

ILLUSTRATED ENCYCLOPEDIA



SPACE



More than 200 keywords

ILLUSTRATED ENCYCLOPEDIA

SPACE



ILLUSTRATED ENCYCLOPEDIA

SPACE

First published in 2012 by Orpheus Books Ltd.,
6 Church Green, Witney, Oxfordshire, OX28 4AW, England
www.orpheusbooks.com

Copyright ©2012 Orpheus Books Ltd.

Created and produced by Nicholas Harris, Sarah Hartley,
Katie Sexton, Ruth Symons and Erica Williams, Orpheus Books Ltd.

Text Ruth Symons

Illustrated by Sebastian Quigley and Gary Hincks

Consultant David Hawksett, astronomer, writer and broadcaster

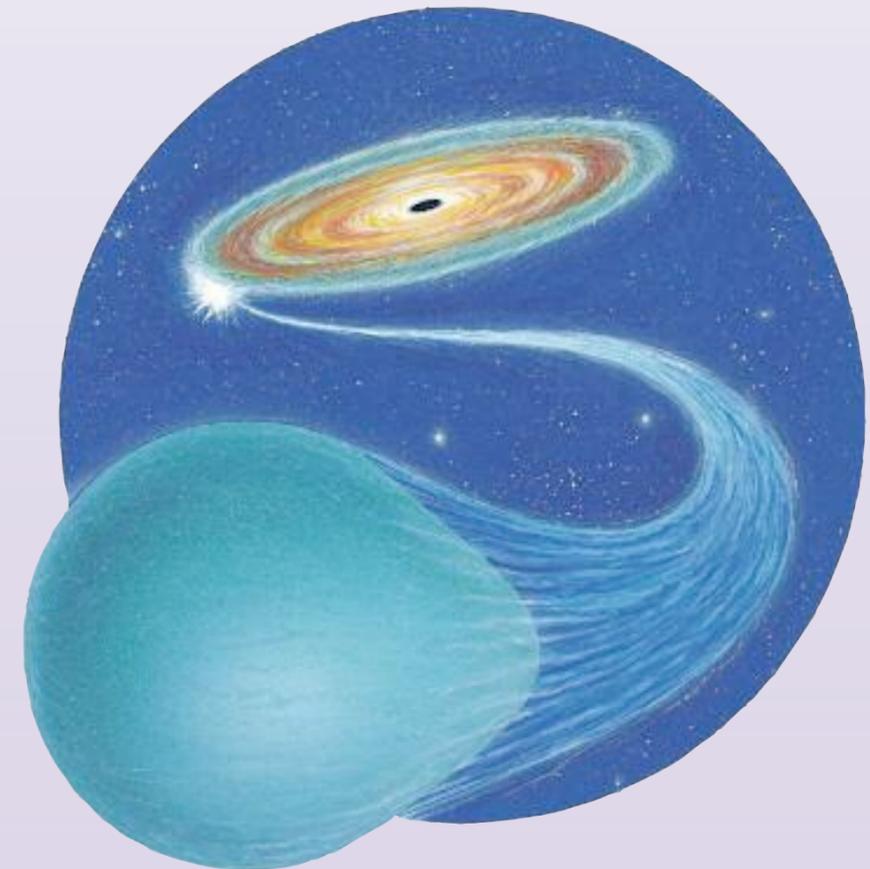
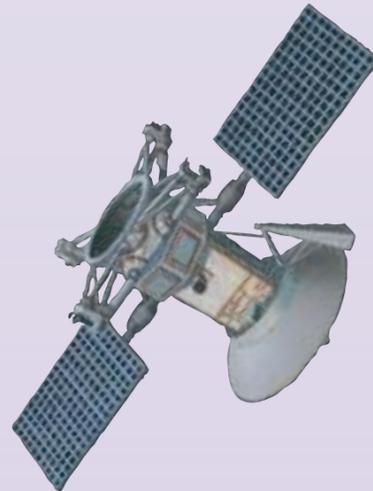
All rights reserved. No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of the copyright owner.

ISBN 978 1 7418 3768 1

Printed and bound in Singapore

Photograph on page 22: NASA

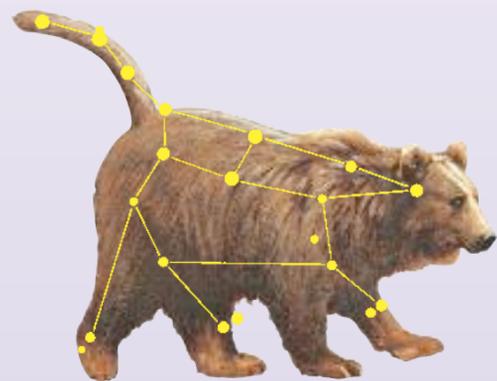
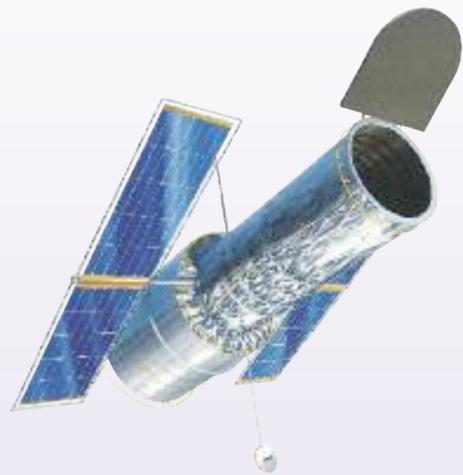
Photograph on page 27: Science Photo Library



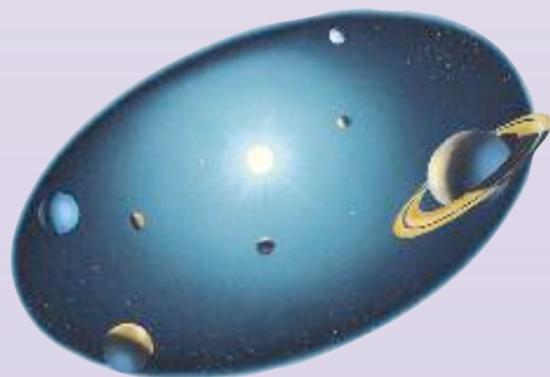
 Orpheus

CONTENTS

ASTRONOMY	6
THE SOLAR SYSTEM	8
THE SUN	10
THE MOON	12
MERCURY, VENUS & MARS	14
JUPITER & SATURN	16
URANUS & NEPTUNE	18
ASTERIODS & COMETS	20

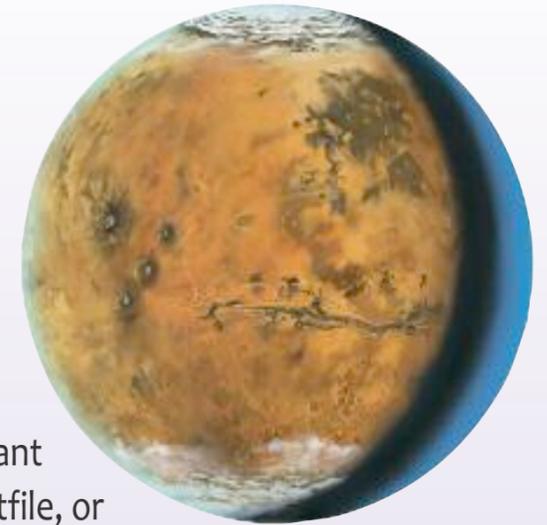


STARS	22
CONSTELLATIONS	24
GALAXIES	26
THE UNIVERSE	28
INDEX	30



ABOUT THIS BOOK

Each double page contains a brief introduction, explaining the general subject, followed by key words arranged in alphabetical order. To look up a specific word, turn to the index at the back of this book: this will tell you which page to go to. If you want to learn more about a subject, take a look at the factfile, or follow the arrows to read related entries.



INTRODUCTION
This explains the general subject and provides some basic knowledge.

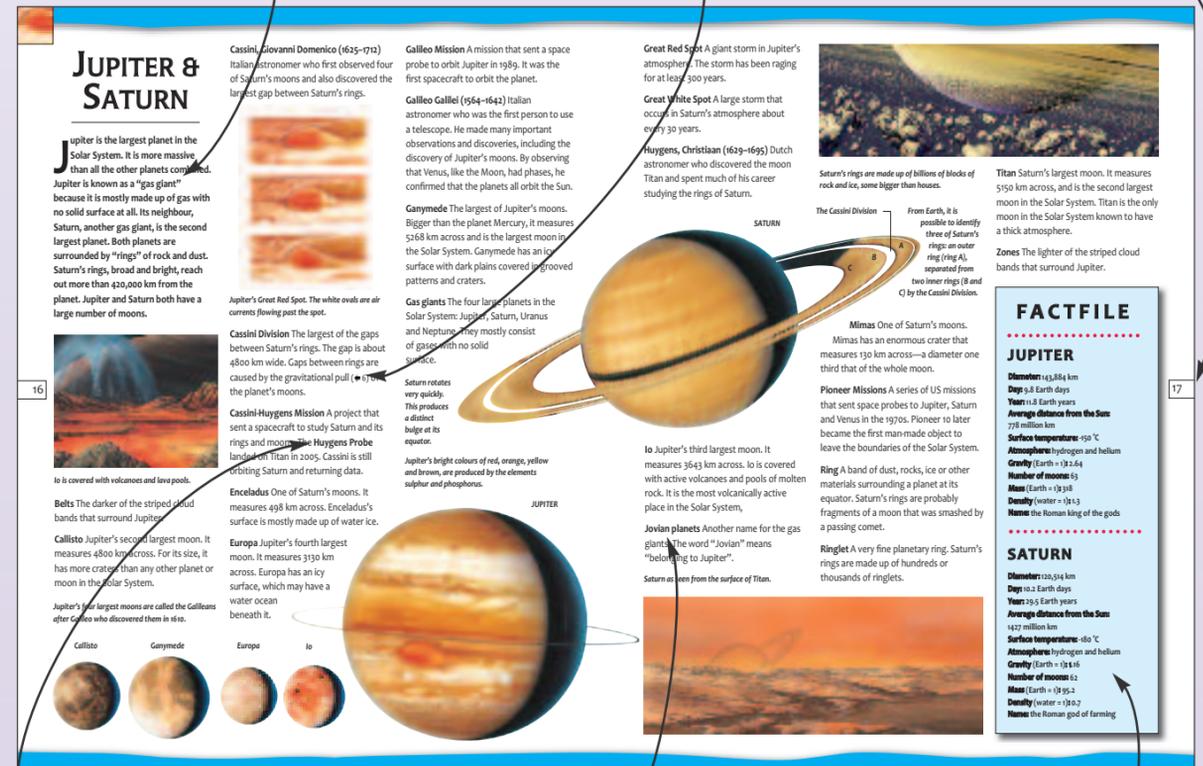
ARROWS
These arrows show you where to look up other words mentioned in the entry. For example, (→26) tells you to go forward to page 26 and (←6) tells you to turn back to page 6.

PAGE NUMBER
Page numbers are easy to find at the side of the page.

BOLD WORDS
These highlight useful words that do not have their own entry.

KEY WORDS AND ENTRIES
Key words are arranged alphabetically across each double page. Each entry provides a short explanation of what the key word means.

FACTFILE
The factfile provides extra information on the subject. Facts are presented in easy to read bullet points.



FACTFILE	
JUPITER	
Diameter:	142,884 km
Days:	9.8 Earth days
Year:	11.8 Earth years
Average distance from the Sun:	778 million km
Surface temperature:	-120 °C
Atmosphere:	hydrogen and helium
Gravity (Earth = 1):	2.4
Number of moons:	15
Mass (Earth = 1):	318
Density (water = 1):	1.3
Name:	the Roman king of the gods
SATURN	
Diameter:	120,514 km
Days:	10.2 Earth days
Year:	29.5 Earth years
Average distance from the Sun:	1,427 million km
Surface temperature:	-150 °C
Atmosphere:	hydrogen and helium
Gravity (Earth = 1):	1.1
Number of moons:	62
Mass (Earth = 1):	95.2
Density (water = 1):	0.7
Name:	the Roman god of farming

ASTRONOMY

Astronomy is the study of space, including planets, stars and galaxies. We can see some objects in space with just the naked eye, but many more, including those that are billions of light years away, can only be studied by using a powerful telescope. Much of what we now know about the planets comes from space probes, which travel through space, sending information back to the Earth.

Albedo A measure of how strongly an object reflects light. A completely dark, non-reflective object has an albedo of 0, while an object that reflects all light that hits it has an albedo of 1. The Earth has an albedo of 0.36 and Venus has an albedo of 0.65.

Aphelion The point in an object's orbit when it is farthest away from the Sun.

Astronaut Someone who is trained to travel into space in a spacecraft.

Astronomical Unit (AU) The average distance between the Earth and the Sun. One AU is 149,597,871 km.

Atmosphere The envelope of gases surrounding a planet, moon or star.

Axis An imaginary straight line that runs through the centre of a planet, moon or star.

Celestial body Any natural object located outside of the Earth's atmosphere.

Conjunction The point when two celestial bodies appear to be in line with each other in the sky, for example when the Moon appears very close to a planet.

Core The innermost part of a planet, moon or star.

Crust The outer layer of a planet or moon.

Day The time that it takes a moon or planet to rotate once on its axis.

Density A measure of how compact something is. An object is denser than another if its atoms (p28) are larger or more closely packed together.



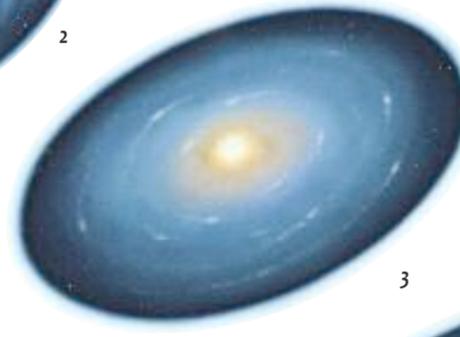
1

THE PLANETS FORM 1 A shock wave causes a cloud of gas and dust to collapse under its own gravity. 2 The collapsed cloud becomes a swirling disc of matter with a bulge at its centre. 3 Small fragments of rock clump together in blocks called planetesimals. 4 The core of the disc becomes a star. The solar wind (p9) strips the four inner planets of their original atmospheres. 5 The Solar System as it is today.



2

3 Small fragments of rock clump together in blocks called planetesimals. 4 The core of the disc becomes a star. The solar wind (p9) strips the four inner planets of their original atmospheres. 5 The Solar System as it is today.



3



4



5

Planetesimal A large lump of rock that orbited the Sun during the formation of the Solar System. The planetesimals collided with each other, eventually building up to form the eight planets of the Solar System.

Pressure The amount of weight, or force, bearing down on an object.

Revolve To spin in a circle around a central point or another object. For example, the Earth revolves on its axis once per day and revolves around the Sun once per year.

Magnetic field

The region surrounding a magnet, an object which has two ends, called **poles**, and a force of attraction between them. The Sun and some planets, including Earth, have magnetic fields.

Mantle The rocky layer that lies between the crust and core of a planet.

Mass A measure of the amount of matter (p28) an object contains

Moon A natural object that orbits a planet.

