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

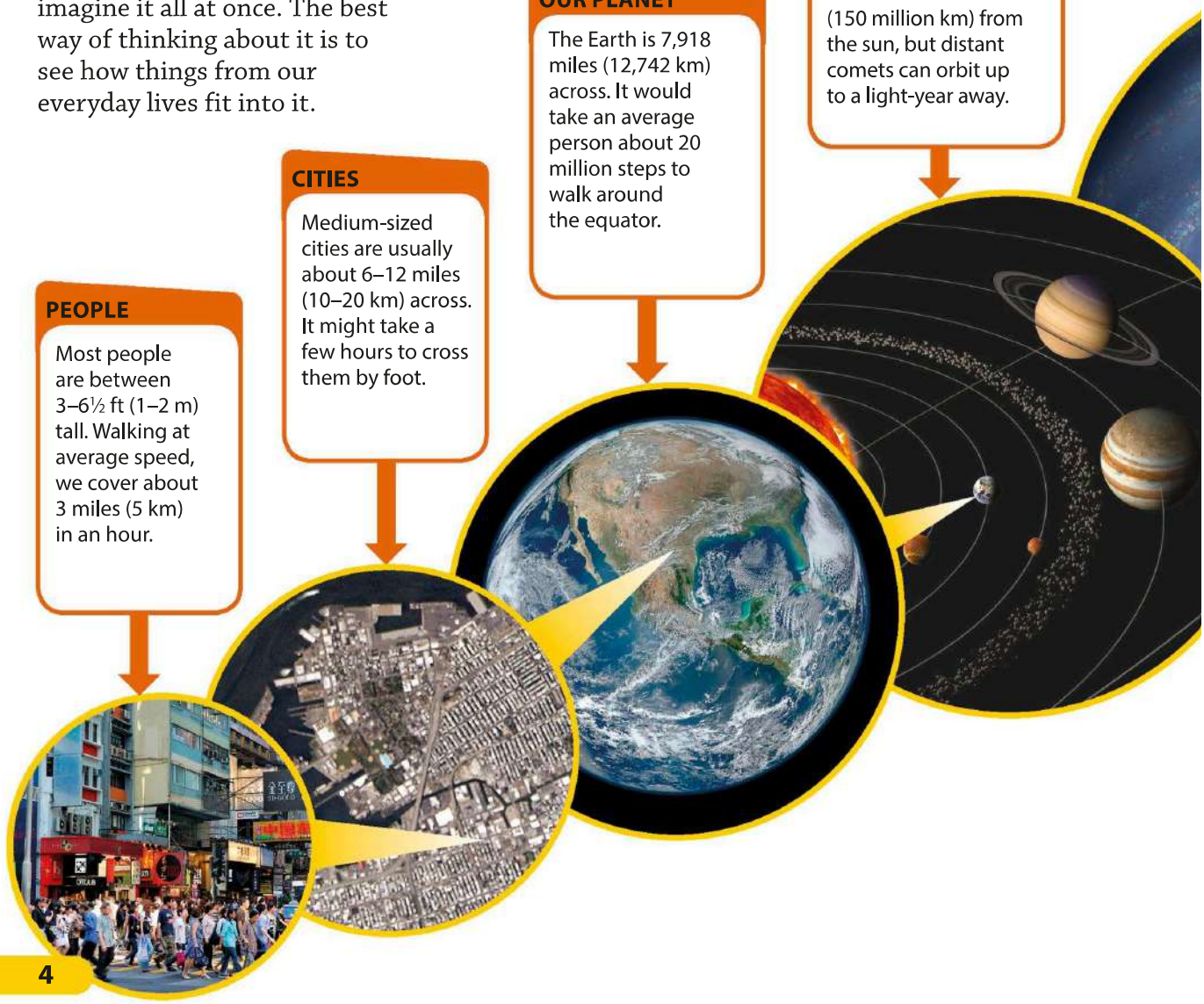
Medium-sized cities are usually about 6–12 miles (10–20 km) across. It might take a few hours to cross them by foot.

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

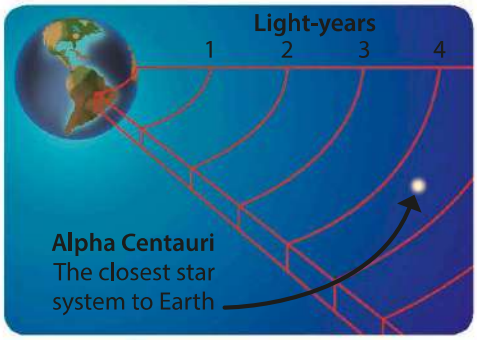
The Milky Way is one of the bigger members of a galaxy group roughly 10 million light-years across.

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.

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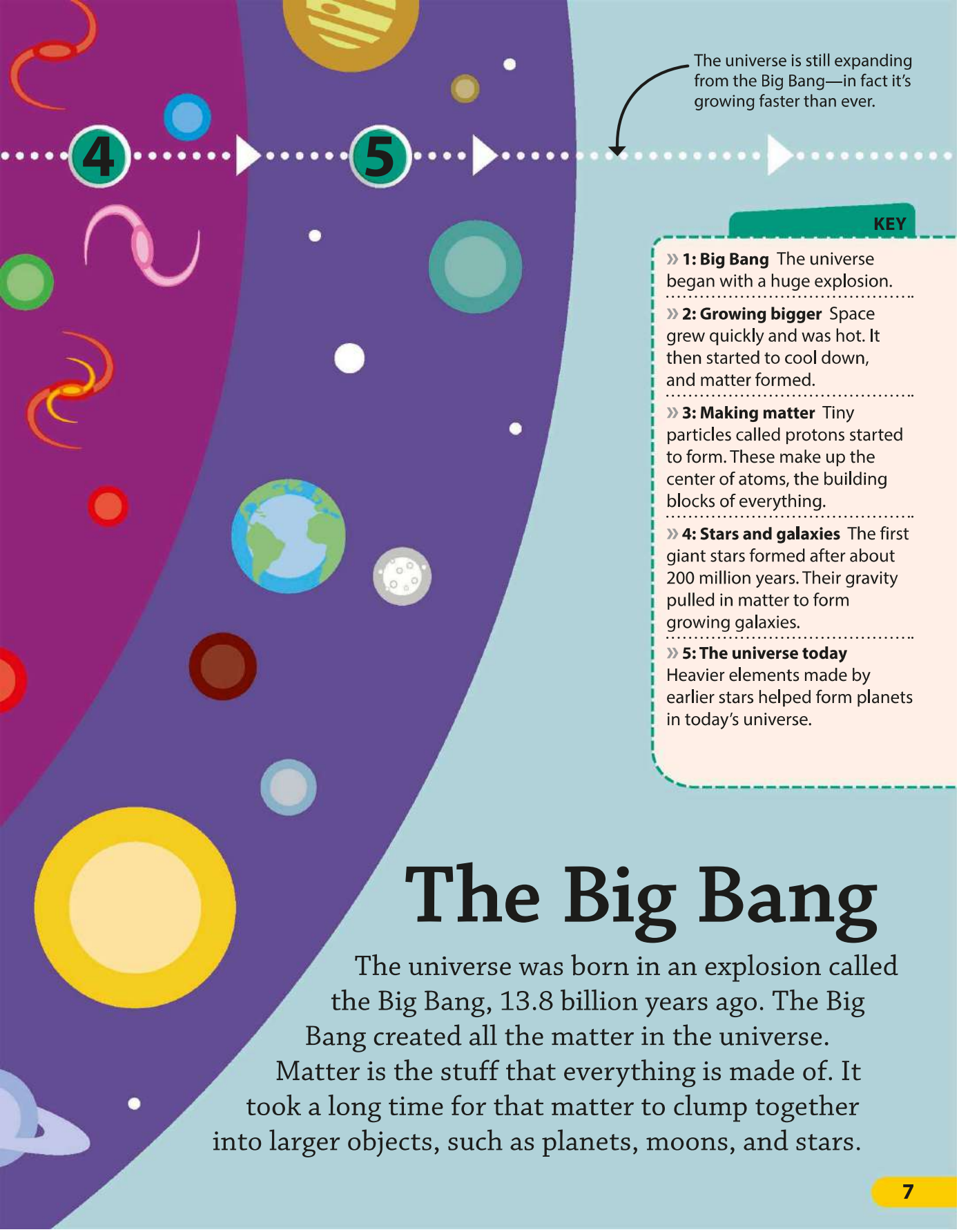


KEY

» **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.

