



Rourke's World of Science
ENCYCLOPEDIA

Volume 7 - Astronomy & Space

Rourke's World of Science
ENCYCLOPEDIA

Volume 7

**ASTRONOMY
AND SPACE**

By Tim Clifford

Editorial Consultant
Debbie Ankiel

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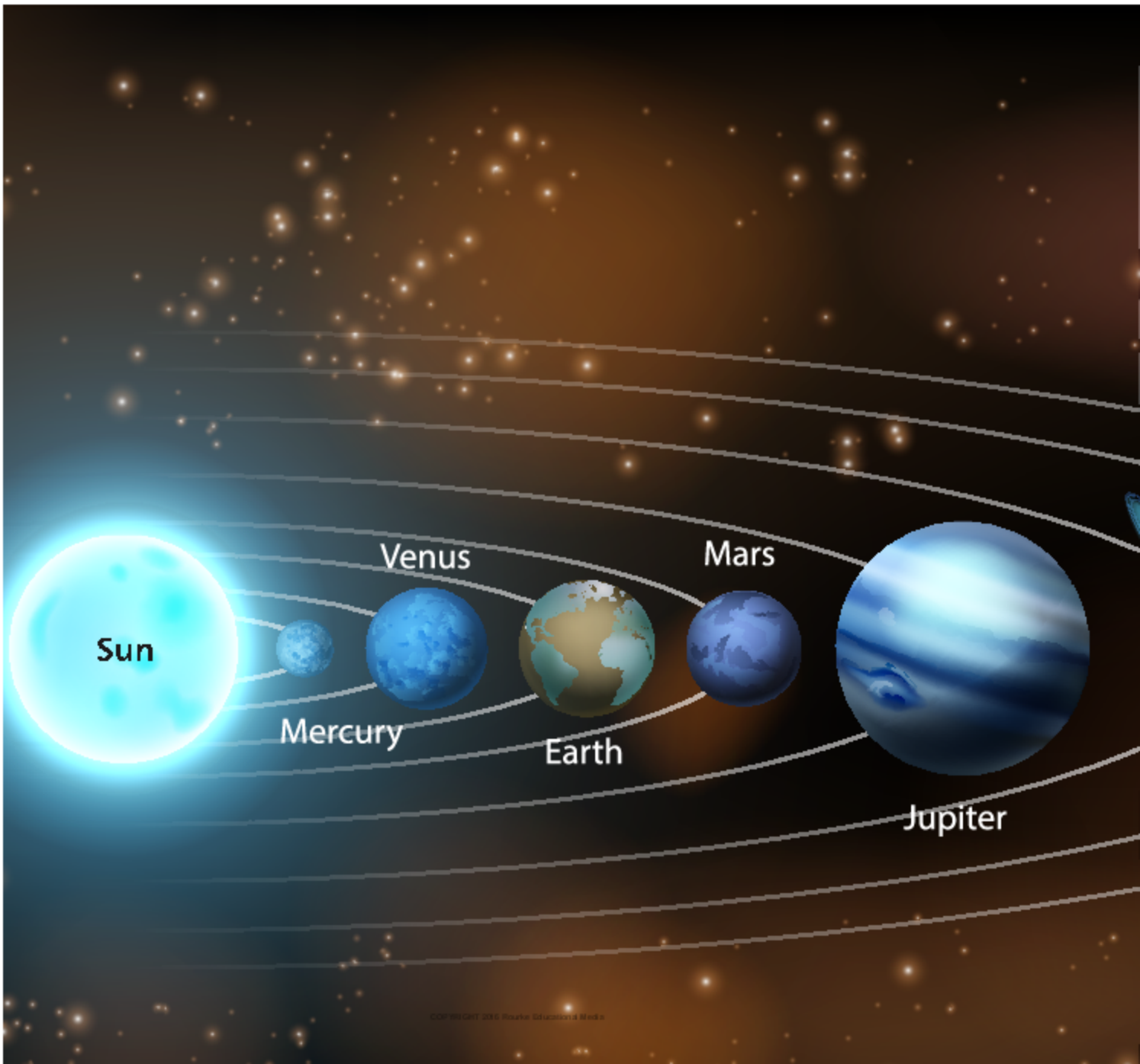
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What Is Astronomy?

Have you ever wondered what exists beyond our planet? Or looked up in the night sky and wondered what it would be like to live on another planet in our solar system?

Do people or other beings live there already? Astronomy is the study of the universe, or outer space, and can help you find the answers to all these questions, and more!



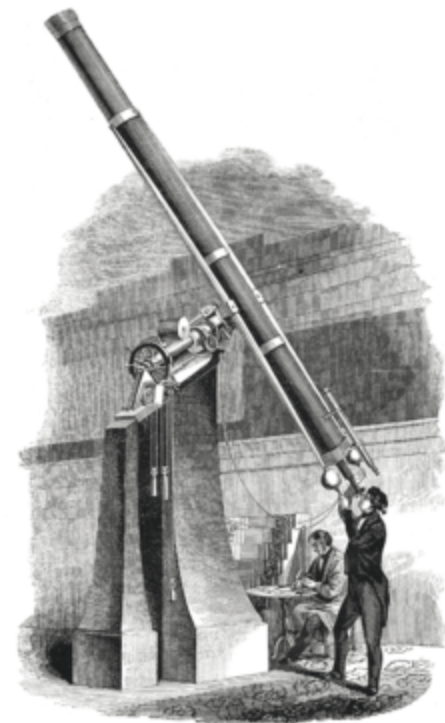
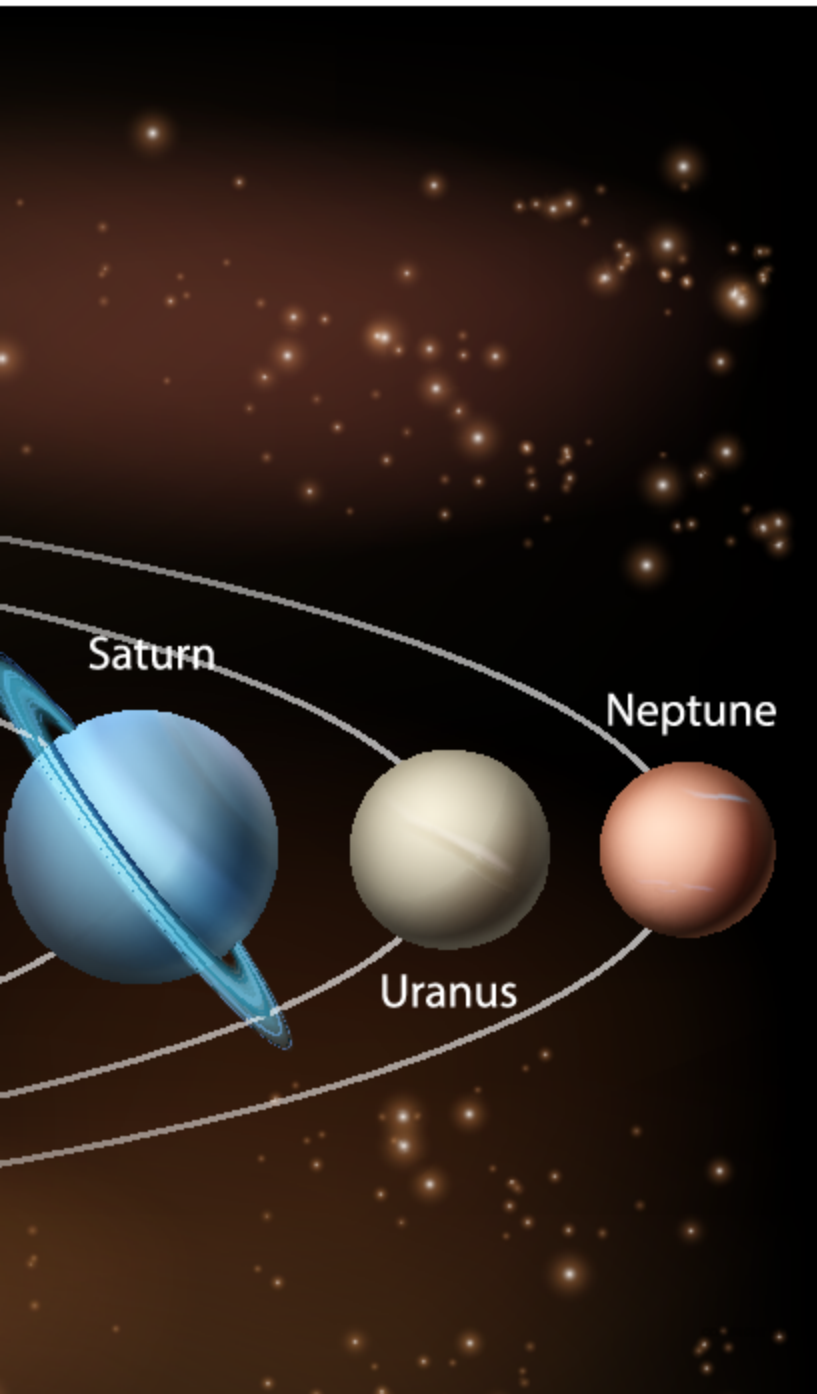
ASTRONOMY & SPACE

Astronomers study all of the objects in the sky outside Earth's atmosphere. Some of the things they study are the sun, moons, stars, planets, galaxies, asteroids, and comets. New technologies such as the Hubble Space Telescope help astronomers make new discoveries about outer space.

The science of astronomy is very old. Throughout Earth's history, people have been curious about what they saw in the sky. Different ideas developed about how the universe worked.



A star photographed by the Hubble Space Telescope. Dust particles can be seen swirling around the star.



This drawing shows an 1848 telescope.

WHAT IS ASTRONOMY?

ASTRONOMY & SPACE

Key Events in the Early History of Astronomy

280 B.C.	Aristarchus thinks the Earth revolves around the sun. He provides the first estimation of Earth-sun distance.
130 B.C.	Hipparchus develops the first accurate star map and star catalogue with over 850 of the brightest stars.
45 B.C.	The Julian calendar, a purely solar calendar, is introduced to the Roman Empire.
140 A.D.	Ptolemy suggests the geocentric theory of the universe in his famous work, <i>Mathematike Syntaxis</i> .
1259 A.D.	An observatory was built for the famous Persian astronomer, Nasir al-Din al-Tusi.
1543 A.D.	Copernicus publishes his heliocentric theory of the universe.
1582 A.D.	Pope Gregory XIII introduces the Gregorian calendar.
1603 A.D.	Johann Bayer introduces his Bayer designation of stars, assigning Greek letters to stars, still in use today.
1608 A.D.	Hans Lippershey, a Dutch spectacles maker invents the telescope.
1656 A.D.	Christian Huygens discovers Saturn's rings and Titan, the fourth satellite of Saturn.
1659 A.D.	Huygens notes markings on Mars.
1666 A.D.	Martian polar ice caps are noted by Cassini.
1668 A.D.	The first reflecting telescope was built by Newton.
1675 A.D.	While in Paris, Danish astronomer Ole Romer measures the speed of light.
1675 A.D.	Cassini discovers that Saturn's rings are split into two parts, the gap is called the "Cassini Division".
1687 A.D.	Newton publishes his theory of gravity. This is viewed as the start of Modern Astronomy.
1705 A.D.	England Halley correctly predicts the return of a comet (Halley's comet) in 1758.
1758 A.D.	Johann Palitzsch observes Halley's comet as predicted by Halley in 1705.
1781 A.D.	Herschel discovers the planet Uranus.
1781 A.D.	Messier discovers galaxies, nebula and star clusters while looking for comets.
1801 A.D.	Piazzi discovers the first asteroid, Ceres.
1840 A.D.	J. W. Draper takes first pictures of the moon.
1846 A.D.	Johann Galle observes and discovers Neptune.
1877 A.D.	Asaph Hall discovers Phobos and Deimos, the moons of Mars.
1877 A.D.	Schiaparelli observes the canals on Mars.
1878 A.D.	The Great Red Spot on Jupiter becomes prominent.
1905 A.D.	Albert Einstein introduces his special Theory of Relativity.
1916 A.D.	Albert Einstein introduces his general Theory of Relativity.
1923 A.D.	Hubble shows that galaxies exist outside the Milky Way galaxy.
1930 A.D.	Clyde Tombaugh discovers Pluto.
1931 A.D.	Karl Jansky discovers cosmic radio waves.
1937 A.D.	The first radio telescope is built by Grote Reber.

ASTRONOMY & SPACE

1957 A.D.	Sputnik, the first manmade object to orbit the Earth, is launched by the Russians.
1958 A.D.	Explorer 1 is launched. This was the first U.S. satellite to orbit the Earth.
1960 A.D.	The field of archaeoastronomy expands in England.
1961 A.D.	Yuri Gagarin becomes the first man in space.
1962 A.D.	John Glenn becomes the first American man to orbit Earth.
1969 A.D.	Armstrong and Aldrin walk on the moon as part of the Apollo 11 mission.
1970 A.D.	The Russian Venera 7 becomes the first spacecraft to land softly on the surface of Venus.
1972 A.D.	The U.S. launches Pioneer 10, the first satellite destined for Jupiter.
1974 A.D.	The U.S. Mariner 10 probe transmits the first image of Mercury.
1976 A.D.	The U.S. Viking probes land on Mars.
1977 A.D.	The rings of Uranus are discovered.
1978 A.D.	Charon, the moon of Pluto, is discovered by James Christy and Robert Harrington.
1980 A.D.	Voyager 1 sends back to Earth the first images of Saturn and its rings.
1986 A.D.	Voyager 2 closes in on Uranus.
1986 A.D.	The Space Shuttle Challenger breaks apart after launch.
1990 A.D.	The Hubble Space Telescope is put into orbit from space shuttle Discovery.
1992 A.D.	The Vatican, under Pope John Paul II, announces that the Catholic Church erred in condemning Galileo's work that proved that the work of Copernicus was valid, mainly that the planets circle the sun and not the Earth.
1994 A.D.	The Comet Shoemaker Levy crashes into Jupiter.
1995 A.D.	The Galileo space probe reaches Jupiter.
1996 A.D.	The Comet Hyakutake is discovered by Yuji Hyakutake.
1997 A.D.	The Mars Pathfinder lands on the Red Planet.
1997 A.D.	Cassini begins its journey to Saturn.
1998 A.D.	The Lunar Prospector reaches the moon.
1998 A.D.	Construction begins on the International Space Station.
1998 A.D.	The Galileo space probe discovers the origin of Jupiter's Rings.
1998 A.D.	John Glenn returns to space after 36 years.
1999 A.D.	Scientists discover the real Hubble Constant.
1999 A.D.	Chandra X-ray Observatory is put into orbit. Col. Eileen Collins becomes the first woman shuttle commander.
1999 A.D.	NASA loses the Mars Climate Orbiter and the Mars Polar Lander.
2000 A.D.	The space shuttle Endeavor makes a detailed, global map of Earth.
2000 A.D.	The NEAR spacecraft reaches asteroid Eros.
2000 A.D.	New evidence is found for water on Mars.
2013 A.D.	NASA's Voyager 1 spacecraft reached interstellar space.
2013 A.D.	Physicists in Antarctica find the first evidence of cosmic rays from outside the solar system.
2013 A.D.	NASA's Curiosity rover discovers signs that ancient Mars could have supported life in the form of primitive microbes.

Views of the Universe

Long ago, before the invention of the telescope, people had a much different idea of what the universe was like. The two major views of the universe through the course of history are the geocentric view and the heliocentric view.

The Geocentric View

In 140 A.D. a Greek astronomer named Ptolemy wrote that the Earth was the center of the universe. He thought all the stars, the sun, and the moon revolved around it. This made sense because that is how things looked in the sky from Earth. We call Ptolemy's theory the geocentric view. It is derived from *geo* (Earth) and *centric* (center). Astronomers believed the geocentric view for 1,500 years until 1543.



Claudius Ptolemaeus (c. 100 AD – c. 168 AD), is known in English as Ptolemy.

The Heliocentric View

About 500 years ago, Copernicus found that the Earth and other planets revolve around the sun. His theory was published in 1543. We call Copernicus's theory the heliocentric view because *helios* means sun. Astronomers still base their understanding of the solar system on Copernicus's heliocentric view.

Nicolaus Copernicus (1473-1543)



Getting to know...

Nicolaus Copernicus was born in 1473 in what is now Poland. His father died when Copernicus was only ten. His uncle, a Catholic bishop, raised him. In 1491, he became interested in studying the skies. He collected many books on astronomy and studied with famous astronomers.

In 1513, Copernicus built an observatory. He realized that Earth and the other planets revolve around the sun. This is the heliocentric view. Many people did not believe him. The Catholic Church banned his ideas for the next three hundred years.

We call Copernicus the father of modern astronomy even though Greek, Indian, and Muslim astronomers before him believed that the sun was the center of the solar system as well.