Orbit The circular or elliptical (oval-shaped) path that one object takes around another object. For example, the Moon orbits the Earth, while the Earth orbits the Sun.

Perihelion The point in an object's orbit when it is closest to the Sun.

Planet A large, round object that orbits the Sun. A planet does not share its orbit with any other objects.

Eclipse The passage of one celestial body in front of another, totally or partially hiding it from an observer.

Equator An imaginary line around a planet's middle, half way between its north and south poles.

Flyby The flight of a space probe very close to a planet or moon, from where it can obtain detailed images.

Gravity The force that attracts all objects to each other. The larger an object's mass, or the greater its density, the greater its **gravitational pull**. The greater the distance between objects, the smaller the force of gravity between them. Gravity is the force that keeps the planets in orbit around the Sun.

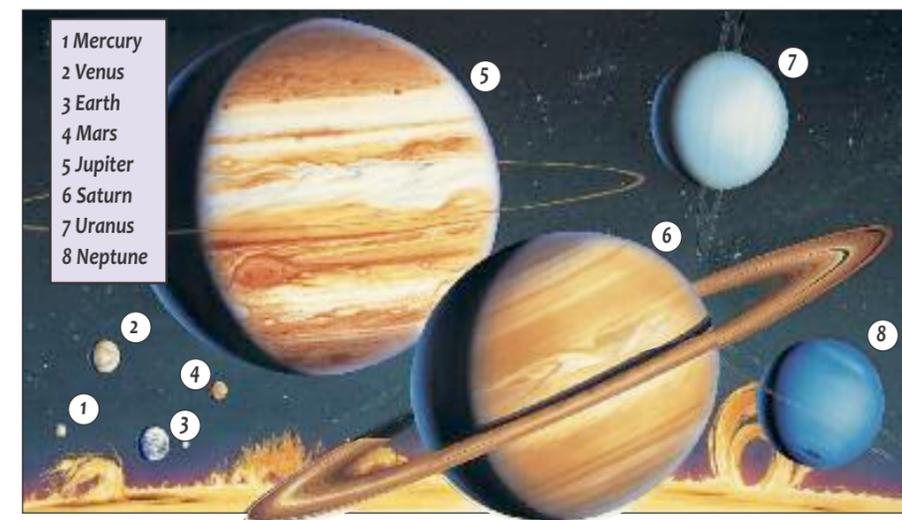
Heliocentric Centred around the Sun.

Lander A spacecraft designed to land on a planet, moon or asteroid in order to gather information from its surface.

Lava Hot molten, or melted, rock.

Light year The distance a ray of light travels in one year. One light year is approximately 9.46 million million km.

The diagram below shows the distances of the planets from the Sun measured in Astronomical Units (AU).



The planets illustrated to scale (above)



THE STORY OF ASTRONOMY



Nicholas Copernicus

★ Early cultures believed that the Sun and Moon were gods, the Earth was flat and the sky was a great dome suspended above it.

★ In later years astronomers from ancient Greece proved that the Earth was round. Greek astronomer, Aristarchus (310-230 BC), was the first to propose that the planets orbit the Sun. Most astronomers of his time thought that the Sun, Moon and planets travelled in circular paths around the Earth.

★ Polish priest and astronomer Nicolaus Copernicus (1473-1543) declared that the Sun lay at the centre of a system of the planets and only the Moon orbited the Earth.

★ German astronomer Johannes Kepler (1571-1630) showed that the planets moved in elliptical orbits.

★ Galileo Galilei (1564-1642) was the first astronomer to use a telescope. By observing that Venus, like the Moon, had phases (p13), he confirmed Copernicus's theory that the planets orbit the Sun.

Space probe An unmanned spacecraft guided from Earth. Some space probes have passed close to, entered orbit around or landed on other planets and moons.

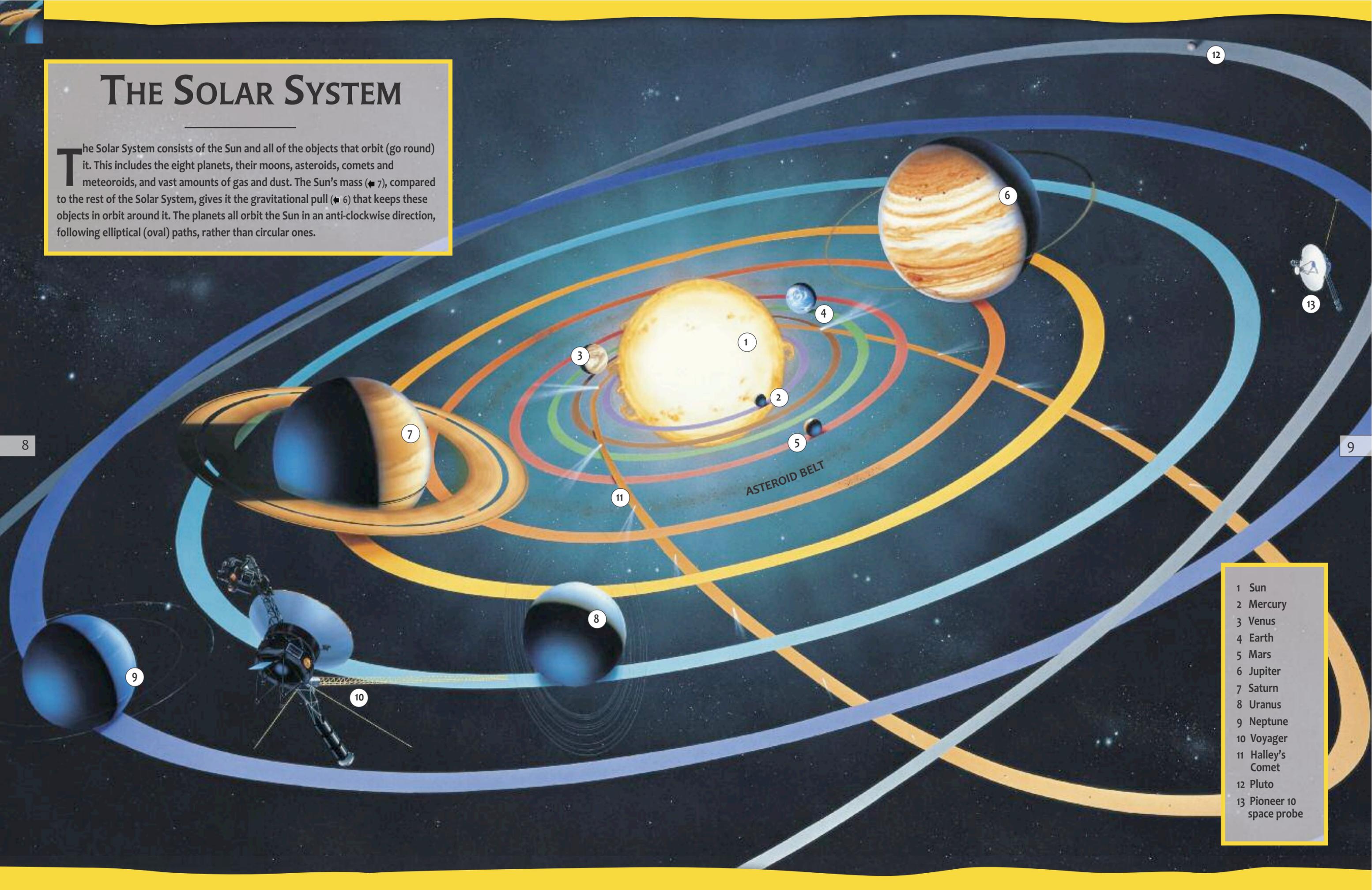
Telescope An instrument that makes distant objects appear closer.

Volcano An opening in a planet or moon's surface through which hot, molten rock and gases spurt out.

Year The time that it takes an object to complete one full orbit of the Sun.

THE SOLAR SYSTEM

The Solar System consists of the Sun and all of the objects that orbit (go round) it. This includes the eight planets, their moons, asteroids, comets and meteoroids, and vast amounts of gas and dust. The Sun's mass (7), compared to the rest of the Solar System, gives it the gravitational pull (6) that keeps these objects in orbit around it. The planets all orbit the Sun in an anti-clockwise direction, following elliptical (oval) paths, rather than circular ones.



- 1 Sun
- 2 Mercury
- 3 Venus
- 4 Earth
- 5 Mars
- 6 Jupiter
- 7 Saturn
- 8 Uranus
- 9 Neptune
- 10 Voyager
- 11 Halley's Comet
- 12 Pluto
- 13 Pioneer 10 space probe

THE SUN

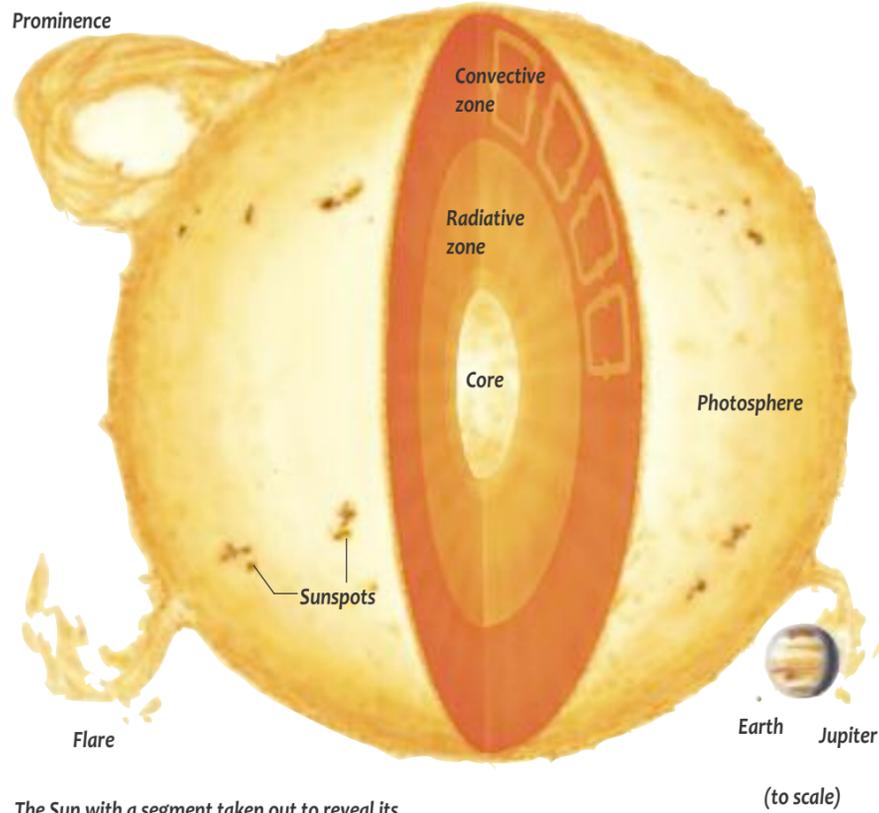
The Sun is a star at the centre of our Solar System. It is one of billions of stars in the Milky Way Galaxy, itself one of billions of galaxies in the Universe. Like all stars, the Sun is an enormous spinning globe of glowing gas that produces massive amounts of energy by converting hydrogen into helium. To us on Earth, the Sun is of crucial importance since no life could exist without it. The Sun is about 4.6 billion years old. It will keep shining for around another 5 billion years.

Chromosphere A thin layer of the Sun's atmosphere around 2000 km deep, just above the photosphere and beneath the corona. The chromosphere can reach temperatures of up to 20,000°C.

Convective zone The uppermost inner layer of the Sun. Hot gas bubbles up to the surface of the convective zone before sinking down to be reheated again.

Corona The Sun's hot outer atmosphere. The corona extends for millions of kilometres into space. It is visible from Earth only during a total solar eclipse.

Flare An explosion of hydrogen in the Sun's atmosphere, releasing enormous amounts of energy.



The Sun with a segment taken out to reveal its internal layers (above)

Granules Bubbles in the Sun's photosphere. Granules occur where heat rises up from the convective zone.

Heliosphere A magnetic "envelope" that surrounds the Sun and extends to the edge of the Solar System. The heliosphere is created by the solar wind.

Infrared radiation A form of electromagnetic energy (▶ 29). Infrared radiation is what we feel as heat. More than half of the energy the Sun gives off is in the form of infrared radiation.

Nuclear fusion The process by which the Sun generates energy. Inside the Sun's core, hydrogen atoms fuse together to form atoms of helium. The energy released through this process is the source of the Sun's light and heat as well as other forms of radiation.

Photosphere The surface of the Sun, from where the Sun radiates its energy. The photosphere is the part of the Sun that we can see. The photosphere is only about 500 km thick and, at 5500°C, is much "cooler" than the Sun's core. It is in a state of constant motion, like water boiling in a kettle.

Plasma Gas that is heated to such a high temperature that its atoms become electrically charged. The Sun's inner layers and atmosphere are in a plasmic state.

Prominence A flaming arch of gas that leaps off the photosphere and out into the corona. Prominences are held up by the Sun's magnetic field (▶ 6)



About five billion years from now, the hydrogen that the Sun uses as fuel will start to run out, and the Sun will balloon into a red giant (▶ 23), engulfing Mercury, Venus and Earth. Above is an artist's impression of what the Earth's surface may look like when this happens.



The Sun grows to the size of a red giant.

Radiation The transmission of heat, light and other forms of energy. Radiant energy travels in waves. Different forms of radiation are classified in the electromagnetic spectrum (▶ 29).

Radiative zone One of the inner layers of the Sun. Energy radiates out through this layer from the Sun's core.

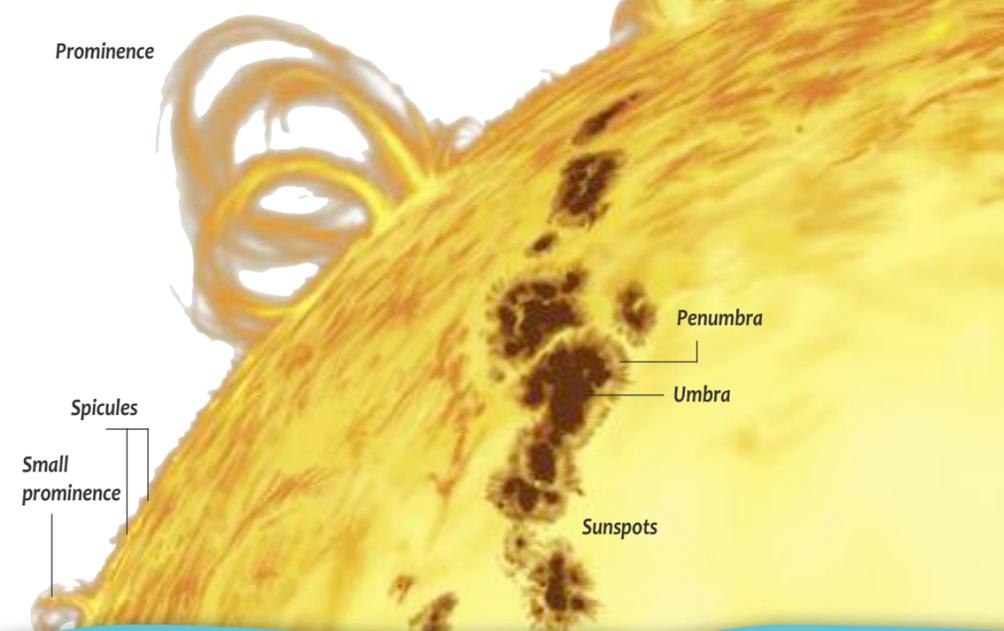
Solar core The innermost part of the Sun. The core is a region of high pressure (200 billion times that on the Earth's surface) and intense heat (about 15 million°C). This is where the energy that keeps the Sun shining is produced by nuclear fusion. Energy flows out from the core through the radiative zone to the convective zone.

