

DK findout!

Universe



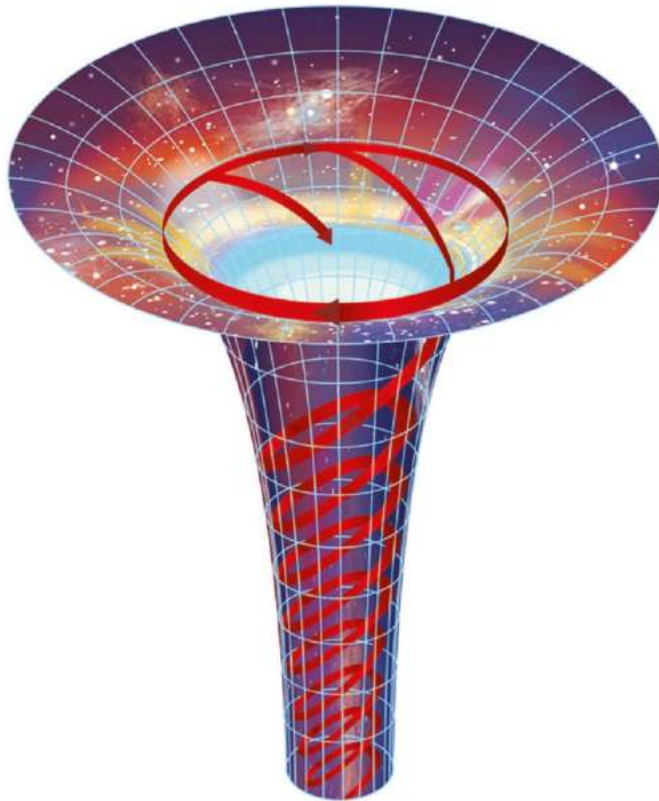
What do you want to **findout?**

Fun Facts, Amazing Pictures, Quizzes



findout!

Universe



Author: Giles Sparrow
Consultant: Jerry Stone



Penguin
Random
House

Senior editor Carrie Love

Project art editor Lucy Sims

Project editor Ishani Nandi

Editor Anwasha Dutta

Assistant editor Shambhavi Thatte

US editor Allison Singer

Art editors Kartik Gera, Shipra Jain

Managing editors Laura Gilbert, Alka Thakur Hazarika

Managing art editors Diane Peyton Jones,
Romi Chakraborty

Jacket designer Suzena Sengupta

Jacket coordinator Francesca Young

DTP designers Rajesh Singh Adhikari, Pawan Kumar

Picture researcher Sakshi Saluja

CTS manager Balwant Singh

Pre-producer Rob Dunn

Senior producer Isabell Schart

Creative director Helen Senior

Publishing director Sarah Larter

Educational consultant Jacqueline Harris

DIGITAL OPERATIONS, DELHI

Editor Suruchi Bhatia

Production co-ordinator Manish Bhatt

DK CREATIVE, DELHI

Assistant editor Perna Grewal

Art editors Radhika Banerjee, Mohd Zishan

Managing editor Monica Saigal

Deputy managing art editor Ivy Sengupta

eISBN: 9781465483348

Digital edition published by
Dorling Kindersley Limited

First American edition, 2018

Published in the United States by DK Publishing
345 Hudson Street, New York, New York 10014

Copyright © 2018 Dorling Kindersley Limited
DK, a Division of Penguin Random House LLC

All rights reserved.

Without limiting the rights under the copyright reserved above, no part of this publication may be reproduced, stored in or introduced into 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.

Published in Great Britain by Dorling Kindersley Limited

DK books are available at special discounts when purchased in bulk for sales promotions, premiums, fund-raising, or educational use.

For details, contact: DK Publishing Special
Markets, 345 Hudson Street, New York,
New York 10014 SpecialSales@dk.com

A WORLD OF IDEAS:
SEE ALL THERE IS TO KNOW

www.dk.com

Contents

4 Our place in space

6 The Big Bang

8 Space objects

10 Life of a star

12 Star birth

14 Types of stars

16 Multiple stars

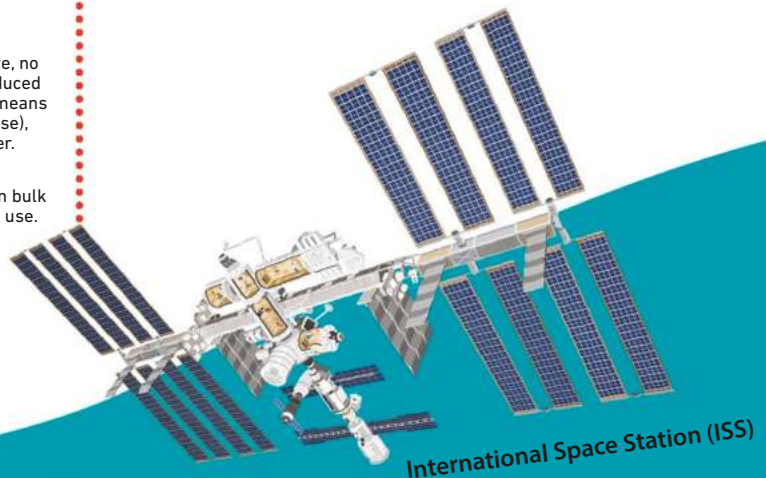
18 Black holes

20 Galaxies

22 Milky Way

24 The Sun

26 Solar System



International Space Station (ISS)



Replica of Galileo's telescope

28 Beyond Neptune

30 Rocky planets

32 Gas giants

34 Earth's Moon

36 Moons

38 Rocks in space

40 The view from Earth

42 Constellations

44 Astronomy

46 Meet the expert

48 Space photos

50 Exploring space

52 Exoplanets

54 Is there life out there?

56 James Webb Telescope

58 Universe facts and figures

60 Stargazing

62 Careers in space

64 Glossary

66 Index

68 Acknowledgments

69 Quiz

70 Quiz answers

Moon rock



Inside the planet Mars



Hockey Stick Galaxy



Space Shuttle Discovery

Our place in space

Our universe is enormous—in fact it's everything there is. Long ago, people used to think that Earth was the center of everything, but now we understand that our planet is just one tiny speck in space.

Where do we fit in?

The scale of the universe is so huge that we can't really imagine it all at once. The best way of thinking about it is to see how things from our everyday lives fit into it.

PEOPLE

Most people are between 3–6½ ft (1–2 m) tall. Walking at average speed, we cover about 3 miles (5 km) in an hour.

CITIES

Medium-sized cities are usually about 6–12 miles (10–20 km) across. It might take a few hours to cross them by foot.

OUR PLANET

The Earth is 7,918 miles (12,742 km) across. It would take an average person about 20 million steps to walk around the equator.

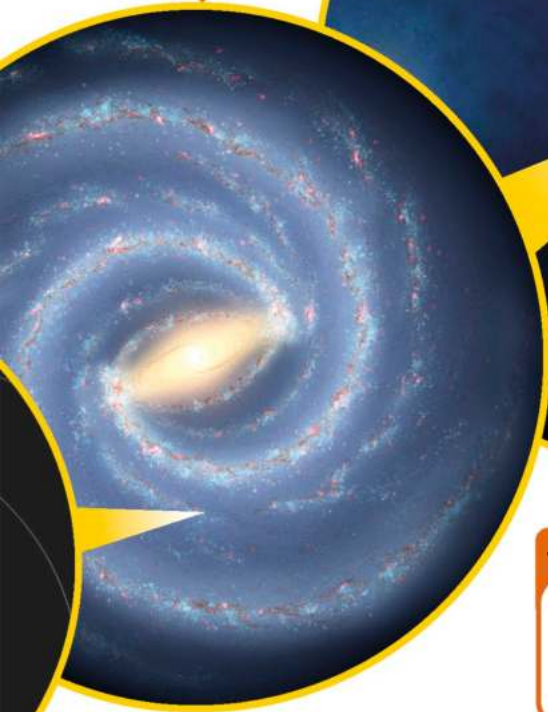
THE SOLAR SYSTEM

Our solar system is mostly empty space. Even our moon is 30 Earth diameters away. Earth is 93 million miles (150 million km) from the sun, but distant comets can orbit up to a light-year away.



THE MILKY WAY

Our home galaxy is about 100,000 light-years across and contains between 100 and 400 billion stars. Our solar system is about 26,000 light-years from the center.



THE LOCAL GALACTIC GROUP

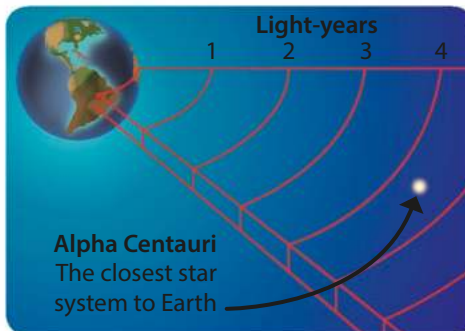
The Milky Way is one of the bigger members of a galaxy group roughly 10 million light-years across.

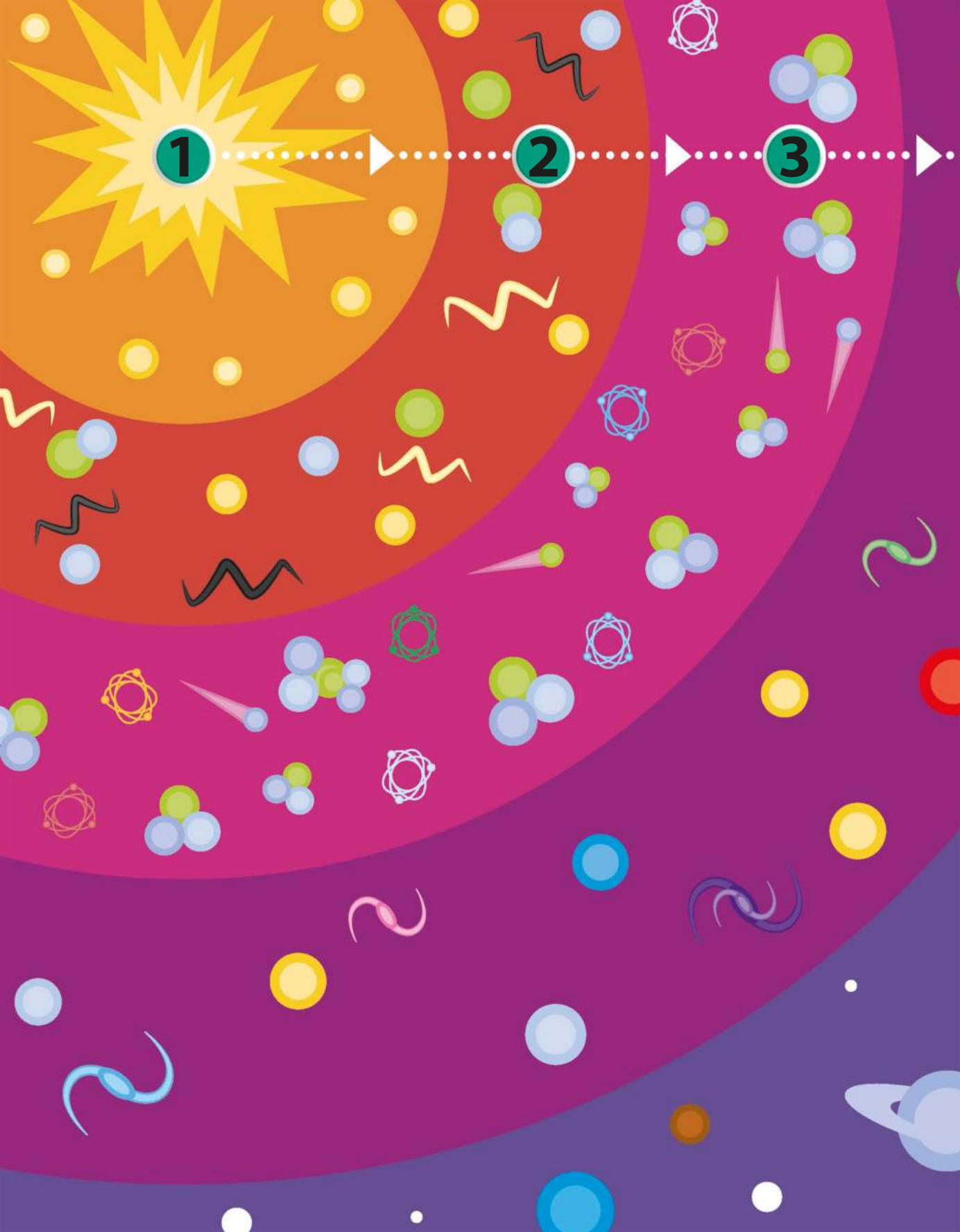
UNIVERSE OF GALAXIES

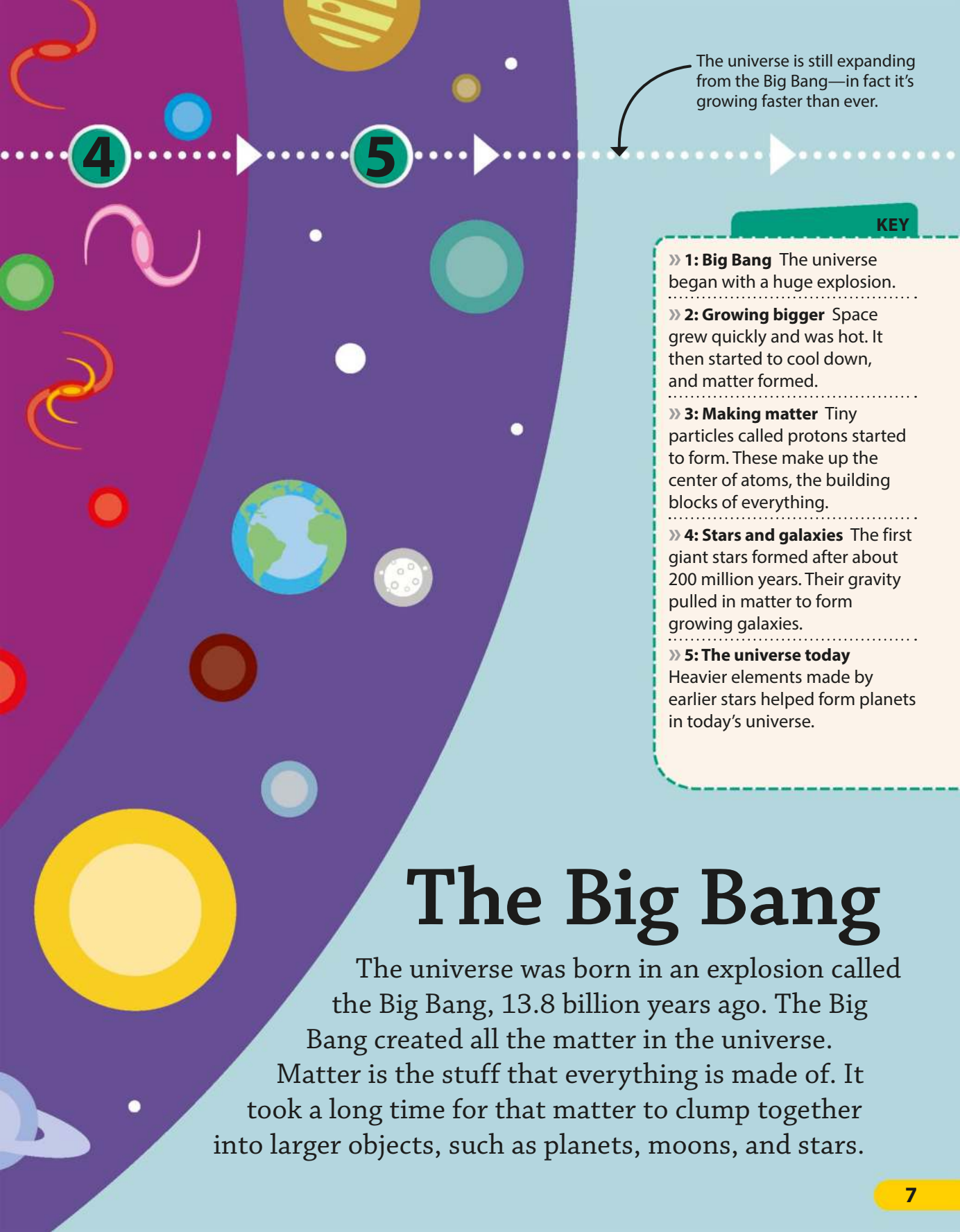
The universe contains at least 200 billion galaxies and stretches across at least 156 billion light-years. We can see objects up to 92 billion light-years away.

What is a light-year?

Astronomers measure huge cosmic distances in terms of light-years, the distance that light (the fastest thing in the universe), travels in one year. One light-year is about 5.9 trillion miles or 9.5 trillion km.







The universe is still expanding from the Big Bang—in fact it's growing faster than ever.

KEY

- » **1: Big Bang** The universe began with a huge explosion.
- » **2: Growing bigger** Space grew quickly and was hot. It then started to cool down, and matter formed.
- » **3: Making matter** Tiny particles called protons started to form. These make up the center of atoms, the building blocks of everything.
- » **4: Stars and galaxies** The first giant stars formed after about 200 million years. Their gravity pulled in matter to form growing galaxies.
- » **5: The universe today** Heavier elements made by earlier stars helped form planets in today's universe.

The Big Bang

The universe was born in an explosion called the Big Bang, 13.8 billion years ago. The Big Bang created all the matter in the universe.

Matter is the stuff that everything is made of. It took a long time for that matter to clump together into larger objects, such as planets, moons, and stars.



Stars

Stars are huge balls of gas that release heat and light. They are often found in pairs or clusters.



Space objects

The Universe contains objects, from asteroids, planets like Earth, to stars, many far bigger than our Sun, and enormous galaxies! Then there are the objects that humans have sent into space, including satellites and spacecraft.



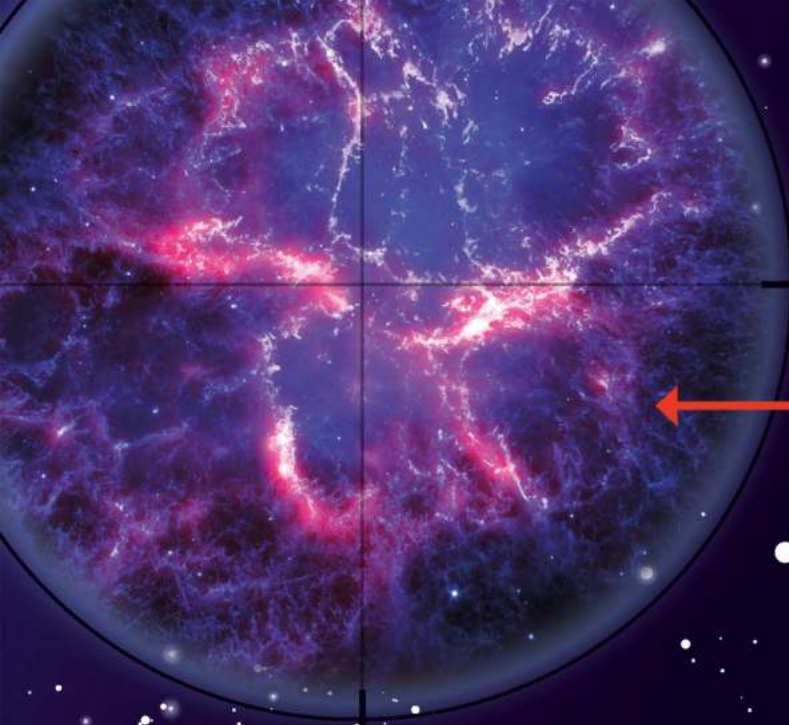
Planets

There are different types of planet that orbit the stars; rocky planets like the Earth, gas planets like Jupiter, and dwarf planets like Pluto. The planet shown here is Venus.



Galaxies

Galaxies are the largest objects in the Universe. They are made up of many millions of stars, along with gas and dust.



Interstellar clouds

Interstellar space is the name for the areas between stars. Gas and dust clouds in these regions are called nebulae. These clouds provide the raw materials to form stars.



Artificial objects

Since 1957, humans have built and launched satellites into orbit around Earth for various uses, and sent space probes out to explore the other objects in our Solar System.