ASTRONOMY & SPACE

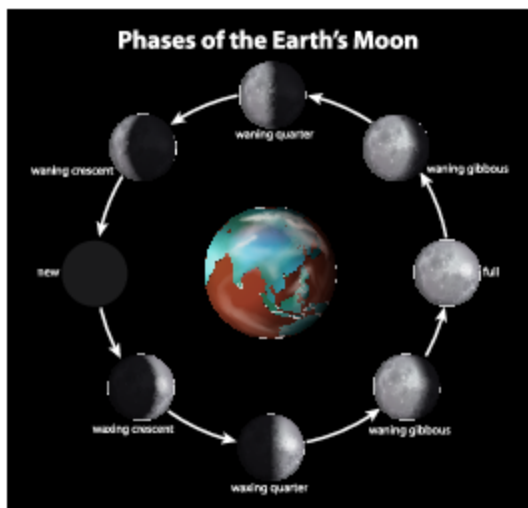
We now know that our solar system is part of a bigger universe, or cosmos. The size of the universe is unimaginable. It includes all the matter, energy, and space in all the galaxies.

How People Used the Skies

People have always found the skies fascinating. They found the skies helpful, too. They developed calendars based on the moon and sun. They used the stars and midday sun to navigate.

The Lunar Calendar

Early on people noticed that there were $29\frac{1}{2}$ days between two full moons. They created a 354 day calendar. Based on the phases of the moon, they divided the calendar into 12 lunar months.



The lunar calendar is based on the phases of the moon.

Today, the Islamic calendar is still a purely lunar calendar. It has twelve months based on the moon's movements.

The Solar Calendar

Later calendars used the movements of the sun rather than the moon. The ancient Egyptians created the first 365 day solar calendar. The ancient Romans made adjustments and added one extra day every four years. Do you know what we call these longer years? Yes, they are leap years.



Based on the heliocentric view, the Earth revolves around the sun.

Words to know

- observatory** (uhb-ZUR-vuh-tor-ee): a building that has telescopes and other instruments astronomers use to study the sky
- revolve** (ri-VOLV): to orbit around an object
- theory** (THIHR-ee): an idea that explains how or why something happens
- universe** (YOO-nuh-vurss): everything that is in space including the Earth, stars, and planets

ASTRONOMY & SPACE

The Gregorian Calendar

Even with the improvements, the calendars being used were still not quite right. In 1582, Pope Gregory XIII corrected the problems. He ordered that three leap years should be skipped every 400 years. We use the Gregorian calendar today, named for Pope Gregory. It is the most widely used calendar in the world.

The Days of the Week

You may wonder why there are seven days in a week. No one seems to agree on any single reason for a seven day week. But they do agree on the origins of each day's name.

In English, three days (Saturday, Sunday, and Monday) are named for objects in the solar system. The other four days (Tuesday, Wednesday, Thursday, and Friday) are named for Norse gods. See the chart below.

Navigation

Ancient people learned to navigate by using the sun and stars. Using the stars and sun people could find their north-south position when crossing deserts and seas where there were no landmarks to guide them.

During the day, the sun's movement in the sky guided them. At night, they used a star called Polaris, or the North Star.



All stars are fixed in a set position in the sky relative to each other. It is the movement of the Earth that makes the stars and the sun appear to move across the sky.

Named After	Originally	Now
The Sun	Sun's Day	Sunday
The Moon	Moon's Day	Monday
Tiw, Norse God of war	Tiw's Day	Tuesday
Woden, German for Odin, chief Norse god	Woden's Day	Wednesday
Thor, Norse god of thunder	Thor's Day	Thursday
Frigg, the Norse goddess of love	Frigg's Day	Friday
Saturn	Saturn's Day	Saturday

ASTRONOMY & SPACE

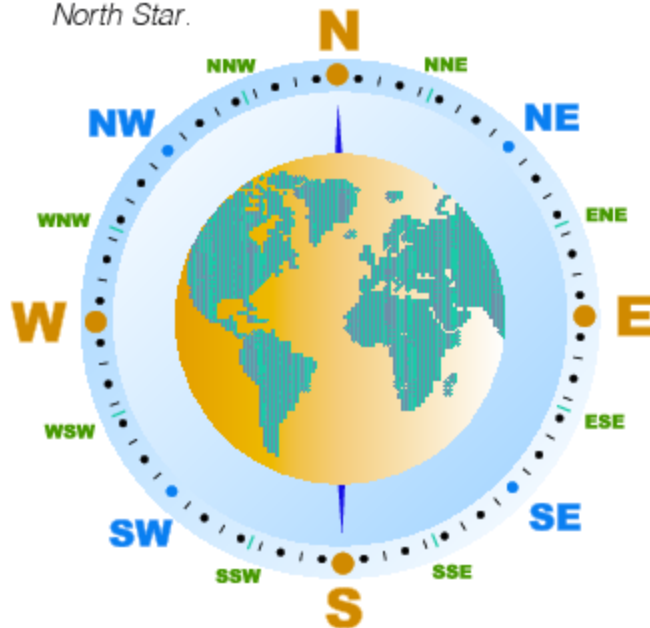
Polaris is always due north. Earth's North Pole points to Polaris. Over the next 13,000 years, Earth's North Pole will slowly shift to point to a star called Vega.



Polaris, is also known as the North Star.



Vega could someday be known as the North Star.



Earth's North Pole points to Polaris, but is slowly moving and will eventually point to Vega.

Over time, people developed different tools to make navigation using the sun and stars easier.




The compass is one of the most important navigational tools ever invented.

Many of the tools were difficult to use and caused blindness. People had to look directly into the sun to use the tools properly. In 1595, John Davis invented the back-staff. It prevented blindness because the user stood with his back to the sun.



Words to know

-  **lunar** (LOO-nur): to do with the moon
- navigate** (NAV-uh-gate): to travel using maps, compasses, or the stars to guide you
- solar** (SOH-lur): to do with the sun

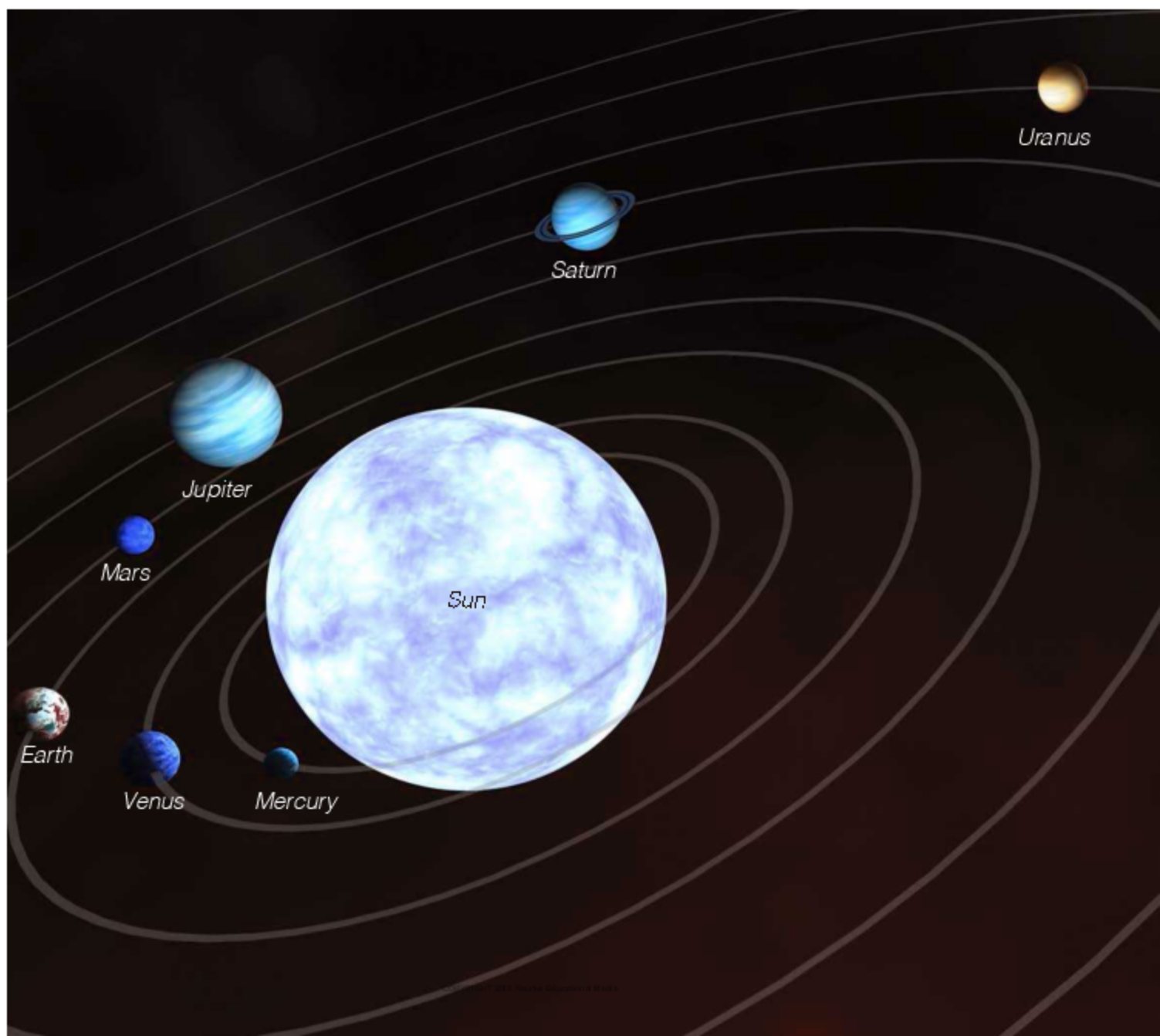
WHAT IS ASTRONOMY?

The Solar System

A solar system is a group of planets and one or more stars. Our solar system has just one gigantic star, the sun. It also has eight planets and five dwarf planets. Many planets have their own moons. There are also thousands

of asteroids, meteoroids, and comets.

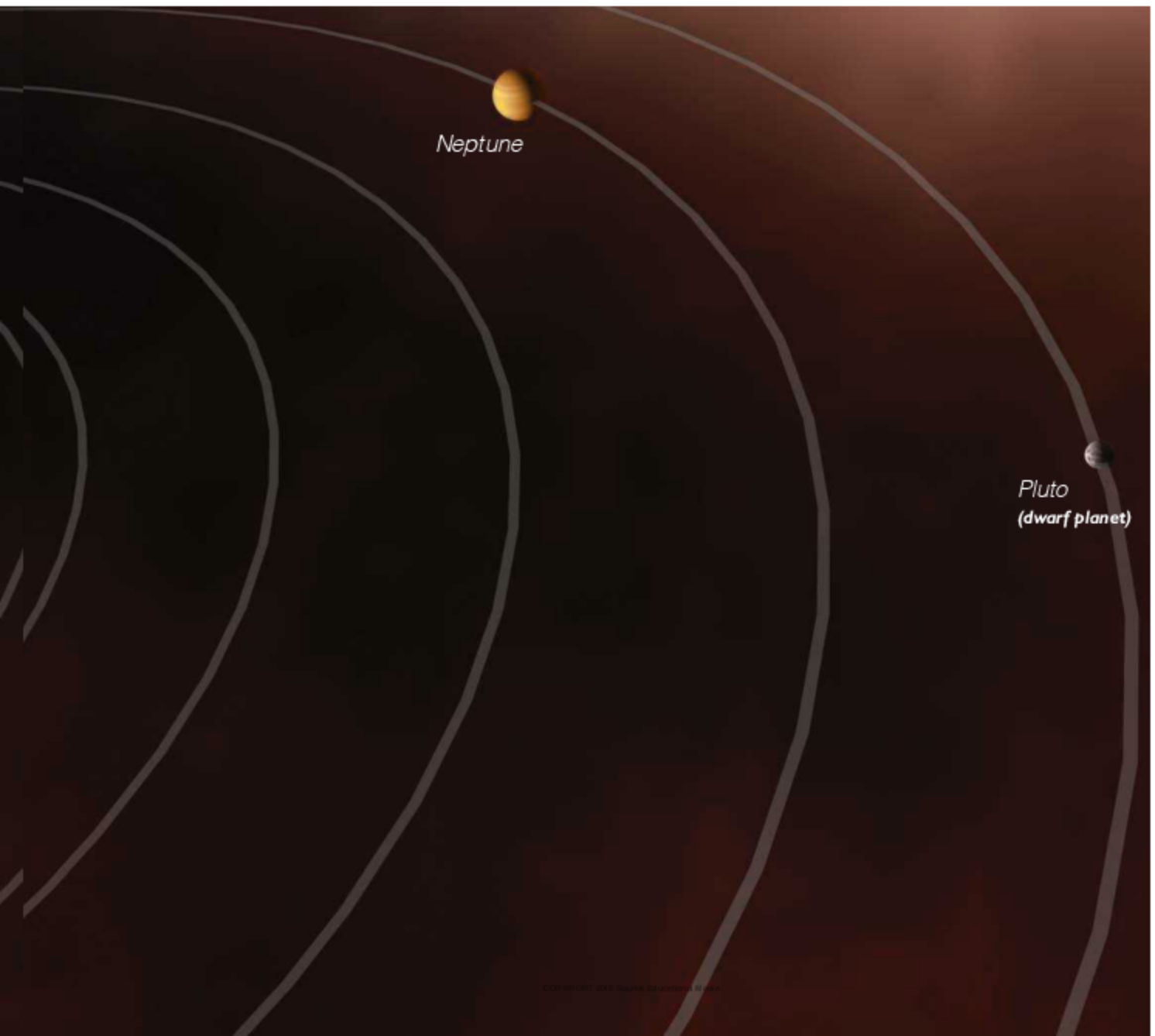
Gravity from our huge sun holds the solar system together. Planets, asteroids, and comets revolve around (orbit) the sun. Moons orbit some of the planets.



ASTRONOMY & SPACE

A year for a planet is the amount of time it takes the planet to make one complete revolution around the sun. The planets also rotate on an axis. One day on a planet is the time it takes for the planet to make one complete rotation (360 degrees) on its axis. It takes Earth about 24 hours to complete one rotation.

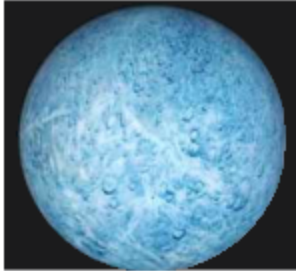
There are 5 recognized dwarf planets in our solar system. They are Ceres, Pluto, Haumea, Makemake and Eris. With the exception of Ceres, which is located in the asteroid belt, the other dwarf planets are found in the outer solar system.



Inner Planets

There are inner and outer planets. Mercury, Venus, Earth, and Mars are the inner planets. They orbit close to the sun. The inner planets are very rocky. They are smaller than the outer

planets. An asteroid belt separates the inner planets from the outer planets.



Mercury



Venus



Earth



Mars

Outer Planets

Jupiter, Saturn, Uranus, and Neptune are the outer planets. They orbit far from the sun. The outer planets are all much larger than the

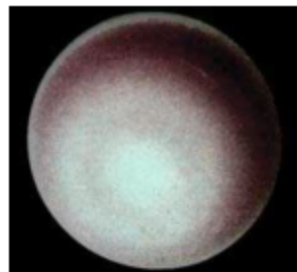
inner planets. We call the outer planets the gas giants because they are made mostly from gasses.



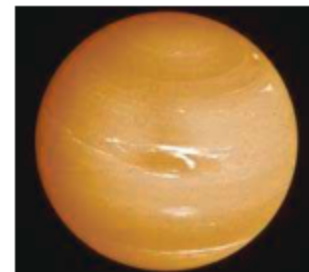
Jupiter



Saturn



Uranus



Neptune

Are you wondering about Pluto? In the past, we thought Pluto was a planet but astronomers now classify it as one of the dwarf planets. The other dwarf planets are Ceres, Eris, Haumea, and Makemake. Ceres and Eris are both large asteroids. Astronomers discovered Eris in 2005. Eris is larger

than Pluto and is even farther away from the sun.

NASA's *New Horizons* spacecraft has given scientists their first clue about why Pluto has a reddish hue.

Looking back at Pluto seven hours after its historic July 14 flyby, *New Horizons* captured a striking view of the



The image from NASA's New Horizon spacecraft shows the structured layer of haze around Pluto.

distant world backlit by the sun. The image shows a surprisingly diffuse and structured layer of haze in Pluto's atmosphere rising more than 100 miles (160.93 km) off the surface -- five times higher than predicted by computer models.