Solar eclipse The passage of the Moon between the Sun and the Earth, blocking out some or all of the Sun's light (see diagram opposite).

Solar wind A stream of subatomic particles (▶ 28) that flows steadily away from the Sun. This occurs because gases in the corona have too much energy to be held in by even the Sun's strong gravitational field (▶ 6).

Spicule A narrow, flaming jet of gas that leaps up to 10,000 km above the photosphere then falls back.

Sunspot A darker, cooler area that appears temporarily on the Sun's photosphere. Sunspots are places where lines of magnetic force (▶ 6) pass through the photosphere. They usually occur in small groups. The dark inside of a sunspot is called the **umbra** and the lighter outside is called the **penumbra**.



FACTFILE

Diameter: 1,400,000 km
Rotation period at equator: 25.4 days
Rotation period at poles: 34 days
Surface temperature: 5500 °C
Core temperature: 14,000,000 °C
Composition: hydrogen (73.4%), helium (24.9%), traces of oxygen, carbon and other elements
Mass (Earth = 1): 330,000
Average density (water = 1): 1.4

★ The Sun contains more than 99% of all the matter in the Solar System.

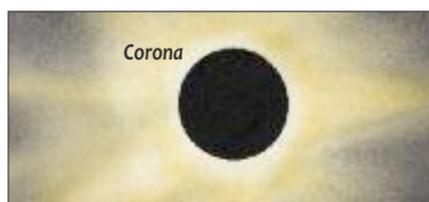
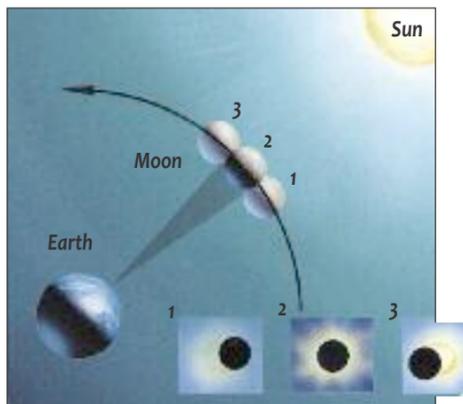
★ About three-quarters of the Sun is made up of hydrogen.

★ The Sun is so big that approximately 1,400,000 globes the size of the Earth could fit inside it.

★ Never look directly at the Sun or look at it through binoculars or a telescope. This can blind you or seriously damage your eyesight.

★ If the Earth were any closer to the Sun it would have been too hot for life to develop. If it were any farther away from the Sun it would be too cold for life.

★ It takes about eight minutes for light to travel from the Sun to the Earth.



A solar eclipse. By coincidence, the Sun and Moon appear the same size in our sky. When the Moon passes between the Earth and the Sun it may partially or fully block out the Sun. During a total eclipse, the Moon covers the Sun's surface entirely and we can see the corona.

THE MOON

The Moon is a ball of rock that travels around the Earth. It is the brightest object in the night sky, although it does not give out its own light, but reflects light from the Sun. The Moon is about four billion years old. It may have formed when a large object crashed into the young Earth and the resulting debris came together to form our Moon. There is neither air nor liquid on the Moon. It is a barren world, made up of craters, mountain ranges, and wide lava plains. The Moon spins once on its axis in exactly the time it takes it to orbit the Earth. This means that we only ever see one side of the Moon.

Apogee The point in the Moon's orbit when it is farthest away from the Earth.

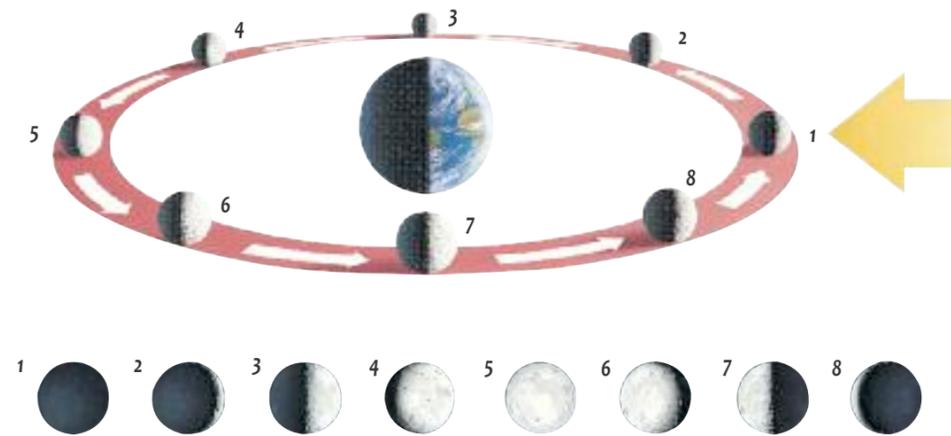
Apollo 11 The mission that first put men on the Moon. The Lunar Module of Apollo 11 touched down on 20th July 1969. US astronauts Neil Armstrong and Buzz Aldrin were the first people to walk on the Moon.

Basin A large dip in the surface of the Moon. Basins are shallower than craters.

Crater A saucer-shaped dip on the surface of the Moon. Craters, or **impact craters** are formed when large lumps of rock, called meteorites, collide with the Moon. They are also found on the surface of other moons, asteroids and planets, including Earth.

Crescent Moon A phase of the moon that occurs just before and after every New Moon. A crescent moon appears as a small curved sliver of light.

Earthshine Sunlight reflected from the Earth and on to the Moon's surface. The reflected light makes the dark surface of the Moon appear to glow.



THE PHASES OF THE MOON: The moon only spins once as it travels round the Earth, so the same face remains pointed towards us at all times. When the face pointed towards us is turned away from the Sun we cannot see the moon at all. This is called

a New Moon (1). When it is turned towards us we see a Full Moon (5). In between these phases it passes through crescent (2), quarter (3) and gibbous (4) phases.

Full Moon A phase of the Moon. During a Full Moon, the visible side of the Moon is turned towards the Sun and lit up so that it appears as a full disc of light.

Gibbous Moon A phase of the Moon that occurs between Half Moon and Full Moon. The Moon appears as an oval of light.

Half Moon One of the phases of the Moon, sometimes called a **Quarter Moon**. In a Half Moon, only half of the visible side of the Moon is lit up.

Luna Programme A Russian space project that sent several space probes to the Moon. In 1959, the **Luna 2** became the first man-made object to touch the Moon. In the same year, the **Luna 3** took the first photographs of the far side of the Moon.

Lunar A word that means "about the Moon".



A lunar eclipse in progress (above)

Lunar eclipse The passage of the Earth between the Sun and Moon during which the Earth casts a shadow on the Moon.

Lunar month The time it takes the Moon to pass from New Moon to New Moon—about 29 and a half days.

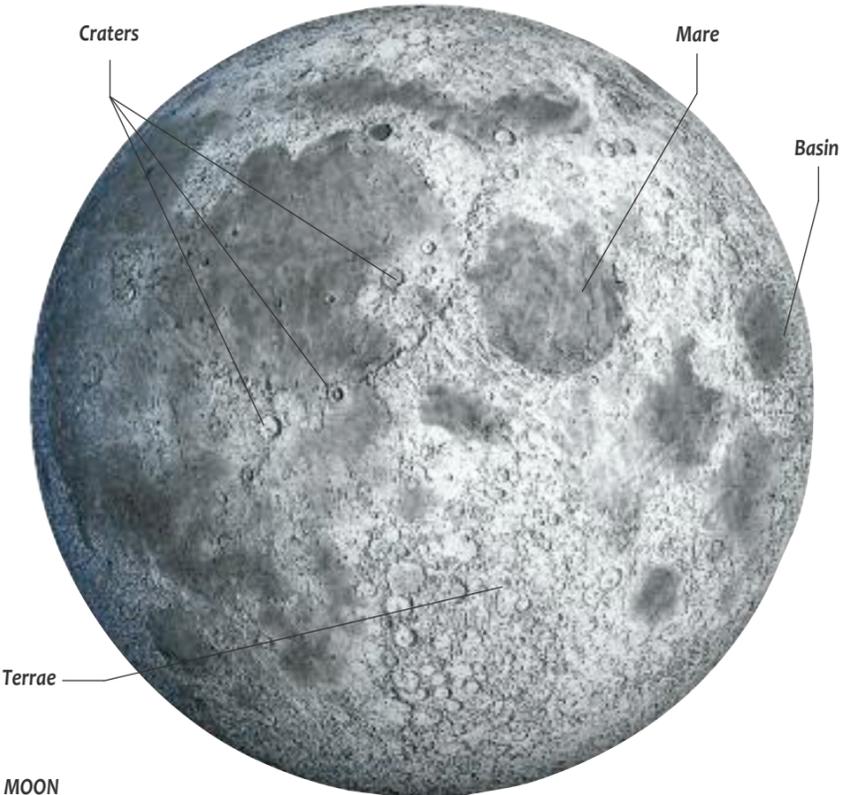
Mare A smooth lava plain on the surface of the Moon, formed when lava from ancient eruptions turned to solid rock. To the observer, it appears as a dark patch. *Mare* is the Latin word for sea. This is because early astronomers believed the plains were seas.

New Moon One of the phases of the Moon. A New Moon occurs when the Moon lies between the Sun and the Earth so that the side facing us does not reflect any light.

Perigee The point in the Moon's orbit when it is closest to the Earth.

Phase The different appearance of an object as it orbits the Earth. The lunar phases refer to our changing view of the Moon throughout the month. The Moon appears to change shape because our view of its sunlit part changes (see opposite).

Craters on the surface of the Moon (below)



THE MOON

Regolith A layer of loose dust, soil and rock that covers harder layers of rock. It is found on many moons and asteroids.

Rilles Cracks, or channels, that run across the smooth parts of the Moon, probably caused by ancient volcanic eruptions.

Selenography The study of the surface of the Moon.

Terrae The light areas on the Moon as we can see it from Earth. These are highlands of mountains and crater edges.

Waning The period between a Full Moon and a New Moon, when the visible part of the Moon becomes smaller and smaller.

Waxing The period between a New Moon and a Full Moon, when the visible part of the Moon becomes larger and larger.

FACTFILE

- Diameter:** 3476 km
- Day:** 27.3 Earth days
- Average distance from the Earth:** 384,600 km
- Surface temperature:** -155 °C to +105 °C
- Atmosphere:** practically none
- Gravity (Earth = 1):** 0.16
- Mass (Earth = 1):** 0.012
- Density (water = 1):** 3.34

★ The Moon is just over a quarter the size of the Earth. Most other moons are smaller in comparison to their "parent planet".

★ Because the Moon has no atmosphere, it has no wind or rain. This means that footprints, left on the Moon by astronauts, remain there undisturbed.

★ A total of twelve men have walked on the Moon. The first to do so was Neil Armstrong, on 20th July 1969.



US astronaut Buzz Aldrin standing beside the lunar module of Apollo 11. The lunar module was called Eagle.

MERCURY, VENUS & MARS

Mercury, Venus, Earth and Mars are known as the “inner planets” because they are the planets closest to the Sun. They are also called the “terrestrial” planets, meaning “Earth-like”. This is because, like the Earth, they are mostly made up of rocks. Mercury is a small planet covered with craters. Venus is about the same size as the Earth, shrouded in clouds of sulphuric acid, beneath which it is covered with lava plains and volcanoes. Because its cloud cover reflects light from the Sun, it is a very bright object in the night sky. Mars is a reddish-brown planet. Like Earth it has volcanoes, mountains, canyons and polar icecaps.

Beta Regio A canyon (a deep narrow valley) on Venus that is nearly 1 km deep.



The space probe Magellan, launched in 1989, used radar to build up a picture of the entire globe of Venus.

Borealis Basin A large flat dip in the surface of Mars. The Borealis Basin may have been created by an impact with an asteroid.



MERCURY

Mercury is covered in craters, made by meteoroids. These would normally burn up as they pass through a planet's atmosphere, but Mercury's atmosphere is too thin for this to occur.

Caloris Basin The largest crater on Mercury. It measures 1500 km across and is one of the largest craters in the Solar System.

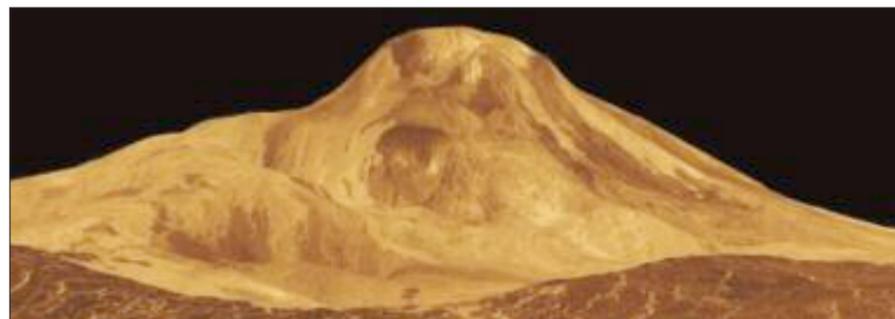
Deimos The smaller of Mars's two tiny moons. It measures 16 km across at its widest. Astronomers believe that it may once have been an asteroid.

Dust storm A storm created when strong winds lift up loose dust and blow it into clouds. Dust storms on Mars can sometimes cover the entire planet.

Greenhouse effect Warming caused when heat from the Sun becomes trapped by a planet's atmosphere. The intense temperatures on the surface of Venus are the result of heat being trapped by the planet's thick atmosphere.

Iron oxide Otherwise known as rust, iron oxide is a reddish-brown chemical that gives Mars its distinctive colour.

Maat Mons (below) is the highest volcano on Venus.

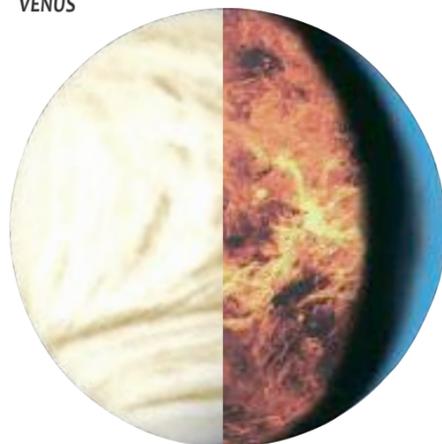


Ishtar Terra A region of mountains on Venus that covers an area the size of Australia. The highest of these mountains is slightly taller than Mount Everest on Earth.