Natural satellites

Moons are objects that orbit around planets (and sometimes around smaller objects, such as rocky asteroids). They are natural satellites, and range from large complex worlds to smaller rocks.



Life of a star

Stars live and die at different speeds depending on how much fuel they have to burn. Massive stars shine more fiercely but live much shorter lives than smaller ones. They also die in different ways.



Protostar

A star is born from a collapsing cloud of gas and dust. It warms up as the gas molecules collide, until eventually it begins to shine.

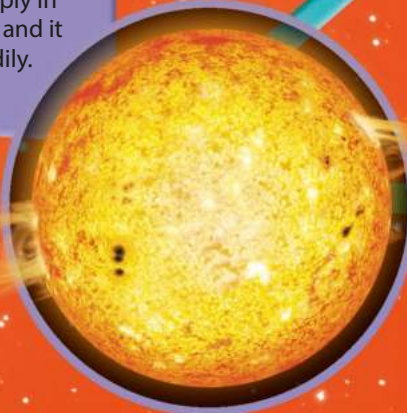


Red giant

After a few billion years, a small star like the sun goes through changes that allow it to keep shining. It gets much brighter, swells in size, and turns red.

Main-sequence star

A star's "main sequence" stage is the main part of its life. During this stage it burns through the fuel supply in its hot core, and it shines steadily.



Red supergiant

The biggest, brightest stars run out of fuel in just a few million years. They swell in size to become supergiants.





Planetary nebula

Eventually a red giant becomes unstable and puffs off its outer layers into a glowing gas bubble called a planetary nebulae.



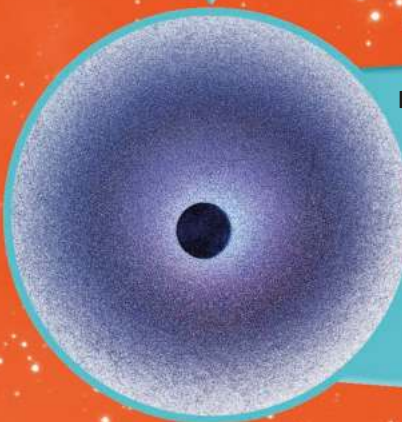
White dwarf

The Earth-sized core of the red giant survives. It cannot make any more energy, but it still shines because its surface is extremely hot.



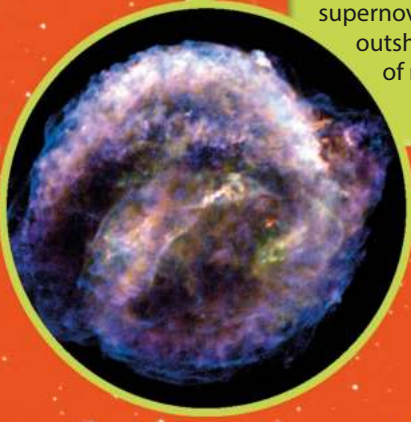
Neutron star

The core of a giant star is forced together, creating a neutron star as big as a city. It is surrounded by a huge cloud of superhot gas.



Black dwarf

Over many billions of years, a white dwarf slowly cools down until it can become a thick, dark black dwarf.



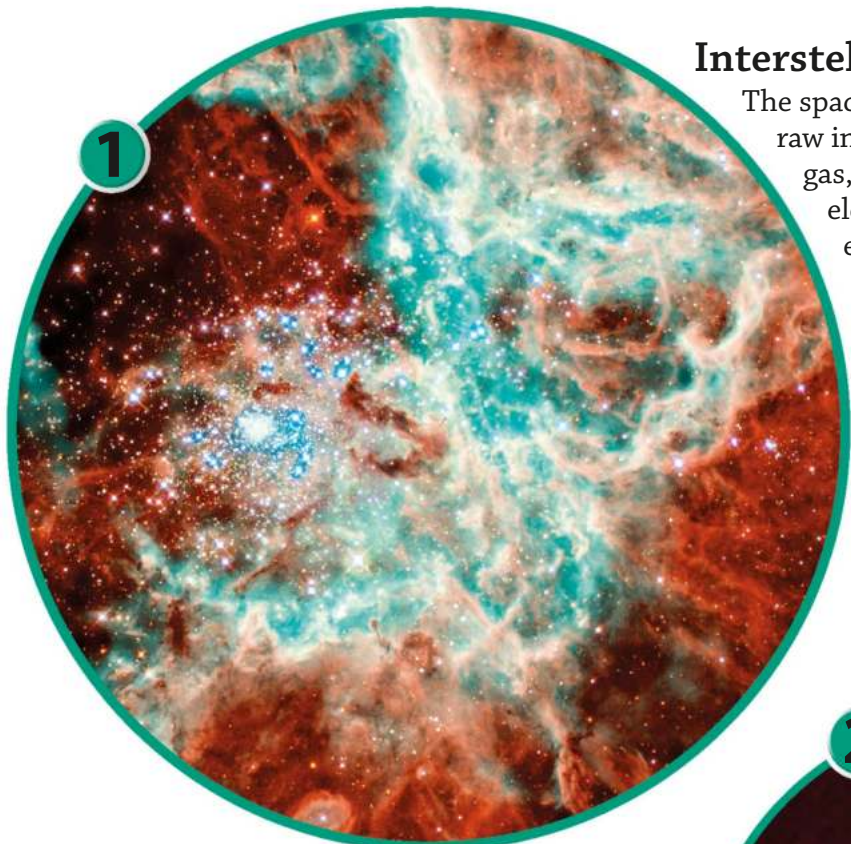
Supernova

When a supergiant runs out of fuel, it dies in a huge explosion called a supernova that can outshine a galaxy of normal stars.



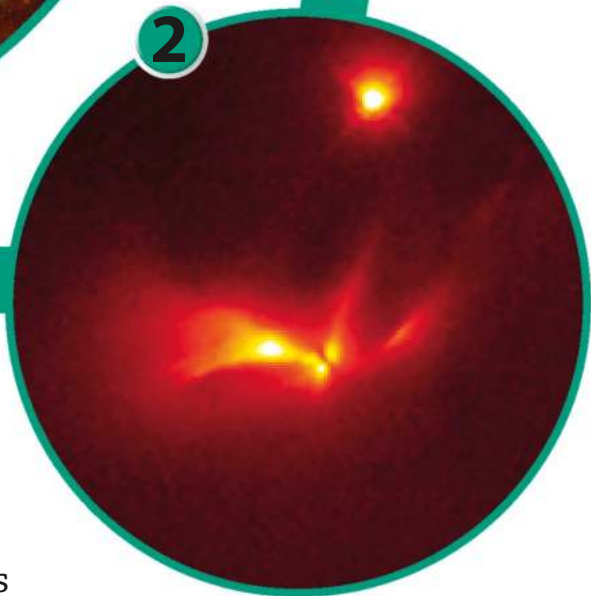
Black hole

A black hole is a point in space that sucks in anything that comes close to it. Stars with very heavy cores (centers) collapse to create black holes.



Interstellar clouds

The space between stars contains raw ingredients—pure hydrogen gas, dust, and other heavy elements made by stars that exploded long ago. Where these materials join together, they form clouds called nebulae.



Star birth

Stars are born when huge clouds of gas and dust floating in space are condensed by gravity, or are disturbed by either the gravity of another star passing nearby or the shockwave from a supernova explosion. Hundreds or thousands of stars may be born from a single cloud.

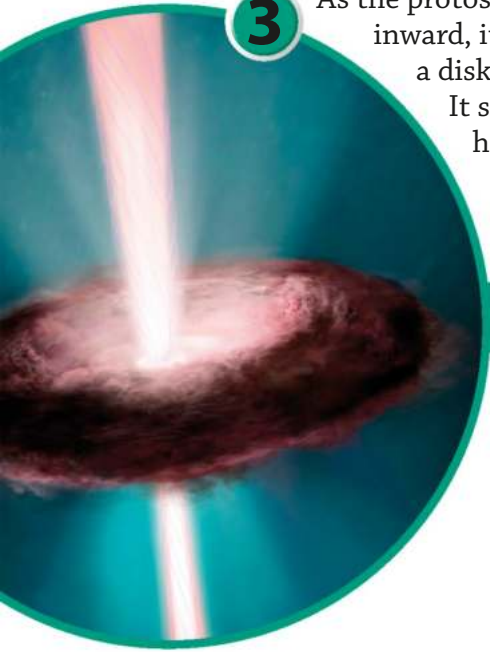
Protostar

As a nebula collapses, it separates into protostars—knots of gas that will each form one or more stars. A protostar's gravity pulls in material from its surroundings.

Spinning disk

3

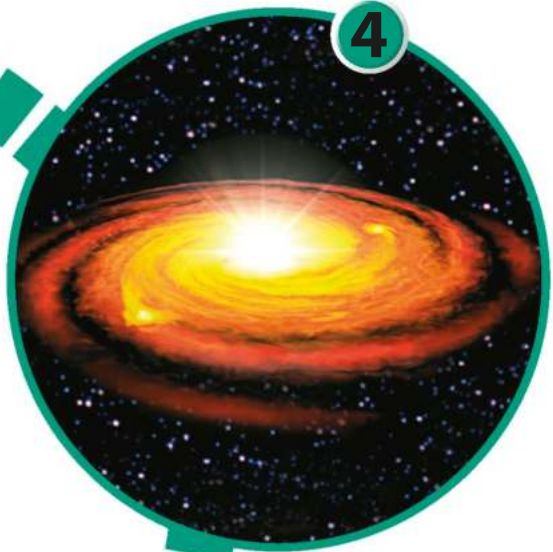
As the protostar draws matter inward, it flattens out into a disk with a bulging center. It spins quickly and gets hotter and hotter as it pulls in more material, spitting out extra matter in jets.



REALLY?

The **thickest** nebulae can produce clusters of more than **100,000** stars!

4



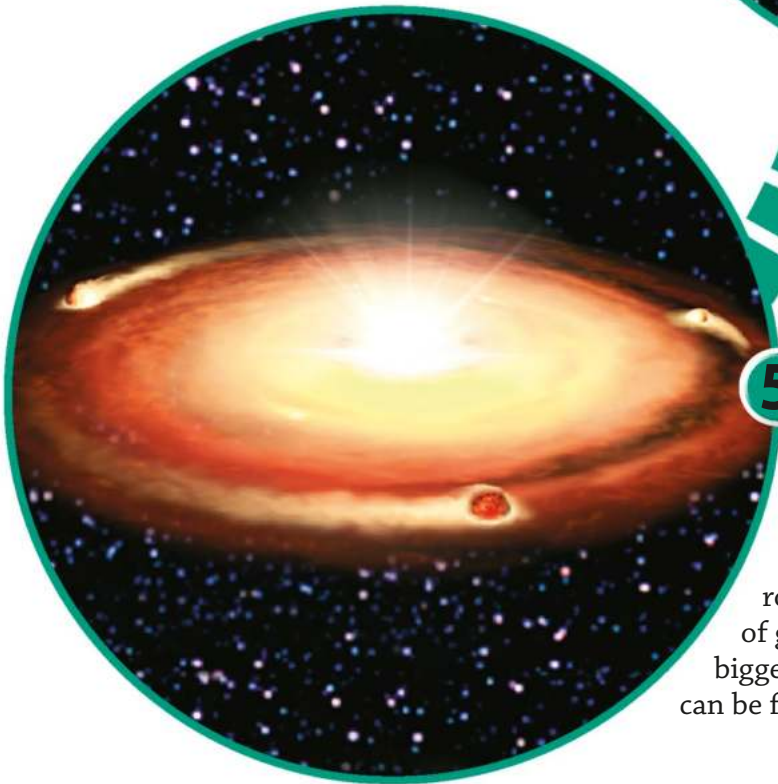
New star

Eventually the gas at the center of the disk gets hot and thick enough for nuclear reactions to begin, turning it into a shining star.

5

Planets form

Material left in the disk around the star can now start to form a system of planets, which can include both rocky planets and those made mostly of gas. Gas planets are generally much bigger than rocky planets, but either type can be found close to a star or farther away.



Types of stars

The billions of stars in the sky vary hugely in colour, size, and brightness. Some of these differences are because stars are born with varying weights, and some because they are at different stages in their life cycle.

Colour range

A star's colour depends on how hot it is. A star's temperature is measured in degrees Kelvin (K). Zero degrees Kelvin is -273°C (-458°F).

Hottest

> 30,000 K

10,000 – 30,000 K

Blue giant

Stars with several times the Sun's mass shine a hundred times brighter, so their super-hot surfaces appear blue.

Blue supergiant

These stars weigh tens of times more than the Sun and shine a hundred-thousand times more brightly.

The Sun

The Sun is an average star with a yellow surface. It will shine steadily for billions of years before turning into a red giant.

! WOW!

Most blue giant stars exist for less than 100 million years.

The Sun



White dwarf

Red dwarf

Dwarf stars

Red dwarfs are normal stars that are much cooler, fainter and smaller than the Sun. Red dwarfs are the most common type of star in the Milky Way. White dwarfs are as big as planets. They are the burnt-out cores of stars.

Coldest

5,200 – 6,000 K 3,700 – 5,200 K 3,000 – 4,000 K 2,400 – 3,700 K

Orange giant

Stars with less mass than the Sun do not brighten or swell so much near the end of their lives.

Red giant

Near the end of their lives, stars like the Sun briefly shine as brilliant, huge but cool red giants.

Red supergiant

These are the biggest stars of all, with puffy atmospheres that can be larger than Jupiter's orbit around the Sun.

Multiple stars

Stars are born in large groups out of gas clouds that fall apart. Some drift away to become single stars like the sun, but most spend their whole lives in pairs, triplets, or bigger groups.



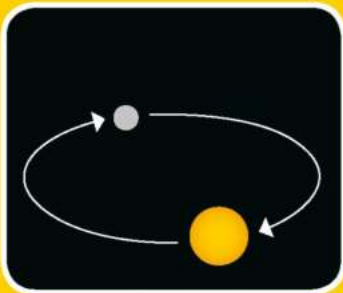
Binary stars

Astronomers call a pair of stars in orbit around each other a “binary system.” The time it takes stars in a binary system to circle each other can vary from a few hours to thousands of years.

This multiple star system has two binary pairs in orbit around each other.

Merging stars

Two stars in a binary pair may not have the same mass, or amount of matter. If this is the case, they will age at different rates. This can allow one star to steal material from the other.



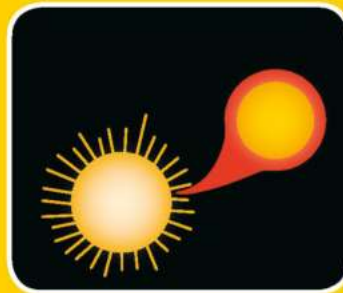
1. Orbiting stars

In this binary pair, one star is a white dwarf and the other is about to become a red giant.



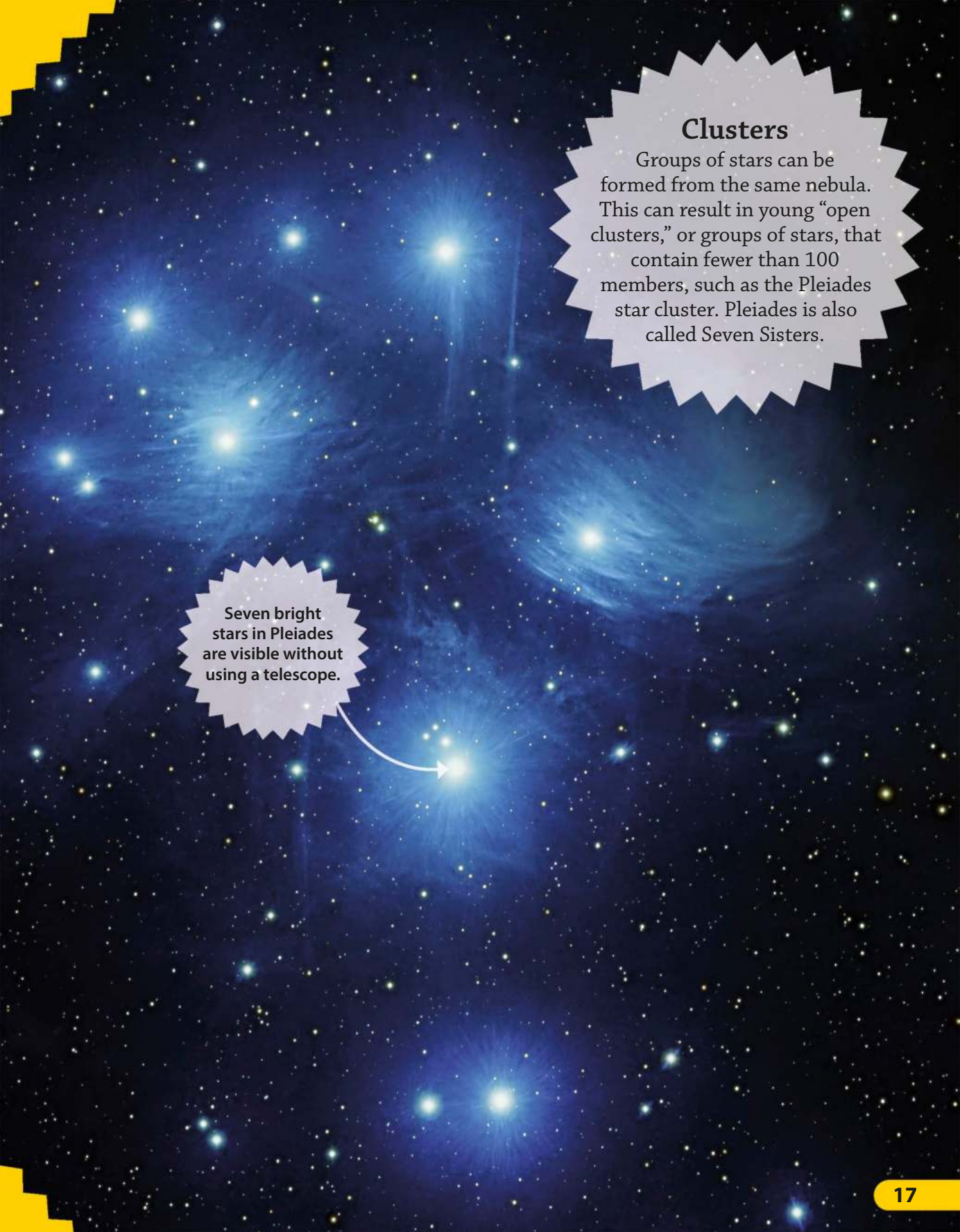
2. Matter transfer

The white dwarf star steals gas from the outer layers of the star that has become a red giant.



3. White dwarf explodes


The shell of hot gas around the white dwarf burns away in an explosion called a nova.



Clusters

Groups of stars can be formed from the same nebula. This can result in young “open clusters,” or groups of stars, that contain fewer than 100 members, such as the Pleiades star cluster. Pleiades is also called Seven Sisters.

Seven bright stars in Pleiades are visible without using a telescope.



Black holes

A black hole is an area of space that has an incredibly strong gravity. It sometimes forms when a star collapses and dies, when huge clouds of gas join together in new galaxies, or when stars collide. If something comes too close to a black hole, it will fall in and never escape!

FACT FILE

» **1. Singularity** The center of a black hole is called the singularity. At this point, gravity becomes limitless, and the normal laws of science no longer apply.

» **2. Event horizon** This boundary marks the space where even light cannot escape the black hole's gravity. This is why the black hole appears completely black.