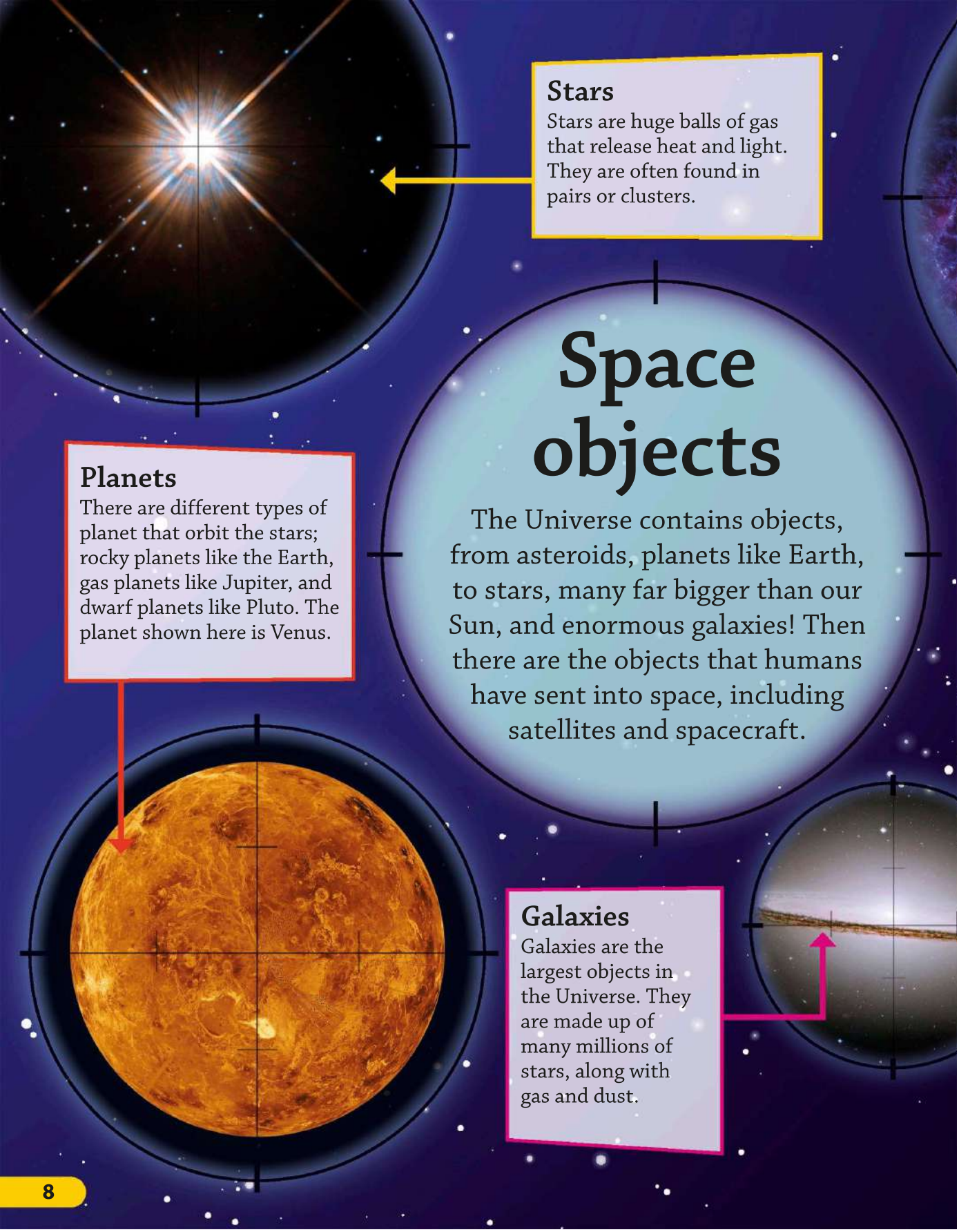
» **3: Making matter** Tiny particles called protons started to form. These make up the center of atoms, the building blocks of everything.

» **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.



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.

Stars

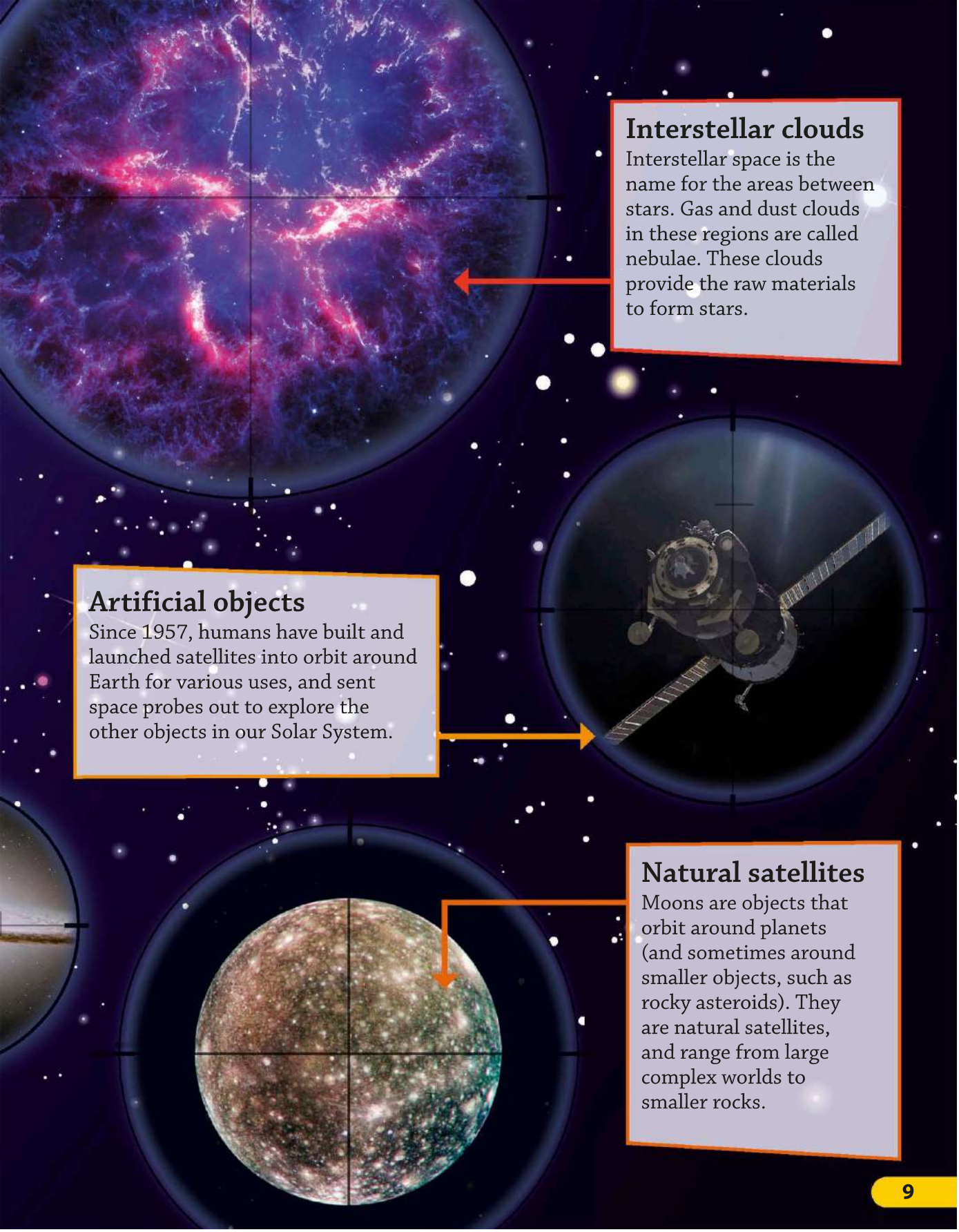
Stars are huge balls of gas that release heat and light. They are often found in pairs or clusters.