Magellan Probe A US space probe sent to Venus in 1989. The probe used radar to build up pictures of the planet. Radar detects objects by sending out radio waves and receiving their “echoes”.

Mariner Programme A US project that sent space probes to observe Mercury, Venus and Mars between 1964 and 1973.

VENUS



On the left we can see Venus as it appears from space, shrouded in thick cloud. On the right, is what the surface of Venus looks like beneath the clouds.

Martian polar caps Two large areas of frozen carbon dioxide and water that cover the land at Mars's north and south poles.

Maxwell Montes A mountain range on Venus. It contains the highest summit on the planet.

Messenger A US space probe launched in 2004 to observe Mercury.



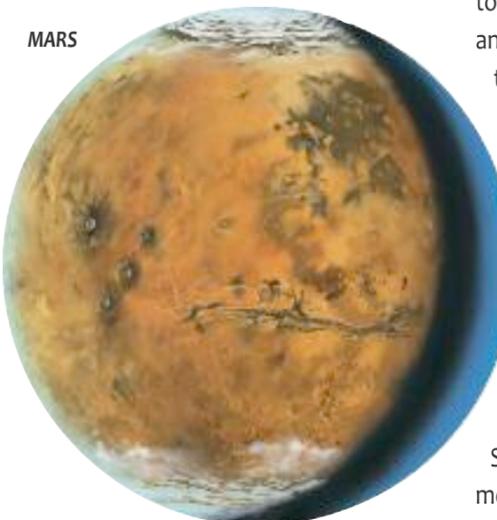
Olympus Mons An enormous volcano on Mars. At 27 km high and 700 km wide, it is more than twice as high as Mount Everest on Earth, and its base covers an area of land larger than England.

Pathfinder Probe A US space probe that was sent to Mars in 2007. The probe dispatched the small **Sojourner Rover**, which was the first wheeled vehicle to travel across the Martian surface.

Phobos The larger of Mars's two tiny moons. It measures 26 km across at its widest. Astronomers believe that it may once have been an asteroid. Phobos will probably collide with Mars in about 50 million years.

Pioneer Venus Project A US probe that was launched in 1978 to carry out experiments on Venus's atmosphere.

Sulphuric acid A very corrosive acid that makes other substances disintegrate. Venus is covered with thick clouds of sulphuric acid.



MARS

A number of valleys and channels have been carved into the Martian plains. These are thought to have been formed by rivers or seas that no longer exist.

Tharsis Bulge A large mound on the Martian equator, where several massive volcanoes are found, including **Arsia Mons**, **Ascraeus Mons**, and **Pavonis Mons**.

Valles Marineris A huge canyon on Mars. At 200 km wide and 7 km deep it is more than four times deeper than the Grand Canyon on Earth and as long as the United States is wide.



Deimos

Phobos

Venera Missions A series of Soviet space probes sent to observe Venus. In 1967, Venera 4 was the first space probe to enter another planet's atmosphere. In 1970, Venera 4 was the first space probe to land successfully on the surface of another planet and send information back to the Earth.

Viking Programme Two US space probes that were sent to Mars in 1975 to search for evidence of life, past or present.

Wrinkle ridges Enormous cliffs on the surface of Mercury that were created as the planet's surface cooled down and shrank over time. Some of Mercury's “wrinkle ridges” are more than 4 km high.

FACTFILE

MERCURY

Diameter: 4880 km
Day: 58.6 Earth days
Year: 88 Earth days
Average distance from the Sun: 58 million km
Surface temperature: -180 °C to +430 °C
Atmosphere: traces of helium
Gravity (Earth = 1): 0.38
Number of moons: none
Mass (Earth = 1): 0.055
Density (water = 1): 5.4
Name: the Roman messenger of the gods

VENUS

Diameter: 12,105 km
Day: 243 Earth days
Year: 225 Earth days
Average distance from the Sun: 108 million km
Surface temperature: 490 °C
Atmosphere: carbon dioxide and traces of nitrogen
Gravity (Earth = 1): 0.9
Number of moons: none
Mass (Earth = 1): 0.81
Density (water = 1): 5.2
Name: the Roman goddess of love

MARS

Diameter: 6797 km
Day: 24.6 Earth days
Year: 687 Earth days
Average distance from the Sun: 228 million km
Surface temperature: -120 °C to +25 °C
Atmosphere: carbon dioxide and nitrogen
Gravity (Earth = 1): 0.4
Number of moons: 2
Mass (Earth = 1): 0.11
Density (water = 1): 3.9
Name: the Roman god of war

JUPITER & SATURN

Jupiter is the largest planet in the Solar System. It is more massive than all the other planets combined. Jupiter is known as a “gas giant” because it is mostly made up of gas with no solid surface at all. Its neighbour, Saturn, another gas giant, is the second largest planet. Both planets are surrounded by “rings” of rock and dust. Saturn’s rings, broad and bright, reach out more than 420,000 km from the planet. Jupiter and Saturn both have a large number of moons.

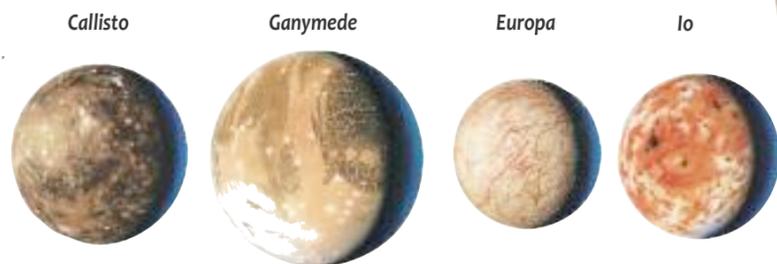


Io is covered with volcanoes and lava pools.

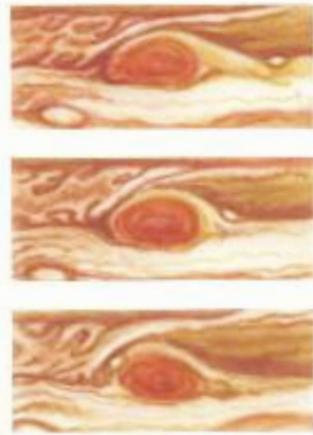
Belts The darker of the striped cloud bands that surround Jupiter.

Callisto Jupiter’s second largest moon. It measures 4800 km across. For its size, it has more craters than any other planet or moon in the Solar System.

Jupiter’s four largest moons are called the Galileans after Galileo who discovered them in 1610.



Cassini, Giovanni Domenico (1625–1712) Italian astronomer who first observed four of Saturn’s moons and also discovered the largest gap between Saturn’s rings.



Jupiter’s Great Red Spot. The white ovals are air currents flowing past the spot.

Cassini Division The largest of the gaps between Saturn’s rings. The gap is about 4800 km wide. Gaps between rings are caused by the gravitational pull (♁♁) of the planet’s moons.

Cassini-Huygens Mission A project that sent a spacecraft to study Saturn and its rings and moons. The **Huygens Probe** landed on Titan in 2005. Cassini is still orbiting Saturn and returning data.

Enceladus One of Saturn’s moons. It measures 498 km across. Enceladus’s surface is mostly made up of water ice.

Europa Jupiter’s fourth largest moon. It measures 3130 km across. Europa has an icy surface, which may have a water ocean beneath it.

Galileo Mission A mission that sent a space probe to orbit Jupiter in 1989. It was the first spacecraft to orbit the planet.

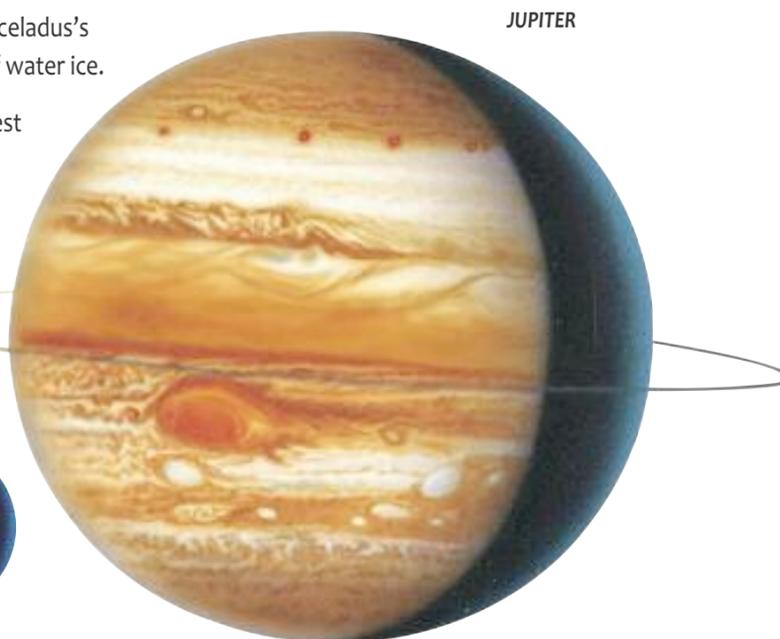
Galileo Galilei (1564–1642) Italian astronomer who was the first person to use a telescope. He made many important observations and discoveries, including the discovery of Jupiter’s moons. By observing that Venus, like the Moon, had phases, he confirmed that the planets all orbit the Sun.

Ganymede The largest of Jupiter’s moons. Bigger than the planet Mercury, it measures 5268 km across and is the largest moon in the Solar System. Ganymede has an icy surface with dark plains covered in grooved patterns and craters.

Gas giants The four large planets in the Solar System: Jupiter, Saturn, Uranus and Neptune. They mostly consist of gases with no solid surface.

Saturn rotates very quickly. This produces a distinct bulge at its equator.

Jupiter’s bright colours of red, orange, yellow and brown, are produced by the elements sulphur and phosphorus.



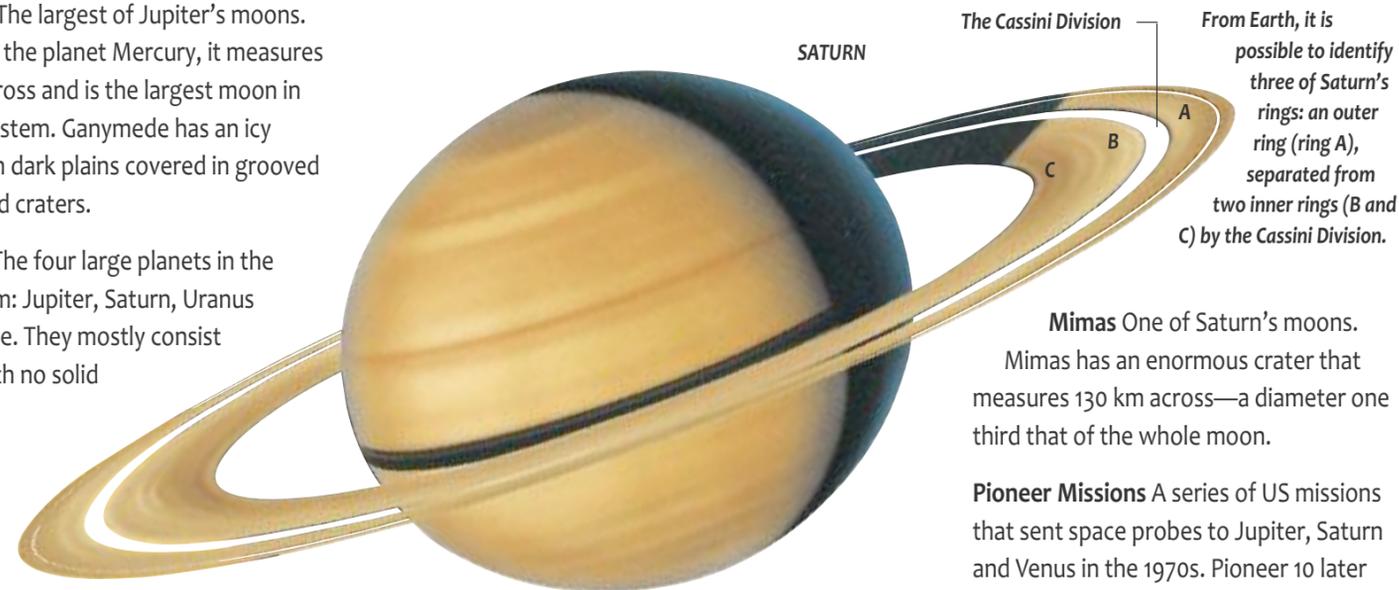
Great Red Spot A giant storm in Jupiter’s atmosphere. The storm has been raging for at least 300 years.

Great White Spot A large storm that occurs in Saturn’s atmosphere about every 30 years.

Huygens, Christiaan (1629–1695) Dutch astronomer who discovered the moon Titan and spent much of his career studying the rings of Saturn.



Saturn’s rings are made up of billions of blocks of rock and ice, some bigger than houses.



Mimas One of Saturn’s moons. Mimas has an enormous crater that measures 130 km across—a diameter one third that of the whole moon.

Pioneer Missions A series of US missions that sent space probes to Jupiter, Saturn and Venus in the 1970s. Pioneer 10 later became the first man-made object to leave the boundaries of the Solar System.

Ring A A band of dust, rocks, ice or other materials surrounding a planet at its equator. Saturn’s rings are probably fragments of a moon that was smashed by a passing comet.

Ringlet A very fine planetary ring. Saturn’s rings are made up of hundreds or thousands of ringlets.

Io Jupiter’s third largest moon. It measures 3643 km across. Io is covered with active volcanoes and pools of molten rock. It is the most volcanically active place in the Solar System,

Jovian planets Another name for the gas giants. The word “Jovian” means “belonging to Jupiter”.

Saturn as seen from the surface of Titan.



Titan Saturn’s largest moon. It measures 5150 km across, and is the second largest moon in the Solar System. Titan is the only moon in the Solar System known to have a thick atmosphere.

Zones The lighter of the striped cloud bands that surround Jupiter.