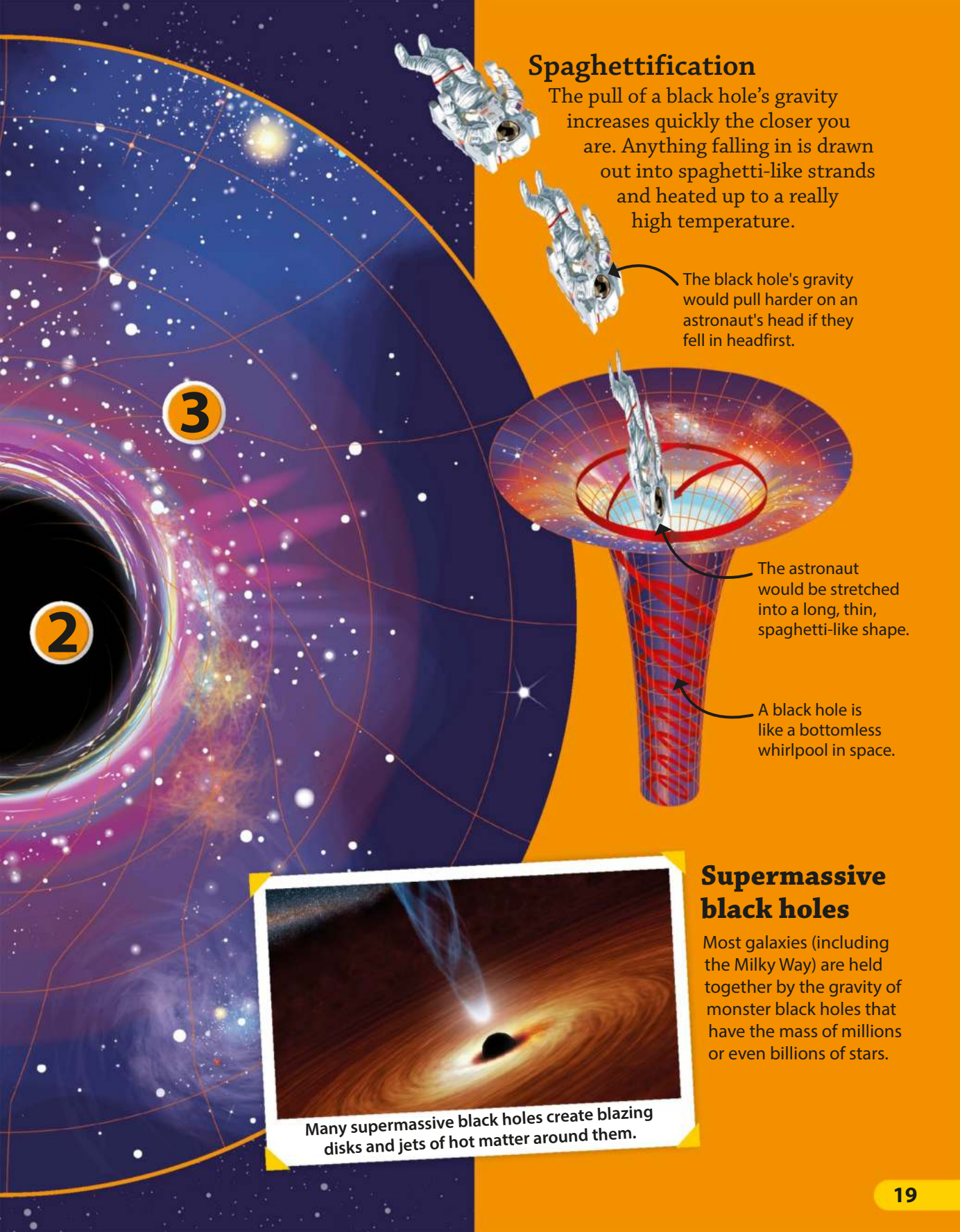
» **3. Ergosphere** This is the area of a black hole where objects have their last chance to escape, depending on the distance between the object and the event horizon.



1

Spaghettification

The pull of a black hole's gravity increases quickly the closer you are. Anything falling in is drawn out into spaghetti-like strands and heated up to a really high temperature.




The black hole's gravity would pull harder on an astronaut's head if they fell in headfirst.

The astronaut would be stretched into a long, thin, spaghetti-like shape.

A black hole is like a bottomless whirlpool in space.

Supermassive black holes

Most galaxies (including the Milky Way) are held together by the gravity of monster black holes that have the mass of millions or even billions of stars.



Many supermassive black holes create blazing disks and jets of hot matter around them.

Galaxies

A galaxy is a collection of stars, gas, and dust held together by the pulling force of gravity. Each galaxy has many millions or even billions of stars, moving together in space. There are three main galaxy shapes—elliptical, spiral, and irregular—with other subtypes.

Spiral galaxy

A lot of galaxies look like whirlpools. They have a large, very bright ball of stars in their center, with arms of stars, gas, and dust spiraling away from it.



Messier 81



NGC 1300

Barred spiral galaxy

In this shape, a central ball is crossed by a bright bar of stars. The spiral arms begin at each end of this bar. The NGC 1300 is a barred spiral galaxy in the constellation Eridanus. Our own galaxy, the Milky Way, is a barred spiral with the sun in one of its spiral arms.



NGC 5010

Lenticular galaxy

This type of galaxy has a central bulge of stars with no spiral arms. Its shape looks like a lens, a curved piece of glass used in a camera. Astronomers think that lenticular galaxies form after galaxies collide.



Messier 87

Elliptical galaxy

This type has the shape of an ellipse (oval). The stars are very old, and the galaxy doesn't contain much gas or dust. Supergiant ellipticals such as Messier 87 in the constellation Virgo are the largest galaxies of all.

COLLIDING GALAXIES

Galaxies sometimes collide with each other over millions of years. NGC 4656 collided with NGC 4631, also known as The Whale Galaxy, and NGC 462, a small elliptical galaxy.



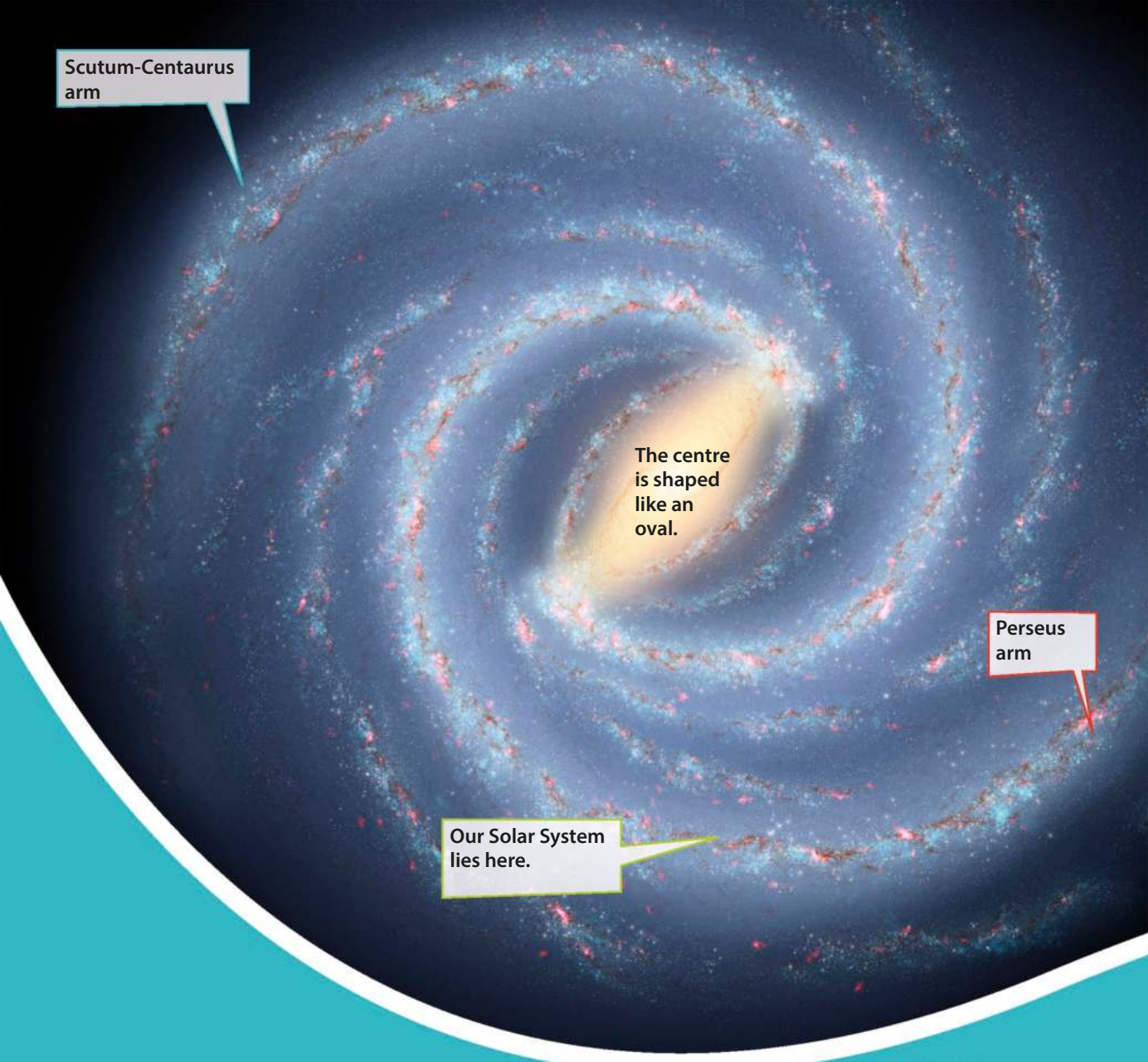
NGC 4656, also called Hockey Stick Galaxy

Irregular galaxy

This type of galaxy is shapeless and mostly made up of gas and dust where new stars are forming. This dwarf galaxy in the constellation Sagittarius has only about 10 million stars.



NGC 6822



Scutum-Centaurus
arm

The centre
is shaped
like an
oval.

Perseus
arm

Our Solar System
lies here.

Milky Way

The Milky Way is our home galaxy. It is an enormous spiral galaxy, containing billions of stars. These are grouped together in “arms”, which spiral out from the centre. Our Solar System sits inside one of the arms.

! WOW!

The Sun takes
240 million years
to make **one**
orbit around the
Milky Way.

Bright young stars mark out spiral

Centre of the Milky Way

From side-on, the Milky Way looks like a flattened disc with a bulge at the centre. It has lots of stars in the space around the disc.

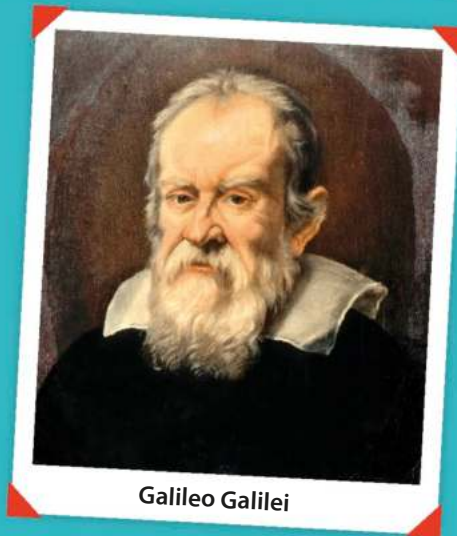
Shape

The Milky Way is a barred spiral galaxy. An oval bulge packed with red and yellow stars is surrounded by a disc, whose brightest blue and white stars make a pattern that looks like a spiral.

The centre of the Milky Way is crowded with stars, all orbiting around an enormous black hole.

Galileo Galilei

When Italian astronomer Galileo Galilei pointed his first telescope at the pale band of the Milky Way in 1609, he discovered it was made from countless stars.



Galileo Galilei

Replica of Galileo's telescope



The sun

The sun is the nearest star to the Earth. It lies at the center of our solar system and is a huge ball of gas. The sun produces heat and light. Without it, our planet would be lifeless. It takes the sun's light about eight minutes to reach the Earth!

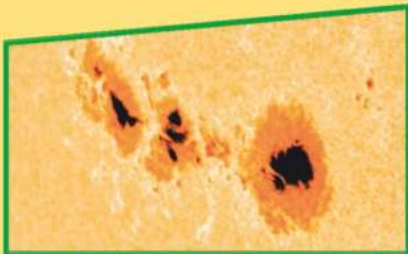
Solar gases

The sun is mostly made of hydrogen, the lightest gas of all. At the sun's center, hydrogen transforms into helium, releasing energy.



Solar flares

The sun sometimes releases huge bursts of energy that send clouds of gas shooting across the solar system at high speed.



Sun spots

These shifting patches on the sun's surface mark places where the temperature is lower than the surrounding areas.



Parker Solar Probe

Exploring the sun

Robotic probes that study the sun must be heavily shielded from its rays. This spacecraft, built to fly into the outer part of the solar atmosphere, will face temperatures of more than 2,500 °F (1,370 °C).

Scorching surface

The sun's surface is a layer where its gases are so thick that we can't see through them. Here temperatures are around 9,900 °F (5,500 °C).



Solar system

The solar system is the area of space in which we live. It contains our star, the sun, at the center, as well as eight planets and their moons, plus dwarf planets, comets, and asteroids. The eight planets orbit, or travel around, the sun.

10

» **1: The sun**

The sun provides light that reflects off other solar system objects, which is how we can see them.

» **2: Mercury**

This scorching-hot, innermost planet takes just 88 days to race around the sun.

» **3: Venus**

This planet orbits the sun in 225 days. Its volcanic surface is hidden by a thick atmosphere.

» **4: Earth**

Our own planet takes 365 days to orbit the sun. This is why our year is 365 days long.

» **5: Mars**

Mars takes 687 days to orbit the sun. A day on Mars is half an hour longer than a day on Earth.

» **6: Jupiter**

Jupiter is the largest planet of all. It spins in less than 10 hours and takes almost 12 years to go around the sun.

» **7: Saturn**

This planet is the most distant one we can see without using a telescope. It takes 29.5 years to orbit the sun.

» **8: Uranus**

This cold world has an 84-year orbit. Unlike the other planets, it lies on its side.

» **9: Neptune**

This outermost major planet takes 165 years to complete a single orbit around the sun.

» **10: Pluto**

The 248-year orbit of this icy "dwarf planet" brings it closer than Neptune when it is nearest to the Sun.

» **11: Comet**

Icy objects from the edge of the solar system heat up and become active as they come close to the sun.

7

9

8

11

Beyond Neptune

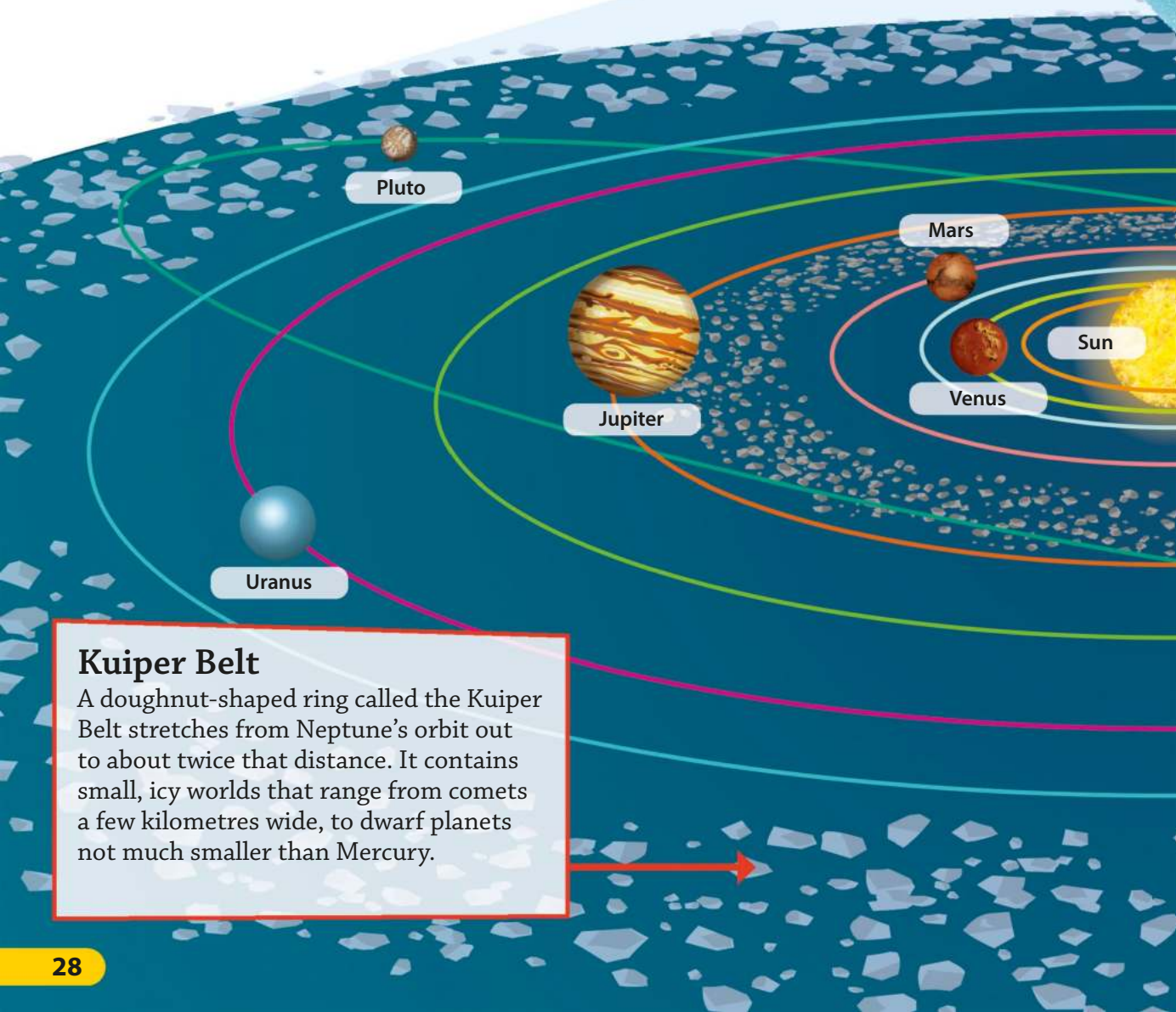
Beyond the orbit of Neptune, countless small, icy objects orbit at the edge of the Solar System. They range from dwarf planets such as Pluto to distant comets forming a shell around the Sun.

Oort Cloud

The Solar System is surrounded by a ball-like shell of comets called the Oort Cloud.

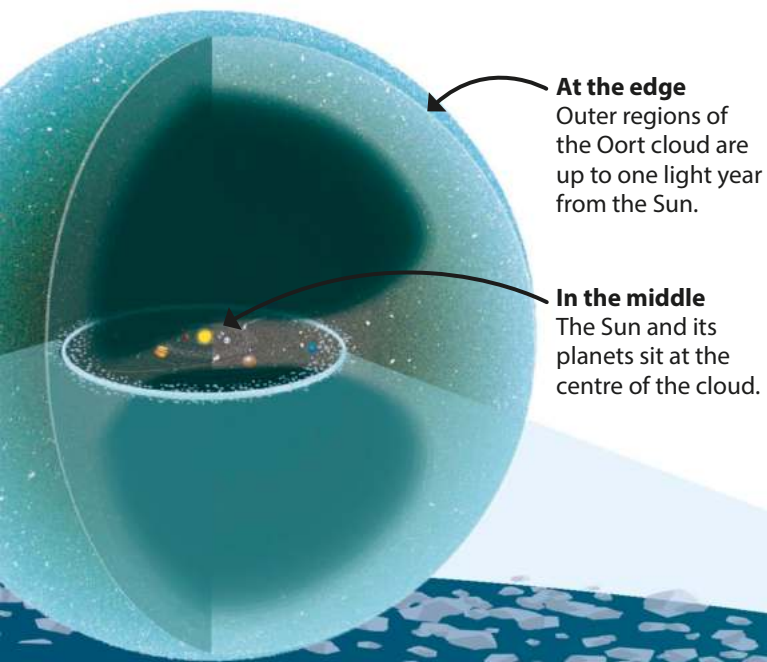
Contains comets

Trillions of comets with a total mass of about five Earths sit in the Oort cloud.



Kuiper Belt

A doughnut-shaped ring called the Kuiper Belt stretches from Neptune's orbit out to about twice that distance. It contains small, icy worlds that range from comets a few kilometres wide, to dwarf planets not much smaller than Mercury.