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.

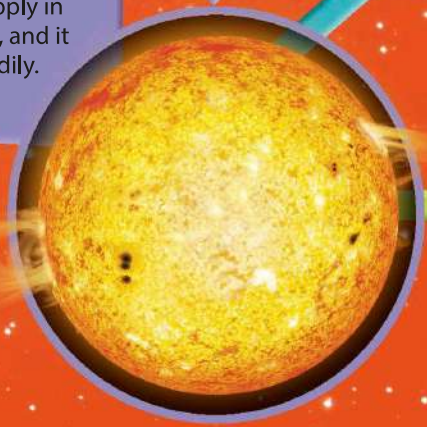
Life of a star

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.

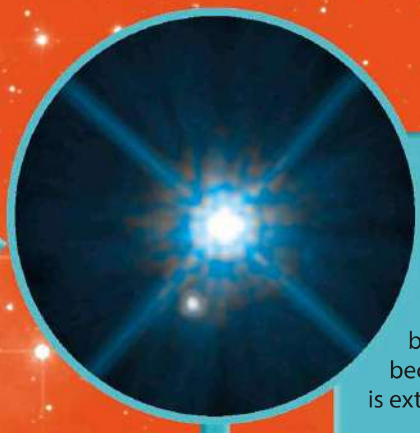
Red giant
After a few billion years, a small star like the sun goes through changes that allow it to keep shining. It gets much brighter, swells in size, and turns red.

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.

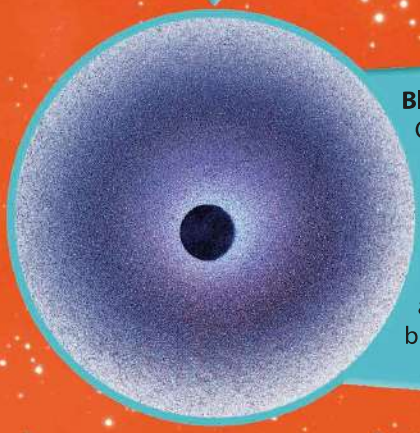


Red supergiant
The biggest, brightest stars run out of fuel in just a few million years. They swell in size to become supergiants.

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



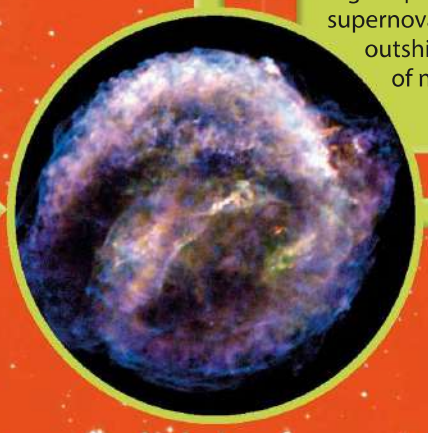
White dwarf
The Earth-sized core of the red giant survives. It cannot make any more energy, but it still shines because its surface is extremely hot.



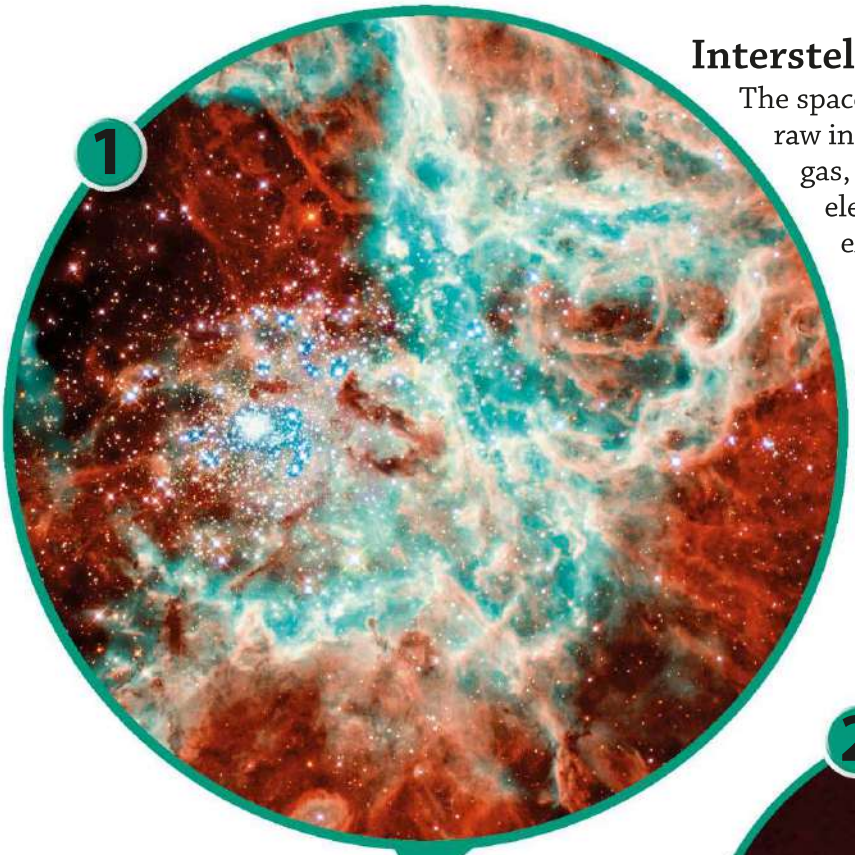
Black dwarf
Over many billions of years, a white dwarf slowly cools down until it can become a thick, dark black dwarf.

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.

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.

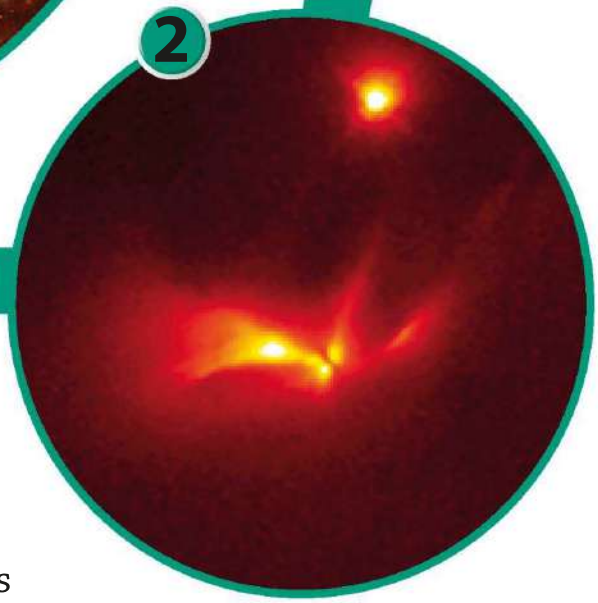


Black hole
A black hole is a point in space that sucks in anything that comes close to it. Stars with very heavy cores (centers) collapse to create black holes.



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.