FACTFILE

JUPITER

- Diameter:** 143,884 km
- Day:** 9.8 Earth days
- Year:** 11.8 Earth years
- Average distance from the Sun:** 778 million km
- Surface temperature:** -150 °C
- Atmosphere:** hydrogen and helium
- Gravity (Earth = 1):** 2.64
- Number of moons:** 63
- Mass (Earth = 1):** 318
- Density (water = 1):** 1.3
- Name:** the Roman king of the gods

SATURN

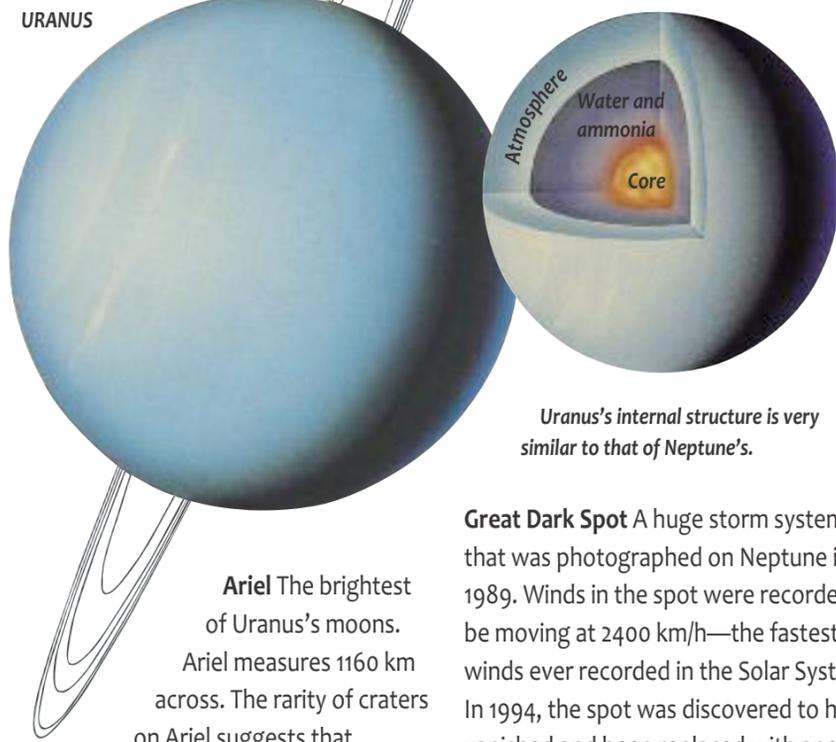
- Diameter:** 120,514 km
- Day:** 10.2 Earth days
- Year:** 29.5 Earth years
- Average distance from the Sun:** 1427 million km
- Surface temperature:** -180 °C
- Atmosphere:** hydrogen and helium
- Gravity (Earth = 1):** 1.16
- Number of moons:** 62
- Mass (Earth = 1):** 95.2
- Density (water = 1):** 0.7
- Name:** the Roman god of farming

URANUS & NEPTUNE

Uranus and Neptune are both gas giants (16). Like the others, they are surrounded by rings (17) and have a large number of moons. Uranus is a featureless blue globe of gas. Uranus orbits the Sun at a very unusual angle. It is tilted at 98° from the vertical, meaning that it orbits the Sun almost on its side. Neptune is a bright blue globe, streaked by fast-moving clouds and the occasional storm. Uranus and Neptune are the most featureless of all the planets in the Solar System.

Adams, John Couch (1819-1892) British astronomer who predicted the existence and position of Neptune. Without knowing it, Adams made his predictions at almost exactly the same time as Le Verrier.

Ammonia One of the most common chemicals found on Neptune and Uranus. A layer of ice and liquid water, ammonia and methane lies between the rocky core and outer atmosphere of both planets.



Uranus's internal structure is very similar to that of Neptune's.

Ariel The brightest of Uranus's moons. Ariel measures 1160 km across. The rarity of craters on Ariel suggests that

volcanic eruptions, and movements of the moon's crust, may have erased them.

Cryovolcano An ice volcano that forms on cold moons and other objects far out in space. Triton is covered in cryovolcanoes. Rather than molten rock, they erupt nitrogen gas.

Galle, Johann (1812-1910) German astronomer who discovered Neptune in 1846. He was the first person to view Neptune and recognize it as a planet.

Great Dark Spot A huge storm system that was photographed on Neptune in 1989. Winds in the spot were recorded to be moving at 2400 km/h—the fastest winds ever recorded in the Solar System. In 1994, the spot was discovered to have vanished and been replaced with another smaller storm.

Herschel, William (1738-1822) An amateur British astronomer who discovered Uranus in 1781. He was also the first astronomer to realize that the Solar System is, itself, travelling through space.

Le Verrier, Urbain (1811-1877) French astronomer who predicted the location and existence of Neptune, independently of John Couch Adams.

Methane A chemical found in layers of ice and liquid on Neptune and Uranus. Uranus's upper layer of clouds is made up of methane gas. This layer absorbs red light from the Sun, so that it only reflects blue light. It is this that gives Uranus its blue colour.

Miranda The smallest of Uranus's major moons, measuring 470 km across.

Miranda has a jumbled-up surface, covered with deep grooves, canyons and mountain ranges. Astronomers think the unusual surface was formed by the moon being blasted apart and reassembled again (see left).

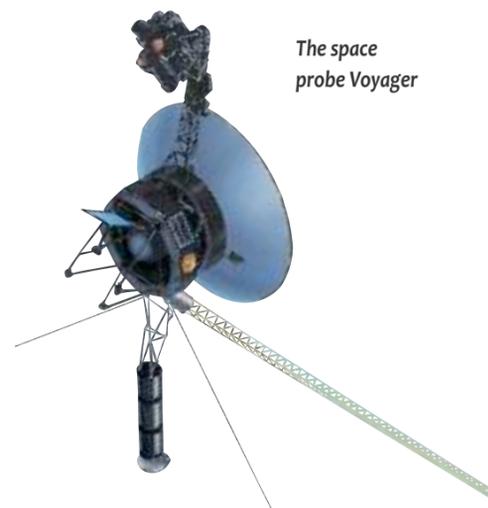


Astronomers believe that Uranus's moon Miranda may once have been smooth (1) before it was blasted apart by a meteoroid (2). Gravity held the shattered fragments together (3) and kept them from drifting into space. The pieces eventually reassembled into a lumpy ball of mixed-up pieces (4), giving Miranda its jagged surface.



Nereid One of Neptune's moons. It measures 340 km across and has a very unusual orbit. It takes it as close as 1.4 million km from Neptune and then as far as 9.6 million km away from it.

Oberon The second largest of Uranus's moons. It measures 1522 km across and is the farthest major moon from the planet. It is covered in deep craters.



The space probe Voyager

Proteus The second largest of Neptune's moons. It measures about 400 km. It reflects very little light, so it appears very dark against the night sky.

"Scooter" A giant, fast-moving storm on the planet Neptune.

Shepherd satellite A moon that orbits a planet close to its rings. Shepherd satellites exert a gravitational pull (16) on a planet's rings, holding them together in a narrow band. Uranus's moons **Ophelia** and **Cordelia** are shepherd satellites.

The volcanoes on Triton are plumes of nitrogen gas that burst through cracks in the moon's icy surface.

Titania The largest of Uranus's moons, made up of ice and rock.

Triton The largest of Neptune's moons and the only major moon in the Solar System to orbit its "parent planet" in the opposite direction to the planet's rotation. At -238°C, it is the coldest known object in the Solar System.

Umbriel One of Uranus's five large moons. It is covered in large craters. One of these, the **Wunda crater** has a ring of bright material at its base. Scientists do not yet understand what this material is.

Voyager Programme A US space mission that sent space probes to Jupiter, Saturn, Uranus and Neptune in the 1980s. They sent back data and images of the planets and their moons and rings. The space probe Voyager carries an audio-visual disc. Should aliens come across it, they would hear the sounds of whales, a baby crying and greetings in 55 languages.



Triton (not to scale)

FACTFILE

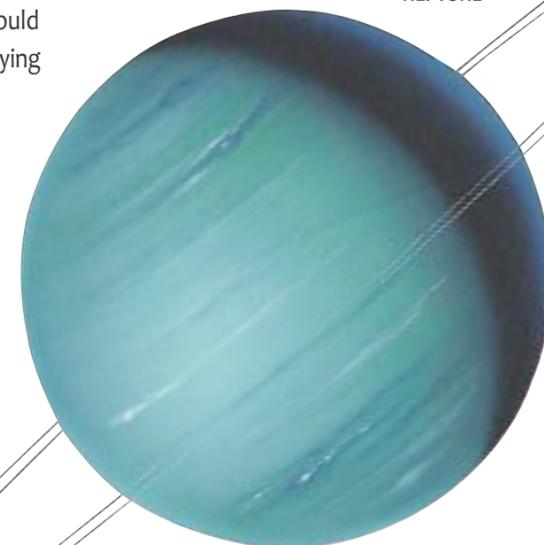
URANUS

Diameter: 51,118 km
Day: 17.2 Earth days
Year: 84 Earth years
Average distance from the Sun: 2869 million km
Surface temperature: -210 °C
Atmosphere: hydrogen, helium and methane
Gravity (Earth = 1): 1.17
Number of moons: 27
Mass (Earth = 1): 14.5
Density (water = 1): 1.3
Name: the Greek god of the sky

NEPTUNE

Diameter: 49,557 km
Day: 16.1 Earth days
Year: 164.8 Earth years
Average distance from the Sun: 4496 million km
Surface temperature: -220 °C
Atmosphere: hydrogen, helium and methane
Gravity (Earth = 1): 1.2
Number of moons: 13
Mass (Earth = 1): 17.14
Density (water = 1): 1.77
Name: the Roman god of the sea

NEPTUNE



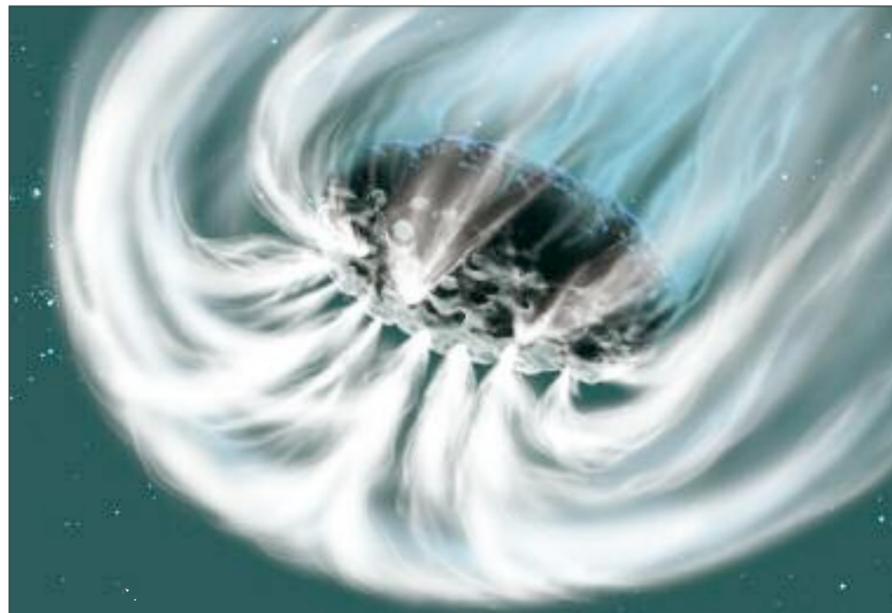
COMETS & ASTEROIDS

The Solar System is full of lumps of dust, rock and ice. These minor objects include comets, asteroids and dwarf planets. Comets are lumps of dust frozen together by ice. Asteroids are rocky objects that orbit the Sun, mostly in a band between Mars and Jupiter. Dwarf planets are large, round objects that orbit the Sun. Together, all of these minor objects only make up a tiny fraction of all the mass (♣ 7) in the Solar System.

A comet has two tails: a straight gas tail and a broader, curved dust tail.

Gas tail
Dust tail
Nucleus

Asteroid A rocky body that orbits the Sun. Asteroids range in size from tiny specks to blocks about 1000 km in diameter. Most asteroids are made of rock, some are made of metal and some are made of rock and metal. They are sometimes referred to as **planetoids** or **minor planets**.



Asteroid Belt The region between Mars and Jupiter where most of the known asteroids in the Solar System lie.

Bolide An unusually bright meteor that explodes in the sky.

Centaur A group of small rocky objects that orbit the Sun between the planets Jupiter and Neptune.

Ceres The smallest dwarf planet in the Solar System and the only one in the asteroid belt. Ceres measures about 950 km across.

Charon Pluto's largest moon. It measures about 1200 km across.

Coma The cloud of dust and gas that comes off a comet as it nears the Sun. The Sun melts the frozen gases and water that make up the comet's nucleus. The solar wind (♣ 11) then "blows" the gases back into a pair of tails.

Comet A lump of dust and ice that orbits the Sun. On nearing the Sun a comet develops two tails of gas and dust. Comets measure a few kilometres across. Their tails stretch behind them for hundreds of millions of kilometres.

As a comet approaches the Sun, the frozen water and gases in its nucleus melt and trail behind it.

Dwarf planet A relatively large, round object that orbits the Sun. Dwarf planets share their orbit with other objects of a similar size to themselves.

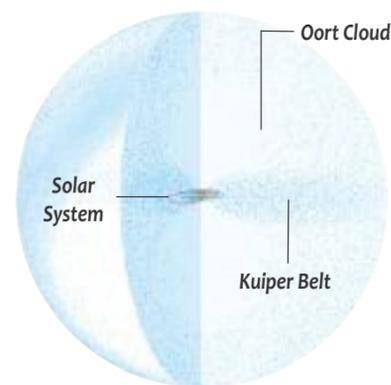
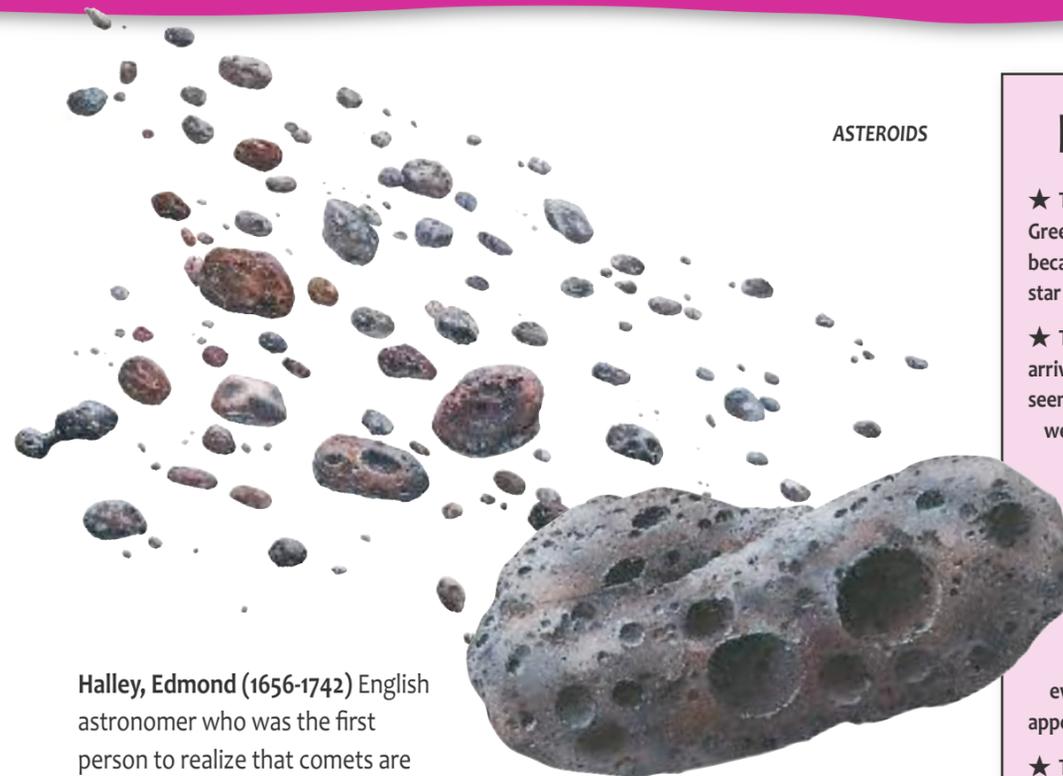


Diagram of the Oort Cloud

Eris The largest dwarf planet in the Solar System. Eris measures 3000 km across. Located far beyond Pluto, it is one of the most distant objects in the Solar System.