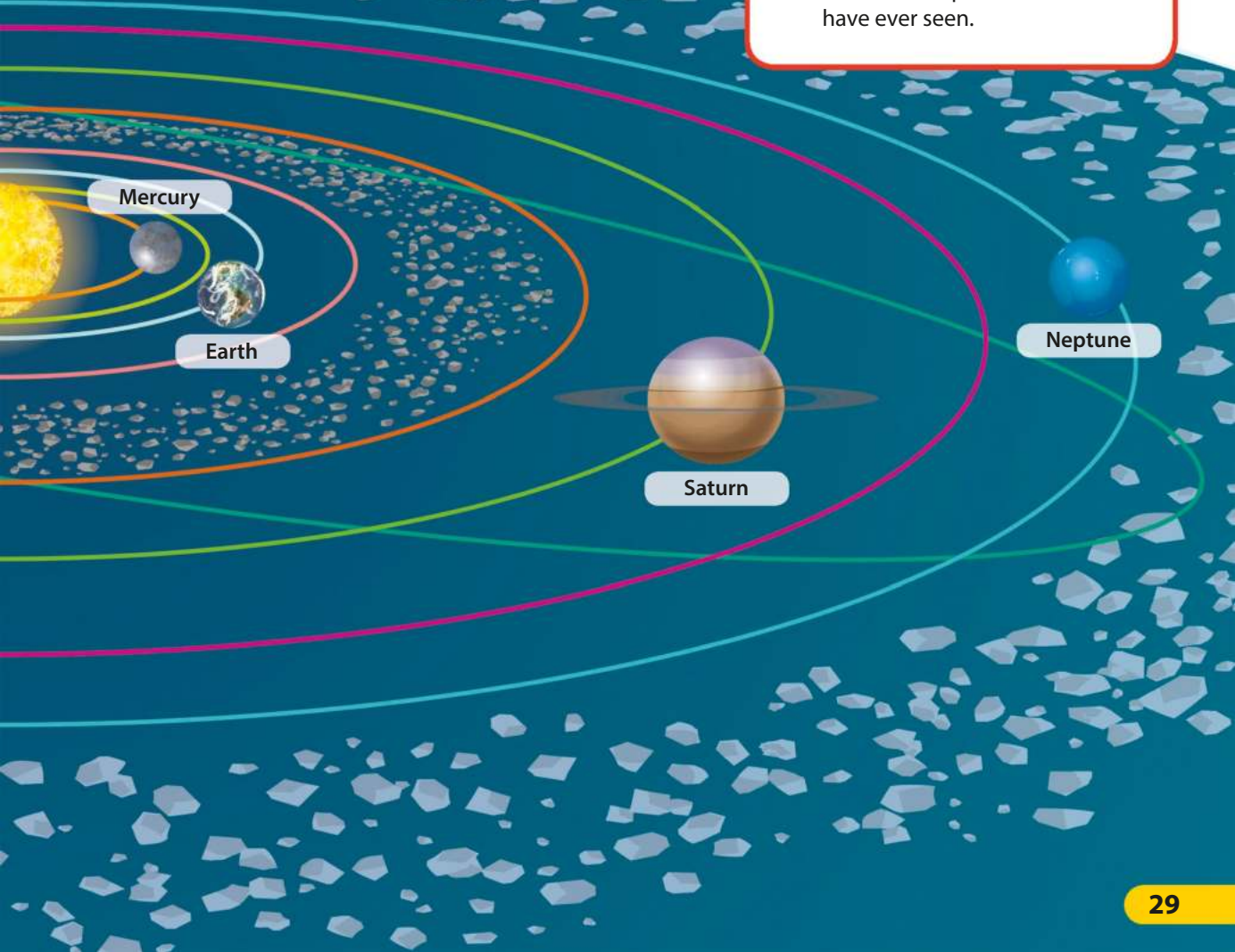
At the edge
Outer regions of the Oort cloud are up to one light year from the Sun.

In the middle
The Sun and its planets sit at the centre of the cloud.

5

KUIPER BELT FACTS

- 1 Icy depths** Temperatures on Pluto can reach -240°C (-400°F).
- 2 What's in a name?** Jan Oort was a Dutch astronomer. The cloud of comets is named after him.
- 3 Stretched orbit** The most distant Kuiper Belt object, Sedna, orbits between 2.5 and 31 times further from the Sun than Neptune.
- 4 Far from the Sun** The Kuiper Belt is 30–50 times further from the Sun than the Earth is.
- 5 Pluto close-up** In 2015, New Horizons space probe took the first detailed photos of Pluto we have ever seen.



Rocky planets

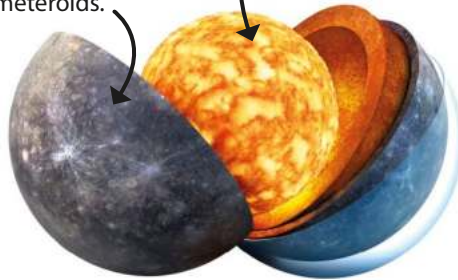
The planets of the inner solar system are all very different. Earth is the largest, followed by Venus, which is nearly the same size. Mars is just over half of the Earth's size, and Mercury is even smaller.

Mercury

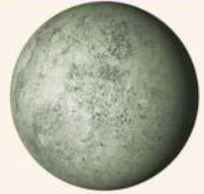
Mercury has an extremely hot, dry, and dusty surface. There is hardly any atmosphere to protect its surface from the strong heat of the sun.

Mercury's surface is shaped by impacts from asteroids, comets, and meteoroids.

Mercury has a large iron core.



FACT FILE



» **Diameter:** 3,032 miles (4,880 km)

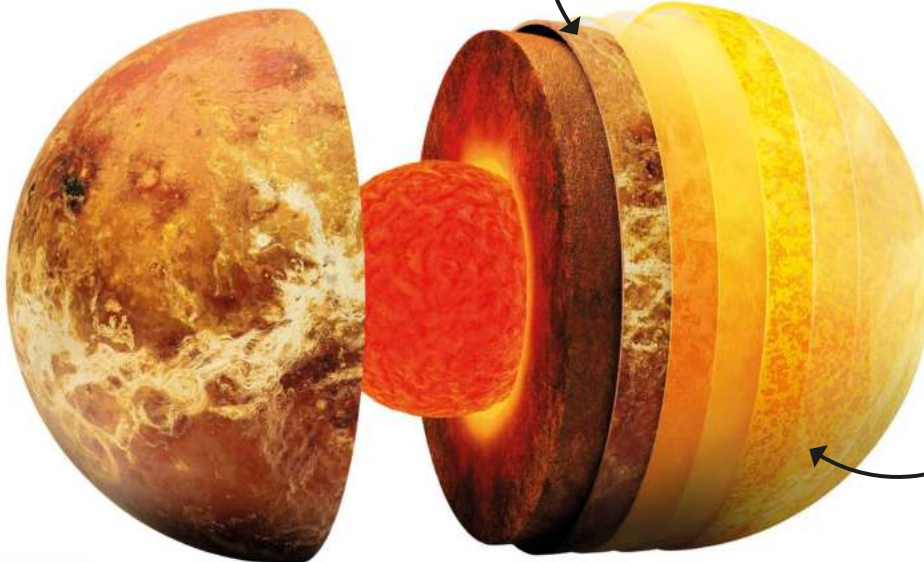
» **Distance from the sun:** 36 million miles (58 million km)

» **Number of moons:** 0

Venus

Venus is the hottest planet in the solar system. Its volcanic, rocky surface is a scorching 900 °F (482 °C).

Volcanic eruptions occasionally flood the entire surface with lava.



Thick atmosphere can crush, boil, and burn any space probe that lands.

FACT FILE



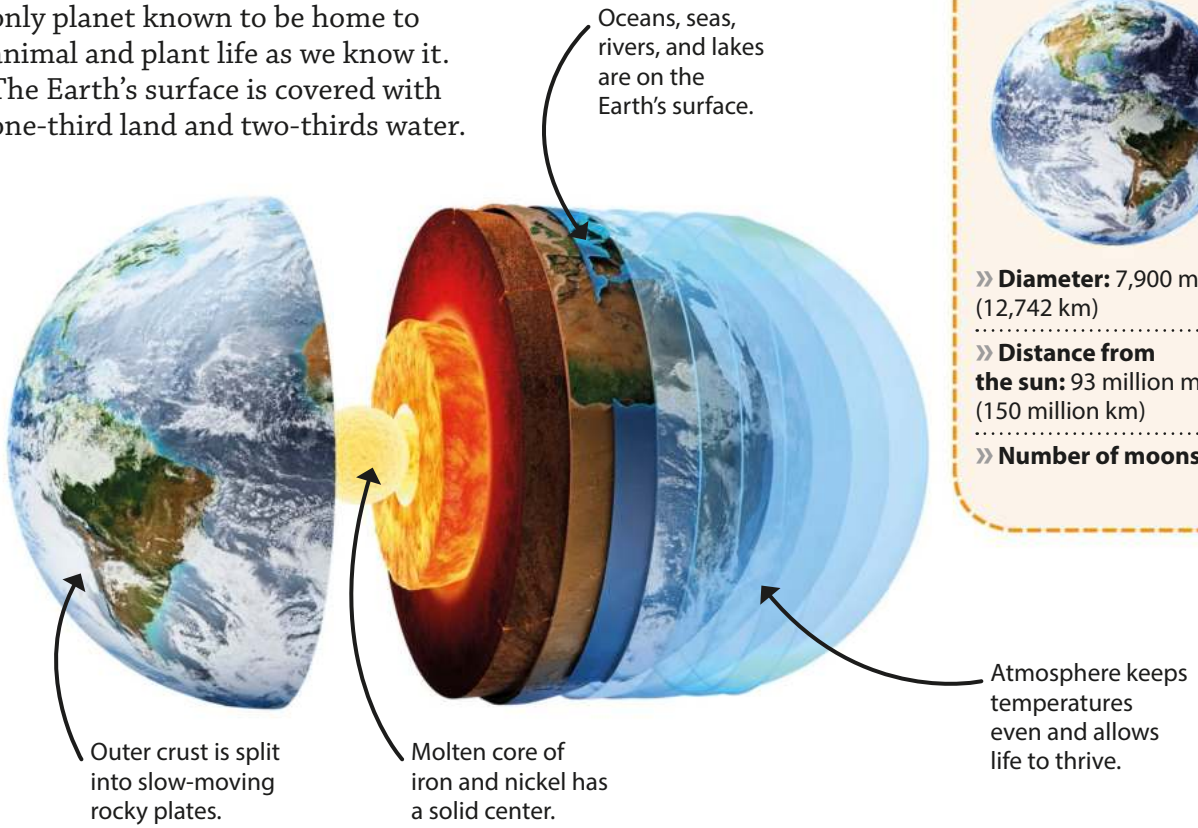
» **Diameter:** 7,520 miles (12,104 km)

» **Distance from the sun:** 67 million miles (108.2 million km)

» **Number of moons:** 0

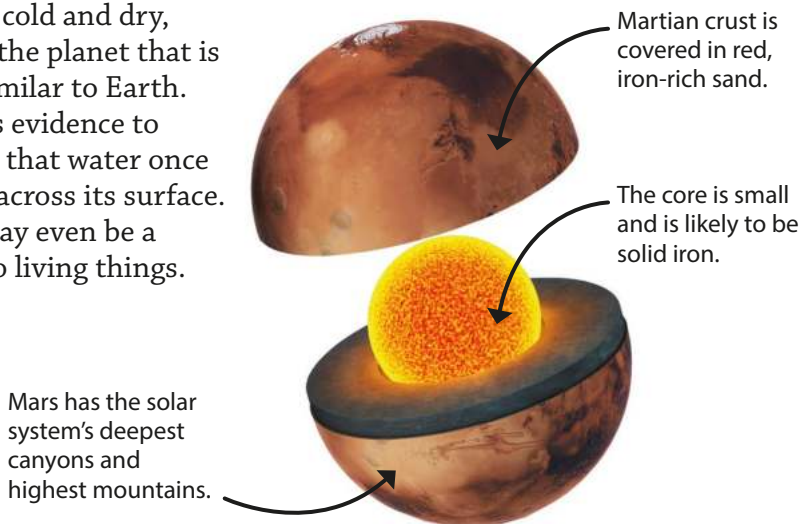
Earth

The Earth is unique because it's the only planet known to be home to animal and plant life as we know it. The Earth's surface is covered with one-third land and two-thirds water.



Mars

Mars is cold and dry, but it's the planet that is most similar to Earth. There is evidence to suggest that water once flowed across its surface. Mars may even be a home to living things.



FACT FILE



- » **Diameter:** 4,211 miles (6,779 km)
- » **Distance from the sun:** 141 million miles (228 million km)
- » **Number of moons:** 2

Gas giants

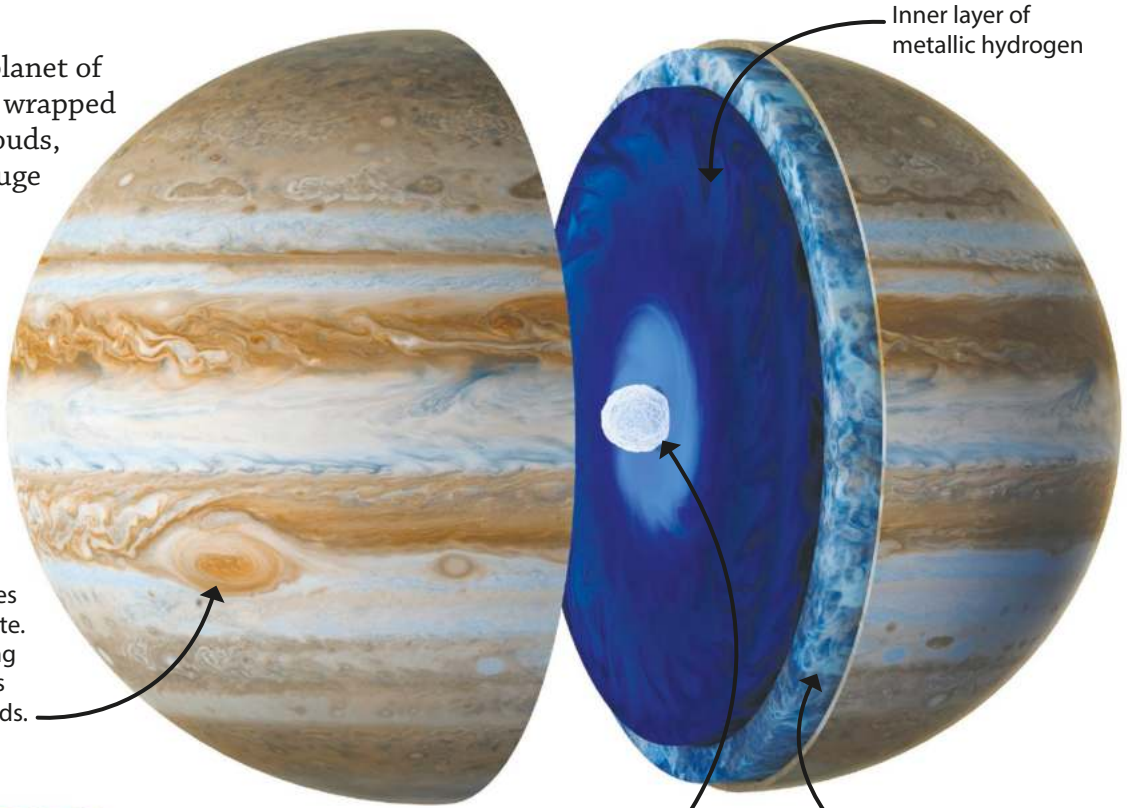
The huge planets of the outer solar system are gas giants or ice giants. They are much larger than Earth, but they are mostly made up of lightweight gases that turn to liquid or slushy ice deep inside. A gas giant's small core is solid and is made of rock.



Jupiter

The biggest planet of all, Jupiter is wrapped in colorful clouds, including a huge storm large enough to swallow the Earth!

Jupiter only takes 10 hours to rotate. This fast spinning makes its clouds stretch into bands.



FACT FILE



» **Diameter:** 88,765 miles (142,984 km)

» **Distance from the sun:** 483 million miles (778.6 million km)

» **Number of moons:** 69

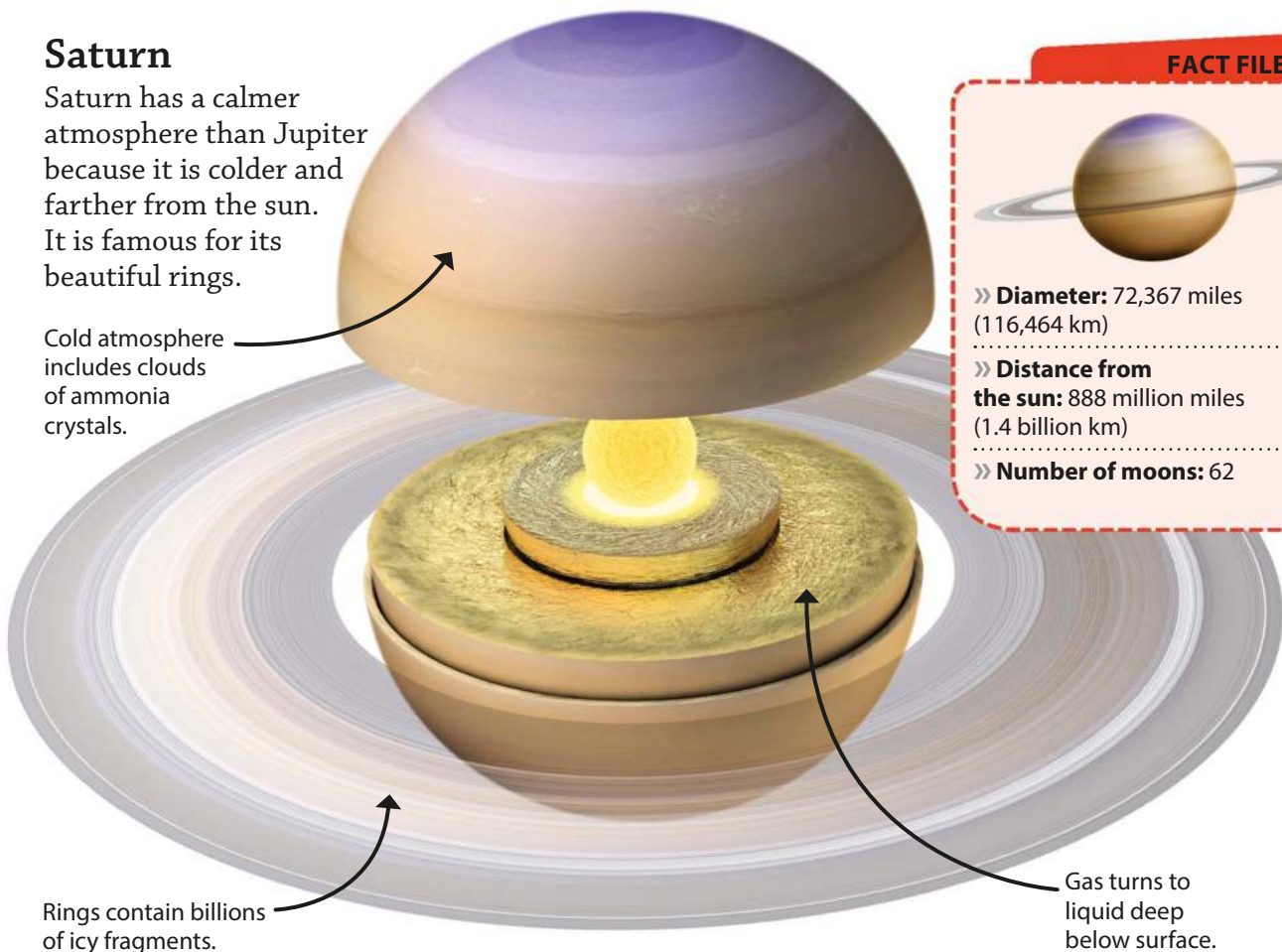
Experts think that Jupiter's core is a ball of molten rock six times hotter than the surface of the sun.

Outer layer of liquid hydrogen and helium

Saturn

Saturn has a calmer atmosphere than Jupiter because it is colder and farther from the sun. It is famous for its beautiful rings.

Cold atmosphere includes clouds of ammonia crystals.



Rings contain billions of icy fragments.

Gas turns to liquid deep below surface.