The Origins of Our Solar System

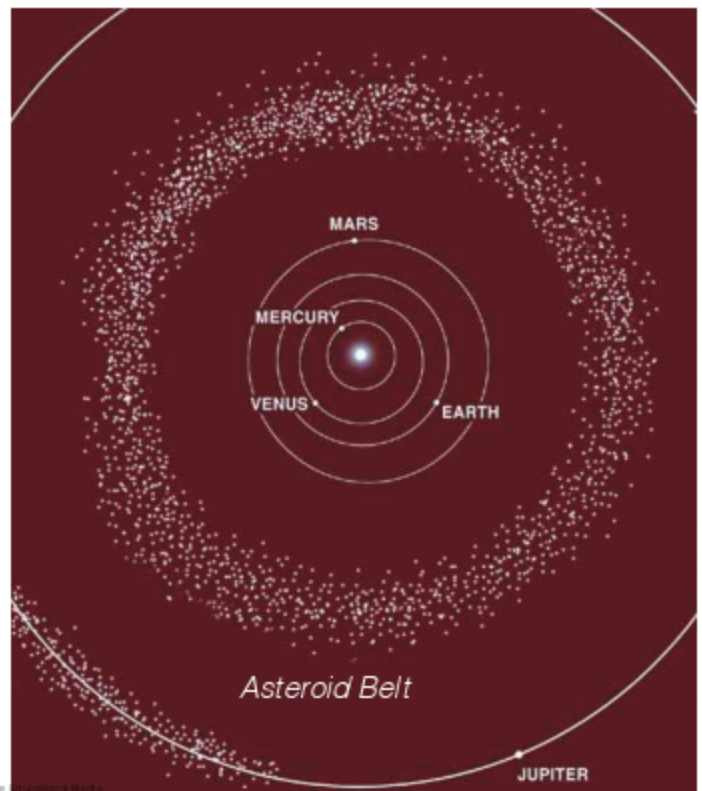
Where did the solar system come from? Many astronomers believe it began as a cloud of dust and gas. Nearly 5 billion years ago, a nearby star may have exploded. The explosion caused the cloud to collapse and spin into a disk. Gravity made the dust and gas pull together into the center of the disk. The force of gravity caused great heat and pressure. Nuclear reactions occurred. These reactions caused the sun to shine for the first time.

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The solar system may have been created from a cloud of gas and dust.

The rest of the solar system also came from that cloud. The dust and gas formed into hot clumps. The clumps began orbiting the sun. As they grew bigger, they became planets and moons.



Many planets and moons still have scars from the formation of the early solar system. Impact craters are holes in the ground that form when material from space slams into a planet, or sometimes even a moon.



The Barringer Crater is a gigantic hole in the middle of the Arizona desert that formed when a meteor crashed to Earth.

All elements that make up the sun and planets came from the ancient dust and gas. This includes all the plants and animals on the Earth. Scientists believe that even the atoms that make up your body are as old as the stars.

Words to know

atom (AT-uhm): the smallest part of an element

axis (AK-siss): the imaginary line going through the middle of a planet or other object that it rotates around

nuclear (NOO-klee-ur): to do with the energy created by splitting atoms

revolve (ri-VOLV): one object moves around or orbits another object

rotate (ROH-tate): an object turning around and around its center point or axis

The Sun

Even though it is 93 million miles away, the sun is the nearest star to Earth. In comparison to other stars, the sun is a medium sized star. All stars, including the sun, are balls of exploding gas. You might think of stars as having points like the ones we draw but stars are shaped more like a ball (sphere).

The sun is the center of our solar system. Another name for the sun is sol.

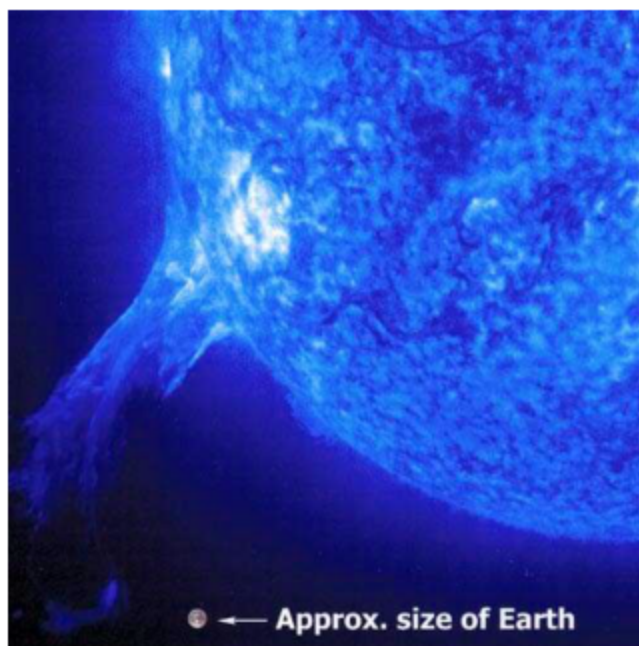


The sun heats the land, ocean, and air.

Most of the light and heat on Earth comes from the sun. Without that heat source, life on Earth could not exist. Scientists believe that eventually changes in the sun will make life on Earth, as we now know it, impossible.

Size

Compared to the Earth, the sun is huge. It is the largest object in our solar system. The sun's diameter is over 864,432 miles (1,392,000 kilometers). That is nearly 109 Earths across. It would take 1,300,000 Earths to fill up the sun.



● ← Approx. size of Earth

If the sun was the size of a basketball, the Earth would be about $\frac{1}{4}$ of an inch (2.2 millimeters).

Because it is so huge, the sun exerts a lot of gravity. This force holds the planets in orbit.

The Sun's Core

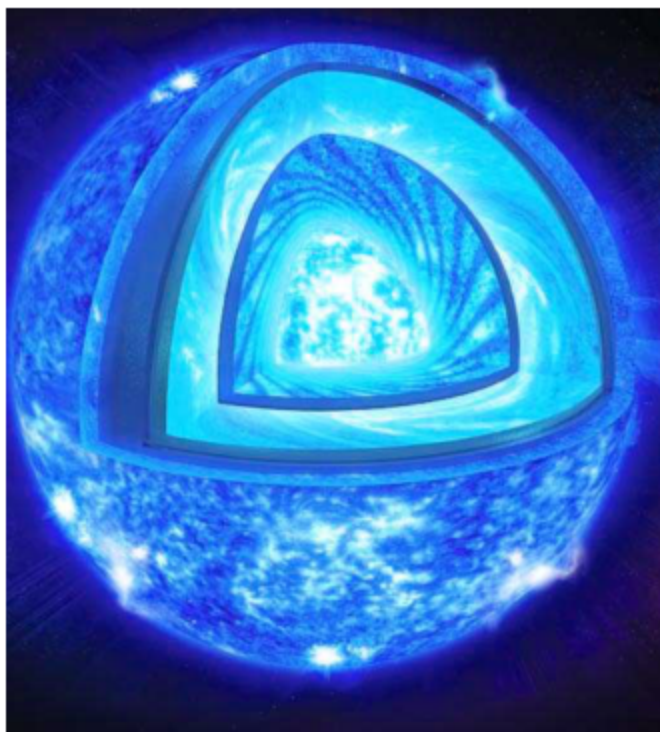
The center (core), of the sun creates solar energy. In the core, temperatures and pressures are very high. This makes nuclear reactions occur. It takes a million years for energy made in the core to reach the surface. The sun releases its energy as heat and light.

The Sun's Outer Layers

The photosphere is the top layer of the sun's surface. This is where we find sunspots. Sunspots appear as dark green areas in the photosphere. Solar flares come from the sunspots. These bright arcs of hot gas can interfere with radio communications on Earth.

The chromosphere is above the photosphere. Light and solar flares pass through the chromosphere on their way out into space.

The corona is the outermost part of the sun's atmosphere.



The core temperature of the sun is over 27 million degrees Fahrenheit (15 million degrees Celsius).

During a solar eclipse, the corona is the part of the sun that is seen shining around the moon. A solar eclipse occurs when the Earth's moon blocks out most of the light from the sun.

Many people are tempted to look directly at the sun during an eclipse. This is very dangerous. Even if you don't feel pain in your eyes, looking directly at the sun can cause permanent eye damage or blindness.



Welding goggles are the best eye protection for looking at an eclipse of the sun.

Mercury

Mercury is the closest planet to the sun. It is a small planet, just a little bigger than Earth's moon. Mercury has a diameter of about 3,029 miles (4,878 kilometers). It revolves, or orbits, around the sun once every 88 Earth days. It has an elliptical orbit. An elliptical orbit is like a stretched out circle (oval shape). Its average distance from the sun is about 36 million miles (58 million kilometers).

Days are very long on Mercury. This is because the planet has a very slow spin. Mercury rotates once every 59 Earth days. One day on Mercury would be 1,416 hours long!

Words to know

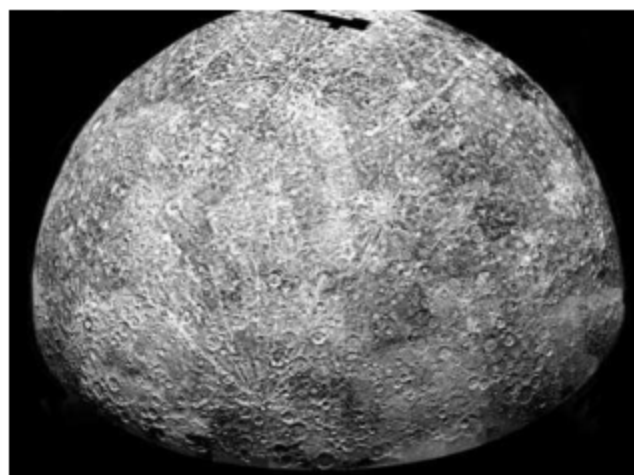
atmosphere (AT-muhss-fih): the mixture of gasses that surround a planet

diameter (dye-AM-uh-tur): a line going straight through the center of a circle, from one side to the other

elliptical (i-LIP-tik-uhl): having an oval shape

gravity (GRAV-uh-tee): the force of attraction of an object

sphere (sfih): a symmetrical geometric shape like a ball, all points on the shape are the same distance from the center



The first telescopic observations of Mercury were made by Galileo in the late 17th century.

ASTRONOMY & SPACE

Temperature

Temperatures get very hot during the daytime. Surface temperatures can reach over 752 degrees Fahrenheit (400 degrees Celsius). At night it gets very cold. It can reach below -279.4 degrees Fahrenheit (-173 degrees Celsius). Mercury has some of the highest and lowest temperatures in the solar system.

Atmosphere

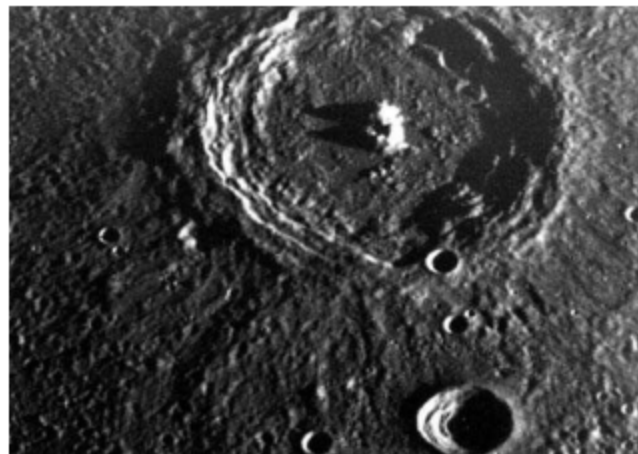
There is almost no atmosphere on Mercury. Because of the heat, any gasses on Mercury would burn up.

Moons

Mercury has no moons.

Special Features

The surface of Mercury is hard and rocky. Impact craters cover the surface. Mercury's craters formed a long time ago during the early history



The craters on Mercury were formed when asteroids and comets struck the surface of the planet.

of the solar system. Some craters are small. Others are very large.

Mercury has cliffs up to 1.8 miles (3 kilometers) high and hundreds of miles long.

Exploration

The first spacecraft to visit Mercury was Mariner 10, in 1974. It took photographs of the planet. It found that Mercury has a weak magnetic field.

Planet	Rotation on axis	Orbit around the sun	Distance from the sun	Number of moons
Earth	24 hours	365 Earth days	93 million miles (149.6 million km)	1
Mercury	1,416 hours	88 Earth days	36 million miles (58 million km)	0

Venus

Venus is the second planet from the sun. Because it is so close to Earth, you can often see Venus in the sky at dusk or dawn, without the use of a telescope.

Sometimes we call Venus our sister planet because it is a lot like Earth. It is about the same size as Earth. Both planets have a near circular orbit around the sun. A lack of craters shows that both planets formed about the same time.



Venus and Earth are sometimes called sister planets.

Although they are alike in many ways, Venus and Earth are different in some very important ways. Venus rotates in the opposite direction as Earth. Its spin is retrograde. That

means it spins backward from the rotation of Earth and the other planets. On Venus, the sun rises in the west and sets in the east. Venus rotates much slower than Earth. It takes about 243 Earth days for Venus to rotate one time. Another difference is that Venus has a very weak magnetic field.

The diameter of Venus is 7,516 miles (12,103 kilometers). Its average distance from the sun is about 67 million miles (108 million kilometers). It takes Venus 225 Earth days to orbit the sun. It might be a little confusing to live on Venus because one planetary year is shorter than one planetary day!



Venus has the slowest rotation period of all the major planets.

Temperature

The surface of Venus is very hot. Temperatures on the surface can reach 880 degrees Fahrenheit (470 degrees Celsius) making it the hottest planet. Venus is far too hot to support life.

Words to know

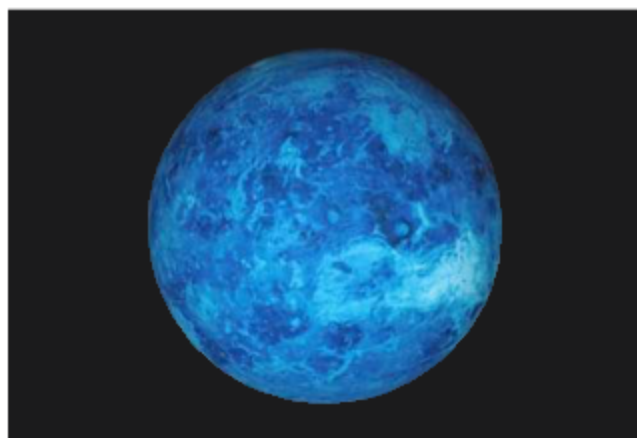
inactive (in-AK-tiv): a volcano that is not currently active or erupting

probe (PROHB): a tool or robotic spacecraft used to explore something

ASTRONOMY & SPACE

Atmosphere

The atmosphere of Venus is mostly carbon dioxide. Because the carbon dioxide is so thick, the pressure on Venus is 90 times that of Earth. The clouds in the upper atmosphere are made of tiny drops of sulfuric acid. The sulfuric acid forms thick clouds that reflect the sun's rays making Venus shine brightly like a star.



The clouds on Venus reflect the light from the sun making the planet seem to shine like a star.

Moons

Venus has no moons.

Special Features

The surface of Venus is rocky. It has many inactive volcanoes. There are also many mountains, some of which are higher than the mountains on Earth.

Exploration

The first spacecraft to successfully orbit Venus was Mariner 2, in 1962. Since then, many other spacecraft have flown by, orbited, or landed on its surface. The Magellan probe has provided maps of Venus.

Planet	Planetary Day (rotation on axis)	Planetary Year (revolution around sun)	Distance from the sun	Number of moons
Earth	24 hours	365 Earth days	93 million miles (149.6 million km)	1
Venus	5,832 hours	225 Earth days	67.2 million miles (108.2 million km)	0

Earth

Earth, our home, is the third planet from the sun. It is the only planet we know of that contains life. The diameter of the Earth is about 7,920 miles (12,754 kilometers). The Earth rotates one time every 24 hours. A planetary day on Earth is 24 hours. Earth's planetary year is about 365 days. It takes the Earth 1 year to revolve, or orbit, the sun.

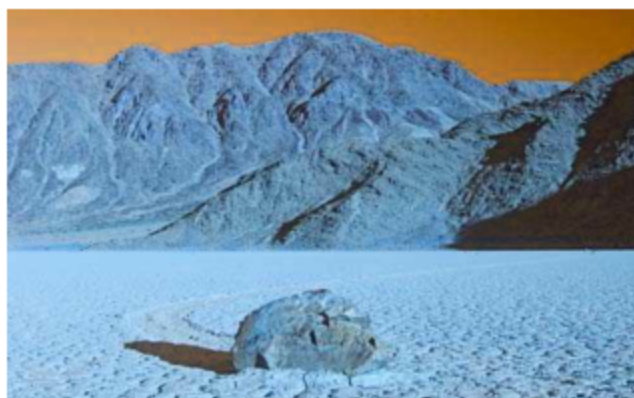
Earth's average distance from the sun is about 93 million miles (150 million kilometers). We call this distance 1 astronomical unit, or AU. We sometimes measure distances to other planets in astronomical units.

Temperature

The coldest parts of Earth can reach -129 degrees Fahrenheit (-90 degrees Celsius). The hottest parts can reach 136 degrees Fahrenheit (58 degrees Celsius). Most life on Earth will survive in places with temperatures somewhere in between.



The lowest recorded temperature in Antarctica was -129 degrees Fahrenheit (-89 degrees Celsius) recorded in 1983.