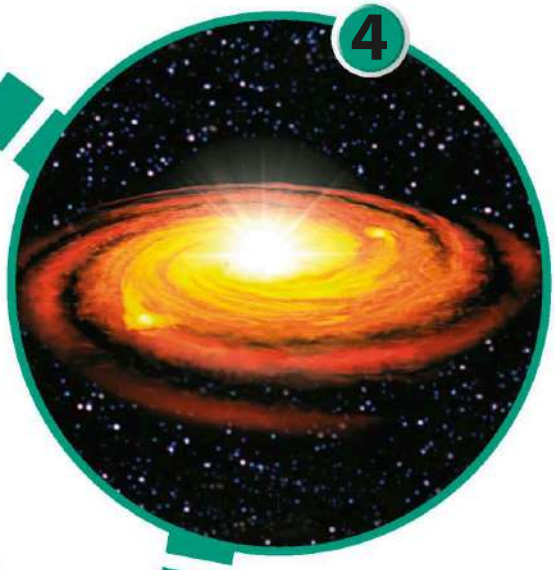
Spinning disk

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!



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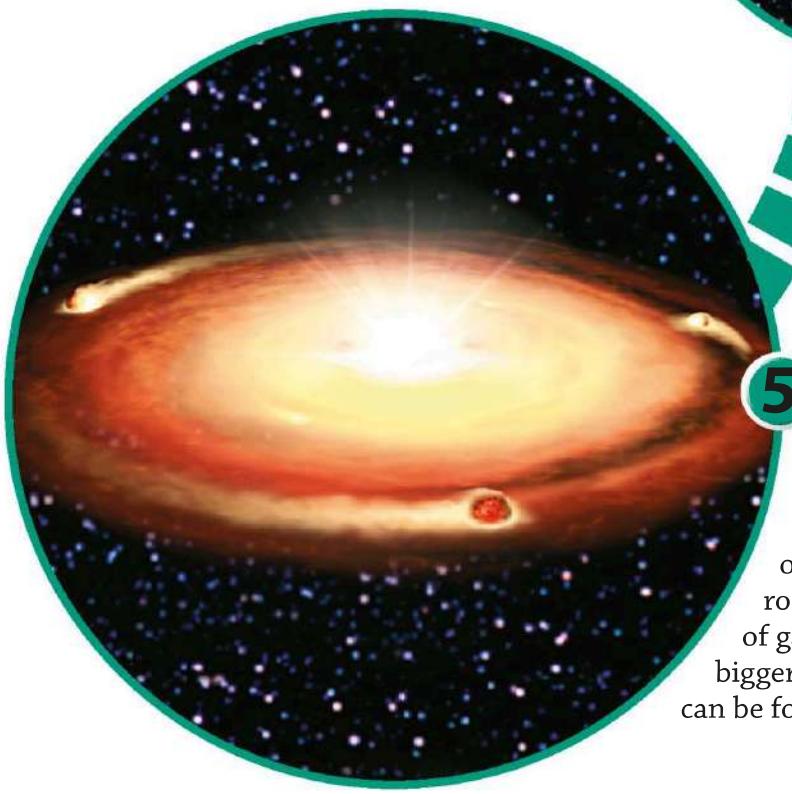
New star

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.



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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.

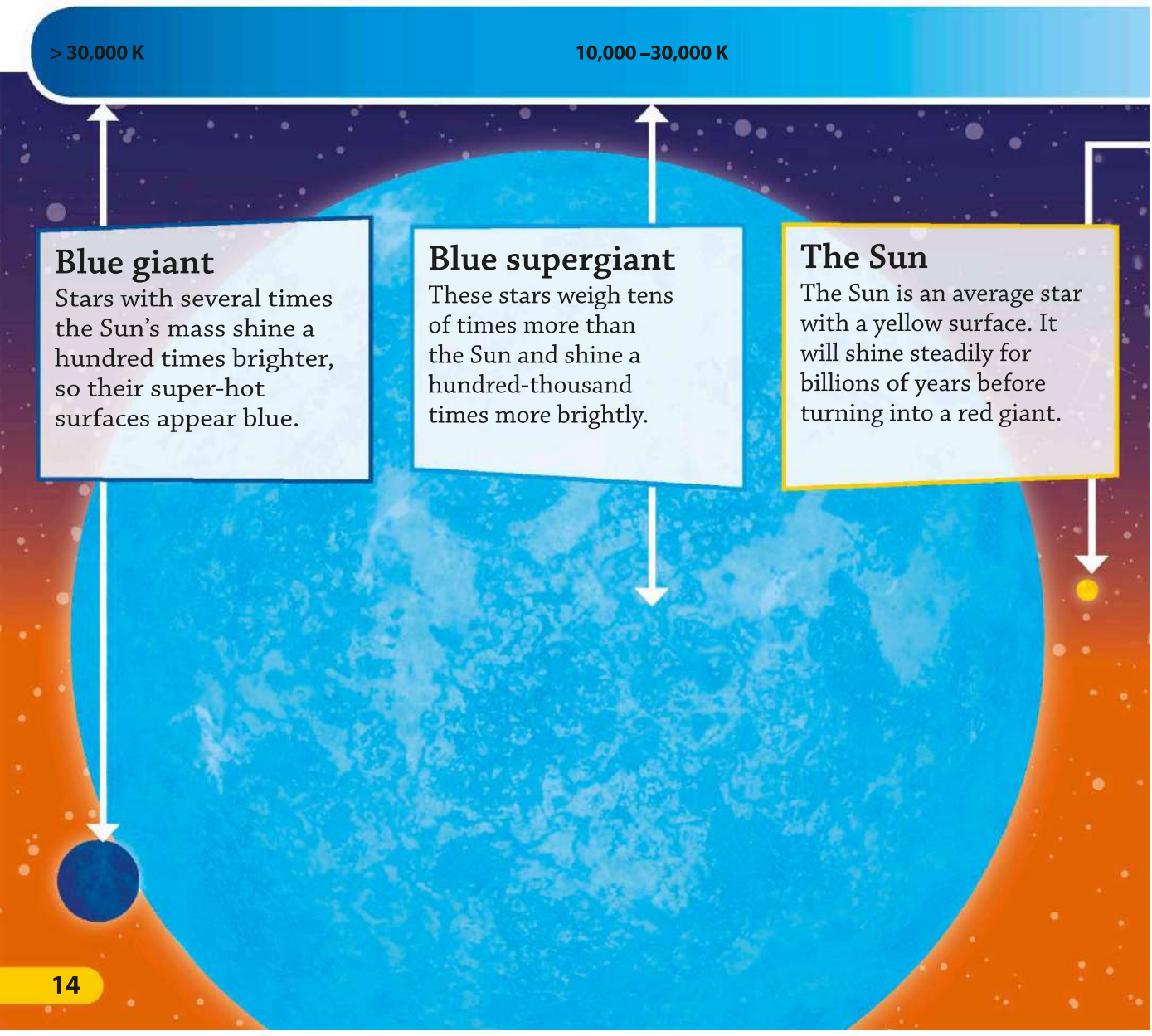
Types of stars

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

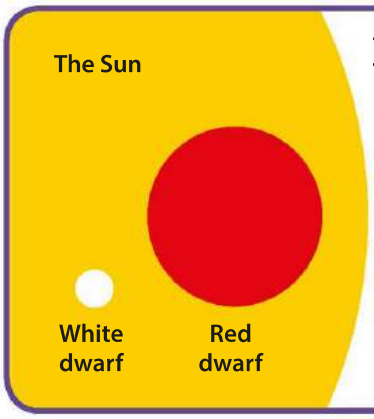
A star's colour depends on how hot it is. A star's temperature is measured in degrees Kelvin (K). Zero degrees Kelvin is -273 °C (-458 °F).

Hottest



WOW!