FACT FILE



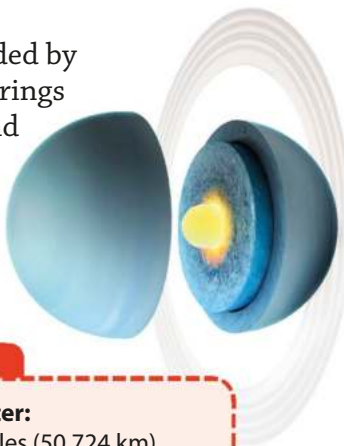
» **Diameter:** 72,367 miles (116,464 km)

» **Distance from the sun:** 888 million miles (1.4 billion km)

» **Number of moons:** 62

Uranus

Uranus is surrounded by at least 11 narrow rings made from dust and rocks. It is tipped over on its side.



FACT FILE



» **Diameter:** 31,506 miles (50,724 km)

» **Distance from the sun:** 1.7 billion miles (2.9 billion km)

» **Number of moons:** 27

Neptune

This blue planet is named after the ancient Roman god of the sea. Neptune is really cold—it's 30 times farther away from the sun than the Earth is.



FACT FILE



» **Diameter:** 30,599 miles (49,244 km)

» **Distance from the sun:** 2.8 billion miles (4.5 billion km)

» **Number of moons:** 14

Earth's moon

The moon is Earth's closest neighbor in space. It circles our planet every 27.3 days. One side always faces Earth, but the area we can see changes as the moon goes through its cycle of day and night. Astronauts landed on the moon in 1969.

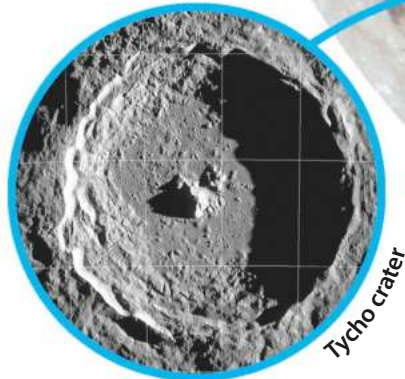


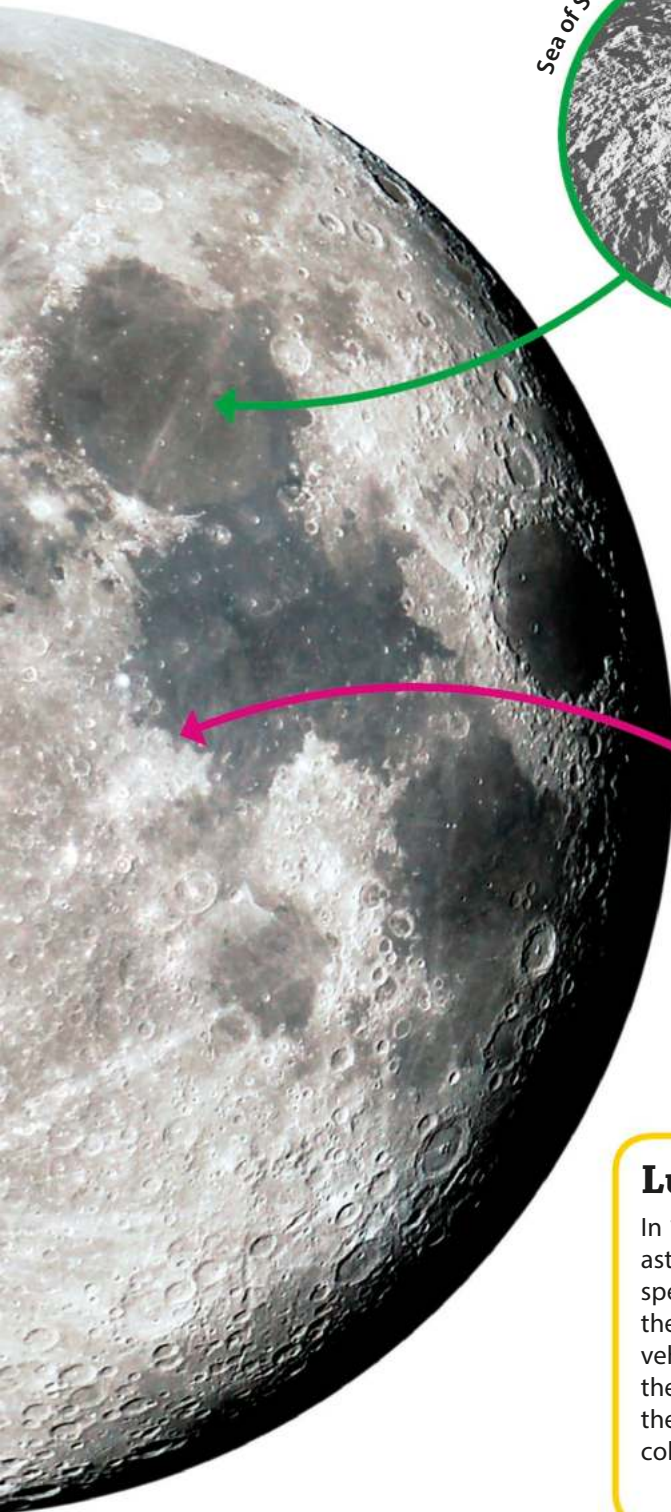
Mountains

Many of the moon's mountain ranges are actually the raised edges of huge craters formed from the largest impacts.

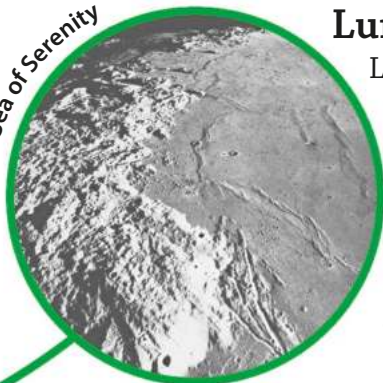
Impact craters

There is no air on the moon to shield it from space rocks hitting its surface. Craters are made when the rocks hit.





Sea of Serenity



Lunar seas

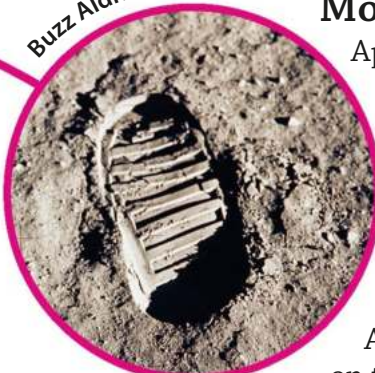
Long ago, lava from deep impacts in the surface and from volcanoes flooded the moon's low-lying areas. It then froze into dark, smooth plains known as seas. The Sea of Serenity was made this way.



REALLY?

The moon is made of rocks thrown off the Earth when the Earth hit a **huge asteroid**.

Buzz Aldrin's footprint



Moon landing

Apollo 11 landed on the edge of the Sea of Tranquility in 1969. It was the first space mission in which astronauts, including Buzz Aldrin, walked on the moon!

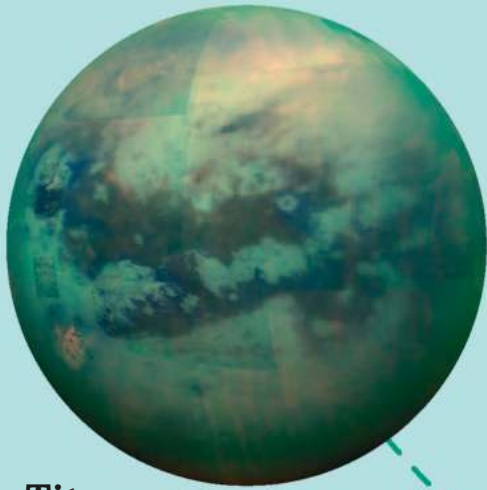
Lunar rover

In 1972, the Apollo 17 astronauts used a special car called the "lunar roving vehicle" to explore the area around their landing site and collect rock samples.



Moons

Most of the planets in the solar system have a moon or moons of their own. Even asteroids can have a moon. Each moon can vary in shape, size, surface, and atmosphere.



Titan

One of Saturn's moons, Titan, is 50 percent larger than the Earth's moon. This moon has a thick atmosphere and oily lakes on its surface.



Dactyl

This tiny moon orbits around an asteroid called Ida. It formed when Ida collided with another asteroid. Dactyl is a part of Ida that broke off in the crash.



Ida (an asteroid)



Jupiter



Pluto



Deimos

Mars has two moons. Deimos is the smaller of the two. In Greek, the word Deimos means "terror."

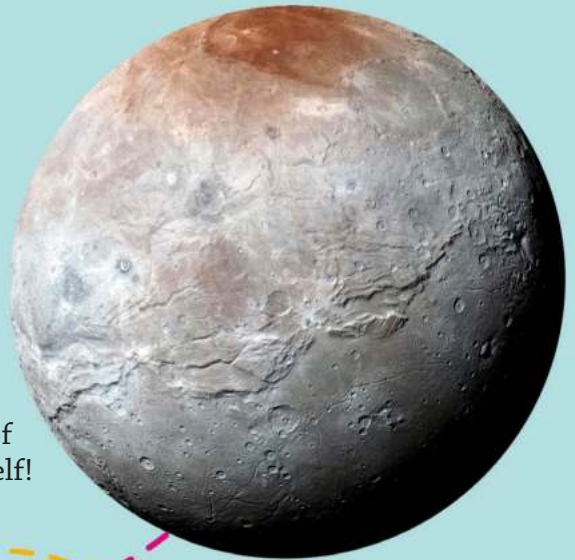
Io

This moon of Jupiter is covered in volcanoes. There are more than 80 major volcanic areas on the surface of Io.



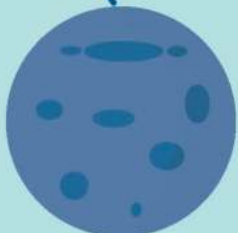
Triton

Neptune has 14 known moons. Triton is the largest. It is bitterly cold and has jets of gas erupting from its surface.



Charon

Pluto has five moons. Charon is the biggest. It is more than half the size of Pluto itself!



Neptune



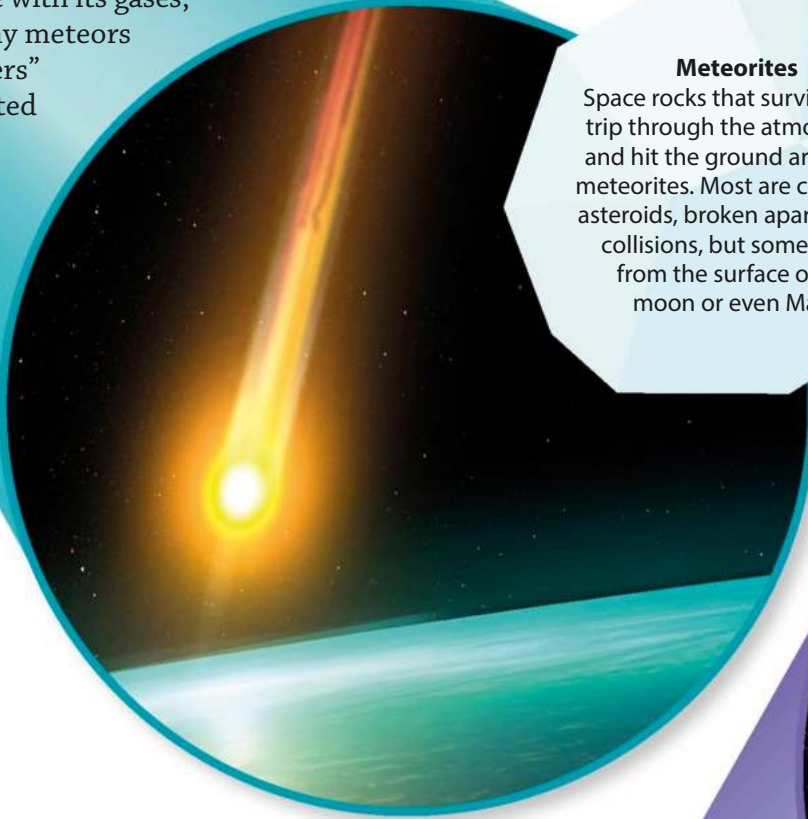
Saturn



Mars

Meteors

Shooting stars or meteors are brief streaks of light across the night sky. They are caused when specks of dust enter Earth's atmosphere, collide with its gases, and heat up. Many meteors arrive in "showers" that are repeated every year.



Meteorites

Space rocks that survive their trip through the atmosphere and hit the ground are called meteorites. Most are chunks of asteroids, broken apart during collisions, but some come from the surface of the moon or even Mars.

Rocks in space

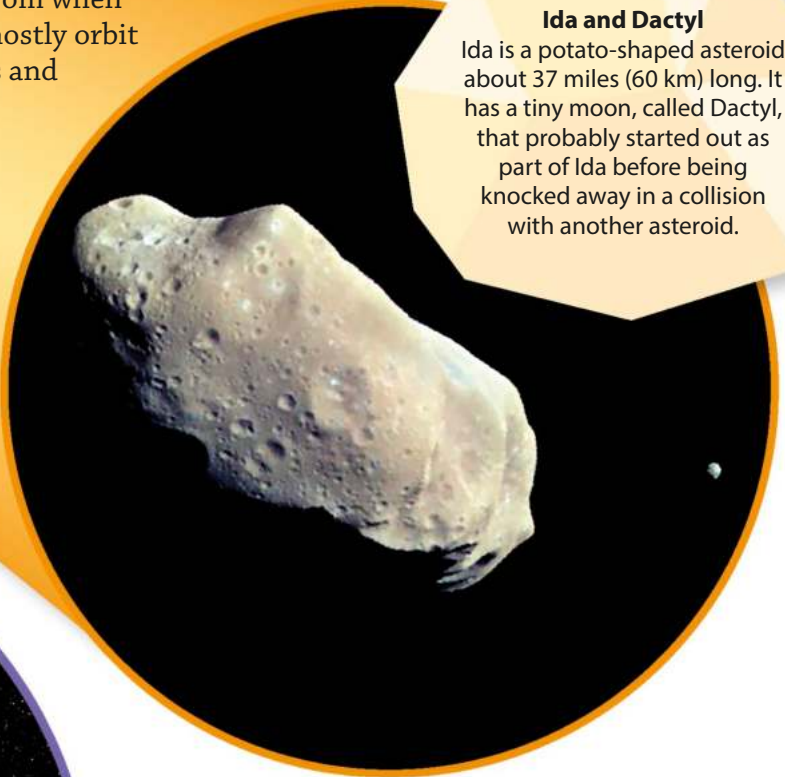
As well as planets and the sun, our solar system is filled with countless smaller objects that have changed little since the birth of the solar system. They range from country-sized asteroids and city-sized comets to tiny flecks of dust.

Comets

Comets are chunks of ice and rock that mostly orbit at the edge of the solar system. When a comet comes close to the sun, some of its ice turns to gas, surrounding it with a fuzzy cloud called a coma, and sometimes a long tail.

Asteroids

Asteroids are rocks left behind from when the solar system formed. They mostly orbit in an asteroid belt between Mars and Jupiter, but some come closer to Earth. Most are small, shapeless lumps of rock, but the largest asteroid of all, Ceres, has ice on its surface and a very thin atmosphere.



Ida and Dactyl

Ida is a potato-shaped asteroid about 37 miles (60 km) long. It has a tiny moon, called Dactyl, that probably started out as part of Ida before being knocked away in a collision with another asteroid.



Comet NEAT

This comet flew past the sun in 2003. It's named after the Near Earth Asteroid Tracking (NEAT) project that discovered it. Its long, stretched orbit means it will not return for tens of thousands of years.



A NEO flies past Earth.

Near-Earth Objects

Some asteroids and comets, called Near-Earth Objects, come close to Earth's orbit through space. There's only a small chance of a collision, but over Earth's long history it's happened many times.


The view from Earth

On a clear night we can see patterns of stars in the sky. These groupings are called constellations. They vary depending on whether we are viewing the sky from above or below the equator, the imaginary line around the middle of Earth. We can also see the Moon, the Milky Way, galaxies, and planets in the night sky.




Milky Way

Our galaxy is a huge, flattened disc of stars, but because our Solar System sits inside this disc, we see many more stars in some directions and far fewer in other directions.




The planet Venus is easy to see as it shines brighter than any star.



The Moon's thin crescent is lit by sunlight, while the rest is lit by earthshine.

Glowing star

Venus is called our evening and morning star. It orbits closer to the Sun than Earth, so it always appears close to the Sun in the sky. We can see Venus glowing in the evening or in the early morning.



Andromeda Galaxy

Brightest galaxy

Most galaxies are too far away to see without a telescope. One huge spiral galaxy two million light years (the distance light travels in a year) away looks like a fuzzy patch in the sky – it's called the Andromeda Galaxy.

Constellations

The stars we see in the night sky from Earth are grouped together in various patterns. These star patterns are known as constellations. There are 88 different constellations. They are named after mythical heroes, animals, and objects.

**Northern
hemisphere**

**Southern
hemisphere**

Northern and Southern stars

Astronomers have divided the night sky into two halves, or hemispheres: the stars seen over the northern half of Earth, and those seen over the southern half of Earth.



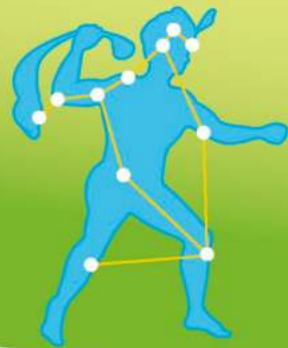
Northern hemisphere



Southern hemisphere



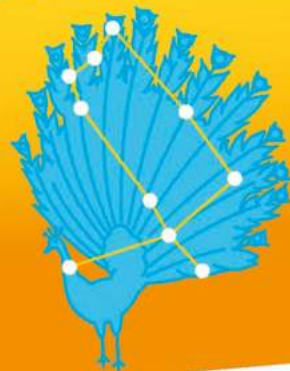
CEPHEUS



Cepheus is the name of a king in an ancient Greek myth. The main stars in this constellation form the shape of a tower. The brightest star is called Alderamin, found on his right armpit. It is best seen in October in the northern night sky.



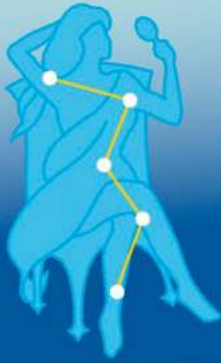
PAVO



This southern constellation is shaped like a peacock with its fan-like tail. Alpha Pavonis is a blue-white giant star on the neck of the bird. It is five times as wide as the sun and shines 2,200 times more brightly.



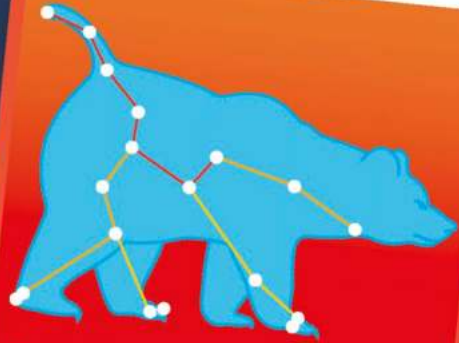
CASSIOPEIA



Cassiopeia is the name of a queen in an ancient Greek myth. This constellation links five bright stars to form a W-shaped pattern on its side. It can be seen throughout the year in the northern night sky.



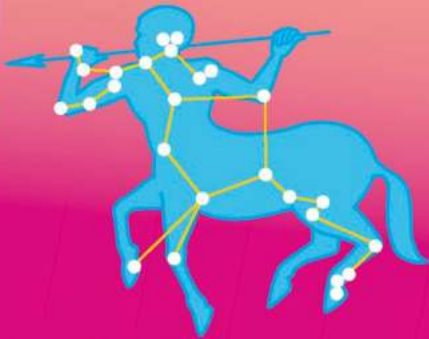
URSA MAJOR



Ursa Major, the Great Bear, is a large constellation seen all year round in the northern night sky. Seven stars (joined in red), starting from the tail to the body, form a saucepan shape called the Big Dipper.



CENTAURUS



This large southern constellation forms a mythical beast called a centaur—half man, half horse. Alpha Centauri is a group of three stars that forms the brightest star in the front hoof. These are the closest stars to Earth after the sun.