Giotto Probe A European space probe that flew by Halley's Comet in 1986, sending back pictures and sampling the gases and dusts given off by the comet.

Halley's Comet A very bright comet that appears in our skies every 76 years.



ASTEROIDS

Halley, Edmond (1656-1742) English astronomer who was the first person to realize that comets are objects that orbit the Sun.

Kuiper Belt A region of the Solar System beyond the planet Neptune. It mainly consists of icy bodies, including the dwarf planet Pluto. The Kuiper Belt is thought to be 20 times as wide as the Asteroid Belt.

Meteor A streak of light in the sky that occurs when a meteoroid enters the Earth's atmosphere. Meteors are sometimes called "shooting stars".

Meteorite A meteoroid that lands on the surface of a planet or moon.

PLUTO



Meteoroid A small lump of rock and dust that hurtles across the Solar System. It was once part of an asteroid or comet.

Meteor shower An event that occurs when a large number of meteors enter the Earth's atmosphere in a short time.

NEOs (Near-Earth Objects) Any object whose orbit brings it close to the Earth.

Oort Cloud A cloud of comets surrounding the Solar System beyond Pluto. Astronomers believe that the Oort Cloud may be the place where comets come from. It lies one fifth of the way between our Solar System and the nearest star, Proxima Centauri (♣ 23).

Pluto Previously thought to be the ninth planet, Pluto is now classified as a dwarf planet. It measures 2274 km across and is the largest object in the Kuiper Belt.

Stardust Probe A US space probe that captured dust grains, or "stardust", floating space, as well as from a comet.

Tombaugh, Clyde (1906-1997) American astronomer who discovered Pluto in 1930.

FACTFILE

★ The name "comet" comes from the Greek *kometes* meaning "long-haired" because a comet's tail makes it look like a star with hair.

★ Throughout history, the unexpected arrival of comets in the sky has often been seen as a sign, or omen, of change. Comets were thought to bring famines, and some people thought that when a comet appeared a king would die.

★ Edmond Halley believed that comets recorded in 1531 and 1607 were earlier sightings of a comet he himself observed in 1682.

Although he did not live to witness the event, Halley's Comet, as it is now called, appeared in 1758, as Halley had predicted.

★ The term "dwarf planet" was only created in 2006 when the discovery of objects larger than Pluto led astronomers to officially reclassify the term "planet".

★ In July 1994, drawn in by gravity, the comet Shoemaker-Levy collided with Jupiter, creating massive fireballs on impact.

★ The largest known meteorite was found in Namibia in 1920. It measures 2.7 m long and 2.4 m wide.



It is feared that one day an asteroid's orbit may bring it into contact with the Earth. An impact could cause climate change sufficient to wipe out many life-forms.

Trojan An asteroid that shares the same orbital path as Jupiter.

Tunguska fireball The name given to the huge explosion in the Tunguska region of Siberia, Russia on 30th June 1908. The Tunguska fireball may have been a comet exploding at an altitude of about 6 km.

STARS

Stars are giant spinning balls of hot gases. They produce tremendous amounts of energy in the form of heat and light, which they radiate (➤11) across space. Stars vary enormously in size and in the amount of light that they give off. Some are smaller than our planet, whilst some are many hundreds of times the size of our local star, the Sun. Like people, stars have a life cycle, and though their lives are billions of years long, they do not last forever. As a rule, the larger a star is, the shorter its life will be. Our Sun is a typical star of average size and brightness.

Betelgeuse A red supergiant in the constellation of Orion (➤24). Betelgeuse is 800 times the size of our Sun and is one of the largest, most luminous stars known.

Binary star A system of two stars that orbit each other.

Black dwarf The last stage in the life of a medium-sized star. A black dwarf is what remains of a white dwarf that has cooled down and shrunk after using the last of its energy.



The Horsehead Nebula

Black hole A region of space from which nothing can escape. A black hole is sometimes left behind when a supergiant star blasts itself apart in a supernova. Black holes cannot be seen because they trap light, but they can be detected by observing the effects of their gravity (➤6).

Brown dwarf A small, cool globe of gas. A brown dwarf is a kind of “failed” star that is too small to produce heat and light.

Blue giant A massive, hot star that was once a larger, cooler red giant. Blue supergiants are rare and have short lives. They often end in a supernova.

Colour index The measure of a star’s colour. It tells scientists how hot a star is. Hotter stars shine blue or white and cooler stars shine red or orange.

Crab Nebula An expanding cloud of gas left behind after a large star exploded in a supernova almost 1000 years ago.

Globular cluster A ball-shaped group of hundreds or thousands of stars, held together by gravity.

Horsehead Nebula A gigantic cloud of dust and gas in the shape of a horse’s head. The Horsehead Nebula is one of the clouds in our galaxy where stars start to form.

Luminosity The amount of light and energy given off by a star.

Magnitude A measure of how bright an object is, where bright objects have low or negative numbers, and dim objects have high numbers. **Apparent magnitude** measures how bright an object appears as it is seen from Earth. **Absolute magnitude** measures how bright an object actually is.

Main sequence The stable middle-period in a star’s life, when it makes energy by converting hydrogen into helium by way of nuclear fusion (➤10). The Sun is a main sequence star.

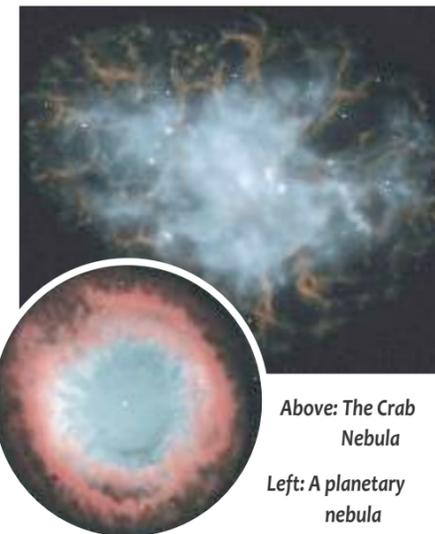
Nebula A cloud of gas and dust where stars are formed.

Neutron star The dense remains of a large star that has collapsed under its own gravity during a supernova.

Nova A star that ejects some of its gases, suddenly becoming much brighter.

Open cluster A group of several thousand stars, loosely held together by gravity.

Parallax An apparent change in the position of an object (eg. a star) resulting from a change in the position of the observer (eg. on Earth).



Above: The Crab Nebula

Left: A planetary nebula

Parsec The unit used to measure parallax. One parsec is about 3.26 light years (➤6).

Planetary nebula A cloud of gas and dust. A planetary nebula is the remnants of a medium-sized star that has shed its outer layers in the final stages of its life cycle.

Polaris A bright star, sometimes called the **North Star**, around which the stars appear to revolve. It lies in line with the Earth’s North Pole and hardly moves in our skies. This makes it useful for locating due North.

Protostar The early stage in a star’s life when it is a cloud of gas and dust held together by gravity, but is not yet hot enough to generate its own energy.



The scale illustration shows the sizes of a red giant and two blue giants. Our Sun, a yellow dwarf, is just a tiny yellow dot by comparison.

Proxima Centauri The second nearest star to the Earth (after the Sun). It is about 4.2 light years (➤6) away.

Pulsar A rapidly spinning neutron star that gives out large amounts of energy.

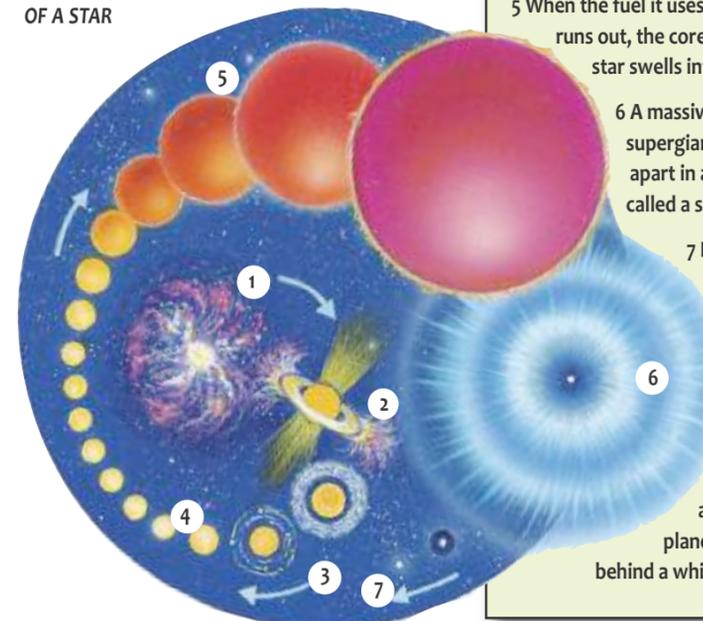
Red dwarf A small, cool star in the long-lasting, middle-period of its life.

Red giant A large, old star with a low temperature and a reddish orange colour.

Sirius The brightest star in the night sky. Sirius appears in the constellation Canis Major (➤24).

Starburst A region within a galaxy where lots of stars are born in a very short time.

THE LIFE CYCLE OF A STAR



Supergiant A large, bright star that is near the end of its life cycle.

Supernova A massive explosion of a supergiant at the end of its life cycle. A supernova happens when a massive star runs out of hydrogen and collapses under its own gravity. It leaves behind a cloud of gas and dust or, in some cases, a neutron star. The most massive supernovas leave behind a black hole.

Variable star A star that varies in brightness and size over time.

White dwarf A small, hot, bright star in the final stage of its life cycle.

Yellow dwarf A small star in the middle-period of its life. Our Sun is a yellow dwarf.

THE LIFE CYCLE OF A STAR

1 A star begins its life as a dense mass of gas and dust called a protostar.

2 The core becomes so hot that nuclear reactions start deep inside it. Gas and dust are blown away, although some remain in a disc surrounding the new star.

3 Planets may form here.

4 The star is now a main sequence star.

5 When the fuel it uses to produce energy runs out, the core collapses and the star swells into a red giant.

6 A massive star will become a supergiant that will blast apart in a mighty explosion called a supernova.

7 It ends its days as a neutron star or a black hole.

A less massive star becomes a red giant. At the end of its life, its outer layers puff away into space (a planetary nebula) leaving behind a white dwarf.



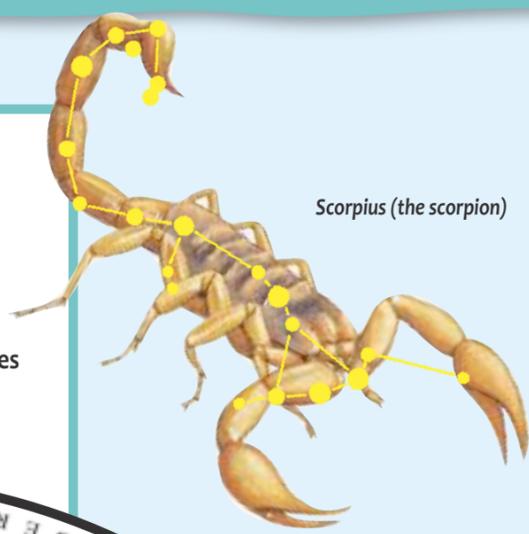
Gas torn from stars by a nearby black hole circles before plummeting inside the black hole.

Even though they are invisible, scientists can tell where black holes are by observing their effects.

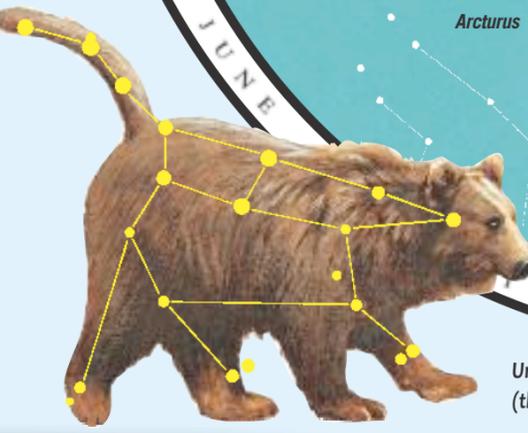
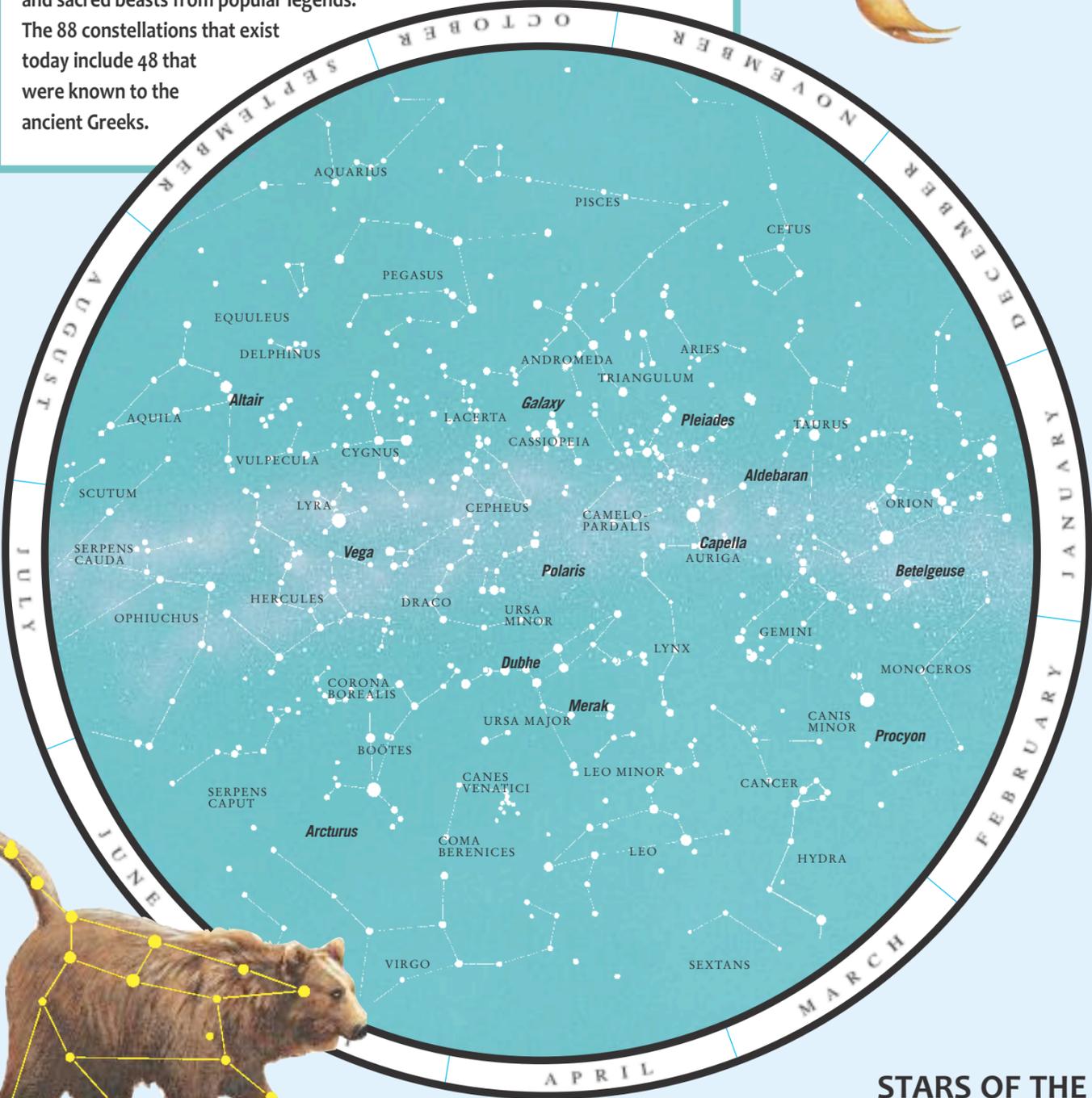
CONSTELLATIONS

A constellation is a group of stars that form a pattern. Years ago, early astronomers grouped the stars into these patterns, imagining their shapes to look like gods, heroes and sacred beasts from popular legends. The 88 constellations that exist today include 48 that were known to the ancient Greeks.