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



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

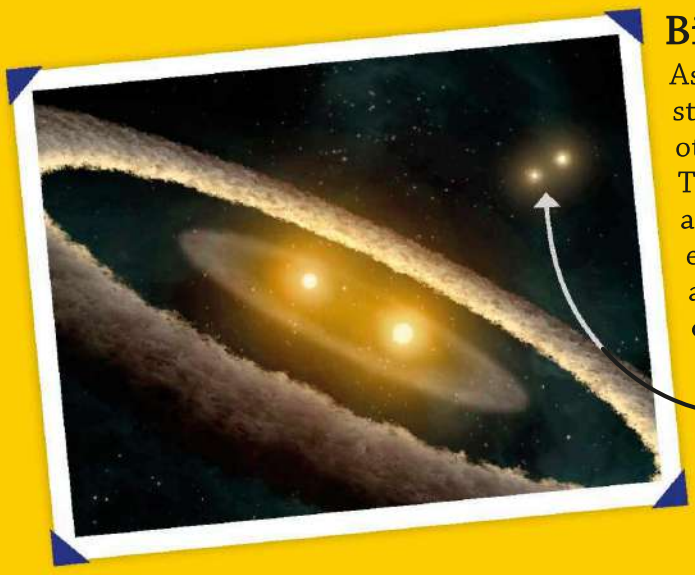
Near the end of their lives, stars like the Sun briefly shine as brilliant, huge but cool red giants.

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.



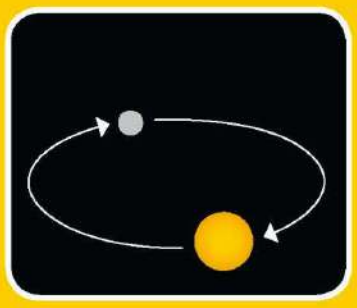
Binary stars

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.

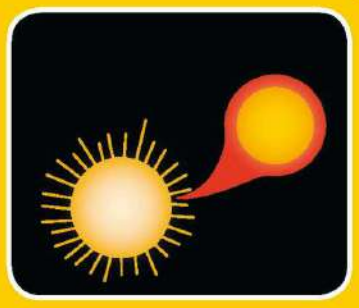
Merging stars

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.

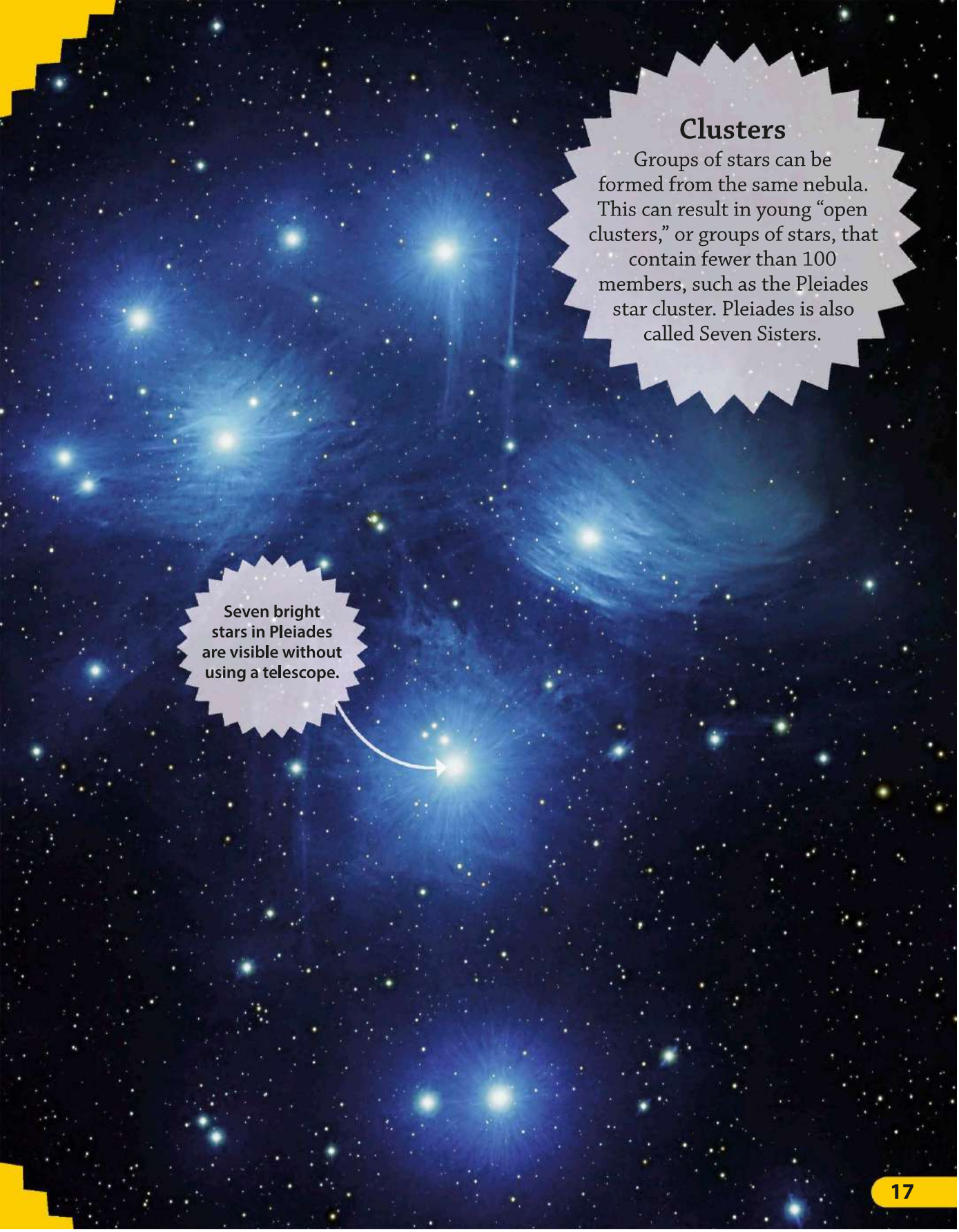


1. Orbiting stars
In this binary pair, one star is a white dwarf and the other is about to become a red giant.

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

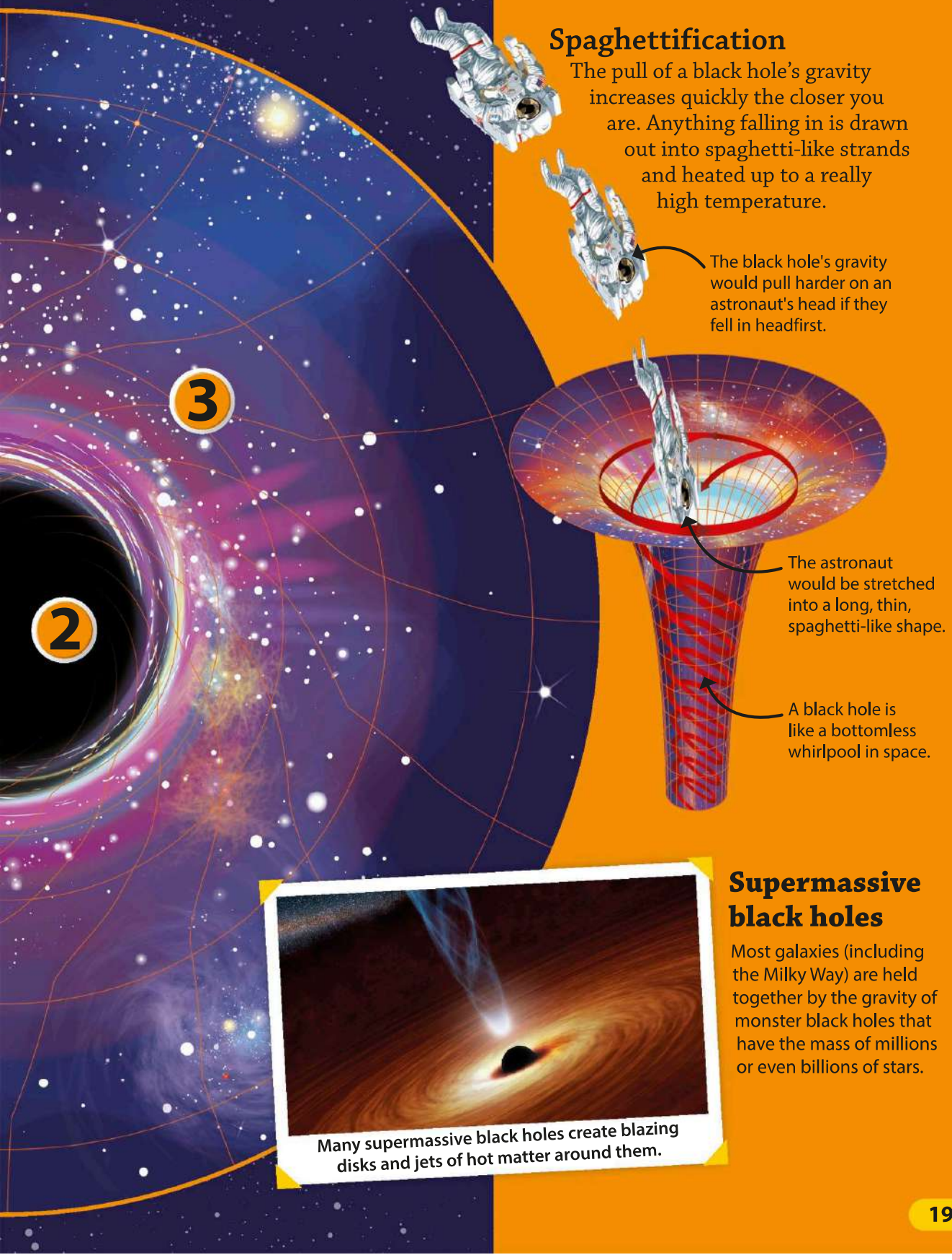
» **1. Singularity** The center of a black hole is called the singularity. At this point, gravity becomes limitless, and the normal laws of science no longer apply.