CRUX



The cross in the southern night sky is the smallest constellation, but it is one of the easiest to spot. It is best seen in May. Four main stars create the cross pattern. There is also a bright cluster of stars within the constellation that is called the Jewel Box.

Astronomy

Astronomy is the science of studying planets, stars, and other space objects. Since we aren't able to visit most of them, astronomers learn about these objects by collecting information using telescopes.

Newton's reflector

Sir Isaac Newton was a scientist who made amazing discoveries in the 1600s. In 1668, he made a telescope that used a curved mirror to collect light. It made an image that is brighter and more detailed than we could see with our own eyes.



PARKES OBSERVATORY

Many objects that do not shine in visible light still give off invisible radio waves.

Radio telescopes, such as Parkes Observatory in Australia, collect these weak rays and turn them into electrical signals.



South Pole Telescope



Many space objects create invisible rays as well as light, but these are mostly blocked by Earth's atmosphere. This telescope collects "microwave" rays that make it through the thin Antarctic air.

GREAT CANARY TELESCOPE

This telescope has a 34 ft (10.4 m) mirror that collects two million times more light than a human eye, allowing us to see objects far away. It sits on a mountaintop in the Canary Isles.



Atacama Large Millimeter Array

This radio telescope in Chile uses 66 separate dishes that can be moved around and linked together so they work like a single, much larger telescope.



FAST

China's Five-hundred-meter Aperture Spherical Telescope (FAST) is the world's largest radio telescope. It cannot move, but it can look at different parts of the sky.

Meet the expert

We asked some questions of Suzanna Randall, a European Southern Observatory (ESO) astronomer who currently works at a large radio telescope in the Atacama Desert, in Chile. She is about to start training for a trip to the International Space Station (ISS).

Q: We know it is something to do with the universe, but what is your actual job?

A: As an astronomer, I try to understand the universe by looking at it through telescopes and then comparing what I see with computer simulations. My research focuses on studying pulsating stars using a technique called asteroseismology. My research focuses on studying pulsating stars using a technique called asteroseismology. This allows us to look inside stars using their pulsations (changing levels of brightness), and learn more about their internal structure and how they were formed.

Q: What do you do for ESO?

A: ESO builds and operates some of the world's largest telescopes in the Chilean Atacama Desert. In addition to doing my own scientific research, I support ALMA, the Atacama Large Millimeter/sub-millimeter Array, which is made up of 66 individual antennae that work together to form the largest radio telescope in the world. My tasks for ALMA include helping other astronomers set up their observations, operating the telescope



Atacama Large Millimeter/submillimeter Array

in Chile, and making sure the data is of good quality.

Q: What is the “Astronautin” project?

A: It is a private project to send the first female German astronaut into space, to conduct scientific experiments aboard the International Space Station. I was recently selected as one of two trainees for the program, and I hope to fly into space in the next few years.

Q: What excites you most about this opportunity?

A: The part of the training I am most looking forward to are the parabolic

flights, where I will get to experience weightlessness for the first time. What excites me most about going into space is to break that final frontier and go where not many have gone before. That would really be the adventure of a lifetime!

Q: What is a usual work day like for you?

A: A work day for me can range from sitting in my office analyzing astronomical data or working a night shift in the desert, to giving presentations at events.

Q: What made you decide to become an astronomer?

A: I became fascinated with space at a young age, reading everything I could get my hands on about the subject and going stargazing in my backyard on clear nights. My dream was always to travel to space, but since that seemed completely out of reach, I decided to become an astronomer and study the universe from afar instead. I feel very lucky that I may now get to do both!

Q: What do you love about the universe?

A: I love that the size of the universe is simply mind-boggling!



Space photos

Orbiting high above the atmosphere, the Hubble Space Telescope (HST) gives astronomers on Earth their clearest view of the Universe. Launched in 1990, it is still going strong and providing scientists with information about the way our Universe works.

Aperture door

This shutter can close to protect the mirror and instruments from fierce, direct sunlight.

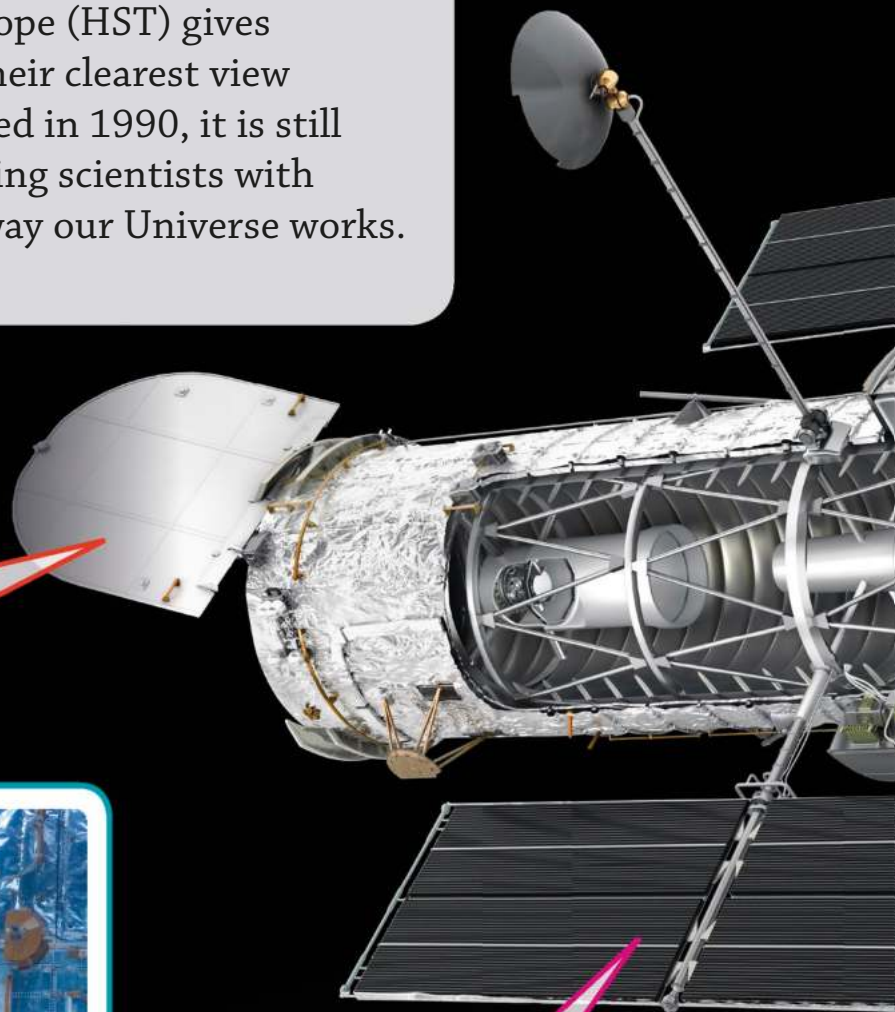


Maintenance

Astronauts using the US Space Shuttle carried out five missions to repair and upgrade the HST, allowing it to operate for much longer than its planned lifetime of 15 years.

Solar panels

Hubble's "wings" use energy from sunlight to make electricity, which powers its computers and instruments.



Primary mirror

A curving mirror, 2.4 metres (7.9 ft) wide, collects light from distant objects, and directs it to cameras to record images and information.



Radio dish

The HST sends pictures and other data back to Earth through a special network of satellites.

Amazing images

The HST has taken thousands of amazing space photos, capturing everything from storms on the outer planets to colliding galaxies and the birth of new stars.



V838 Monocerotis

Dying star

After this dying giant star suddenly grew 600 times brighter than normal in 2002, Hubble captured light from its outburst reflecting off nearby gas clouds.



Hubble Ultra-Deep Field

Galaxies

By staring at the same patch of sky for a million seconds, the HST captured faint light from some of the most distant galaxies in the Universe.

Exploring space

Humans have been exploring space since 1957, when the first artificial satellite was launched. Since then, astronauts have reached the moon, while robot space probes have explored most of the solar system.

First artificial satellite

Sputnik 1 was launched by Russia on October 4, 1957. It beamed radio signals down to Earth.

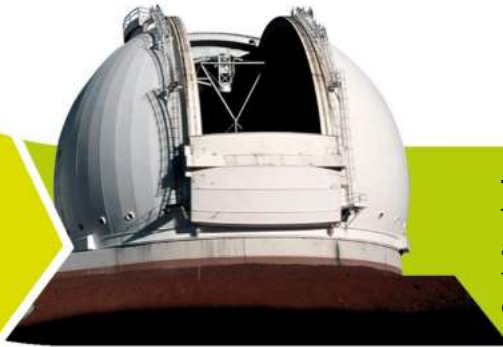


Space Shuttle

Between 1981 and 2011, NASA's Space Shuttle carried 355 different people into space.



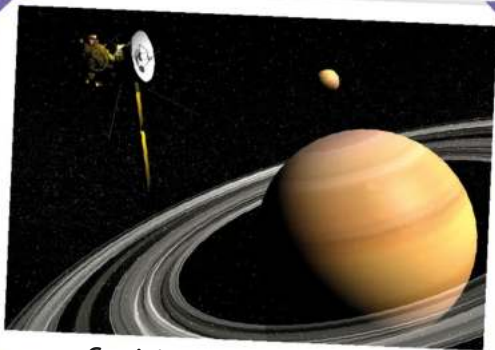
"Buzz" Aldrin



Keck Observatory

Telescopes

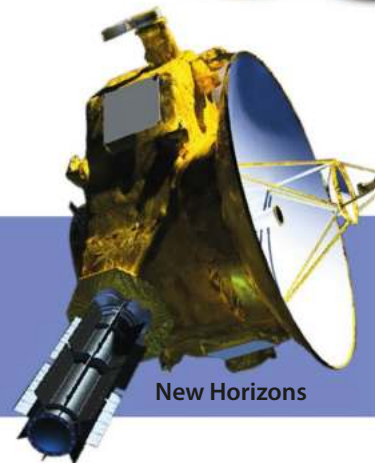
The 1990s saw the use of new and more powerful telescopes that can see objects at the edge of the universe.



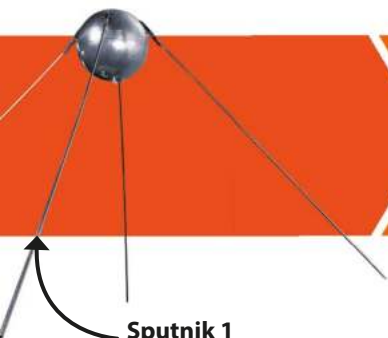
Cassini-Huygens near Saturn

Mission to Saturn

From 2004 to 2017, NASA's Cassini probe sent back pictures of the ringed planet Saturn and its moons.



New Horizons



Sputnik 1

This battery-powered satellite was very basic, with four antennae and a radio transmitter.

First animal in space

Sputnik 2 carried a dog named Laika into space, but she did not survive the trip.



Laika



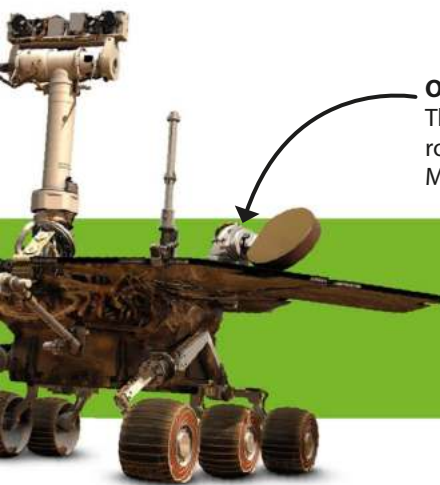
Yuri Gagarin

First man in space

In 1961, Russian astronaut Yuri Gagarin spent 108 minutes orbiting Earth on his Vostok 1 spacecraft.

Man on the moon

In 1969, NASA's Apollo 11 mission landed on the moon carrying astronauts Neil Armstrong, "Buzz" Aldrin, and Michael Collins.



Opportunity

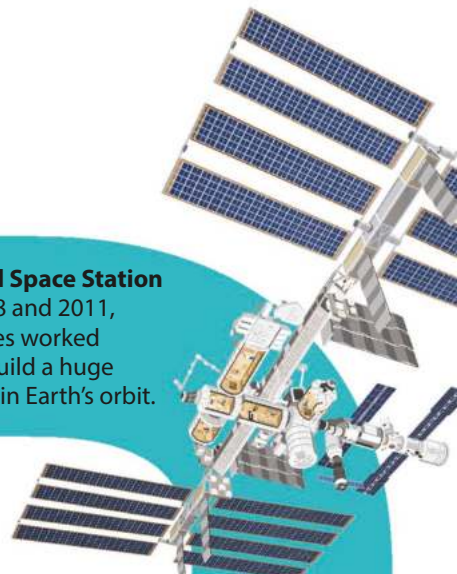
This 5 ft (1.5 m) tall rover has explored Mars since 2004.

Mars rover

In 2004, NASA landed a pair of wheeled robot explorers, Spirit and Opportunity, on Mars.

International Space Station

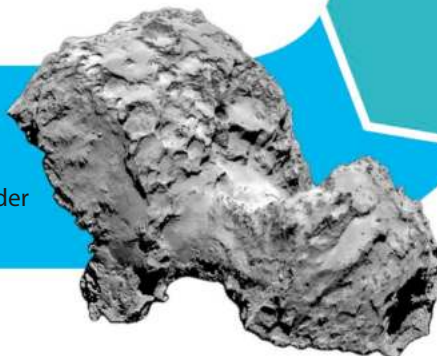
Between 1998 and 2011, space agencies worked together to build a huge space station in Earth's orbit.



Rosetta
This space probe started its mission in 2004 and ended in 2016.



Comet 67P



Pluto explorer

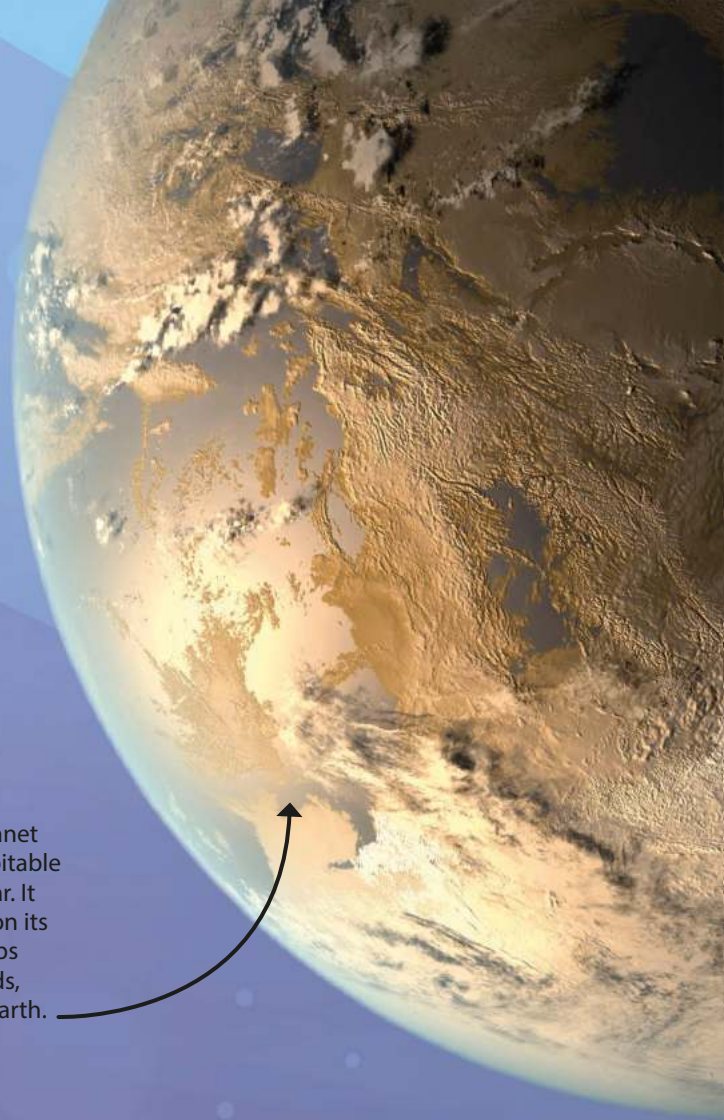
In 2015, NASA's New Horizons space probe collected data and took amazing images of Pluto and its moons.

Rosetta (Philae lander)

The European space probe Rosetta entered orbit around comet 67P in 2014. It put a lander called Philae on its surface.

Exoplanets

Planets orbiting around other stars (not our sun) are called exoplanets. Several thousand have been discovered since the 1990s. Most are very different from Earth, but a few seem to be very much like our planet. They might even be home to living things.



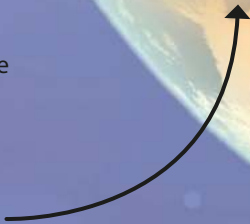
Alien star

The star Kepler-186 is a cool red dwarf much fainter than our sun.



Another Earth?

Kepler-186f is a planet orbiting in the habitable zone around its star. It could have water on its surface and perhaps even oceans, clouds, and ice caps, like Earth.



Discovering exoplanets

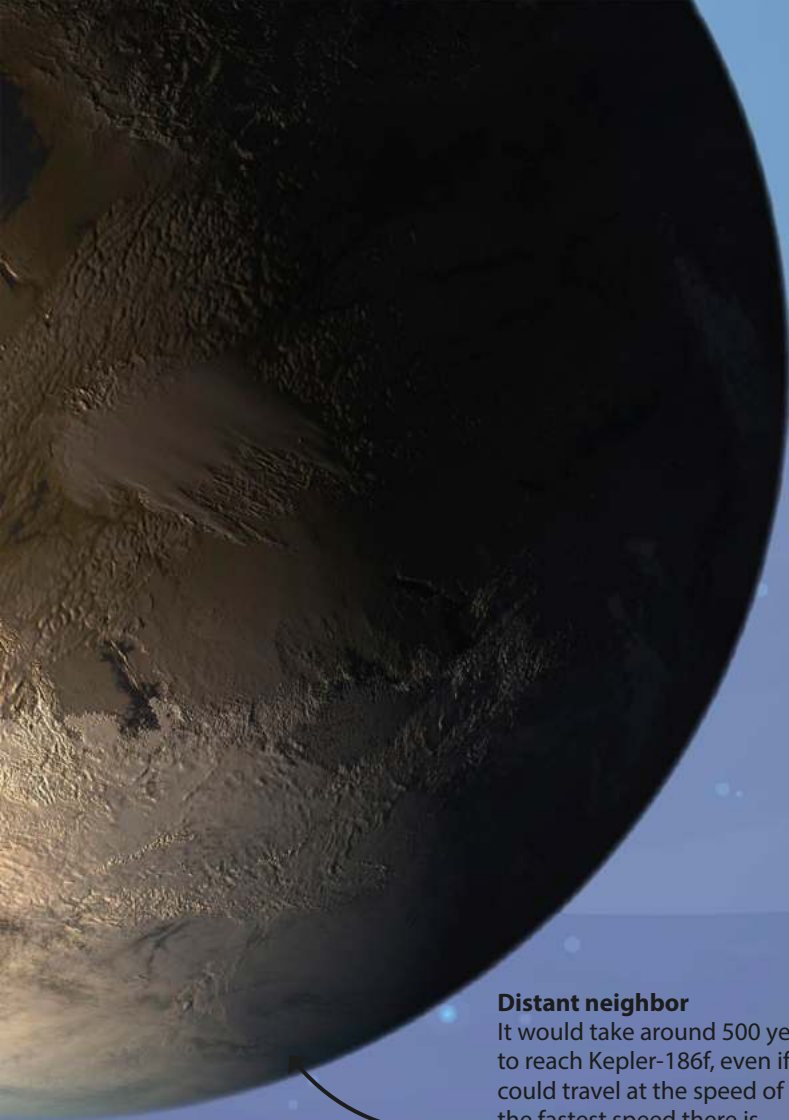
Most exoplanets are too faint to see directly—their dim light is easily drowned out. So astronomers find them by looking for the ways they affect their stars.