The hottest temperature ever recorded in the United States was in Death Valley, California. (shown above) The 134 degrees Fahrenheit (57 Degrees Celsius) temperature was just 2 degrees Fahrenheit (1 degree Celsius) cooler than the hottest in the world. It was recorded in El Azizia, Libya.

Atmosphere

The Earth's atmosphere is made mainly of nitrogen and oxygen. Our atmosphere has more oxygen than any other planet's atmosphere. When people talk about the air, they are really talking about the atmosphere. It is the perfect mix of gasses to support life.

The atmosphere keeps temperatures from getting too high or too low to support life. It also helps keep out harmful radiation from the sun.

Words to know



○ **environment** (en-VYE-ruhn-muhnt): the natural world of the land, sea, and air

mission (MISH-uhn): a group of people sent on a special assignment or job

radiation (ray-dee-AY-shuhn): the sending out of heat or light



Special Features

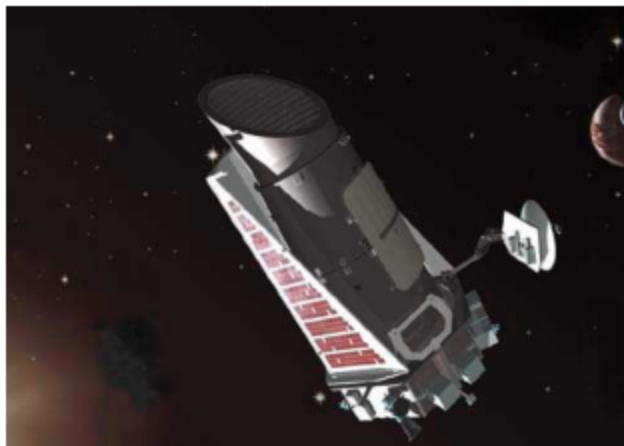
The Earth is the only planet with lots of water. Water covers two-thirds of the Earth. The amount of water on Earth stays about the same. Other planets may have only tiny amounts of ice or steam. Without water, there would be no life on Earth. The Earth orbits the sun in a near perfect circle. This helps keep temperatures from getting too high or too low. About 1.5 million types of animals and plants live in this perfect environment.

Exploration

Even though we live on Earth and explore it every day, there are things about Earth that we can learn from space. Space exploration began by looking at our own planet.

In 1957, Sputnik was the first spacecraft to orbit the Earth. Since then, thousands of spacecraft have studied the Earth from space. Today satellites send information back to Earth that can help us in our daily lives. Meteorologists, more often called weather forecasters, use information from satellites to study and predict the weather.

In 1969, the Apollo 11 spacecraft was the first manned mission to the moon. It carried astronauts Michael Collins, Edwin "Buzz" Aldrin, and Neil Armstrong. Collins orbited the moon during Armstrong and Aldrin's historic moon walk.



Kepler Space Telescope explores the structure and diversity of planetary systems

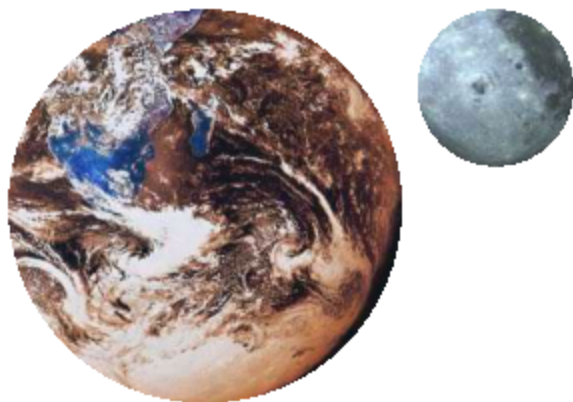
In April, 2014 with the help of NASA's Kepler Space Telescope, astronomers discovered the first Earth-size planet orbiting a star in the "habitable zone" -- the range of distance from a star where liquid water might pool on the surface of an orbiting planet. The discovery of Kepler-186f confirms that planets the size of Earth exist in the habitable zone of stars other than our sun.

In July, 2015, the Kepler Space Telescope is the first NASA mission for detecting Earth-like exoplanets in space. It was launched in 2009 and has, so far, discovered over 1,000 exoplanets. NASA has revealed a new Earth-like planet called Kepler 452b. It is the closest planet to Earth so far and has a rocky surface supporting liquid water and maybe even life. Described as "Earth 2.0", it is referred to as Earth's closest twin with a mass that's five times that of Earth. Will we go there? Not any time soon. Kepler 452b's star is 1,400 light years from Earth.

Earth's Moon

The Earth has one moon. It is about 240,000 miles (384,000 kilometers) from Earth. Its diameter is about 2,159 miles (3,476 kilometers). The moon is about one-fourth as big as the Earth.

The force of gravity ties the moon to the Earth. The moon revolves



The moon is smaller than Earth which means the moon's gravity is one-sixth of the Earth's gravity.

Find out more

There's Water on the Moon

Millions of tons of ice are inside some of the craters on the moon's poles. In the future, space missions might use the water for fuel, or to support life. Would you like to live in a space station on the moon?

around (orbits), the Earth once every 27.3 days. It also takes the moon 27.3 days to rotate one time. This means that the same side of the moon always faces the Earth. Astronauts orbiting the moon are the only humans to see the other side of the moon in person. We only know what it looks like from photographs.

High tides are caused by the gravitational pull of the moon and the sun. The pull stretches the Earth's oceans into an ellipse with Earth in the



In 1968, the Apollo 8 mission took three astronauts to the far side of the moon. They described its appearance as the color of dirty beach sand.

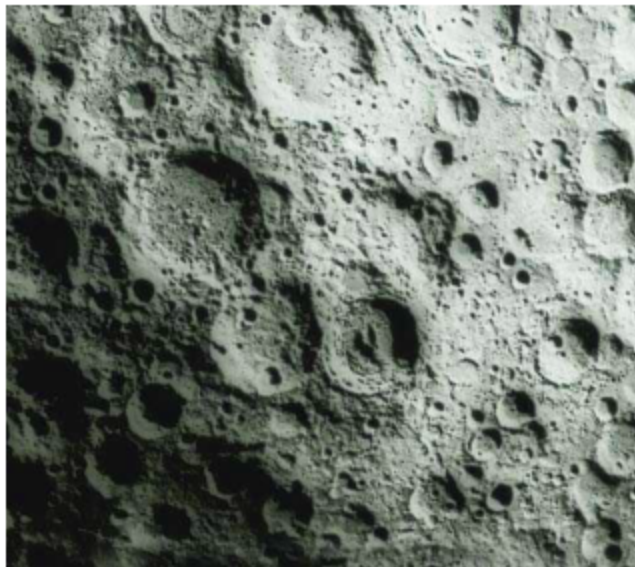
center. The oceans of the Earth seem to bulge out to make the oval shape. Areas on the Earth near the bulge will experience a high tide.

The high tide moves from west to east as the Earth rotates. High tides occur twice a day. This is because the water on the opposite side of the Earth from the moon also bulges.



The Earth rotates much faster than the moon moves in its orbit which creates two high tides per day.

Craters (holes), cover the moon. Meteorites striking the surface of the moon created these bowl-shaped holes.



Craters are formed by an asteroid, meteor, or comet crashing into the surface of the moon. Most of the craters on the moon are circular.

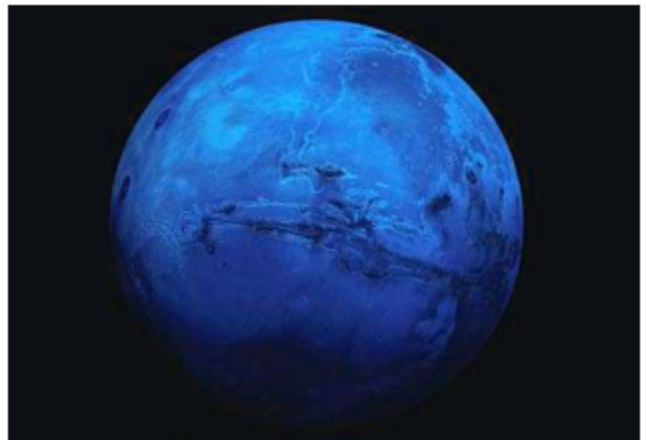
Mars

Mars is the fourth planet from the sun. Sometimes we call it the Red Planet because of its red coloring. Mars looks red because of the pinkish color of its rocks, soil, and sky.

Mars is about half the size of Earth. It has a diameter of 4,219 miles (6,794 kilometers). Its average distance from the sun is about 142 million miles (228 million kilometers). Mars orbits the sun once every 687 Earth days. You can see Mars without a telescope. It appears as a bright red object in the night sky.

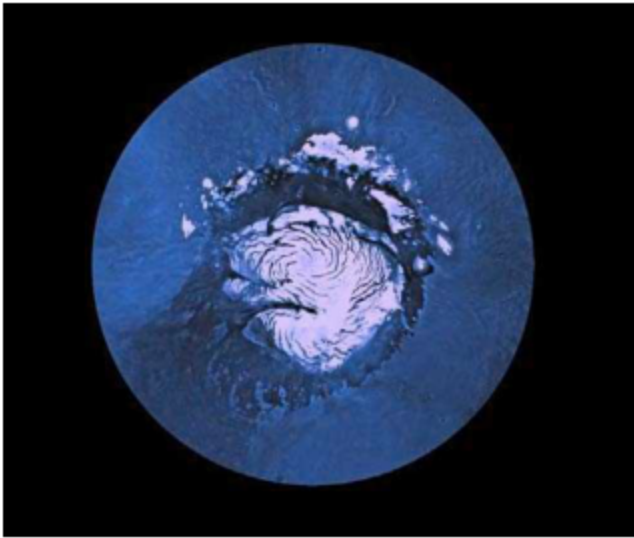
Mars is more like Earth than any other planet. The length of a day on Mars is almost 24 Earth hours. Like Earth, Mars has polar ice caps.

In September, 2014, NASA's Curiosity Mission found a perfect-looking sphere sitting proudly on a flat rock surface on the planet Mars. Of course, we know it is nothing manmade, or alien made. Just a spherical Mar's rock.



Mars is called the Red Planet.

During the winter on Mars, one of the poles is covered in snow and ice. At the same time, it is summer in the other hemisphere of the planet. When one ice cap gets bigger, the other ice cap gets smaller.



The polar ice caps on Mars are made of frozen carbon dioxide and water.

Temperature

It is always cold on Mars. The highest temperature is about 32 degrees Fahrenheit (0 degrees Celsius). But Mars can get much colder than freezing. It can get as cold as -200 degrees Fahrenheit (-144 degrees Celsius).

Mars has an elliptical orbit. As it orbits, the planet gets colder as it travels farther away from the sun.

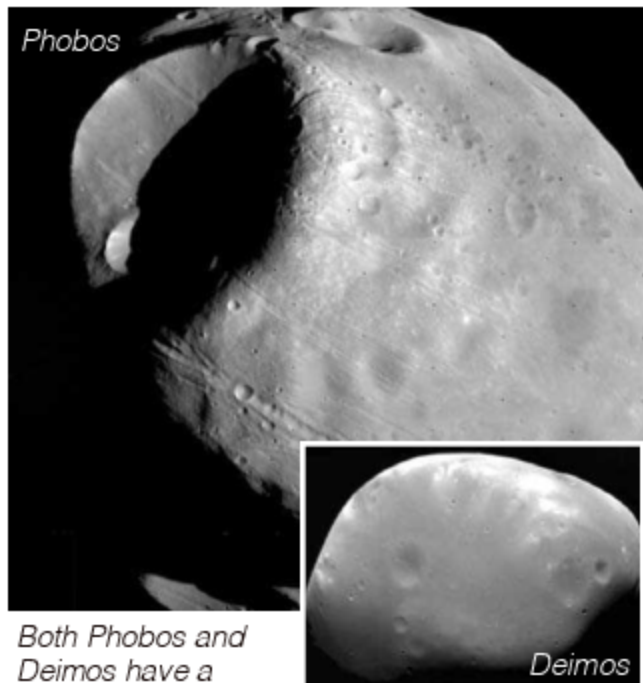
Atmosphere

The atmosphere of Mars is 95 percent carbon dioxide. The atmosphere is very thin. Humans would not be able to breathe the air on Mars. The surface of Mars is also very dry. Sometimes, giant dust storms cover the entire planet.

If you lived on Mars, the sky would not look blue like the sky on Earth does. It would be reddish orange in color.

Moons

Mars has two moons named Phobos and Deimos. They are both odd shaped and were probably asteroids at one time. Phobos is about twice as large as Deimos, but both are tiny compared to Earth's moon. Phobos is only 17 miles (27 kilometers across).



Both Phobos and Deimos have a circular orbit around Mars.

Planet	Planetary Day (rotation on axis)	Planetary Year (revolution around sun)	Distance from the sun	Number of moons
Earth	24 hours	365 Earth days	93 million miles (149.6 million km)	1
Mars	24.6 hours	687 Earth days	141.6 million miles (227.9 million km)	2

Special Features

There are many volcanoes on the surface of Mars. Most of them are in the northern regions of the planet. The biggest volcano is Olympus Mons. It is the largest volcano in the solar system. It is 342 miles (550 kilometers) wide and 17 miles (27 kilometers) high.



Olympus Mons is the tallest known volcano and mountain in our solar system.

Scientists believe that water once existed on the surface of Mars. A huge

canyon called the Valles Marineres is evidence of water in Mar's past. It is over 5 miles (8 kilometers) long. Dried up flood plains and riverbeds also cover parts of the surface.

Exploration

The first probe to go to Mars was Mariner 4, in 1965. Since then, many other spacecraft have visited the planet. Viking 1 and 2 were the first to land on the surface.

Words to know

- canyon** (KAN-yuhn): a narrow, deep river valley
- flood plain** (fluhd plane): an area of low land near a stream or river that easily floods
- hemisphere** (HEM-uhss-fih): one half of a sphere such as the Earth or a planet
- ice cap** (eyess kap): a mound of ice that covers an area of land

Jupiter

Jupiter is the fifth planet from the sun. It is the largest of all the planets in the solar system. It is also the first of the gas giants, or outer planets. All the outer planets are huge balls of gas. The other gas giants are Saturn, Uranus, and Neptune.



Jupiter is the largest planet in the solar system.

Jupiter is a huge planet. It has a diameter of over 88,679 miles (142,000 kilometers). Jupiter is 11 times larger than Earth. This giant planet also has a great mass. Jupiter has much more

mass than all the other planets put together. If Jupiter were 13 times bigger, it would be classified as a star called a brown dwarf instead of a planet. That would make it another star in the solar system.

Jupiter takes more than 11 Earth years to orbit once around the sun. The distance from the sun to Jupiter is over 5 astronomical units or five times the distance of the sun to the Earth. Jupiter spins very fast. It takes a little less than 10 Earth hours for Jupiter to rotate once.

Jupiter shines more brilliantly than any star. It's the second-brightest planet after Venus. In late June and early July of 2015, Venus and Jupiter are closer to each other than they will be until August 27, 2016, but will again present a second – though less close – conjunction in the evening sky on July 31 – the same date as this 2015's Blue Moon.

Temperature

You might think Jupiter would be a frozen planet because it is so far away from the sun but it's not. Jupiter's core is very hot. It can reach temperatures of 43,000 degrees Fahrenheit (24,000 degrees Celsius). In contrast, Jupiter's atmosphere is cold. The clouds average -193 degrees Fahrenheit (-125 degrees Celsius).

Words to know

- mass** (mass): the amount of physical matter that an object contains
- pressure** (PRESH-ur): the force of one object pushing on another
- satellite** (SAT-uh-lite): a moon or other heavenly body that revolves around, or orbits, a larger heavenly body

Atmosphere

The atmosphere of Jupiter is very deep. It is made mostly of hydrogen and helium. Layers of clouds cover the planet. These layers are thin bands made of hydrogen sulfide, ammonia, and water vapor. Clouds near the top of the atmosphere move very quickly. As bands pass each other, they sometimes create a storm. Giant lightning bolts come from the clouds during a storm.

A thin ring of dust orbits the planet far above the clouds. We cannot see the ring from Earth because it is so faint.

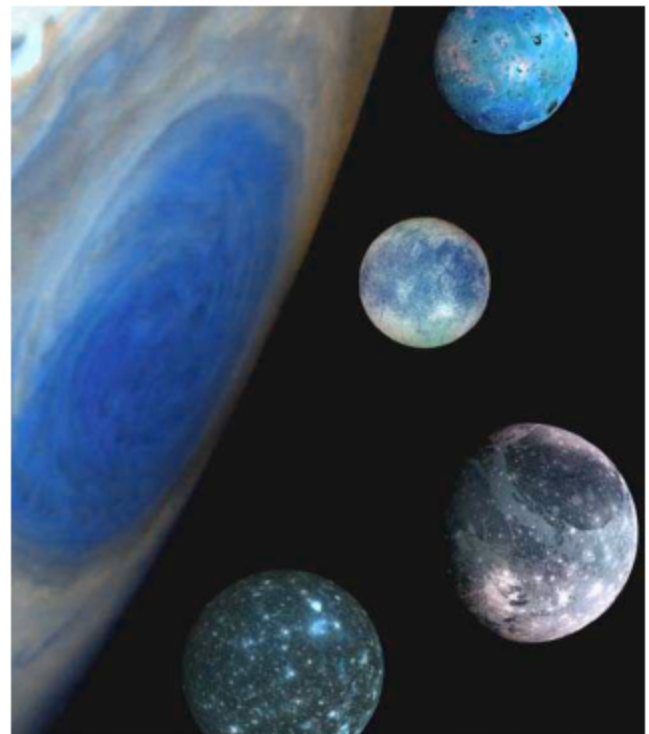


Jupiter is covered with thick clouds that move quickly and may cause storms when they meet.