Astronomers use constellations as a way of mapping the sky. They refer to them to show where stars, galaxies and other objects in the heavens are located.

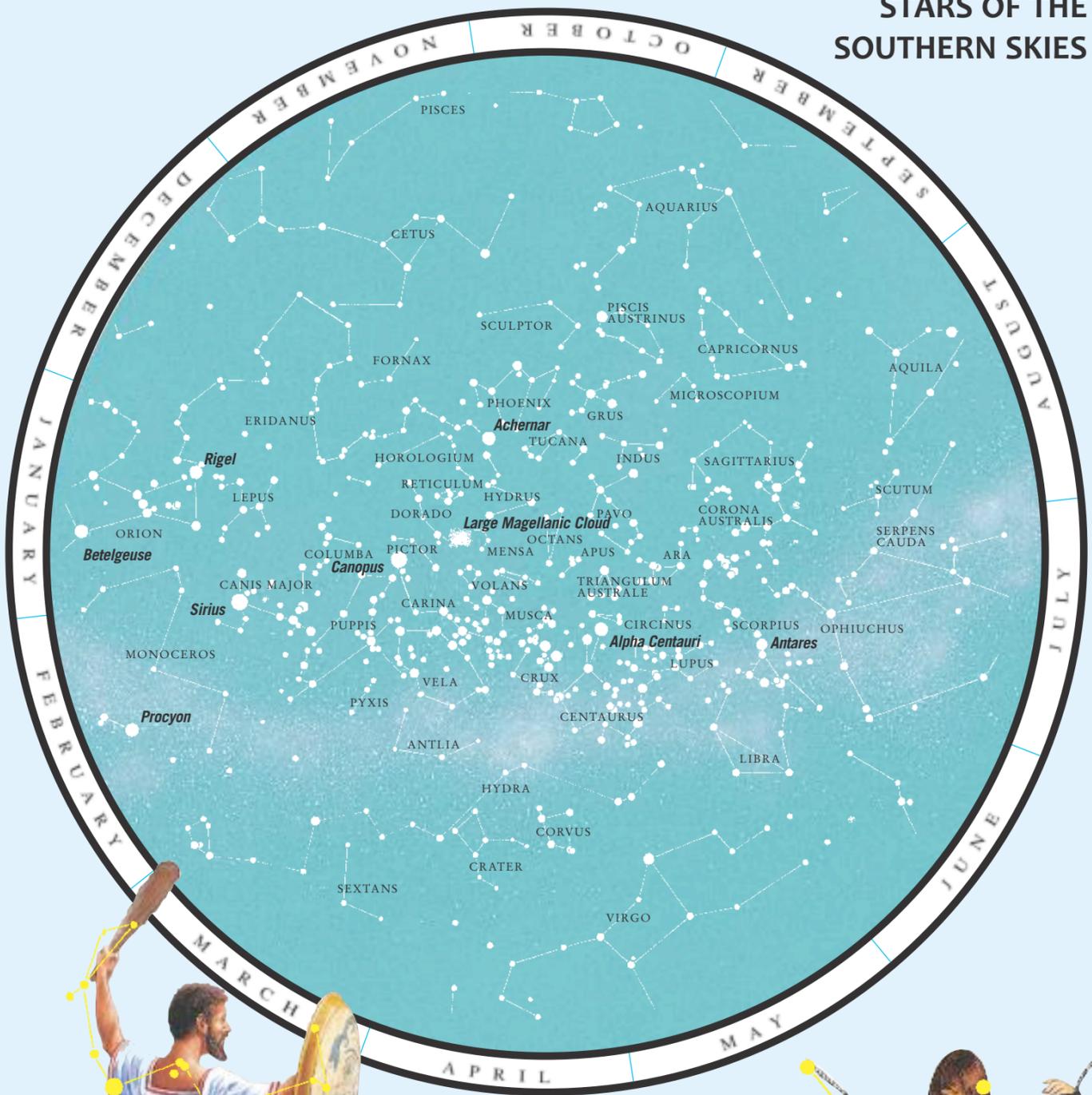


Scorpius (the scorpion)

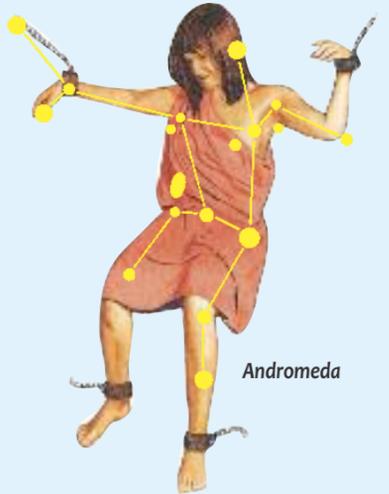


Ursa Major (the Great Bear)

STARS OF THE NORTHERN SKIES



Orion



Andromeda

These charts show the stars and constellations that can be seen from the northern hemisphere (left hand page) and southern hemisphere (right hand page). Turn the book around so that the present month is at the bottom. At 10.00 pm face south if you are in the northern hemisphere, or north if you are in the southern hemisphere. On a clear night you should be able to locate many of the stars and constellations on the chart.

GALAXIES

THE MILKY WAY GALAXY

A galaxy is a gigantic, rotating collection of gas, dust, and billions of stars, all held together by gravity (↔6). Some galaxies only contain a few million stars, while some contain over a trillion. Our own galaxy, the Milky Way, is a vast spiral of about 200 billion stars measuring 100,000 light years across. There are billions more galaxies, of various shapes and sizes, all making up what we call the Universe.

Active galaxy A galaxy that gives off exceptional amounts of energy for its size. The energy is produced by a large black hole (↔22) at the galaxy's centre. This is called an **active galactic nucleus**. There are several different types of active galaxies. These include: **seiferts**, **blazars**, quasars and **radio galaxies**. Some astronomers believe that these are all the same thing but seen from different angles.

Andromeda Galaxy A spiral galaxy found in the constellation Andromeda (↔24). It is the closest spiral galaxy to our own and a member of the Local Group of galaxies. It is one of the few galaxies that can be seen from Earth without using a telescope.

- 1 Nucleus
- 2 Crux-Centaurus Arm
- 3 Perseus Arm
- 4 Orion Arm
- 5 Approximate position of the Sun
- 6 Sagittarius Arm

Barred spiral A spiral galaxy with a long, thin, bar-shaped centre. About two-thirds of all spiral galaxies are barred.

Bulge A large ball of tightly packed stars found at the centre of spiral and elliptical galaxies.

Cluster A group of galaxies held together by gravity.

Different types of galaxies (below)

Dwarf galaxy Any galaxy that measures less than 30,000 light years across.

Elliptical galaxy A round galaxy, shaped like a ball. Elliptical galaxies contain very old stars and little gas or dust.

Filament A long "string" of galaxy superclusters stretching across space. These are linked together like a net made up of strings and knots.

Galactic arms The bright regions of a spiral galaxy that branch out of its centre. Galactic arms are full of bright, young stars.

Galactic halo The round region surrounding the centre of a spiral galaxy. It contains dark matter (↔28) and clusters of stars.

Hubble, Edwin (1889-1953) American astronomer who proved the existence of other galaxies than our own. He also proved that the Universe is expanding.

Right: The Milky Way as seen from the side. It looks like a pair of fried eggs stuck together back-to-back. The "yolks" form the central bulge or nucleus and the "whites" form the spiral-shaped disc surrounding it.



Milky Way Galaxy The galaxy that contains our Sun and Solar System. The Milky Way is a flattened spiral of stars clustered together in space. It is named after the misty band of stars we can see on a clear night—actually our side-on view of the galactic disc and its spiral arms.

Nucleus The centre of a galaxy.

Quasar A very bright area surrounding a black hole (↔22) at the centre of an active galaxy. Its brilliant light comes from a disc of hot gas and dust spiralling into the black hole. One quasar gives off more energy than 100 galaxies combined.

Ring galaxy A galaxy shaped like a hoop surrounding a ball, with a large area of empty space between most of the galaxy and its nucleus. Their shapes can be due to collisions with other galaxies.

Spiral galaxy A spiral-shaped galaxy. Spiral galaxies have a round bulge at their centre, surrounded by a large flat disc, with arms that spiral out from the centre. Their arms contain younger stars and their bulges contains older stars. Our own galaxy, the Milky Way, is a spiral galaxy.

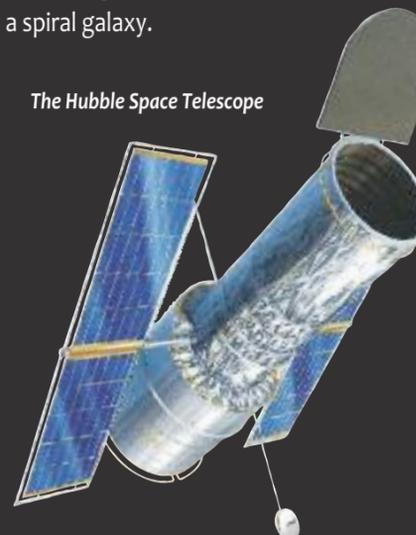
Hubble Space Telescope A telescope that orbits the Earth as a satellite. It is unaffected by weather or pollution, so it can receive pictures that are much clearer than those taken with Earth-based telescopes. It has photographed galaxies as far as 10 billion light years away.

Irregular galaxy A galaxy with no obvious shape. Irregular galaxies contain lots of very young stars.

Lenticular galaxy A flat, disc-shaped galaxy that looks like a spiral galaxy without arms. Lenticular galaxies are made up of old stars near the end of their life cycle.

Local Group A cluster of more than 30 galaxies including the Milky Way.

Magellanic Clouds A pair of galaxies that orbit the Milky Way. The Large Magellanic Cloud and Small Magellanic Cloud are a pair of irregular galaxies that can both be seen without the aid of a telescope.



Starburst galaxy A galaxy in which an exceptionally large number of stars are created. Starburst galaxies are thought to result when two galaxies collide with each other, bringing together dense clouds of gas which collapse, creating stars.

Supercluster A group of clusters of galaxies. Superclusters tend to be stretched into long "strings", called filaments, that stretch across the Universe.

Virgo Cluster A cluster of galaxies within the constellation Virgo (↔24). It is a huge ball of more than a thousand billion stars.

FACTFILE

- ★ Galaxies rotate around their centres.
- ★ The Milky Way Galaxy is so large that, even rotating at a speed of 250 km/s, it takes more than 200 million years to complete one full circle.



Edwin Hubble

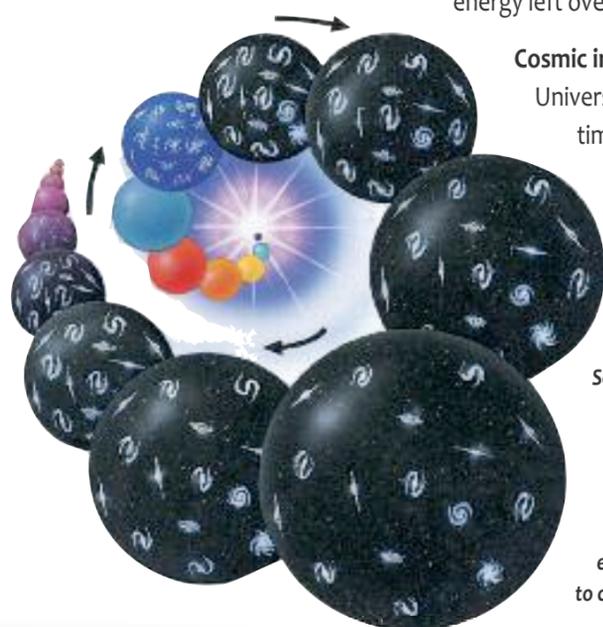
- ★ All galaxies are moving through space and rushing away from each other.
- ★ There are about 100,000 billion galaxies in the Universe.
- ★ The Milky Way contains at least 200 billion stars and measures 100,000 light years across.
- ★ The word "galaxy" comes from the Greek word *galaxias* meaning "milky". The ancient Greeks called the Milky Way the *Kiklos Galaxias*, meaning "Milky Circle". In Greek myth, the Milky Way was a splash of milk spilt across the heavens by the goddess Hera.

THE UNIVERSE

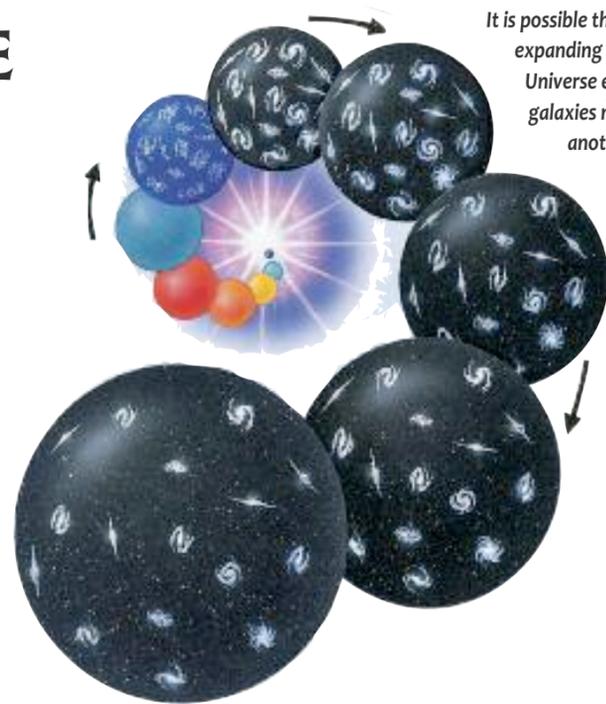
The Universe is made up of everything we know, from the tiniest grain of sand to the most gigantic star. It even includes empty space. Nearly all the matter in the Universe is contained in galaxies, which are grouped into giant clouds called superclusters. These are spread round the Universe like a net. The “holes” between matter are empty spaces, called voids. Scientists think that the Universe began in an incredible explosion about 13.7 billion years ago. A number of theories have been put forward about the future of the Universe.