» **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.

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.



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

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.

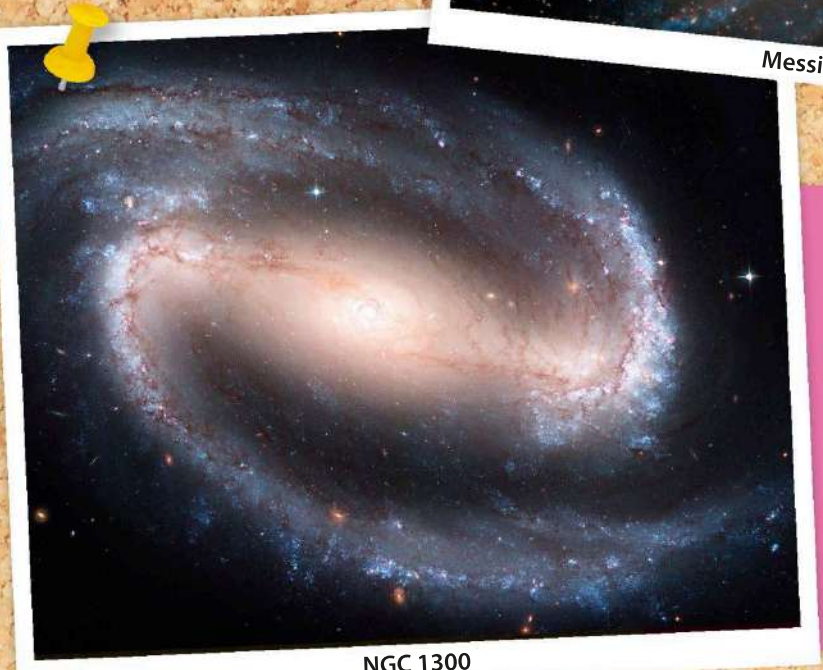
Galaxies

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.

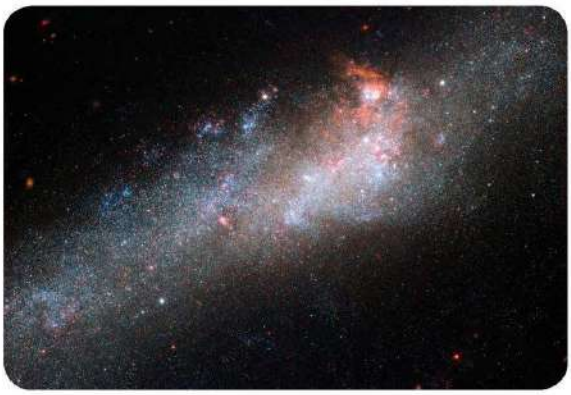
NGC 5010

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.

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

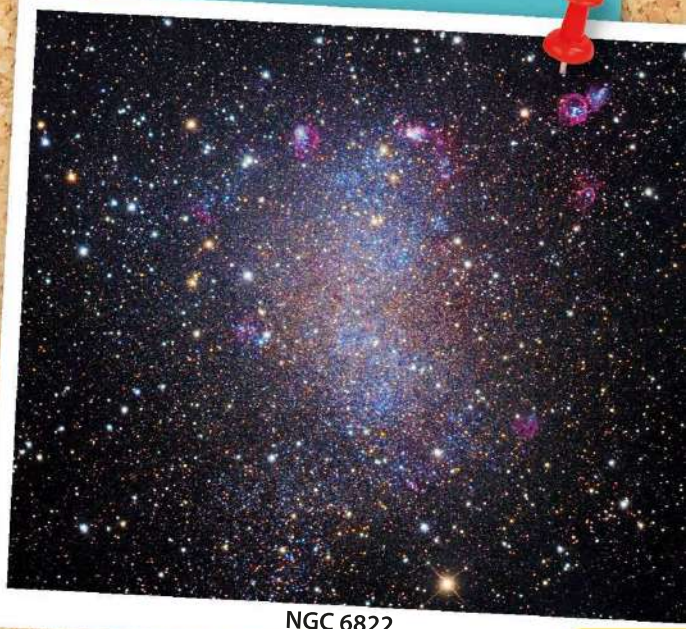
Irregular galaxy

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.