Jupiter creates a huge and powerful magnetic field that surrounds the planet and its moons. It is unlikely that there will ever be a manned space mission to Jupiter. The pressure on Jupiter is so great that it turns gas into liquid. That is enough pressure to crush a spaceship!

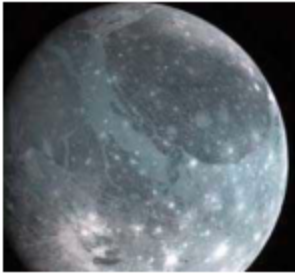
Moons

Jupiter has sixty-three known moons. That is the highest number of moons identified for any planet. Four of these moons are very large. Galileo discovered them in 1610. We know them as the Galilean satellites. They are named Ganymede, Callisto, Io, and Europa.



One of Jupiter's moons, Ganymede, has a diameter greater than the planet Mercury.

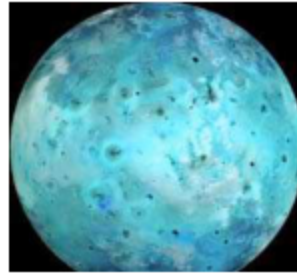
Jupiter's Four Largest Moons



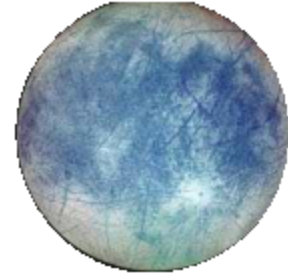
Ganymede is the largest moon in the solar system. Its diameter is 3,280 miles (5,262 km).



Callisto is covered in ancient craters. It is about the same size as Mercury.



Io is about the size of Earth's moon. It has a violent surface with active volcanoes.



Europa is the smallest of the four large moons. It has a smooth and icy surface. It is possible that below the ice there is a layer of liquid water.

The other moons of Jupiter are much smaller. Many of them are recent discoveries. Astronomers discovered more than half of Jupiter's moons after 1999.

Special Features

There is a "Great Red Spot" on Jupiter. This spot is actually a giant storm. It is red from the gases that swirl within it. The spot has existed for hundreds of years. The storm is wider than three Earths!

Exploration

The first spacecraft to visit Jupiter was Pioneer 10 in 1972. Since then, Voyager 1 and 2 have flown past the planet. The Galileo probe began to



The Great Red Spot on Jupiter can be seen with an Earth-based telescope.

orbit Jupiter in 1996. It studied Jupiter and its moons. We learned from data sent back to Earth from the Galileo probe that the winds are stronger on Jupiter than the winds on Earth.

ASTRONOMY & SPACE

Planet	Planetary Day (rotation on axis)	Planetary Year (revolution around sun)	Distance from the sun	Number of moons
Earth	24 hours	365 Earth days	93 million miles (149.6 million km)	1
Jupiter	9.8 hours	about 12 Earth years	483.6 million miles (778.3 million km)	63 (to date)

Saturn

Saturn is the sixth planet from the sun. It is the second largest planet in the solar system. Saturn is one of the four gas giant planets. It is the farthest planet that we can see without the help of a telescope. Saturn is a lot like its neighbor planet, Jupiter. Both planets are made mostly of gases and neither one has a solid surface.

Saturn has a diameter of about 74,085 miles (119,300 kilometers). It is nine times wider than the Earth. Saturn takes over 29 Earth years to revolve around (orbit), the sun. Saturn's shape is like a ball squeezed flat on the top and bottom. Saturn spins very fast causing the flattened shape. It takes just over 10 Earth hours for the planet to rotate once.



Saturn's atmosphere exhibits a banded pattern similar to Jupiter. Saturn's bands are much less visible than Jupiter's.





Saturn spins very fast causing it to appear flat on the top and bottom.

Temperature

The average temperature on the surface of Saturn is very cold. It is about -290 degrees Fahrenheit (-179 degrees Celsius).

Atmosphere

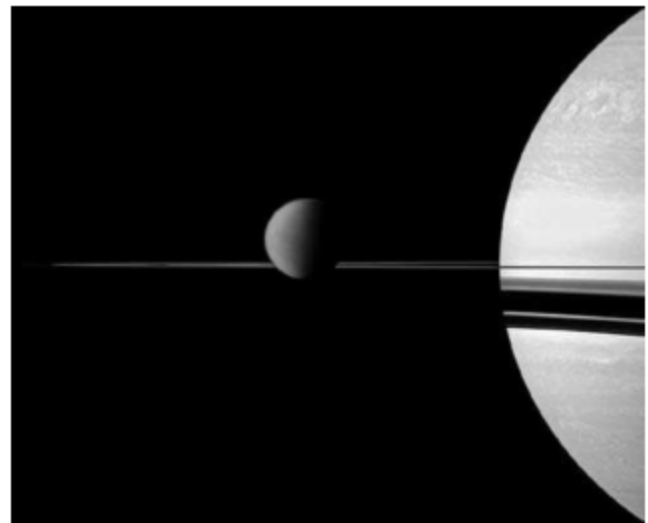
The atmosphere on Saturn is mostly hydrogen. There are also small amounts of helium and methane.

Strong winds blow across the surface of Saturn. These winds move very fast. Its clouds can move at about 1,100 miles per hour (1,800 kilometers per hour). There are wide bands of clouds. These clouds contain storms like those on Jupiter. A layer of haze

covers the upper atmosphere. This haze makes Saturn look yellow.

Moons

At least 56 moons orbit Saturn. Some are a few kilometers across. Others are the size of small planets. Titan is the largest moon of Saturn. It has a thick atmosphere covered in a brownish orange haze. Probes have detected nitrogen and methane on Titan. Many of Saturn's other moons have icy surfaces covered with craters. Some scientists believe that the moons of Saturn and Jupiter are where we might find evidence of simple life forms.



Titan is the largest moon of Saturn.

ASTRONOMY & SPACE

Planet	Planetary Day (rotation on axis)	Planetary Year (revolution around sun)	Distance from the sun	Number of moons
Earth	24 hours	365 Earth days	93 million miles (149.6 million km)	1
Saturn	10.2 hours	about 29 Earth years	886.7 million miles (778.3 million km)	56 (to date)

Special Features

Many people call Saturn the jewel of the solar system or the ringed planet because of its giant, beautiful rings. Galileo discovered the rings in the 17th century.

From Earth, we can see only three big rings. Saturn actually has thousands of small rings called ringlets. The rings are made mostly of ice particles, but

also contain dust and rocks. Some particles are as small as dust. Others are the size of a house. Saturn's rings are about .6 miles (one kilometer) thick. The gravitational pull of Saturn's moons gives the rings their shape.



Galileo Galilei
(1564–1642)

Exploration

The first spacecraft to visit Saturn was Pioneer 11, in 1979. Since then, Voyager 1 and 2 have flown past and studied the planet. In 2004, the Cassini space probe landed on the surface of Saturn's moon, Titan.



The Cassini space probe landed on Titan.

Words to know

band (band): a narrow ring of material that goes around something

haze (hayz): smoke, dust, or moisture in the air that prevents you from seeing very far

Uranus

Uranus is the seventh planet from the sun. It is the third largest planet in the solar system. Like Jupiter and Saturn, it is one of the gas giants.

The diameter of Uranus is 32,168 miles (51,800 kilometers). It takes Uranus 84 Earth years to orbit the sun. The planet rotates once every 17 Earth hours. Uranus does not spin around the sun like the other planets.



The size of Uranus is roughly 14.5 times that of the Earth.

It is tipped on its side and rolls around the sun like a barrel. We can't be sure, but scientists think Uranus is tipped because it was hit by a small planet or comet.

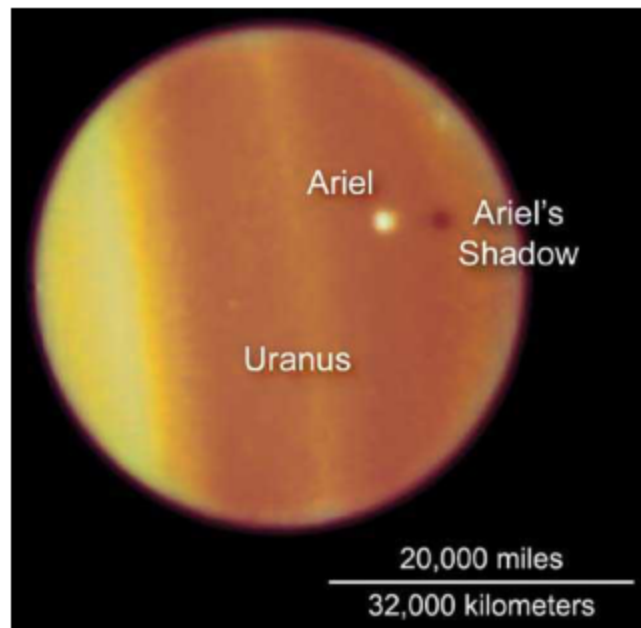
Temperature

Because it is so far from the sun, Uranus is very cold. The average temperature is about -355 degrees Fahrenheit (-215 degrees Celsius). Scientists do think that there is a layer of very hot water, ammonia, and methane on Uranus.

Like Earth, Uranus experiences changing seasons. Because Uranus is tilted on its side, a season lasts a very long time. One season on Uranus can last more than 20 years!

Atmosphere

The atmosphere on Uranus is made mostly of hydrogen, helium, and methane. Methane gives Uranus its blue-green color. Wind speeds on Uranus are much slower than on Saturn and Jupiter.



The methane in the atmosphere gives Uranus its blue-green color.

Moons

Uranus has at least 27 moons. Most of them are very small. The five large moons are mostly made of rock and ice. Miranda is the most unusual moon orbiting Uranus. It looks like a combination of many different pieces. Scientists think it may have been shattered as many as five times. The surface has craters and deep grooves unlike any other moon.

Special Features

In 1977, scientists discovered Uranus' rings. Scientists observed a star blinking on and off as it passed behind the planet. The blinking was caused by the rings blocking the starlight. Pictures taken in 1986 from the Voyager 2 space probe showed that Uranus' rings are made mostly of dark dust.

Exploration

Even though the Voyager 2 space probe launched in 1977, it did not reach Uranus until 1986. This was the first space probe to reach this distant planet. Since that time, we have learned more about Uranus from the Hubble Space Telescope.

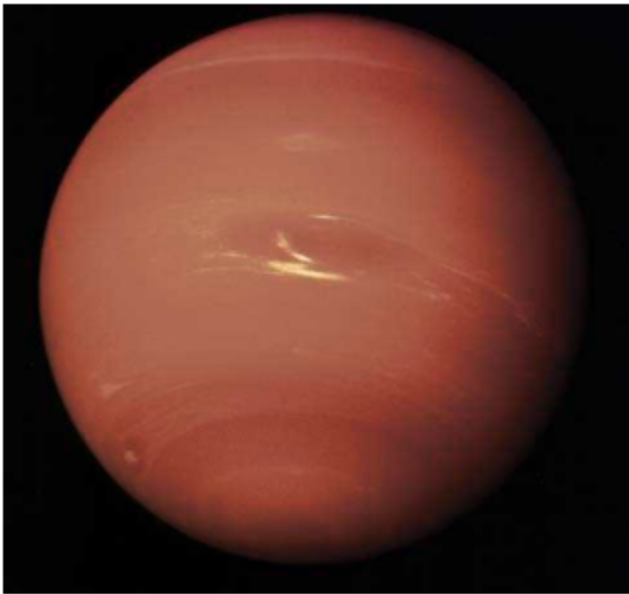
In 2014, observations with the Keck II telescope revealed ravaging storms on planet Jupiter. Astronomers say that the storm is still raging, although it had changed its shape, and possibly its intensity.

Also contributing to the effort was the Hubble Space Telescope, which examined the entire planet of Uranus Oct. 14, 2014 in several wavelengths. The observations revealed storms spanning several altitudes, over a distance of about 5,592 miles (9,000 kilometers).

Planet	Planetary Day (rotation on axis)	Planetary Year (revolution around sun)	Distance from the sun	Number of moons
Earth	24 hours	365 Earth days	93 million miles (149.6 million km)	1
Uranus	17.9 hours	about 84 Earth years	1,784 million miles (2,871 million km)	56 (to date)

Neptune

Neptune is the eighth planet from the sun. It is the smallest gas giant in the solar system. Neptune has a diameter of 30,740 miles (49,500 kilometers).



Neptune is the smallest of all the gas giants.

Neptune is very far away from the sun. Its average distance from the sun is 2.8 billion miles (4.5 billion kilometers). It orbits the sun once every 165 Earth years. In 2011, Neptune will complete its first orbit around the sun since scientists discovered it in 1846. A day on Neptune is just over 16 Earth hours.

If you want to see Neptune from Earth, you must use a telescope. Even with a telescope, Neptune can be hard to see. It looks like a very small bluish ball.

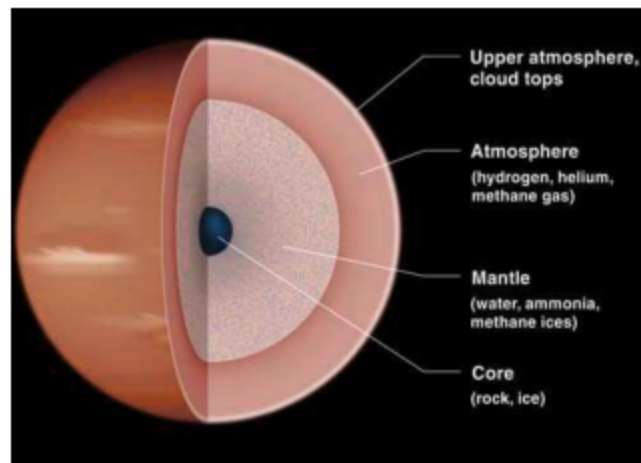
Temperature

Neptune has recorded some of the coldest temperatures in the solar system. It has an average temperature of -355 degrees Fahrenheit (-214 degrees Celsius).

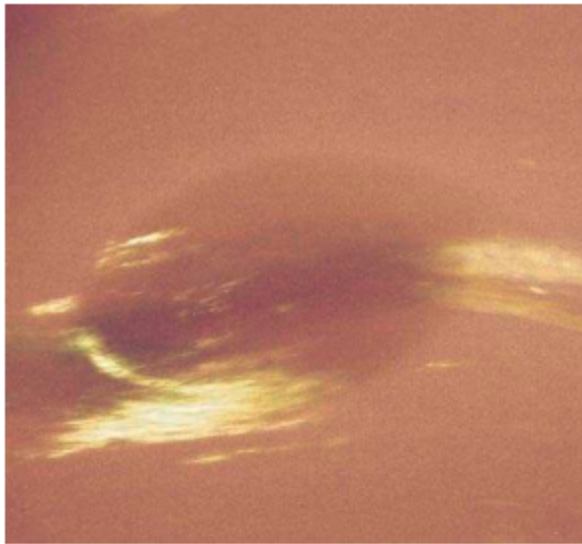
Atmosphere

The atmosphere on Neptune is made of hydrogen, helium, and methane. The methane in the upper layers gives the planet its blue color.

A good nickname for Neptune would be the windy planet. The strong wind rips through the atmosphere at 1,200 miles per hour (2,000 kilometers per hour). These winds are the strongest of any planet in the solar system. Thin white clouds move around the upper atmosphere. A giant storm, the Great Dark Spot continues to move across the surface. The storm is about the size of the Earth.



The layers of Neptune are very similar to those of Uranus.



The Great Dark Spot of Neptune is a storm similar to the Great Red Spot of Jupiter.

Moons

At least thirteen moons orbit Neptune. Triton is the largest moon. It orbits in the opposite direction of Neptune's other moons. This is a retrograde orbit. Triton has a thin atmosphere. The surface temperature of Triton is the coldest of any known moon or planet in the solar system.

The other moons of Neptune are much smaller than Triton.

Special Features

Neptune has rings like the other gas giants, Jupiter, Saturn, and Uranus. There are four rings in all. They are very faint and difficult to see.

Exploration

Neptune was the first planet identified by using mathematical predictions rather than by observation. Neptune was not actually seen until 1846, by astronomers J.G. Galle and Heinrich Louis d'Arrest.