51 Pegasi b

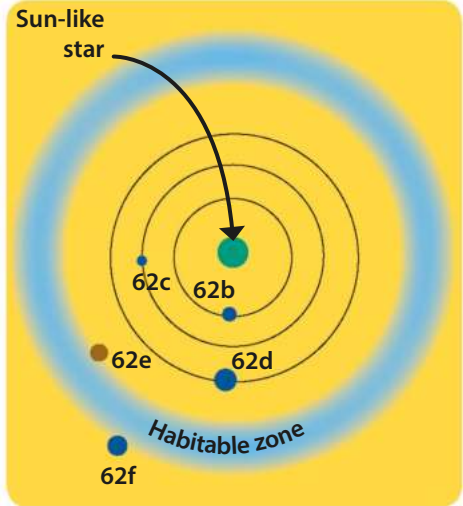
First exoplanet

The first exoplanets to be discovered were huge gas giants even bigger than Jupiter. These are big enough to make their stars “wobble” as they go around them.



Habitable zones

A star's habitable zone is the area that is not too hot or too cold for oceans to survive on an exoplanet's surface. Water is necessary for human life to exist, which is why we continue to search for planets that might have water.



Kepler-62 System

Distant neighbor

It would take around 500 years to reach Kepler-186f, even if we could travel at the speed of light, the fastest speed there is.

! WOW!

Astronomers think there could be 60 billion habitable planets in our galaxy!



Kepler space telescope

New exoplanets

Space telescopes, such as Kepler, find exoplanets by looking for signs that some of a star's light is being blocked by a planet passing in front of it.



Arecibo Observatory, Puerto Rico

Arecibo Observatory

This 1,000-ft (305-m) diameter dish collects radio signals from the distant universe. Volunteers use computers to look for patterns that might hint at other life being present in the universe.

Pioneer 10

Robot space probes such as Pioneer 10 will take thousands of years to reach nearby stars, but they will keep traveling forever. They carry messages from humanity for anyone who eventually finds them.

Is there life out there?

Some of the biggest questions we have are whether life exists elsewhere in the universe, and whether we might one day make contact with intelligent aliens. Here are a few attempts astronomers have made to find them.



Voyager 1 space probe

Voyager 1

The most distant space probe from Earth, Voyager 1 has now left our solar system. It carries a golden disk that can recreate sounds and pictures from Earth.



Pioneer 10 space probe

Messages

The search for intelligent aliens mostly involves looking for signs of their activity, such as radio signals, but humans have also sent messages to the stars.

Arecibo message

In 1974, radio signals were sent from the Arecibo radio telescope to a distant cluster of stars called M13. The message included the numbers one to ten, what a human looks like, the Earth's population, and where the Earth sits in the solar system.

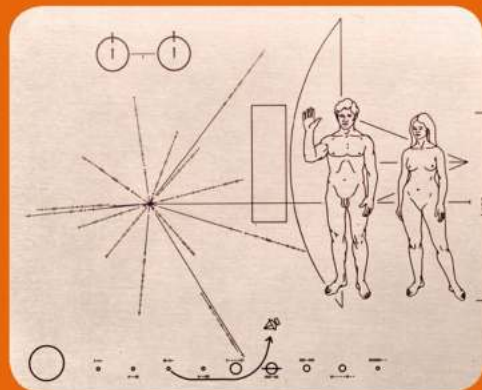


Allen Telescope Array

Forty-two radio dishes scanning the sky in northern California form part of the Search for Extra-Terrestrial Intelligence (SETI) program. As well as looking for alien signals, they measure radio waves coming from natural cosmic sources.



Radio receivers in the Allen Telescope Array



Pioneer plaque


A plaque fixed to Pioneers 10 and 11 shows two humans and the location of our solar system.

James Webb Space Telescope


In 2020, NASA's JWST will be launched into space. It will be the biggest telescope in space, and it will see the universe in more detail than ever before, revealing the secrets of planets, the most distant galaxies, and the very first stars.

Massive mirror

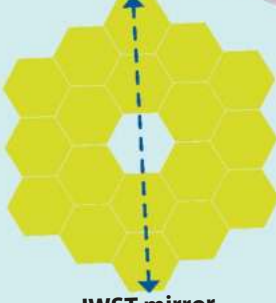
The JWST's huge mirror is about 21 ft (6.5 m) wide—not far off the biggest Earth-based telescopes. It is made of 18 hexagonal segments that unfold after launch.



An average adult person is 6 ft (1.8 m) tall.



Hubble space telescope mirror is 7.8 ft (2.4 m) wide.



JWST mirror is about 21 ft (6.5 m) wide.



WHAT'S IN THE PICTURE?

» **1 Sun-facing side** The JWST keeps its underside facing the sun so the telescope itself is always in the cold and dark.

» **2 Primary mirror** Segments of gold-coated beryllium reflect visible light and infrared rays to the secondary mirror.

» **3 Secondary mirror** This mirror collects light from the primary mirror and bounces it to the tertiary mirror.

» **4 Tertiary mirror** This box-like mirror system directs light to one of several different instruments.

» **5 Science instrument module** Cameras and other devices collect and study the visible and infrared light.

» **6 Solar panels** These panels, in permanent sunlight, make electricity from sunlight to power the telescope.

Sun shield

A high-tech parasol the size of a tennis court protects the telescope in space. It is made from five layers of lightweight material that reflects the sun's heat and light.



» 7 Communications antenna

JWST receives instructions from NASA and sends images and data back to the Earth.

» 8 Trim flaps The flaps help to keep the telescope stable in the "solar wind" of particles blowing out from the sun.

Future missions

New space telescope and robot probes are being launched all the time to help us discover more about different parts of our universe.



OSIRIS-REx

Launched in 2016, this space probe is on its way to an asteroid called Bennu. It will study Bennu from orbit for 500 days before returning to Earth, hopefully with a sample of material from the asteroid's surface, in 2023.

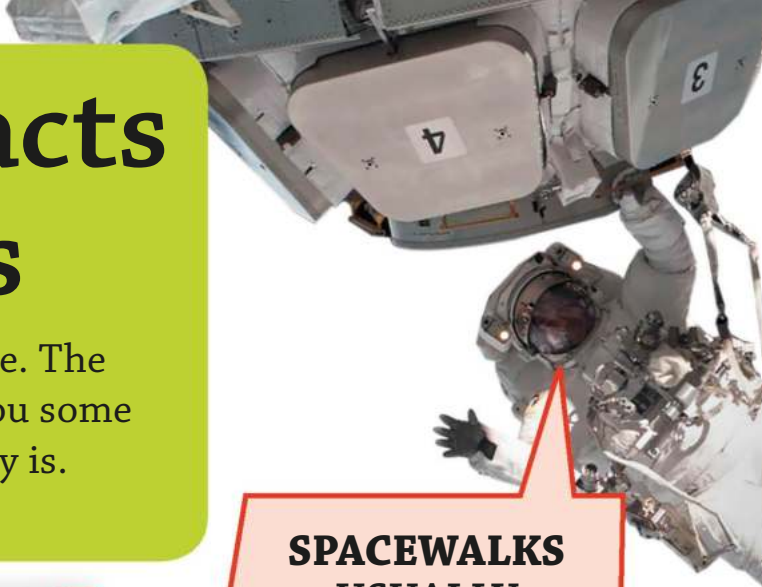


PLANetary Transits and Oscillations of stars

PLATO is planned for launch in 2026. This space telescope will look for signs of exoplanets around yellow dwarf stars, such as our sun, red dwarf stars, and subgiant stars.

Universe facts and figures

Our universe is an amazing place. The facts on these pages may give you some idea of just how amazing it really is.



**SPACEWALKS
USUALLY
LAST BETWEEN
5 AND 8 HOURS.**

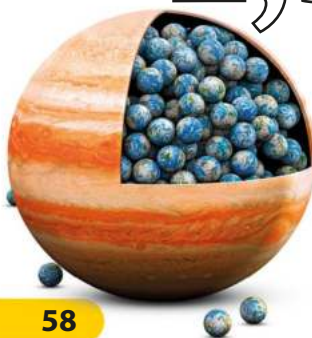


Astronauts learn what it feels like in space by training **40 ft (12 m) underwater** for **8 hours** at a time!



1,300

Jupiter is so large, it can fit more than 1,300 Earths inside it.

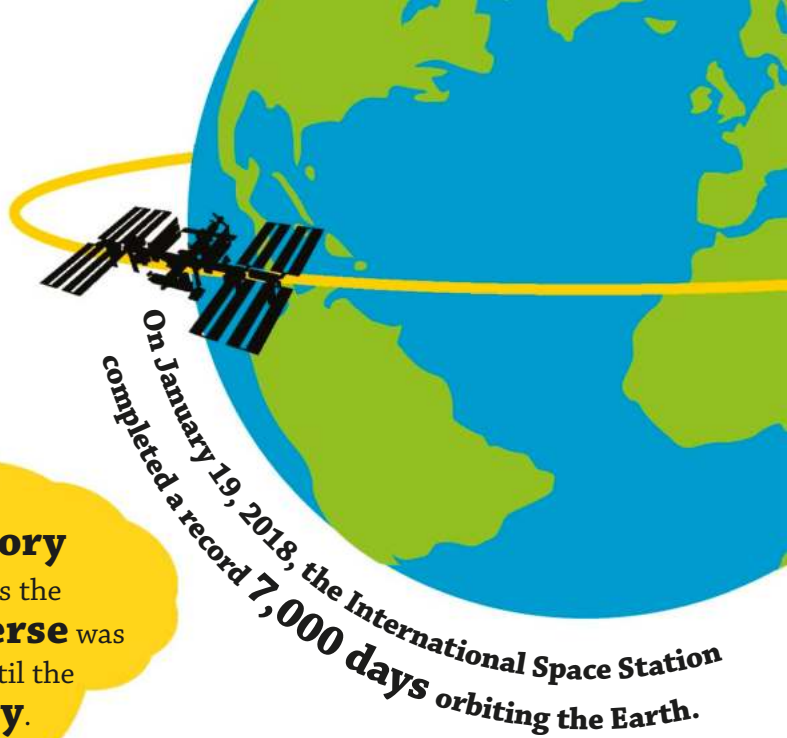


97,000 lb

Scientists estimate that around 97,000 lb (44,000 km) of meteorites and space debris lands on Earth every day.



Space is silent because sound cannot travel without air.



On January 19, 2018, the International Space Station completed a record **7,000 days** orbiting the Earth.

Ptolemy's theory that the **Earth** was the **center** of the **universe** was believed to be true until the **16th century**.



In 2007, tiny creatures called **tardigrades** lived for **10 days** in space outside a Russian unmanned spacecraft.



Studies of lunar rocks brought over by the Apollo missions have revealed that the moon is **4.51 billion years old!**

100 BILLION TRILLION

is the estimated number of stars in the part of the universe we can observe.

8½

It took the Space Shuttle only **8½** minutes to travel from the launchpad to low-Earth orbit.



Looking at the night sky is a wonderful way to learn about the Universe. Take notes on what you see and read the information in this book to help you become a successful astronomer.

Top tips for beginners

Follow these suggestions and you'll get the most out of your experience of observing and studying the Universe.

Look up

Start just by looking up at the night sky without a pair of binoculars or a telescope. Write down what you see.



Choose the best time

Look at the stars when the Moon isn't too close to Full Moon, as the stars are not overwhelmed by the Moon's brightness.



Location

Ask a grown up to take you to a location outside of a town or city as it's darker, because there is no light from buildings and street-lights.



Stargazing diary

Use a diary to make note of all the cool things you spot in the night sky and when they appear.



Night vision

It takes around 20 minutes for your eyes to adjust to darkness. Be patient and stay in the dark, you'll see more this way.



Planetarium

Visit a planetarium to learn more about the night sky.



Find other stargazers

Join other stargazers through local astronomy clubs.



What you'll need

Binoculars

Binoculars collect much more light than a human eye. They reveal details of the night sky.



Compass

Use a compass to help you look in the right direction to see different groups of stars.



Torch

Put red cellophane on the end of a torch. At night, red light is easier on your eyes than white.



Snack

You might be outside for a long time, so bring a snack with you.



Notepad and pen

Always carry a pen and notepad to write down or draw what you have seen.



Chair and blanket

Take a chair and blanket with you to keep comfortable as you stargaze.



What is a star chart?

A star chart is also called a planisphere. It shows what stars are visible at different times and dates.

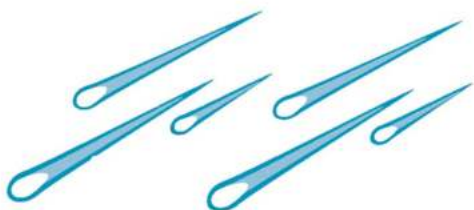


Stargazing

What to spot

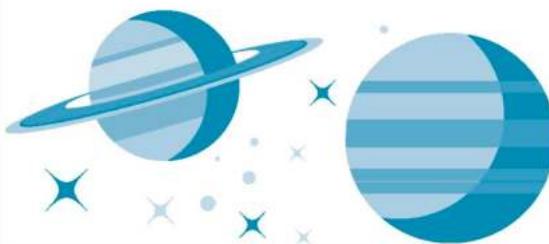
There are lots of exciting things to see in the night sky. Become a stargazer and look for constellations, meteor showers, planets, and our Moon. They're easier to spot than you might first think.

Meteor showers



Watch out for meteors when the Earth is passing through meteoroids and a meteor shower is expected.

Stars and planets



Look for star constellations at night and try to spot planets that are easy to see from the Earth, such as Venus.

ISS



The International Space Station can be seen from the Earth. Check out NASA's website for timings.

The Moon



During one month, draw the shape of the Moon you see each night. You'll soon notice the changes.

Careers in Space



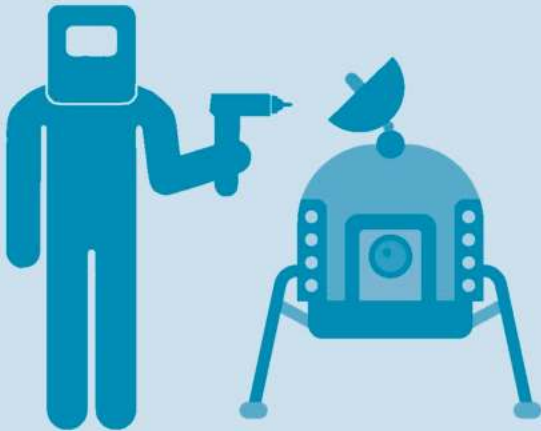
ASTRONAUT

Job description: Astronauts are the people who get to visit space. They work in teams on space missions, they collect data, and conduct experiments in space. They also pilot spacecraft and live on space stations.



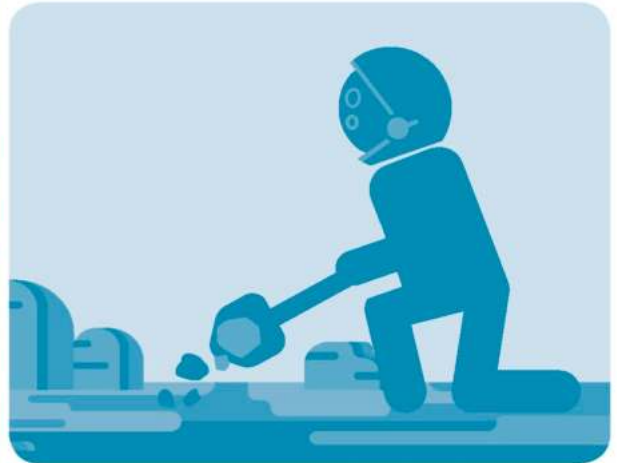
PROGRAMMER/ENGINEER

Job description: This role helps to design and make spacecraft, spacesuits, robots, and equipment that is used in space and on the Earth to help with the study of the Universe.



TECHNICIAN

Job description: Technicians test products to be used in the study of space. They also look after and repair spacecraft, including important equipment for space navigation and communication.



ASTROGEOLOGIST

Job description: Astrogeologists help us to understand what makes up planets, moons, and comets. They look at samples and study the surface of a planet to find out about a planet's history.

We know about the Universe because of the different jobs people do to explore our Solar System and beyond. Here are just some of the main jobs that help our learning. Each one requires a set of skills and lots of training.



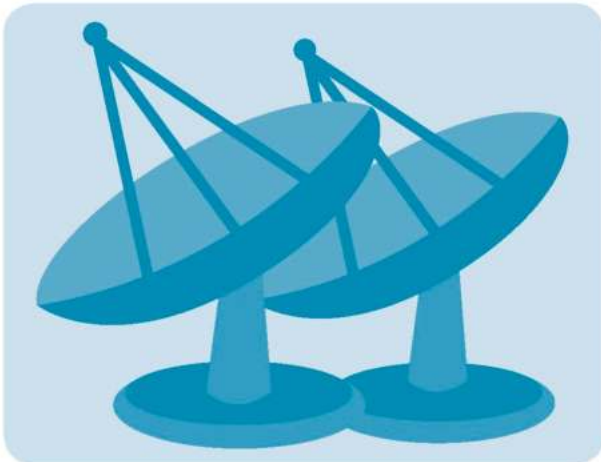
ASTROPHYSICIST

Job description: Astrophysicists use science to understand and explain all about planets, galaxies, and other space objects. They also find out information about the birth, life, and death of stars.



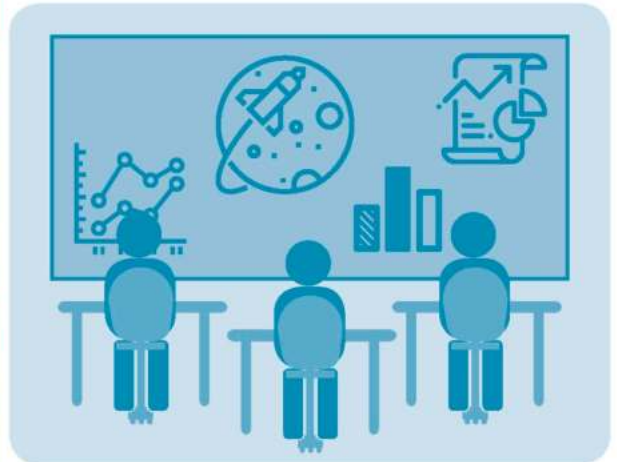
ASTRONOMER

Job description: Astronomers are scientists who study all of the objects in the sky, including the Sun, planets, stars, our Moon, galaxies, black holes, and any other matter found in the Universe.



TELESCOPE OPERATOR

Job description: People who do this job look after telescopes. They carry out routine checks on telescopes, and position them correctly to view the right part of the sky. They help to gather data.



MISSION CONTROL

Job description: Mission control is a group of people who help astronauts by monitoring conditions, looking at data, and watching over a space mission. They also help astronauts with spacewalks and experiments.



Glossary

Here are the meanings of some words that are useful for you to know when learning about the universe.

asteroid Small, rocky object that orbits between the planets

asteroid belt Area between Mars and Jupiter where most asteroids orbit

astronaut Any person that goes into space

atmosphere Layer of gases around a planet or moon

binary star Pair of stars that orbit around each other

black hole Object with such strong gravity that light cannot escape it

comet Small, icy object in orbit around a star

condense Decrease in size or volume

constellation Area of the sky containing a pattern of stars

core Hot center of a planet or star

crater Bowl-shaped hollow in an object's crust, often created by an impact from space

crust Hard outer layer of a rocky planet

debris Material that is left behind after a star or planet has formed

dwarf planet Five objects, including Pluto, known as dwarf planets are smaller than the main eight planets

Earth, the Our planet, the third main planet from the sun

exoplanet Planet that orbits a star outside our solar system

galaxy Huge cloud of stars, gas, and dust in space

gravity Force that pulls things toward objects with mass

hemisphere Astronomers have divided the night sky into two halves, or hemispheres: the stars seen over the northern half of Earth, and those seen over the southern half of Earth.