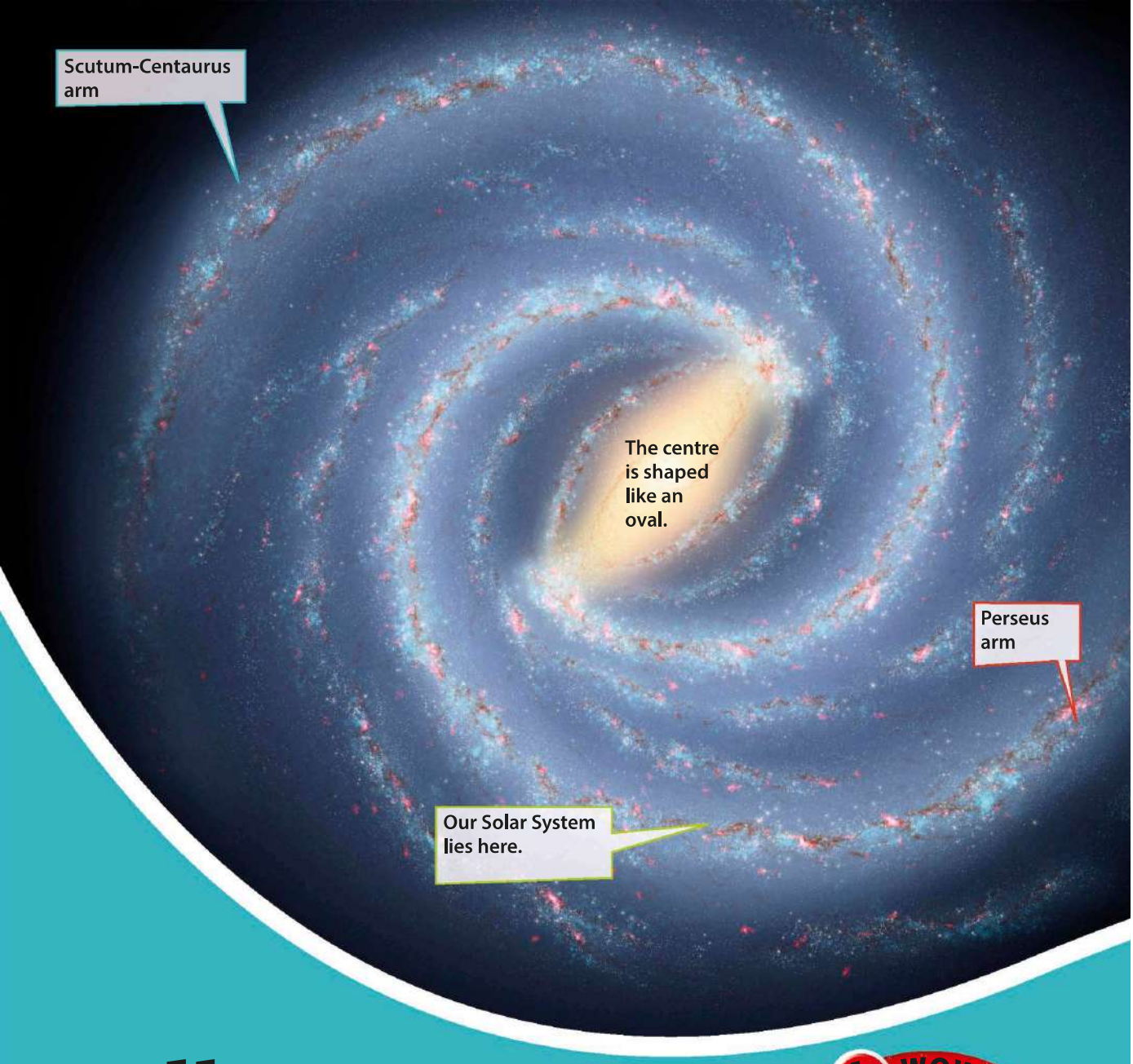
Messier 87

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.



NGC 6822



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.

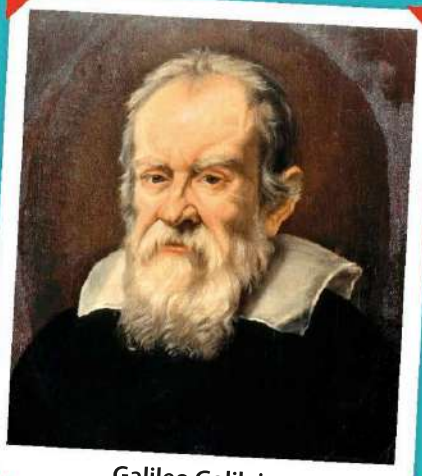
Shape

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

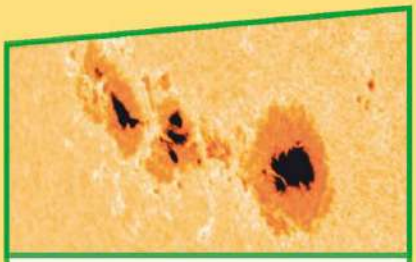
The sun is the nearest star to the Earth. It lies at the center of our solar system and is a huge ball of gas. The sun produces heat and light. Without it, our planet would be lifeless. It takes the sun's light about eight minutes to reach the Earth!

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.

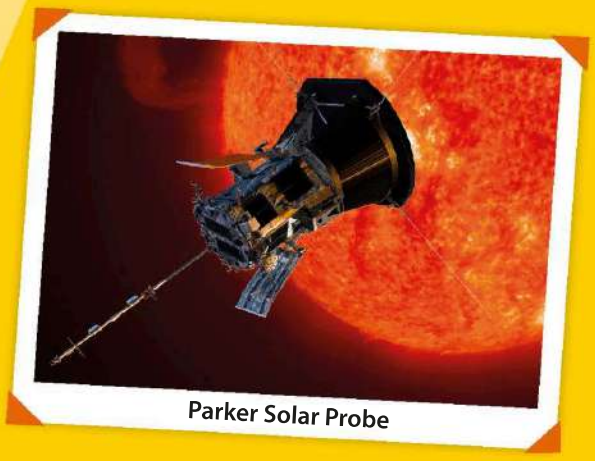
Solar flares

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.



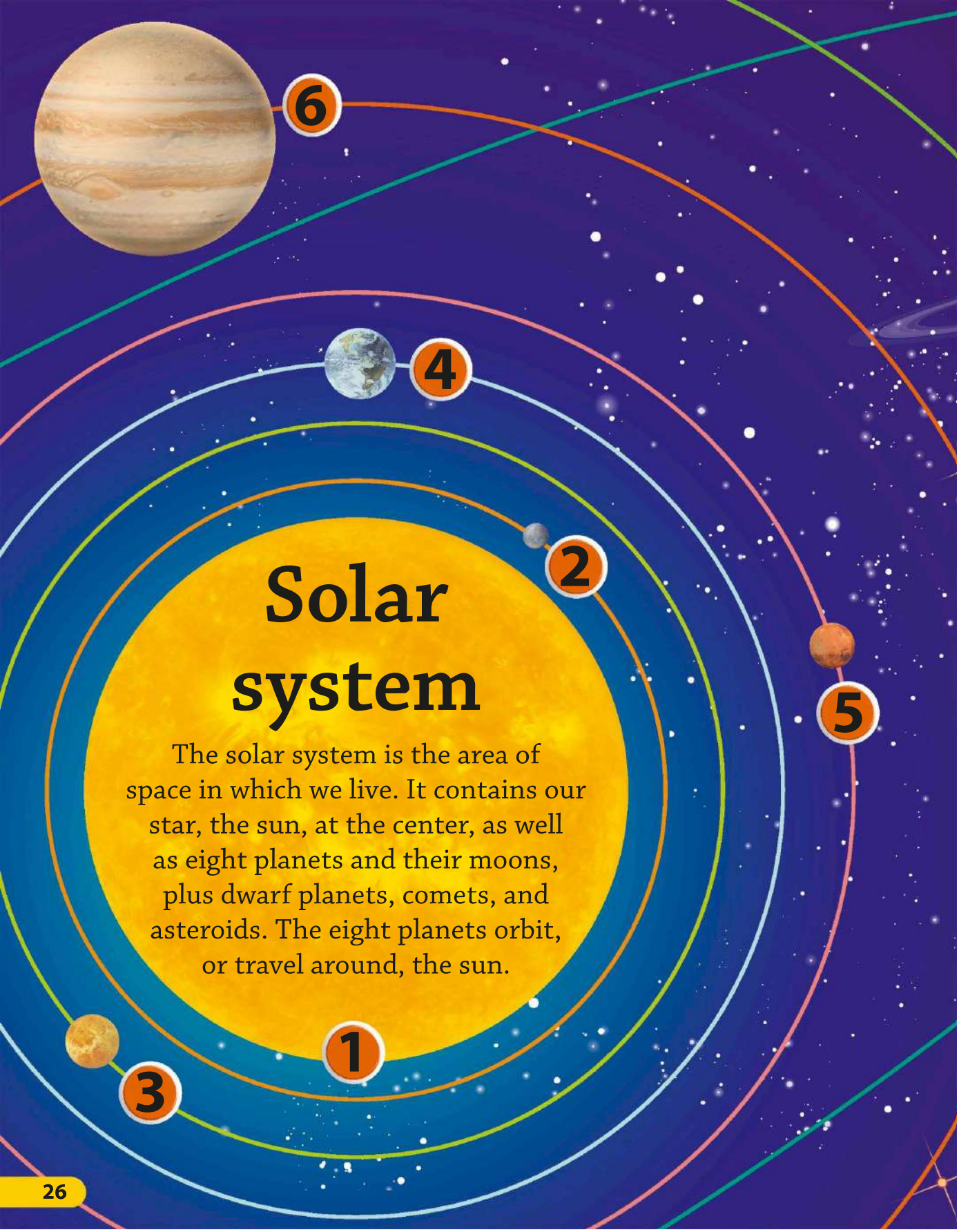
Parker Solar Probe

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).