Accelerating Universe A theory that the Universe is expanding at an increasing speed. This may be caused by a force called dark energy, which could overcome the gravitational force (6) that pulls galaxies towards one another.

Atom A basic building block of matter. It consists of a **nucleus** made up of **subatomic particles** called **protons** and **neutrons**, surrounded by a number of **electrons**. All of these particles were created in the first seconds of the Big Bang.



Some scientists think that all matter in the Universe will eventually collide in a “Big Crunch”. Invisible dark matter in the Universe may exert sufficient gravity to halt its expansion and cause the galaxies to compress together.



It is possible that the Universe will carry on expanding forever. In this sequence, the Universe expands rapidly, with all the galaxies moving away from one another as the Universe inflates like a balloon.

Big Bang The explosion in which the Universe is thought to have been formed. During this explosion, all matter, energy, space and time were created.

Big Crunch The theory that all matter in the Universe will eventually collapse to a single point, bringing about the end of the Universe.

Cosmic microwave background radiation Energy, or radiation (10), that comes from all directions in space. It is thought to be energy left over from the Big Bang.

Cosmic inflation A theory that the Universe expanded to trillions of times its size in the first trillionth of a second of its existence, before continuing to expand at a slower rate.

Cosmology The study of the Universe. A person who studies the Universe is called a **cosmologist**.

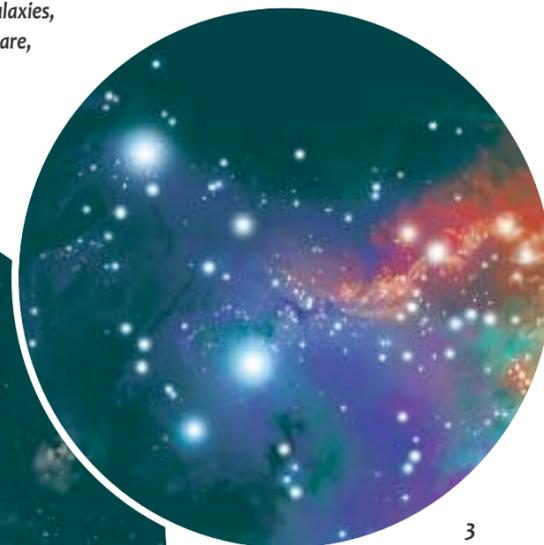
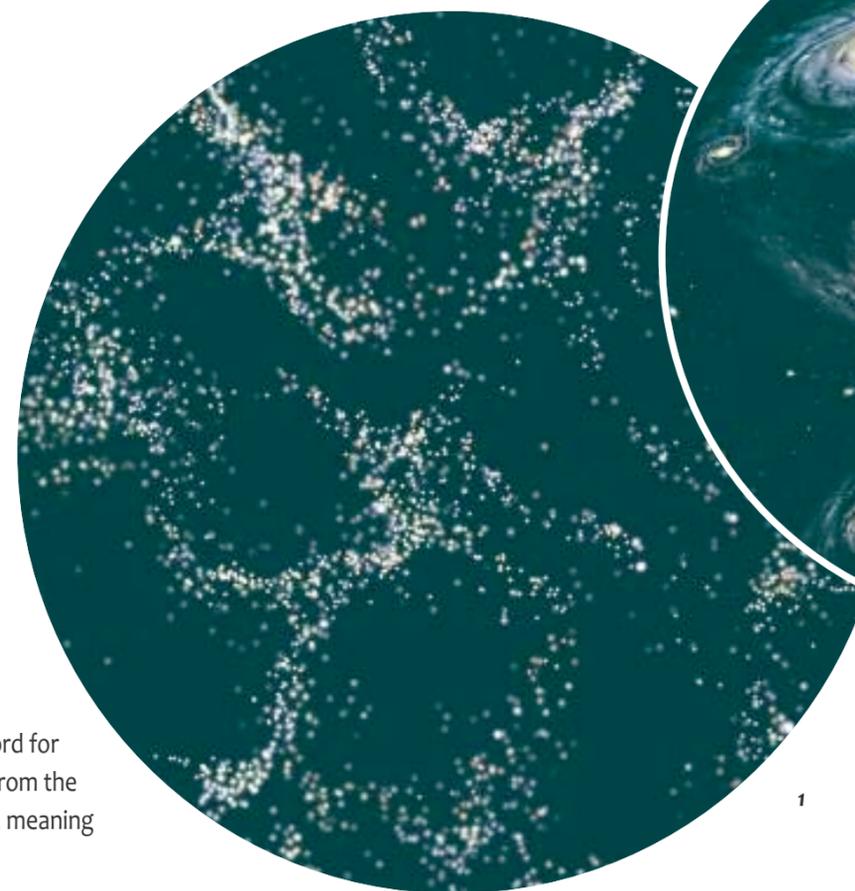
Cosmos Another word for Universe. It comes from the Greek word *kosmos*, meaning “ordered world”.

Critical density The density that all of the matter in the Universe would need to have in order for the Universe to stop expanding. At exactly the critical density the Universe will stop expanding and stay the same size. If the Universe has less than the critical density then it will continue to expand forever. If the Universe has more than the critical density then it will eventually be collapsed by its own gravity.

Dark energy A force that could potentially overcome the gravitational pull of other objects. Dark energy is still just a theory, meaning that scientists think it may exist, but have yet to prove it.

Dark matter The invisible matter that is believed to hold the Universe together. Scientists think that dark matter makes up 90% of the Universe. Dark matter cannot be seen, but it can be detected by observing the effects of its gravity on other objects.

The Universe is made up of trillions of galaxies, grouped into clusters of galaxies, which are, themselves, grouped into superclusters. 1 Universe; 2 Galaxy cluster; 3 Stars in a galaxy.



Red shift Light travels in waves. Red light has a longer wavelength (the distance between wave crests) than other colours. When a light source moves away from you, its wavelength stretches and it appears more red. This is red shift. All galaxies other than our own show red shift. This indicates that they are moving away from us and that the Universe is expanding.

Void A region of space that is completely empty of matter, even dark matter.

Hubble’s Law Edwin Hubble’s theory that the farther away a galaxy is from the Earth, the faster it is moving away from the Earth. The observation that galaxies are moving away from each other is used as evidence of the Big Bang and Accelerating Universe theories.

Matter The “stuff” that everything in the Universe is made of. Anything that has mass and takes up space is made of matter. Every object, substance and material in the Universe is made of matter.

Multiverse Theory The theory that there may be other universes than our own, sometimes called “parallel universes”.

Observable Universe The parts of the Universe that we can observe from Earth (with telescopes). We can see these distant regions because the light they emit has had time to reach us since the Big Bang.

Einstein, Albert (1879-1955) German-born physicist who is famous for his theories about space, time, matter, gravity and light. He is most famous for his theories of relativity. In 1921, he was awarded a Nobel Prize for Physics.

Electromagnetic Spectrum A classification of different types of radiation (energy that travels in waves). Radio waves, microwaves, light and X-rays are all forms of electromagnetic radiation. They all travel at the same speed, but have different wavelengths—the distance between one wave crest and the next—and emit different amounts of energy.

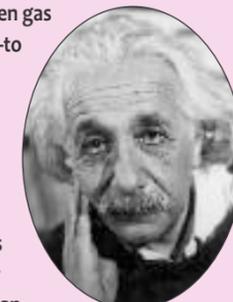
FACTFILE

★ The commonest elements in the Universe are hydrogen, helium and oxygen.

★ About three-quarters of all matter in the Universe is hydrogen.

★ After the Big Bang, it took about 300,000 years for the first atoms—atoms of hydrogen gas and helium gas—to come together.

★ The observable Universe is at least 92 billion light years wide. It probably contains more than 100 billion galaxies.



Albert Einstein

INDEX

Page numbers in **bold** refer to main entries.

A

Absolute magnitude 22
Accelerating Universe 28-29
Active galactic nucleus 26
Active galaxy 26
Adams, John Couch 18
Albedo 6
Ammonia 18
Andromeda 24-25, 26
Aphelion 6
Apogee 12
Apollo 11 12
Apparent magnitude 22
Ariel 18
Arsia Mons 15
Artificial satellites 7
Ascreaus Mons 15
Asteroid Belt 20-21
Asteroids 6, 13-15, 20-21
Astronaut 6, 12-13
Astronomical unit (AU) 6
Astronomy 6
Atmosphere 6, 13-15, 17, 21
Atom 6, 28
Axis 6, 12

B

Barred spiral 26
Basin 12-13
Belts 16
Beta Regio A canyon 14
Betelgeuse 22
Big Bang 28-29
Big Crunch 28
Binary star 22
Blazars 26
Black dwarf 22
Black hole 22-23, 26-27
Blue giant 22-23

Bolide 20
Borealis Basin 14
Brown dwarf 22
Bulge 26

C

Callisto 16
Caloris Basin 14
Canis Major 23-24
Canyon 14-15
Cassini Division 17
Cassini, Giovanni Domenico 16
Celestial body 6
Centaur 20
Ceres 20
Charon 20
Chromosphere 10
Cluster 26
Colour index 22
Coma 20
Comet 17, 20-21
Constellations 23-25
Convective zone 10
Cordelia 19
Core 6
Corona 10-11
Cosmic inflation 28
Cosmic microwave background radiation 28
Cosmologist 28
Cosmology 28
Cosmos 28
Crab Nebula 22-23
Crater 12-14, 16-19
Crescent moon 12
Critical density 28
Crust 6
Cryovolcano 18

D

Dark energy 28
Dark matter 26, 29
Day 6
Deimos 14-15
Density 6
Dust storm 14
Dwarf galaxy 26
Dwarf planet 20-21

E

Earth 6-7, 9-15, 21, 23, 26-27, 29
Earthshine 12
Eclipse 6
Einstein, Albert 29
Electromagnetic Spectrum 11, 29
Electrons 28
Elliptical galaxy 26
Equator 6
Eris 20

F

Filament 26
Flare 10
Flyby 6
Full moon 12-13

G

Galactic arms 26
Galactic halo 26
Galaxy 4, 22-24, 26-29
Galle, Johann 18
Galileo Galilei 7, 16
Ganymede 16
Gas giants 16-18
Gibbous moon 12
Giotto Probe 20
Globular cluster 22
Granules 10
Gravitational force 28
Gravitational pull 6, 8, 16, 19
Gravity 6, 18, 20, 22-23, 26, 29
Great Dark Spot 18
Great Red Spot 16-17
Great White Spot 17
Greenhouse effect 14

H

Half moon 12
Halley, Edmond 21
Halley's Comet 9, 20
Heliocentric 6
Heliosphere 10

Herschel, William 18
Horsehead Nebula 22
Hubble Space Telescope 27
Hubble, Edwin 26-27, 29
Hubble's Law 29
Huygens, Christiaan 17

I

Impact craters 12
Infrared radiation 10
Io 16-17
Iron oxide 14
Irregular galaxy 26-27
Ishtar Terra 14

JK

Jovian planets 17
Jupiter 6, 9, 10, 16-17, 20-21
Kuiper Belt 20-21

L

Lander 6
Lava 6, 12-14
Le Verrier, Urbain 18
Lenticular galaxy 27
Light year 6, 23, 26, 29
Local Group 26-27
Luminosity 22
Luna 2 12
Luna 3 12
Luna programme 12
Lunar 12
Lunar eclipse 13
Lunar month 13

M

Magellan Probe 14
Magellanic Clouds 27
Magnetic field 7, 10
Magnitude 22
Main sequence 22
Mantle 7
Mare 13
Mariner Programme 14
Mars 6, 9, 14-15, 20
Martian polar caps 14

Mass 7, 8, 20, 29
Matter 7, 29
Maxwell Montes 14
Mercury 6, 9, 11, 14-16
Messenger 14
Meteor 20-21
Meteor Shower 21
Meteorite 21
Meteoroid 18, 21
Methane 18
Milky Way Galaxy 26-27
Mimas 17
Minor planets 20
Miranda 18
Moon 6-7, 10, 12-13, 16
Multiverse Theory 29

N

Natural satellite 7
Nebula 23
NEOs (Near-Earth Objects) 21
Neptune 7, 9, 18-19, 21
Nereid 19
Neutron star 23
Neutrons 28
New Moon 12-13
North Star 23
Nova 23
Nuclear fusion 10, 22
Nucleus 20, 26-28

O

Oberon 19
Observable Universe 29
Olympus Mons 15
Oort cloud 20-21
Open cluster 23
Ophelia 19
Orbit 7
Orion 22, 24-25, 26

P

Parallax 23
Parallel universes 29
Pathfinder Probe 15
Pavonis Mons 15
Penumbra 11
Perigee 13

Perihelion 7
Phase 7, 12-13, 16
Phobos 15
Photosphere 10-11
Pioneer 10 space probe 9
Pioneer Missions 17
Pioneer Venus Project 15
Planet 4, 6-8, 13-21
Planetary nebula 23
Planetesimal 7
Planetoid 20
Plasma 10
Pluto 7, 9, 20-21
Polaris 23
Poles 6-7, 14
Pressure 7
Prominence 10-11
Prominence 11
Proteus 19
Protons 28
Protostar 23
Proxima Centauri 21, 23
Pulsar 23

QR

Quarter moon 12
Quasar 26-27
Radiation 10-11, 28-29
Radiative zone 11
Radio galaxies 26
Red dwarf 23
Red giant 11, 22-23
Red shift 29
Regolith 13
Relativity 29
Revolve 7
Rilles 13
Ring 17
Ring galaxy 27
Ringlet 17
Rings 17-19

S

Satellite 4, 7, 27
Saturn 6, 9, 16-17
"Scooter" 19
Selenography 13
Seyferts 26
Shepherd satellite 19
"Shooting stars" 21

Sirius 23
Sojourner Rover 15
Solar core 11
Solar eclipse 10-11
Solar System 7, 8, 10, 14, 16-18, 20-21, 27
Solar wind 7, 10-11, 20
Space probe 7
Spicule 11
Spiral galaxy 26-27
Star 6, 10, 21-25, 27
Starburst 23
Starburst galaxy 27
Stardust Probe 21
Subatomic particles 11, 28
Sulphuric Acid 15
Sun 4, 6-12, 14, 18, 20-23, 26-27
Sunspot 10-11
Supercluster 26-29
Supergiant 22-23
Supernova 22-23

T

Telescope 4, 7, 16, 26-27, 29
Terra 13
Tharsis Bulge 15
Titan 17
Titania 19
Tombaugh, Clyde 21
Triton 19
Trojan 21
Tunguska fireball 21

U

Umbra 11
Umbriel 19
Universe 4, 10, 26, 28-29
Uranus 6, 9, 18-19

V

Valles Marineris 15
Variable star 23
Venera Missions 15
Venus 6, 9, 11, 14-17
Viking Programme 15
Virgo 24, 27

Virgo Cluster 27
Void 28-29
Volcano 7, 14-15, 17, 18-19
Voyager 9, 19
Voyager Programme 19

W

Waning 13
Waxing 13
White dwarf 22-23
Wrinkle ridges 15
Wunda crater 19

YZ

Year 7
Yellow dwarf 23
Zones 17

