a man called Isaac Newton who lived in England about 300 years ago—maybe you've heard the story about the apple falling on his head, helping him to figure out how gravity works. You probably have not learned about this new unit yet. Even your parents might not know much about it, because it wasn't used so much, not even by their teachers and other grownups when they were as work, when your parents were your age. More people use these newtons today, and you will use them more often as you get older. On Earth, if you weigh 51 kilograms or 112 pounds, your weight in this different meaning, measured in these new units, is 500 newtons. We only use this "weight" for some special purposes, when we are really interested in how hard we push down on something because gravity is pulling us.

Then your weight in newtons would be just a less on the Moon, about nine-tenths of what it is on Earth. To find your weight in newtons as you stand on the Moon, just take your weight from the doctor's office on Earth, and if that weight is in kilograms, multiply it by 9. Or if that weight is in pounds, multiply it by 4. But then you'll have to add in the weight of your spacesuit as well, because that is pressing down on the surface just like you are.

Other factors to consider

When measuring weight in the doctor's office:

- Atmosphere

When measuring weight in newtons in a physics class:

- Atmosphere
- Rotation
- Free fall

Weight in newtons vs. weight in the doctor's office

That way you know that if somebody talks about their weight in newtons, it is a special meaning of the word *weight*. You have now learned that this weight is something different from the normal meaning we use when we go shopping, or when we weigh ourselves to keep track of our health and fitness, or to be grouped into different weight classes so we compete against people our own size in many sports, such as judo, boxing, weight-lifting, and wrestling.

How the Solar System was born

Our **solar system** is a part of an entity called our **universe**. There were many attempts made in the past to explain how our solar system and universe came into existence as we observe it today. The currently accepted theory of the universe's formation is called the **Big Bang Theory**.

Big Bang Theory

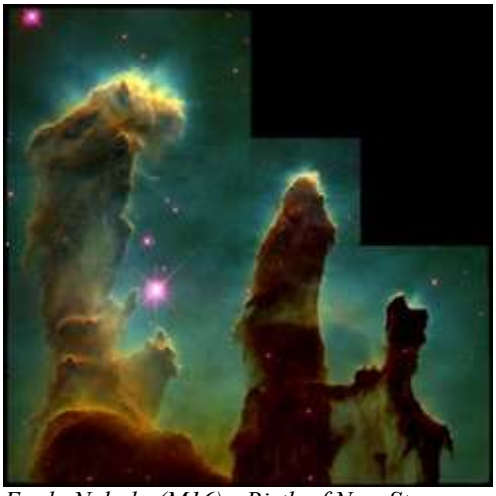
This theory is based around the idea that an enormous explosion occured about 13.7 billion years ago. That is about 13,700,000,000 years ago. This is three times the age of Earth! The Big Bang was not a usual explosion in space because space and time themselves were made in the explosion. This explosion caused the formation of the matter and energy in the universe. At first, the universe was very hot. The planets, stars and all other heavenly bodies formed starting some time after the Big Bang after the universe had cooled down.

The universe had been expanding and cooling since the Big Bang. Most galaxies are moving further away from our Milky Way galaxy. The exceptions are the few galaxies that are close enough to the Milky Way for gravity to overcome the universe's expansion.

Scientists can still see the faint light from when the universe was hot. Over time, the universe's expansion stretched out the light, turning it into weak microwave light. Scientists can detect this microwave light.

Solar System Formation

The solar system formed out of a big cloud of gas and dust about 4.6 billion years ago.



Eagle Nebula (M16) - Birth of New Stars

Stars and solar systems that are very similar to the Sun are now forming in the Eagle Nebula (also known as M16). While this is not a picture of our own sun, it can give you an idea of what our solar system looked like billions of years ago. These gas clouds that you see in this image were formed from earlier stars that exploded and left stuff behind.

Small finger-like parts of these clouds, especially at the "top" of the first column on the left, are the new stars that are forming. Astronomers who have been watching these stars form have seen changes happen in just a few years, which

is a very rapid change for the life of a star.

Glossary

A Glossary of words used in this book:

- Asteroid - a large rocky object that orbits a star, but is too small to be a planet.
- Astronomer - a person who studies stars and planets.
- Atmosphere
- Basalt Lava - molten basalt, a kind of rock.
- Carbon dioxide - a gas that animals breathe out and plants take in.
- Centaur
- Channel - a groove in the surface of something.
- Comet - a small icy object orbiting a star.
- Continent - a huge landmass on a planet.
- Core - the center of a planet or star.
- Crater - a hole in a planet's surface made by a meteorite falling on it.
- Crust - the outermost layer of a planet's surface.
- Energy - what you use to do work.
- Environment - the conditions on a planet.
- Equator - an imaginary line around a planet, perpendicular to the axis of rotation.
- Erosion
- Gas Giant - one of the four outer planets made out of giant balls of gas.
- Hemisphere - one half of a planet's surface.
- Lagrange point
- Lava - molten rock above a planet's surface.
- Mantle - a layer of molten rock below a planet's crust.
- Mass - the size of something.
- Meteor - a small or medium-size rock from space that has not entered a planet's atmosphere yet.
- Methane - a gas that makes up most of the gas giants.
- Near Earth Asteroid
- Orbit - the path that an object takes around a larger object.

- Orbit System - a planet and its moons rotating around a star.
- Organic Compounds - compounds (collections of atoms) containing carbon.
- Planet - the celestial body that has a greater mass than all other objects of the same orbit system together and that describes a well-defined, special orbit around a star.
- Radar - radio waves used to find distances to and make maps of things.
- Rotate - to turn on an axis.
- Scarp - a type of cliff.
- Silicate
- Surface Area - the area on the outside of something.
- Tectonic Plate
- Terrestrial Planets - the four planets closest to the Sun.
- Trojan asteroid
- Star - a huge ball of gas that produces light itself.
- Volcanic - something that relates to volcanoes.
- Volume - the size of an object.

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