In 1989, Voyager 2 became the first space probe to visit Neptune giving us our first chance to learn more about this distant planet.

Planet	Planetary Day (rotation on axis)	Planetary Year (revolution around sun)	Distance from the sun	Number of moons
Earth	24 hours	365 Earth days	93 million miles (149.6 million km)	1
Neptune	19.1 hours	165 Earth years	2,794.4 million miles (2,871 million km)	13 (to date)

The Dwarf Planets: Pluto, Ceres, and Eris

According to the International Astronomical Union, which sets definitions for planetary science, a dwarf planet is a celestial body that:

- *Orbits the sun.*
- *Has enough mass to assume a nearly round shape.*
- *Has not cleared the neighborhood around its orbit.*
- *Is not a moon.*

The first five recognized dwarf planets are Ceres, Pluto, Eris, Makemake, and Haumea. Scientists believe there may be dozens or even more than 100 dwarf planets awaiting discovery.

Pluto

In 1930, when astronomer Clyde Tombaugh discovered Pluto, he identified it as a very small planet. Astronomers classified Pluto as a planet for 76 years. Then on August 24, 2006, the International Astronomical Union (IAU) changed Pluto's label from a planet to a dwarf planet.

Scientists reclassified Pluto as a dwarf planet because there are other objects in its orbital path. Two other dwarf planets are Ceres and Eris.

Pluto's diameter is smaller than the Earth's moon. It has an elliptical orbit. Pluto's distance from the sun ranges between 2.7 and 4.6 billion miles (4.4 and 7.4 billion kilometers). From 1979 to 1999, Pluto was closer to the sun than Neptune. It takes Pluto 249 Earth years to orbit the sun once. Pluto orbits in what we call the Kuiper Belt.



A Planet	A Dwarf Planet	Small Solar-System Bodies
<ul style="list-style-type: none"> • is in an orbit around the sun • is big enough for gravity to squash it into a round ball • has cleared other things out of its orbital path 	<ul style="list-style-type: none"> • is in an orbit around the sun • is big enough for gravity to squash it into a round ball • has not cleared other things such as ice out of its orbital path • is not a satellite 	<ul style="list-style-type: none"> • are all other objects except for satellites orbiting the sun

ASTRONOMY & SPACE

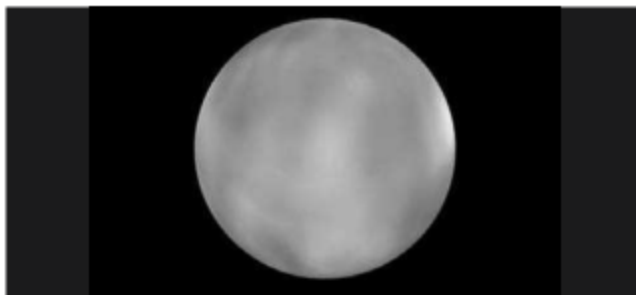
Pluto's Moons

Pluto has three moons. They are Charon, Nix, and Hydra.

Ceres

Ceres is the smallest dwarf planet. It is about the same size as Texas. It is the only dwarf planet in the main asteroid belt. Unlike most objects in the belt, Ceres is a sphere.

Scientists discovered Ceres in 1801. They first thought it was a planet, but then changed the classification to an asteroid. For another 150 years, scientists considered Ceres to be the



Ceres is the smallest dwarf planet in the solar system.

largest identified asteroid. In 2006, scientists upgraded Ceres to be a dwarf planet.

Eris

Although Eris is called a dwarf planet, it is the ninth largest object orbiting the sun. It is just slightly larger than Pluto. It has its own moon, Dysnomia. Scientists discovered Eris in 2005. Some astronomers initially called it the tenth planet. However, based on the definition developed by the IAU, it is recognized as a dwarf planet along with Pluto and Ceres.

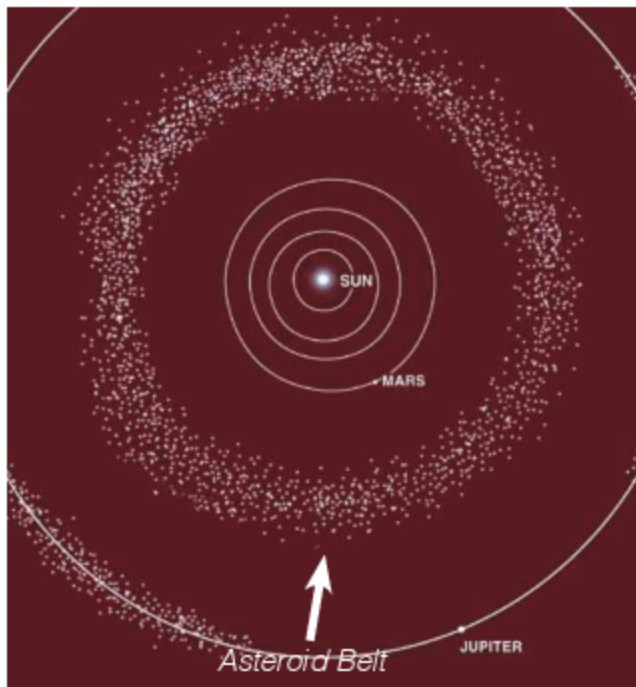
Eris is located in the outer regions of the Kuiper Belt, which is a band of small bodies orbiting the sun beyond Neptune.

Dwarf Planet	Diameter	Location	Number of moons
Pluto	1,143 miles (2,274 kilometers)	Kuiper Belt	3 (to date)
Ceres	590 miles (950 kilometers)	Asteroid Belt	0
Eris	1,489 miles (2,397 kilometers)	Kuiper Belt	1

Asteroids, Meteoroids, and Comets

Asteroids

Asteroids are objects that orbit the sun. They might also be called planetoids, minor planets or small solar system bodies. They are usually made of rock or iron, similar to the makeup of the four inner planets. Asteroids come in many different sizes and shapes. Some are large, but others are as small as pebbles. Most are in the asteroid belt between the orbits of Mars and Jupiter.



Ada's moon



Some asteroids even have moons. In 1993, the space probe Galileo found a moon orbiting the asteroid Ida.

Most scientists think asteroids are pieces of material left over from the formation of the solar system. Asteroids could be material that never formed into a planet.

Meteoroids

Meteoroids are large sand to boulder size pieces of debris in the solar system. Many meteoroids form when asteroids break apart. A meteoroid that hits the Earth's atmosphere usually burns up in a streak of light. This visible streak of light is a meteor. People sometimes call a meteor a shooting star. A meteorite is a meteor that strikes the Earth.

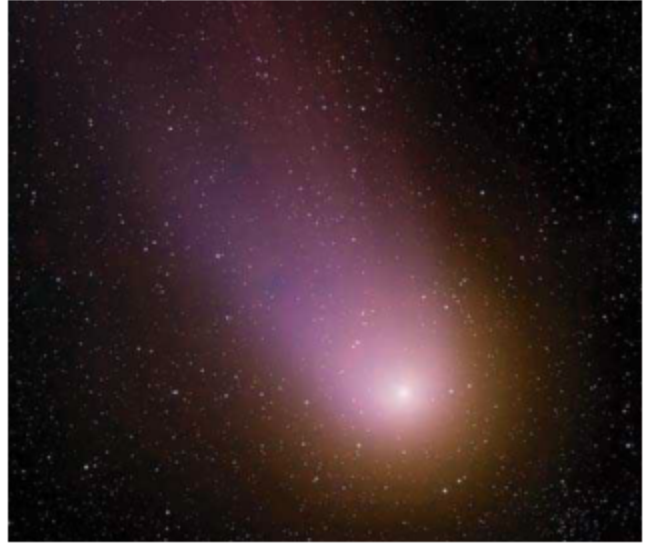


A falling star or shooting star is actually a meteor.

Comets

A ball of ice and dust particles that orbits the sun is a comet. A comet is like a giant, dirty snowball. The orbit of a comet is constantly changing. Sometimes, a comet orbits close to the sun and then will be thrown far out into space. Most comets are too faint to be seen without a telescope. We can see comets only when they are heated and illuminated as they near the sun. As the comet gets closer to the sun, the nucleus of the comet begins to melt. The melting particles following behind the comet are its tail. The tail can extend for millions of miles or kilometers away from the sun.

Between 1995 and 1997 the Comet Hale-Bopp was the clearest comet people on Earth had seen for over 100 years. It was so bright it could be seen without using a telescope. Unless you plan to live a very long time, you will



Most comets are too faint to be visible without the aid of a telescope.

not see Hale-Bopp again. Hale-Bopp won't be visible again from Earth for about 2,380 years!

Find out more

Halley's Comet

Perhaps the most famous comet of all is Halley's Comet. It was named after Edmond Halley, an astronomer and mathematician. Halley correctly predicted in 1705 that a certain comet would return in 1758.

Halley's Comet is visible every 75-76 years. The last time it was visible from Earth was 1986. Scientists predict Halley's Comet will be visible again in the year 2061. How old will you be the next time Halley's Comet passes near the Earth?

Because it looks like a huge fireball in the sky, many people used to think that Halley's Comet was a sign of bad luck. Some people even thought it was the end of the world!

Stars

On a clear night, you can see thousands of stars shining in the sky. From Earth, they seem to be small points of light. Yet many of them are larger than our sun. There are far more stars in space than you can see with the naked eye. There are so many that you could never count them all. Our sun is a medium sized star. It is one of the billions of stars in space.



Stars have been important for celestial navigation, orientation, and even for religious practices.

What Is a Star?

Stars are huge balls of spinning hot gas. Hydrogen and helium make up most stars including our sun. There are many different types of stars. Stars can differ in size, color, and brightness.

Constellations

Thousands of years ago, people saw shapes of animals and people in

the stars. We call these groups of stars constellations because they form a pattern when viewed from Earth. Today, constellations describe the positions of stars. People have divided the stars into 88 constellations as a way to identify and locate stars.

Magnitude

As you look into the night sky, you will see that some stars seem brighter than others. We call the brightness of a star its magnitude. Scientists give stars numbers to show how bright they are. Dim stars get high numbers. Bright stars get low numbers. Some stars are so bright their magnitudes are negative numbers.

If a star has a magnitude of six or less, we can see it from Earth without a telescope.



The apparent brightness of a star is measured by its magnitude.

Well Known Constellations



ORION. This constellation looks like a hunter with his bow drawn.



THE BIG DIPPER. Many people think the Big Dipper is a constellation, but it is not. It is a group of stars in the constellation Ursa Major.



URSA MAJOR. Also known as the Great Bear. If you look closely, you can see that the tail of the bear is made from the same star pattern as the Big Dipper.



GEMINI. These stars look like twins holding hands.

Distance between Stars

The stars look very close together as we view them from Earth. In fact, stars are very far apart. We measure a star's distance from Earth in light years. One light year stands for how far light can travel in a year. One light year is equal to about 5.9 trillion miles (9.5 trillion kilometers).

The closest star to Earth is the sun. It is 93 million miles away. The next closest star is Proxima Centauri. It is about 4.2 light years away from Earth. That is about 25 trillion miles (40 trillion kilometers) away!

Types Of Stars

Stars come in many different sizes and colors. We call big stars giants and small stars dwarfs. Astronomers give each star a letter that describes the size, color, and temperature of the star. The types of stars are O, B, A, F, G, K, and M. Type O stars are big and hot. Type M stars are much smaller and cooler.

Blue giants are Type O stars. They are very bright and blue in color. Red dwarf stars are Type M and live long lives. Our own sun is a Type G, or yellow, star. All these types of stars are identified as main sequence stars. All main sequence stars are in a stable time of their lives.

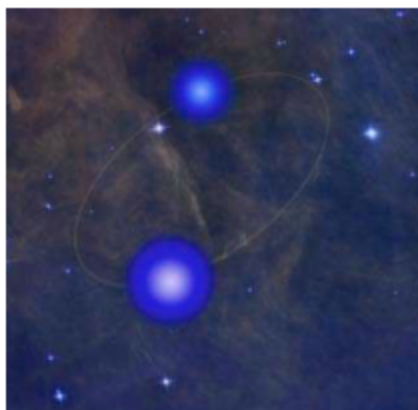
Stars in green are visible without the use of a telescope.

The Ten Closest Stars Outside Our Solar System

Star Name	Distance from Earth (in light years)	Magnitude (lower numbers are brighter)
Proxima Centauri	4.2	11
Alpha Centauri A	4.3	-0.01
Alpha Centauri B	4.3	1.3
Barnard's Star	5.9	9.5
Wolf 359	7.7	13.5
Lalande 21185	8.2	7.5
Sirius A	8.6	-1.5
Sirius B	8.6	8.4
Luyten A	8.7	12.5
Luyten B	8.7	13



A red giant

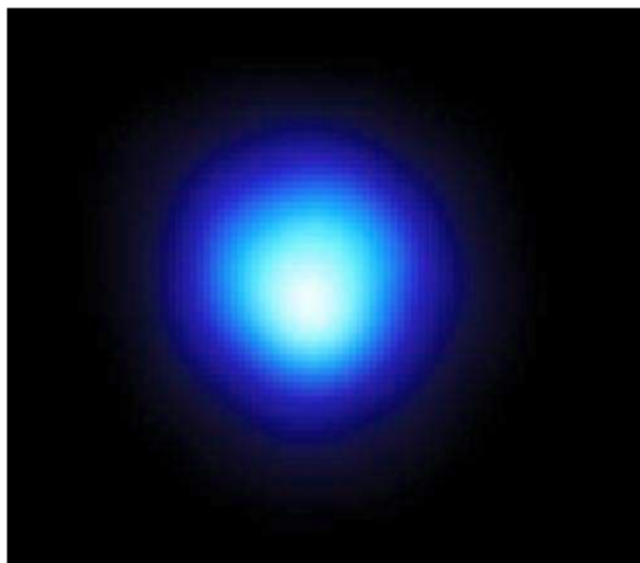


A brown dwarf



A white dwarf

Supergiants are the largest stars in the sky. The largest supergiants are the red supergiants. They appear very bright because they are so big. The star Betelgeuse is a red supergiant over 800 times bigger than the sun.



Betelgeuse is the second brightest star in the constellation Orion.

It might surprise you to know that the supergiants have a shorter life span than smaller stars. Their size makes them hotter than other stars making them burn out faster.

Cecilia Payne-Gaposchkin (1900-1979)



Getting to know...

Cecilia Payne-Gaposchkin was born in England in 1900. Because girls were not taught science in school, she taught herself. Payne attended Cambridge University. She moved to the United States to work at the Harvard Observatory and to teach at the university. She was called an assistant because women could not join the faculty.

Payne-Gaposchkin studied the spectra of stars. She realized that all stars are made mostly of hydrogen and helium. She discovered that the variation among stars comes from different temperatures, not different elements. The light from each element creates a unique set of colored lines called spectra.

The Life Cycle of a Star

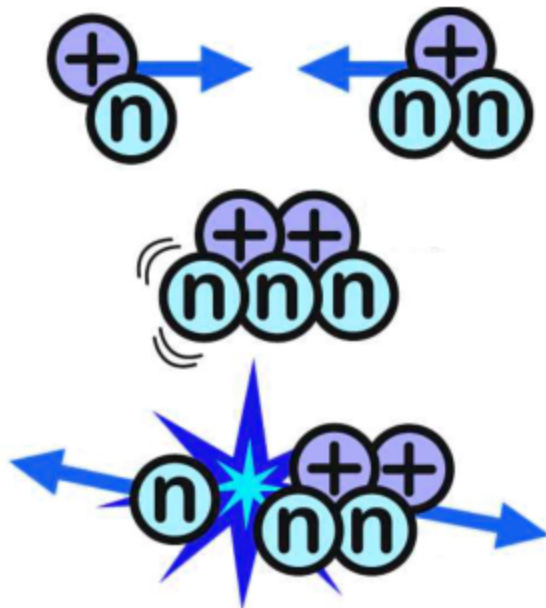
Stars do not live forever. They are born, shine for a period of time, and then eventually go out.

Birth of a Star

A cloud of dust and gas, called a nebula, begins to form in outer space. Over time, the cloud becomes so massive that gravity makes it collapse in on itself. When it does, it becomes a star.

Life of a Star

A star spends most of its life in a stage called main sequence. During this stage, a star gives off energy and light from nuclear fusion. It will shine energy into space.



Nuclear fusion is the process where multiple atomic particles join together to form a heavier nucleus. It is accompanied by the release of energy.