Jupiter Fifth main planet from the sun, and the largest of all the planets in our solar system

light-year Distance light travels in one year; a unit used to measure distances in astronomy

lunar Word meaning "belonging to the moon"

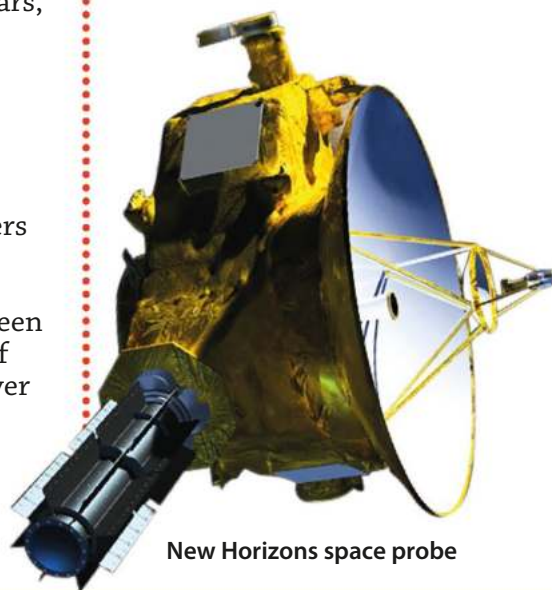
mass The amount of matter that an object contains

Mars Reddish-colored fourth planet from the sun

Mercury Smallest main planet in our solar system, and also the closest to the sun

meteor Shooting star caused by dust entering Earth's atmosphere

meteorite Rock from space that hits a planet's surface



New Horizons space probe

Milky Way Spiral galaxy that contains our solar system

moon Natural satellite orbiting around a planet or other object

nebula Cloud of gas and dust in space

NEO (Near Earth Object) Asteroid or comet whose orbit brings it close to Earth's

Neptune Eighth and outermost main planet in our solar system

nova Star that suddenly increases in brightness

orbit Path that one object takes around another thanks to the pull of gravity

parabolic flight Flight simulation that makes someone feel weightless

planet Large object in its own orbit around a star

Pluto Icy dwarf planet orbiting beyond Neptune

protostar Star in the early stages of formation

red dwarf Small, very faint but common type of star

red giant Dying star that is very big and bright

red supergiant Dying monster star

Astronaut on a spacewalk mission

rover Wheeled robot that explores the surface of a planet or a moon

satellite Any object in orbit around another one

Saturn Sixth main planet in the solar system, famous for its rings

solar Word meaning "belonging to the sun"

solar system Region of space dominated by the sun, and all the objects within it

space Mostly empty region between objects such as planets, stars, and galaxies

spacecraft Vehicle (with or without a crew) that travels through space

spacesuit Clothes that protect an astronaut from exposure to space

spacewalk Any activity that an astronaut does outside of their spacecraft

space probe Robot that explores space and sends information back to Earth

star Huge ball of gas generating heat and light



supernova Brilliant explosion that marks the death of some stars

telescope Device that creates bright, magnified images of distant, faint objects

universe Whole of space and all the objects within it

Uranus Seventh main planet from the sun, smaller than Jupiter or Saturn but much bigger than the Earth

Venus Second planet from the sun

volcano Gap in a planet's crust that erupts hot, molten rock from below

white dwarf Tiny but still hot and glowing core of a dead star



Index

A

Aldrin, Buzz 35, 50, 51
aliens 54–55
Allen Telescope Array 55
Alpha Centauri 5
Andromeda Galaxy 41
Apollo missions 35, 50, 51, 59
Arecibo Observatory 54, 55
Armstrong, Neil 51
asteroid belt 39
asteroids 9, 35, 36, 39, 57
astronauts 34, 35, 50–51, 58
astronomers 46–47, 52, 54
astronomy 44–57
Atacama Large Millimeter Array
45, 46
atmosphere 15, 25, 27, 30, 31,
33, 36, 38, 39, 45, 48
atoms 7

B

barred spiral galaxies 20, 23
Bennu 57
Big Bang 6–7
binary stars 16
black dwarfs 11
black holes 11, 18–19, 23
blue giants 14, 15
blue supergiants 14

C

Cassini-Huygens mission 50
Cassiopeia 43
Centaurus 43
Cepheus 42
Ceres 39
Charon 37
cities 4

clusters 13, 17
colliding galaxies 21, 49
Collins, Michael 51
comets 27, 28, 38–39, 51
constellations 40, 42–43
core 10, 11, 15, 30, 31, 32
craters 34
crust 31
Crux 43

D

Dactyl 36, 39
Deimos 37
dwarf planets 28
dwarf stars 15

E

Earth 4, 27, 31, 34–35, 40–41,
59
elliptical galaxies 21
ergosphere 18
European Southern
Observatory (ESO) 46–47
event horizons 18
exoplanets 52–53, 57
expanding universe 7
extraterrestrial life 54–55

F

FAST (Five-hundred-meter
Aperture Spherical Telescope)
45

G

Gagarin, Yuri 51
galaxies 5, 7, 8, 19, 20–23, 40,
41, 49
Galilei, Galileo 23

gas giants 13, 32–33, 52
gravity 12, 18, 19
Great Canary Telescope 45

H

habitable zone 52, 53
helium 24
hemispheres 42–43
Hubble Space Telescope (HST)
48–49, 56
hydrogen 24

I

Ida 36, 39
impact craters 34
International Space Station
(ISS) 46, 51, 59
interstellar clouds 9, 12
Io 37
irregular galaxies 21

J

James Webb Space Telescope
(JWST) 56–57
Jupiter 27, 32, 36–37, 58

K

Keck Observatory 50
Kepler space telescope 53
Kepler-186 52
Kepler-186f 52–53
Kuiper Belt 28, 29

L

Laika 51
lenticular galaxies 21
life 31, 53, 54–55
light-years 5

Local Galactic Group 5
lunar rocks 35, 59
lunar rovers 35
lunar seas 35

M

main-sequence stars 10
Mars 27, 31, 37, 51
matter 7
matter transfer 16
Mercury 27, 30
messages to the stars 55
meteorites 38, 58
meteors 38
microwaves 45
Milky Way 5, 15, 19, 22–23, 40
moon 34–35, 41, 59
moon landings 34, 35, 51
moons 9, 26, 32, 36–37
mountains, lunar 34
multiple stars 16–17

N

NASA 50, 51, 56, 57
natural satellites 9
Near Earth Asteroid Tracking
(NEAT) 39
Near-Earth Objects (NEO) 39
nebulae 12, 13
Neptune 27, 28, 33, 37
neutron stars 11
New Horizons space probe
50–51
Newton, Isaac 44
night sky 40–43
northern hemisphere 42–43

O

observatories 44–47, 50
Oort Cloud 28–29
Opportunity rover 51
orange giants 15

OSIRIS-REx 57

P

Parkes Observatory 44
Pavo 42
people 4
Philae lander 51
photography, space 48–49
Pioneer 10 54–55
planetary nebulae 11
planets 7, 8, 13, 26–27, 30–33,
52–53
PLATO (PLANetary Transits
and Oscillations of stars) 57
Pleiades 17
Pluto 27, 28, 29, 32, 37, 51
protons 7
protostars 10, 12–13
Ptolemy 59

R

radio signals 54, 55
radio telescopes 44, 45, 46
Randall, Suzanna 46–47
red dwarfs 15, 52, 57
red giants 10, 15, 16
red supergiants 10, 15
reflecting telescopes 44
rings 33
robot probes 54, 57
rocky planets 13, 30–31
Rosetta space probe 51

S

satellites 9, 50, 51
Saturn 27, 33, 36, 50
Sea of Serenity 35
Sea of Tranquility 35
Search for Extra-Terrestrial
Intelligence (SETI) 55
seas, lunar 35
singularity 18

solar flares 24
solar panels 48, 56
solar system 4, 22, 24, 26–27,
28–39
South Pole Telescope 44–45
southern hemisphere 42–43
space debris 58
space exploration 50–51
space probes 9, 25, 29, 50–51,
54, 57
Space Shuttle 48, 50, 59
space telescopes 48–49, 53,
56–57
spacewalks 58

T

tardigrades 59
telescopes 23, 44–45, 46,
48–49, 50, 54–57
Titan 36
Triton 37

U

Uranus 27, 33
Ursa Major 43

V

Venus 27, 30, 41
volcanoes 35, 37
Voyager 1 54

W

water 31, 52, 53
white dwarfs 11, 15, 16

Y

yellow dwarfs 57



Acknowledgments

The publisher would like to thank the following people for their assistance: Shalini Agrawal and Desiree Johnson for editorial assistance, Polly Goodman for proofreading, Helen Peters for compiling the index, Anne Damerell for legal assistance, Dan Crisp for illustrations, and Seepiya Sahni for design assistance. The publishers would also like to thank Suzanna Randall for the “Meet the expert” interview.

The publisher would like to thank the following for their kind permission to reproduce their photographs:

(Key: a-above; b-below/bottom; c-center; f-far; l-left; r-right; t-top)

2 Getty Images: SSPL (bc). **3 ESA / Hubble:** NASA (bl). **NASA. 4 Dreamstime.com:** Cao Hai (bl). **NASA. 5 NASA and The Hubble Heritage Team (AURA/STScI):** NASA, ESA, H. Teplitz and M. Rafelski (IPAC / Caltech), A. Koekemoer (STScI), R. Windhorst (Arizona State University), and Z. Levay (STScI) (tr). **NASA: JPL-Caltech (cl).** **Science Photo Library:** Mark Garlick (c). **8-9 NASA:** Hubble Heritage Team (cb). **8 NASA:** ESA / Hubble (tl); JPL (bl). **9 NASA. 10 NASA:** ESA / Herschel / PACS / L. Decin et al (br); JPL-Caltech / ESA, the Hubble Heritage Team (STScI / AURA) and IPHAS (c). **10-11 NASA and The Hubble Heritage Team (AURA/STScI):** NASA, ESA, and the Hubble Heritage Team (STScI / AURA)-ESA / Hubble Collaboration (Background). **11 ESO:** I. Appenzeller, W. Seifert, O. Stahl (tl). **NASA and The Hubble Heritage Team (AURA/STScI):** NASA, ESA, and K. Sahu (STScI) (tc). NASA: CXC / NCSU / S.Reynolds et al (bl); X-ray: NASA / CXC / University of Amsterdam / N.Rea et al; Optical: DSS (cl); ESA (bc). **12 NASA and The Hubble Heritage Team (AURA/STScI):** NASA, N. Walborn and J. Maíz-Apellániz (Space Telescope Science Institute, Baltimore, MD), R. Barbá (La Plata Observatory, La Plata, Argentina) (tl); NASA, ESA, J. Muzerolle (STScI), E. Furlan (NOAO and Caltech), K. Flaherty (University of Arizona / Steward Observatory), Z. Balog (Max Planck Institute for Astronomy), and R. Gutermuth (University of Massachusetts, Amherst) (cr). **13 NASA and The Hubble Heritage Team (AURA/STScI):** NASA, ESA, and A. Feild (STScI) (tl). **14 Dreamstime.com:** Levgenii Tryfonov / Triff (crb). **15 Dreamstime.com:** Levgenii Tryfonov / Triff (clb). **16 NASA:** JPL-Caltech / UCLA (cl). **17 Dreamstime.com:** Tragoolchitr Jittasaiyapan. **19 NASA:** JPL-CalTech (cb). **20 NASA:** Hubble Heritage Team, ESA (bl); X-ray: CXC / SAO; Optical: Detlef Hartmann; Infrared: JPL-Caltech (cr). **21 ESA / Hubble:** NASA (cra). Getty Images: Robert Gendler / Visuals Unlimited, Inc. (br); Stocktrek Images

(clb). NASA: ESA / Hubble (tl). **22-23 NASA:** JPL-Caltech (t). **23 Alamy Stock Photo:** Heritage Image Partnership Ltd (cb). **Getty Images:** SSPL (b). **NASA and The Hubble Heritage Team (AURA/STScI):** NASA, ESA, SSC, CXC, and STScI (cr). **Science Photo Library:** Chris Butler (tr). **24-25 Dreamstime.com:** Levgenii Tryfonov / Triff. **24 NASA:** SDO / AIA / Goddard Space Flight Center (clb). **25 NASA:** Johns Hopkins APL / Steve Gribben (tr); SDO / HMI (tl). **26 Dreamstime.com:** Levgenii Tryfonov / Triff (c). **27 NASA:** JHUAPL / SwRI (tc). **34 NASA. 35-35 Dreamstime.com:** Astrofireball (c). **34 NASA. 36-37 NASA:** JPL / University of Arizona (ca). **36 NASA. 37 NASA:** JHUAPL / SwRI (cr); JPL (tr, tl). **38 Dreamstime.com:** Eraxion (cr). **38-39 NASA. 39 123RF.com:** Mopic (crb). **NASA:** JPL (tr). **40 Dreamstime.com:** Zhasmina Ivanova. **41 ESO:** Y. Beletsky (l); Babak Tafreshi (r). **42-43 Dreamstime.com:** Michal Rojek (Background). **44 Dreamstime.com:** Antonio Ribeiro (br). **Getty Images:** SSPL (bl). **44-45 Science Photo Library:** NSF / Steffen Richter / Harvard University (t). **45 Alamy Stock Photo:** Blickwinkel (bl); Newscom (tr); Xinhua (br). **46-47 ESO:** Hill Media / Astronautin. **46 Suzanna Randall:** (cra). **48 NASA. 48-49 NASA. 49 NASA:** ESA (cra); ESA / S. Beckwith (STScI) and The HUDF Team (crb). **50 Alamy Stock Photo:** Richard Wainscoat (c). **Dreamstime.com:** Elena Duvernay / Elenaphoto21 (bl). **Getty Images:** Photo 12 / UIG (br). **NASA. 51 123RF.com:** Paul Wishart / British Council (ca). **Alamy Stock Photo:** SPUTNIK (tr). **ESA:** Rosetta / MPS for OSIRIS Team MPS / UPD / LAM / IAA / SSO / INTA / UPM / DASP / IDA (br). **Getty Images:** Elena Duvernay / Stocktrek Images (cb). **NASA:** JPL / Cornell University (cl). **52-53 NASA:** Ames / JPL-Caltech / T. Pyle (t). **52 NASA:** JPL-Caltech (br). **53 NASA:** Ames / JPL-Caltech (bl). **54 Alamy Stock Photo:** LOOK Die Bildagentur der Fotografen GmbH (tl). **NASA. 55 Alamy Stock Photo:** World History Archive (crb). **Getty Images:** Mark Thiessen (clb). **NASA. Science Photo Library:** (cr). **56-57 NASA:** Northrop Grumman Corporation. **57 Alamy Stock Photo:** NASA Image Collection (ca). **ESA:** (crb). **NASA:** GSFC (cra). **58 NASA. Science Photo Library:** Mark Garlick (bl). **58-59 Dreamstime.com:**

Sebastian Kaulitzki / Eraxion (c). **59 NASA. 60 Alamy Stock Photo:** Newscom (tl). **Getty Images:** Photo 12 / UIG (br). **65 NASA. 66 ESO:** I. Appenzeller, W. Seifert, O. Stahl (tl). **68 Dreamstime.com:** Tedsstudio (tl)

Cover images: Dreamstime.com: Levgenii Tryfonov / Triff (crb); **ESA / Hubble:** NASA, M. Robberto (Space Telescope Science Institute / ESA) and the Hubble Space Telescope Orion Treasury Project Team tl; **Getty Images:** Elena Duvernay / Stocktrek Images tr, Alberto Ghizzi Panizza / Science Photo Library bl; **NASA:** JPL / Cornell University br, X-ray: CXC / SAO; Optical: Detlef Hartmann; Infrared: JPL-Caltech cr; **Science Photo Library:** Mark Garlick fcr; **Quiz & answers: Alamy Stock Photo:** Richard Wainscoat cb; **Dreamstime.com:** Astrofireball cr, Eraxion cla/ (2), Sebastian Kaulitzki / Eraxion cla; **Getty Images:** Photo 12 / UIG cla/ (Space probe); **NASA:** ESA / Rosetta / MPS for OSIRIS Team MPS / UPD / LAM / IAA / SSO / INTA / UPM / DASP / IDA cr/ (2), Hubble Heritage Team, ESA c.

All other images © Dorling Kindersley
For further information see: www.dkimages.com

findout! Quiz

Test your knowledge about the Universe and find out even more fun facts!

1

Which is the biggest gas giant?

2

Which galaxy does the Earth belong to?

3

True or false: Blue stars are hotter than red ones.

4

The Sun is mainly made up of which two gases?

5

Which moon is Neptune's largest?

6

What type of galaxy is oval-shaped?

7

Which 1969 mission first put men on the Moon?

8

Which telescope will be launched in 2020?

9

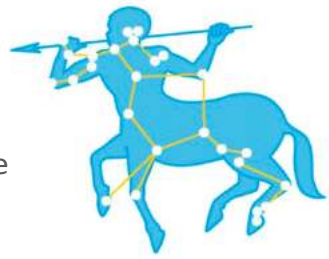
How long ago did the Big Bang take place?

10

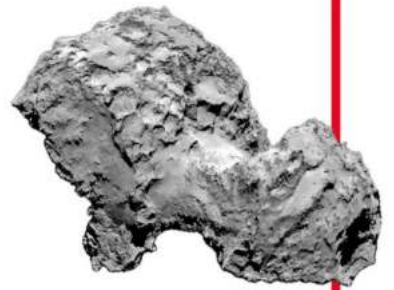
Where would you find the Sea of Tranquility?

Turn over to discover the answers

Quiz answers

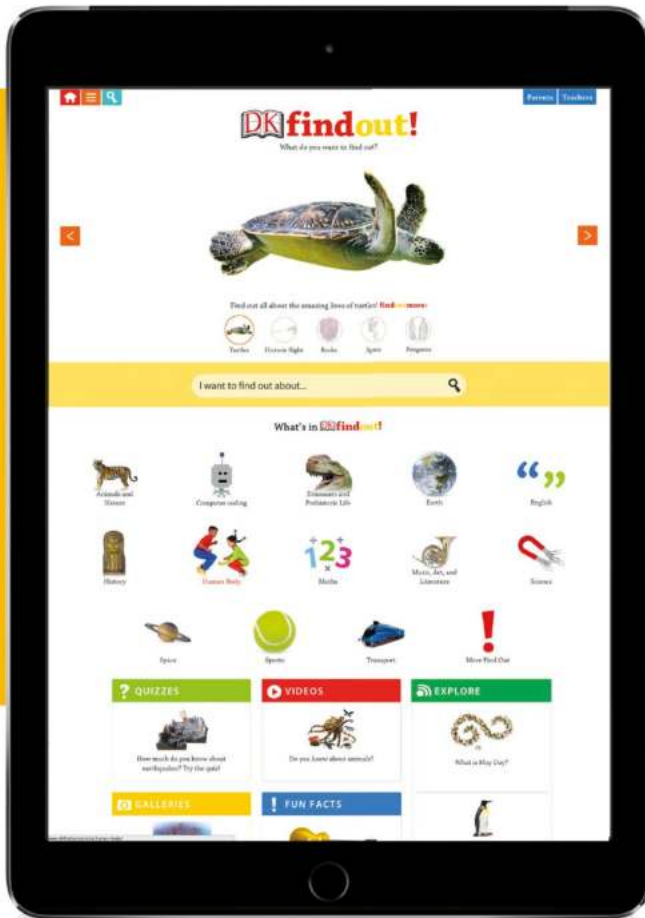


- 1** **Jupiter.** Find out just how big this massive planet is on page 32.
- 2** **The Milky Way.** Find out about more about our home galaxy on pages 22–23.
- 3** **True.** Find out about the different types of star on pages 14–15.
- 4** **Hydrogen and helium.** Find out how hot the surface of the Sun is on page 25.
- 5** **Triton.** Discover more about this moon on page 37.
- 6** **Elliptical galaxy.** Find out what other shapes galaxies can have on pages 20–21.
- 7** **Apollo 11.** Find out more space exploration milestones on pages 50–51.
- 8** **James Webb Space Telescope.** Find out how it is different from the Hubble telescope on page 56.
- 9** **13.8 billion years.** Find out more about how the Universe was born on page 7.
- 10** **On the Moon.** Find out about the other features on the Moon on pages 34–35.



findout!

**The only FREE online encyclopedia
a child will ever need**



- ▶ **Perfect for homework help**
- ▶ **Fun, interactive quizzes, videos, and animations**
- ▶ **Thoroughly fact-checked by experts**
- ▶ **Safe for children to use with you — or on their own**



“This is pretty awesome.”

Primary school pupil, age 9

What do you want to find out?

www.dkfindout.com