Nebulas

Cat's Eye Nebula



Veil Nebula



Helix Nebula

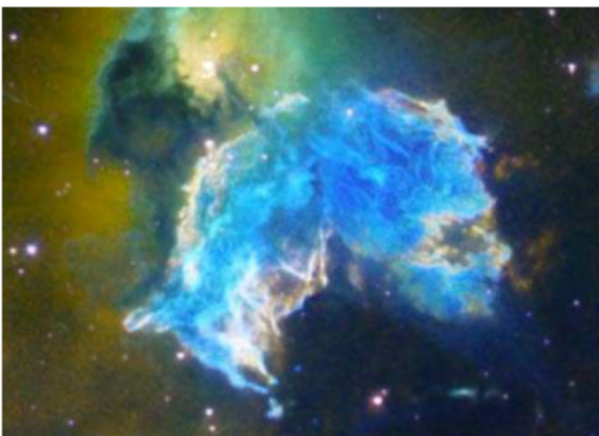


Death of a Star

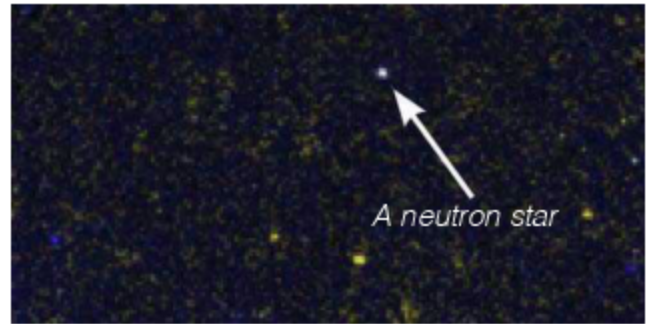
Stars like our sun have a predictable life cycle. Over time, our sun will burn up most of its hydrogen. It will cool a little and start to shrink. It will then start to use helium as fuel and grow into a red giant. Eventually the sun will swallow up Mercury and Venus. Once the sun uses up the helium fuel, it will shrink into a tiny white dwarf star. The sun will then completely cool and stop shining. Don't worry, this won't happen for another five billion years or so!

A dying star that has a core with two to three times more mass than our sun will eventually collapse in on itself. The material of the star collapses so quickly that it creates an explosion called a supernova. From the Earth, supernovas look like bright lights in the night sky.

A supernova may leave behind a neutron star. In a neutron star, all the



A supernova is an explosion of a dying star.



material is pressed into a dense ball only a few miles or kilometers across.

Neutron stars sometimes give off light at regular intervals as they spin. We call these stars pulsars.

Nebulas may form from the particles given off by the stars collapse. Over time, these nebulas can form into new stars.

A dying star that has a core greater than three times the mass of our sun will collapse into a black hole. The gravity of a black hole is so strong that even light can't escape. It looks black because no light gets out. Most scientists believe that a few black holes have been detected orbiting distant stars. They suck in material from the star and then throw it out into space at a rate near the speed of light.

Words to know

dense (denss): crowded or thick

nuclear fusion (NOO-klee-ur FYOO-zuhn): the release of energy when atoms are combined, or fused, together

Galaxies

A galaxy is a system of dust, gas, and stars that collects over a very large area. Gravity binds the objects in a galaxy together. Within each galaxy are billions of stars.

Types of Galaxies

The four basic shapes of galaxies are elliptical, spiral, barred spiral, and irregular. Elliptical galaxies are the most common type. Spiral galaxies, barred spiral galaxies, and irregular galaxies are less common.

Galaxy Shapes

Elliptical galaxies usually contain many old stars. Often, these stars are red giants and are near the ends of their lives. Some elliptical galaxies are shaped like spheres, while others are shaped like footballs.



Spiral galaxies have gigantic arms of stars that spread out, or radiate, from a center filled with stars. The bright stars in the center are red giants. Most of the bright stars in the arms are hot, young blue stars. All the stars in a spiral galaxy orbit the center.



Barred Spiral galaxies have two spiral arms connected by a bar of stars in the center.



Irregular galaxies look like a cloud of stars. They have odd shapes unlike elliptical and spiral galaxies.



ASTRONOMY & SPACE

Scientists believe that stars in a galaxy will group, or cluster, together in two different ways.

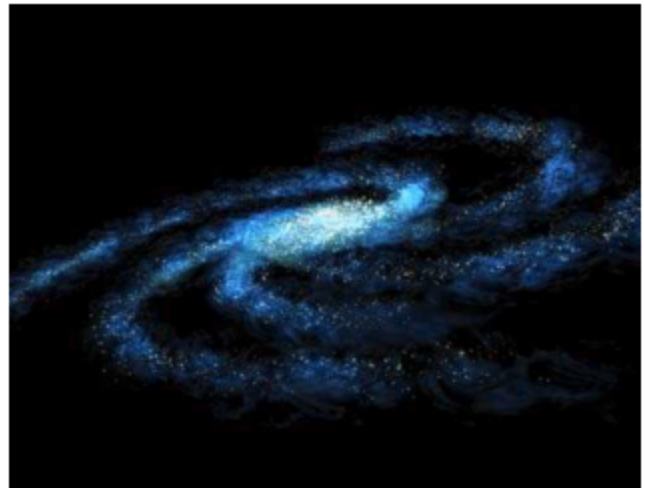
	Open Clusters (Galactic Clusters)	Globular Clusters
Number of stars	From a few stars up to thousands of stars	Thousands to millions of stars
Gravitational bind	Loosely pulled together	Tightly pulled together
Age	Less than a few hundred million years old	10 to 16 billion years old
When viewed from Earth	Individual stars can be seen and look bright	Individual stars can be seen and look dim

The Milky Way

Our galaxy, the Milky Way, is one of many galaxies in a large group of galaxies called the Local Group. Some scientists think the Milky Way is a spiral galaxy, while others think it is a barred spiral galaxy.

Many stars group together near the center of the galaxy. Giant arms of stars spread out from the center. The sun is one of billions of stars in the Milky Way. Our solar system is nestled in one of the spiral arms about 32,000 light years away from the center.

The Milky Way is over 140,000 light-years across. It is also nearly 2,000 light-years thick. It will take our



A galaxy may contain star systems and interstellar clouds and may have different shapes.

solar system nearly 230 million years to complete one orbit of the galaxy's core.



The Milky Way as seen from Death Valley. The best time of year to view the Milky Way from the Northern Hemisphere is between July and September.

If you look at the sky on a very clear night, you may be able to see the light of a billion distant stars in a milky path. This path of light is our galaxy.

Other Galaxies

Billions of galaxies fill the void of outer space. Many of these galaxies are grouped together. The Milky Way belongs to a cluster of galaxies known as the Local Group. It contains about

21 galaxies. The Local Group is part of a large supercluster of galaxies called the Virgo Supercluster.

The Milky Way has two irregular companion galaxies called the Small Magellanic Cloud and the Large Magellanic Cloud.



The Milky Way and Andromeda galaxies are part of the Virgo Supercluster.



The Large Magellanic Cloud is a dwarf galaxy that orbits the Milky Way.



The Small Magellanic Cloud is a galaxy that belongs to the Local Group along with the Milky Way.

Find out more



Galaxies Can Collide

Sometimes, the huge gravity created by galaxies can make them collide, or hit each other! Their stars do not actually bump into each other, but the particles in their gas clouds do collide. These collisions may cause many new stars to form.

The Andromeda galaxy is the closest spiral galaxy to the Milky Way. You can see the Andromeda galaxy on a very clear night as a fuzzy spot in the sky.



The Andromeda galaxy is a spiral galaxy about 2.5 million light years away.

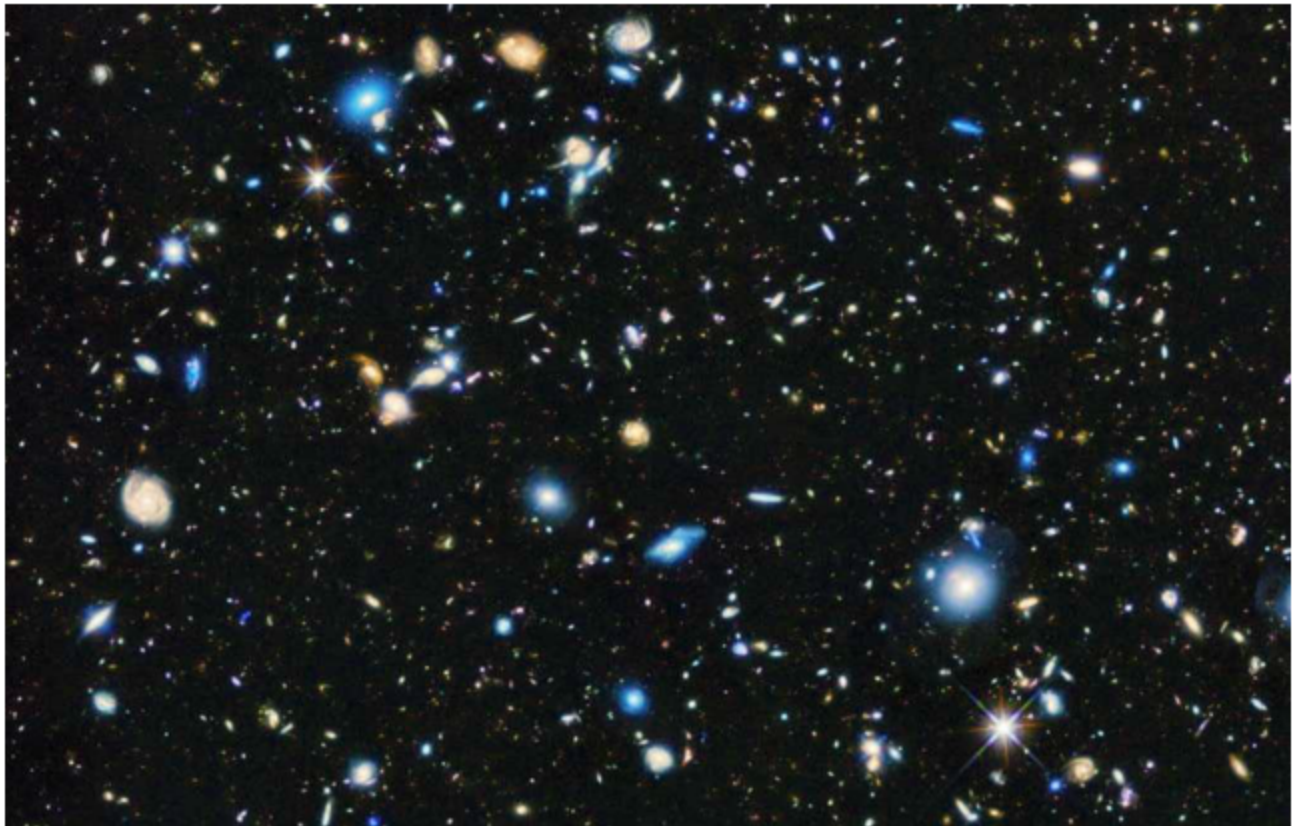
The Universe

The universe is everything. It contains all galaxies, stars, planets, and matter that have ever existed or ever will exist. Everything you can possibly think of is part of the universe. The cosmos is another word for universe.

It is impossible to imagine the size of the universe. Think of words like huge, gigantic, enormous, and vast. The universe is bigger than all those words put together!

The Earth is a tiny planet orbiting one of 400 billion stars in our galaxy. There are over 100 billion galaxies.

We are only beginning to understand how the universe works. Scientists still have more questions about the universe. There are many more questions than there are answers. We don't know exactly how galaxies form and where stars originate. Theories about the universe are constantly being developed and tested. This is the nature of science. How we look at the universe will change as technological advances reveal more of the universe's secrets.

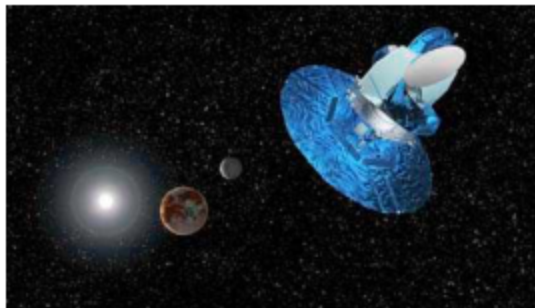


The universe contains all the galaxies, stars, planets, and types of matter. The universe continues to expand.

ASTRONOMY & SPACE

Origins of the Universe

Many scientists believe that the universe is between 15 and 20 billion years old. They believe this because nearly all the galaxies in the universe are traveling away from one another. Scientists can

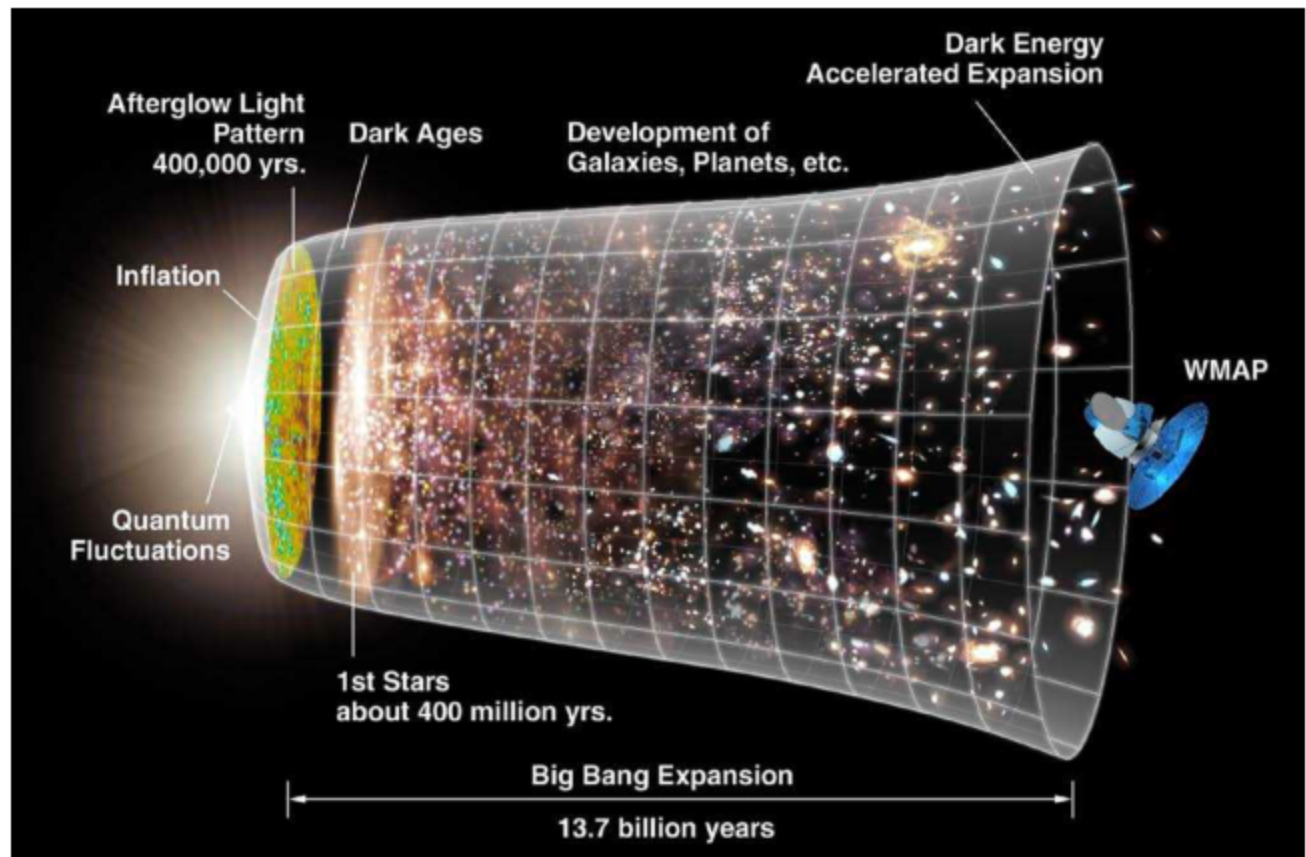


Satellites in space help collect data for scientists.

measure the rate at which the galaxies are moving apart.

The Big Bang Theory

Many scientists think that everything in the early universe was packed tightly into a single point. There were no galaxies, stars, or planets. Space, as we know it, did not exist. This single point was super hot and thick. Then this single point exploded. Scientists call this the Big Bang. Because of this huge explosion, the universe began to expand. This created matter, energy, space, and time.



A graphical representation of the expansion of the universe, courtesy of NASA (WMAP stands for Wilkinson Microwave Anisotropy Probe).

The Big Bang is a theory based on the motion of galaxies and many mathematical calculations. Scientists still measure cosmic background radiation that came from the Big Bang.

There are over 100 billion galaxies in the visible universe. Most of these galaxies belong to clusters and superclusters. These superclusters are groups of galaxies that are drawn together in groups. They stretch out across the universe and may span several hundred million light years. The patterns of these superclusters can tell scientists a lot about the early history of the universe.

Find out more

Dark Matter

Much of the universe is not visible even with the assistance of telescopes. Mathematical formulas and calculations help scientists figure out what is in outer space.

Astronomers have measured the amount of mass needed to hold galaxies together and to explain their motion through space. The number that they have calculated is far greater than the amount of material that has been observed. This "missing" mass is sometimes called dark matter.

Intergalactic space is the space between galaxies. It might contain a lot of dark matter. This matter may



The Local Supercluster contains our galaxy the Milky Way.

take the form of dust, cold gas, dead stars, or black holes. Maybe dark matter is something else. We don't know for sure.

Over the centuries, people have wondered why the night sky is not lit up with light from the billions of stars in the Milky Way and other galaxies. One explanation is that dark matter is common throughout the universe. It might block some of the light from distant stars and galaxies. We know that there are giant dark clouds around the Milky Way. Some light from distant stars cannot reach Earth because of these dark clouds.

Possible Ends of the Universe

Have you ever wondered if the universe will come to an end? If so, how do you think it will end? Scientists have several theories. The most common theories are the Open Universe Theory and the Closed Universe Theory.

The Open Universe Theory

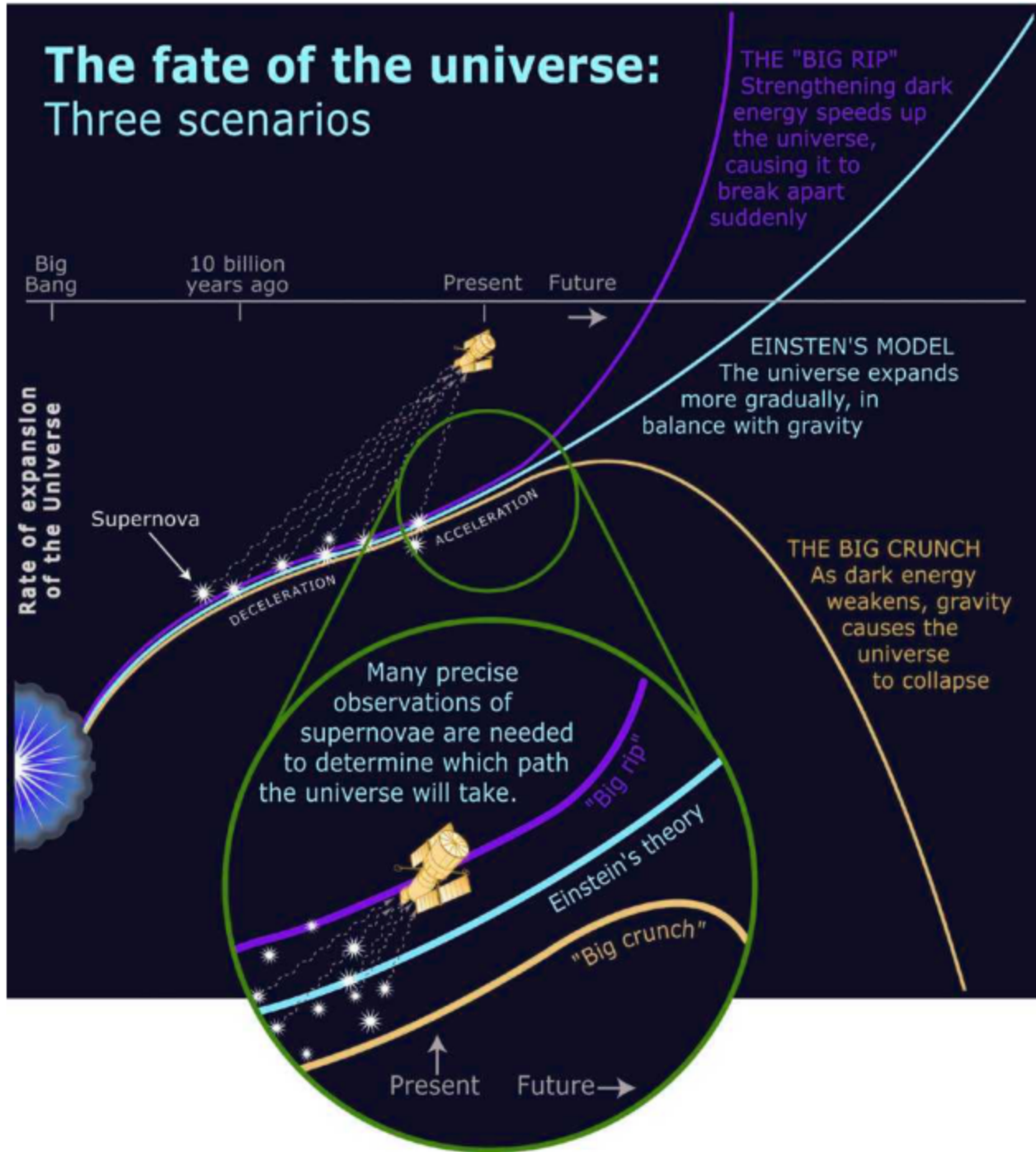
Some scientists think that the universe will continue to grow, or expand, forever. They believe that the galaxies will continue to move away

from each other. At some point, the continuous growth will use up all of the energy in the universe. When this happens, scientists believe the universe will end by getting too hot, too cold (the Big Freeze), or ripping apart (the Big Rip). Scientists call this the Open Universe Theory.

The Closed Universe Theory

Other scientists believe that the universe will stop expanding. They think that the gravity from all the galaxies combined with all the material in the universe will begin to pull the universe back together. The universe will start to shrink, or contract. Eventually, all the energy, matter, space, and time will come together, or collapse, in the Big Crunch. After the Big Crunch, another explosion might begin a new universe. Scientists call this the Closed Universe Theory.

So who is right? Is the universe open or closed? It all depends on how much matter is in the universe. Current measurements still allow for both possibilities but most data suggests the universe will not collapse.



There are many theories about how the universe will end.

Stephen Hawking (1942-)



Getting to know...

Stephen Hawking was born in England in 1942. In 1963, Hawking was diagnosed with amyotrophic lateral sclerosis. This fatal disease destroys the spinal cord and weakens the muscles. Hawking did not let this disease deter him from his passion for mathematics and physics.

Hawking earned a Ph.D. at Cambridge University. He began to study black holes. He found that they leak some radiation, which makes them become smaller. A black hole explodes if it gets too small, much like the Big Bang that started the universe.

Then in 1985, Hawking lost the ability to speak and began to use a computer voice. He became more famous after publishing *A Brief History of Time* in 1988. This book explains the origin of the universe to the public.

In 2005 at the age of 63, Hawking along with fellow physicist Leonard Mlodinow published *A Briefer History of Time*. This book seemed to be easier to read than the first book and this second version of the book provided more current and updated information.

Space Exploration

Humans have always had a need to explore. In ancient times, people could study only the places where they lived. They could only wonder about the rest of the world and what might exist in the universe.

Over the years, new technologies developed. With improved modes of transportation, we could explore more of the Earth. Today, with advanced mathematics, telescopes, unmanned spacecraft, and manned spacecraft, we have more options for exploring the universe.

Telescopes

One of the first tools that helped scientists study the sky was the telescope. There are many different types of telescopes, but all telescopes have one thing in common. They help us study things that are far away.

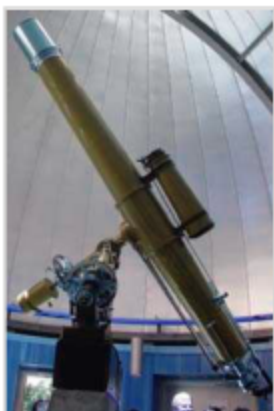


A refractor telescope

Telescopes Used For Astronomy

Optical telescopes

gather light to create images. These telescopes are used for astronomy. If you look at a tree through an optical telescope it will appear upside down.



X-ray and gamma-ray telescopes

can be difficult to use. They are usually used on satellites or high-flying balloons.



The Gamma-ray Large Area Space Telescope, or GLAST.



Radio telescopes gather very quiet sounds from space using large dishes and antennas.



Space telescopes are out in space. Space telescopes can see things and hear things that are too far away or blocked from the view of telescopes on Earth.

Space Probes

A space probe is an unmanned spacecraft that collects information about outer space. The 1950s marked the beginning of the use of space probes to study the Earth, its moon, the other planets, and the universe. They can be

as small as a coffee can or bigger than a bus. Some probes send pictures back to Earth. Others provide different kinds of information. For example, a probe may explore the surface of a moon or planet.

The earliest probes simply orbited the Earth or the moon. Later probes explored other planets.

Edwin Powell Hubble (1889-1953)



Getting to know...

Edwin Powell Hubble was born in Missouri in 1889. His family moved to Chicago in 1898. In high school, Hubble earned good grades but excelled in sports. After high school, he studied astronomy and mathematics at the University of Chicago. Hubble studied law, coached basketball, and taught physics and Spanish. Then he decided to pursue astronomy as a career.

Hubble worked at Yerkes Observatory in Wisconsin. It had a 40-inch refracting telescope, the largest in the world at that time. Hubble also used its 24-inch reflecting telescope to study nebulae.

In 1919, he went to Mount Wilson Observatory in California. It had a new 100-inch reflecting telescope. Using this telescope, Hubble proved the existence of other galaxies. He also introduced the classification system for galaxies. In 1929, he formulated Hubble's Law, which helped astronomers figure out the age of the universe and prove that the universe was expanding.

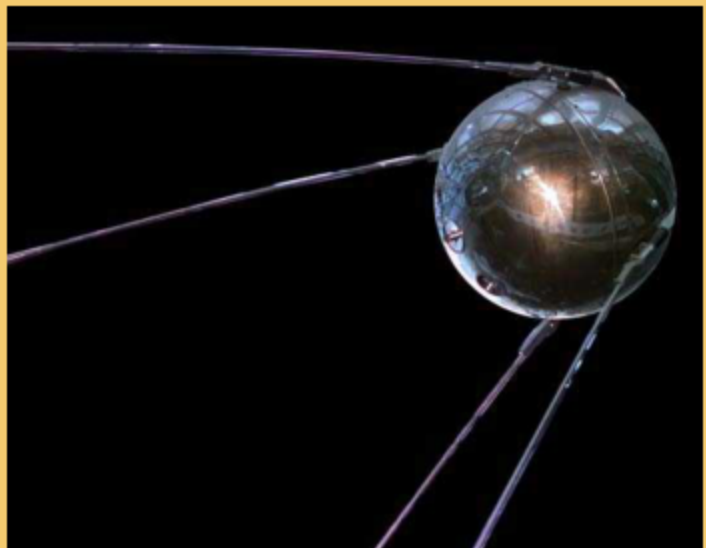
Hubble helped design the 200-inch reflecting telescope at Mount Palomar Observatory, in California. He died in 1953. The Hubble Space Telescope is named in his honor.

Find out more

The Sputnik Program

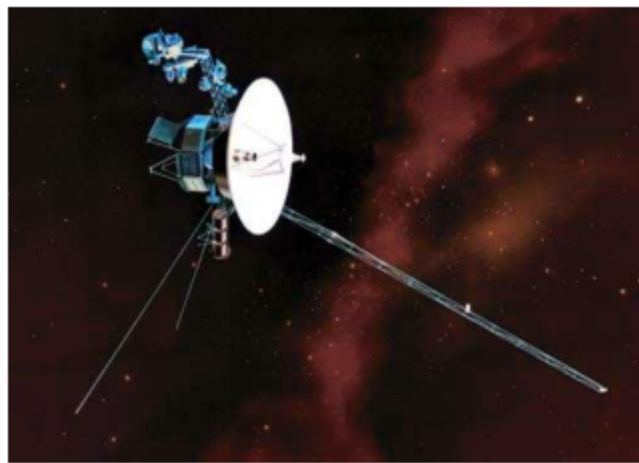
The Sputnik program was a series of unmanned space missions launched by the Soviet Union in the late 1950s. It included Sputnik 1, the first manmade object to orbit Earth.

1957, the Russian spacecraft called Sputnik 1 was the first manmade object ever to reach outer space.



Some probes just take pictures as they pass by planets. Others orbit planets and study them in more detail. Scientists drop probes into the atmospheres of other planets. A few probes even land on the surface of the planets and moons they are studying.

The Americans launched *Voyager 1* and *Voyager 2* in 1977. *Voyager 1* is the first probe ever to leave the solar system. It is the manmade object that has traveled the farthest away from Earth. Thirty years after launching, *Voyager 1* and *Voyager 2* continue to explore the deepest parts of the universe. Scientists with NASA's Deep Space Network communicate with the probes daily.



Voyager 1.

The Mars Pathfinder was launched on December 4, 1996 by NASA aboard a Delta II. After a 7-month voyage, it landed on Mars on July 4, 1997. The lander opened, exposing the rover, called *Sojourner*, that was used for many

different experiments on the Martian surface.

Humans in Space

Space has fascinated humans for centuries. Since the early 1960's, humans have traveled into orbit around the Earth. By 1969, humans had walked on the moon.

Astronauts and cosmonauts are men and women who travel into space. Many astronauts travel into the local space around the Earth. Some stay for a few days. Others remain in space for several months.

Launched in 1973, Skylab was the first American space station. In 1986 the Russians launched the space station Mir. Initially, satellites and rockets were launched to transport astronauts and supplies to the space stations. Now we use space shuttles.

Today many countries work together to man, build, and maintain the International Space Station (ISS).

ASTRONOMY & SPACE

A History of Manned Spaceflight

April 12, 1961	Yuri Gagarin becomes the first human in space aboard Vostok 1.
May 5, 1961	Alan Shepard Jr. becomes the first American in space aboard Freedom 7.
February 20, 1962	John Glenn becomes the first American to orbit the Earth aboard Friendship 7.
June 16, 1963	Valentina Tereshkova becomes the first woman in space aboard Vostok 6.
July 20, 1969	Neil Armstrong and Buzz Aldrin become the first humans to land and walk on the moon.

A History of the United States Space Shuttle Program

April 12, 1982	John Young and Robert Crippin are pilots of Columbia, the first space shuttle.
June 18, 1983	Sally Ride became the first American woman in outer space, aboard the space shuttle Challenger.
August 30, 1983	Guion S. Bluford became the first African-American astronaut in outer space.
January 28, 1986	The space shuttle Challenger was destroyed after launch. All the astronauts, including teacher Christa McAuliffe, were killed.
September 29, 1988	Discovery is the first space shuttle launched after the Challenger disaster.
February 1, 2003	The space shuttle Columbia broke apart when it re-entered Earth's atmosphere, killing all the astronauts.
July 26, 2005	Eileen Collins commands the first space shuttle mission since the Columbia disaster.
August 8, 2007	Teacher and astronaut, Barbara Morgan, is the first teacher in space aboard the space shuttle Endeavour.
February 24, 2011	Shuttle Discovery launches on its 39th and final flight with the last U.S. module for the space station. The shuttle is promised to the Smithsonian National Air & Space Museum.
May 16, 2011	Shuttle Endeavour launches on its 25th and final flight with the \$2 billion Alpha Magnetic Spectrometer particle detector. The shuttle is promised to the California Science Center in Los Angeles.
July 8, 2011	Shuttle Atlantis is scheduled to launch on the 135th and final flight in the 30-year-old program, a 12-day cargo run to the space station. The shuttle will be staying at the Kennedy Space Center in Florida, becoming a permanent exhibit at the Visitors Center.

The ISS has been home to many different astronauts and cosmonauts from around the world since November 2, 2000.

Space is not an easy place for humans to live. There is no air. Humans must stay inside spaceships or special space suits. This protects them from the harsh conditions of outer space. People are also weightless in

outer space. This poses challenges to human health.

The conditions of space are unique. People can perform laboratory experiments and study things that are difficult or impossible to study on Earth.

People Who Study Space

Astronomers are people who study the sky. They make a career out of studying the sky. Amateur astronomers look at planets, stars, and galaxies as a hobby.

Astrophysics deals with the behavior and physical properties of all the objects in space.

Cosmology studies the origin and structure of the universe itself.

Scientists who study the sky use mathematics to predict the paths of planets, asteroids, and comets.

Advanced forms of mathematics like chaos theory are used to describe the motions of galaxies and to explain the origins of the universe.

Astronauts who travel into space have backgrounds in physics, chemistry, medicine, and engineering. Mechanical engineers and electrical engineers design and build spaceships, probes, and space stations. People in all different fields of science study space and our place within it. Someday you may work in space, discover new information about the universe, or develop technology to be able to live on another planet!

Words to know

chemistry (KEM-is-tree): the scientific study of substances

physics (FIZ-iks): the science that deals with matter and energy

properties (PROP-ur-teez): special qualities or characteristics

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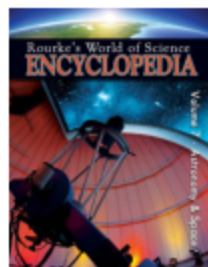
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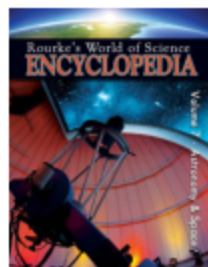
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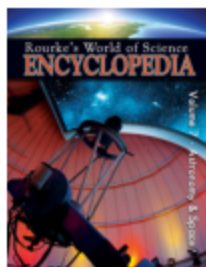
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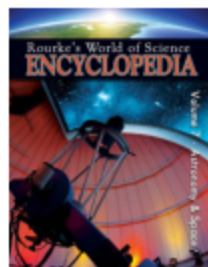
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