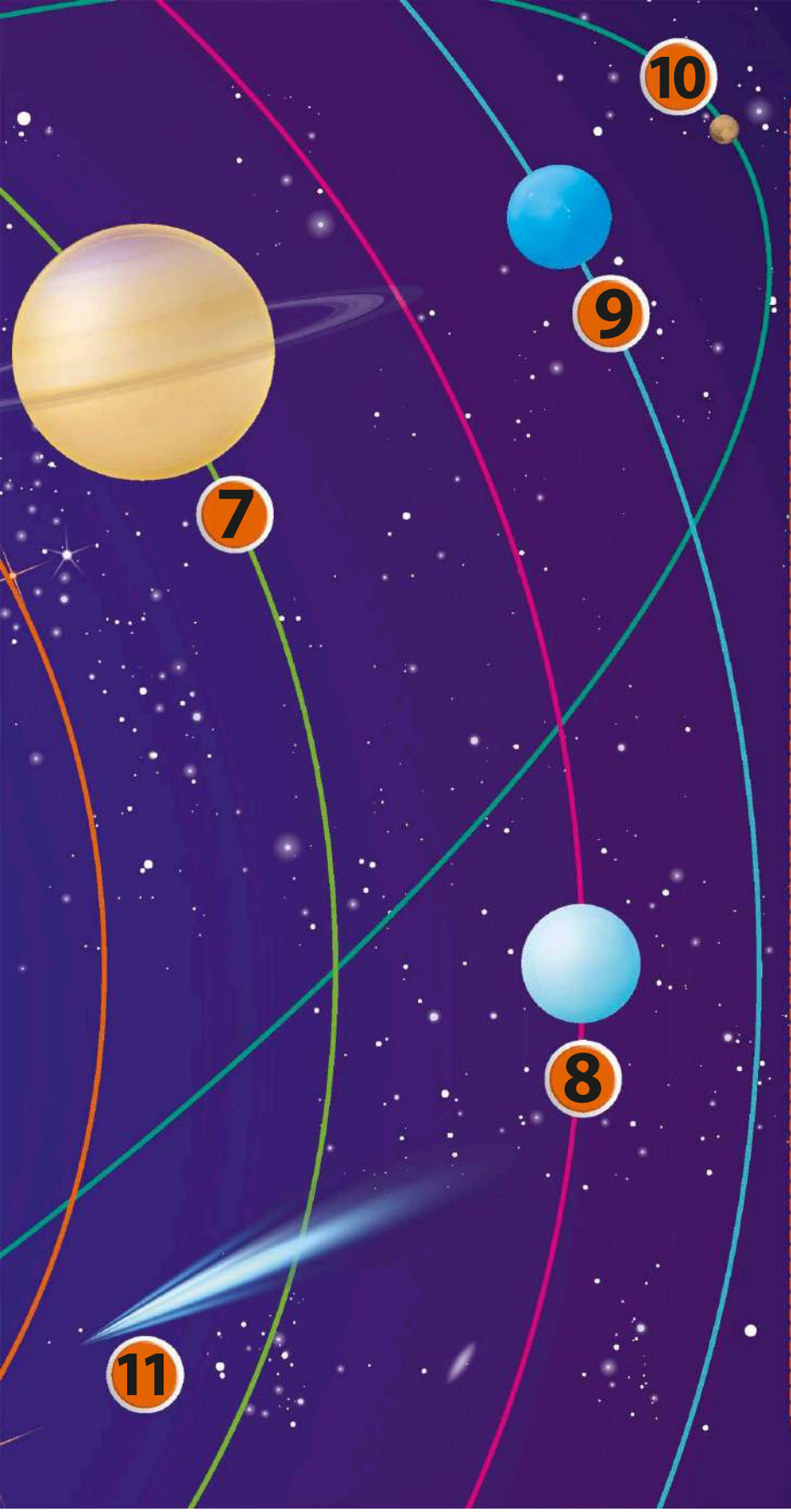
Scorching surface

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.



KEY

» **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.

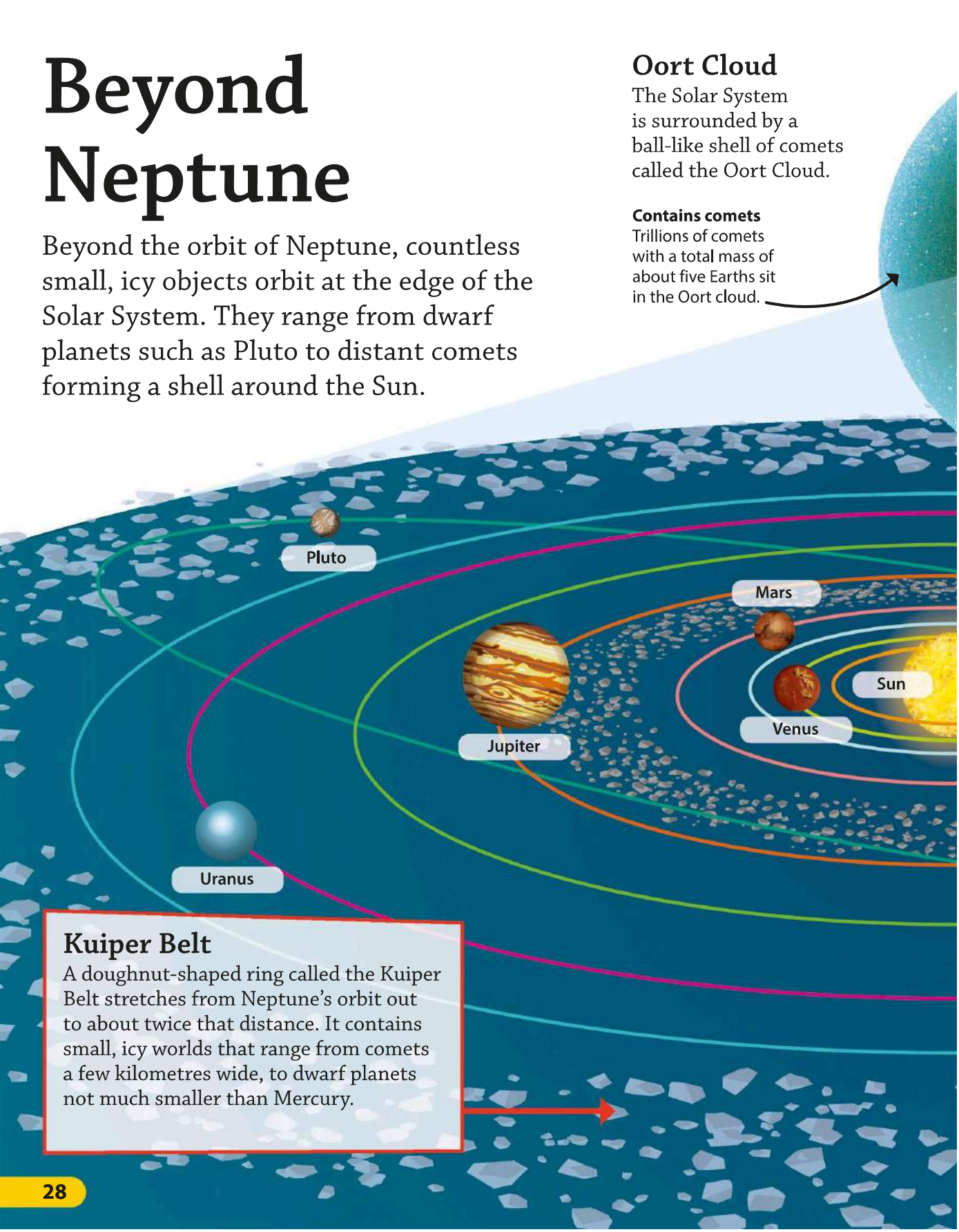
Beyond Neptune

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

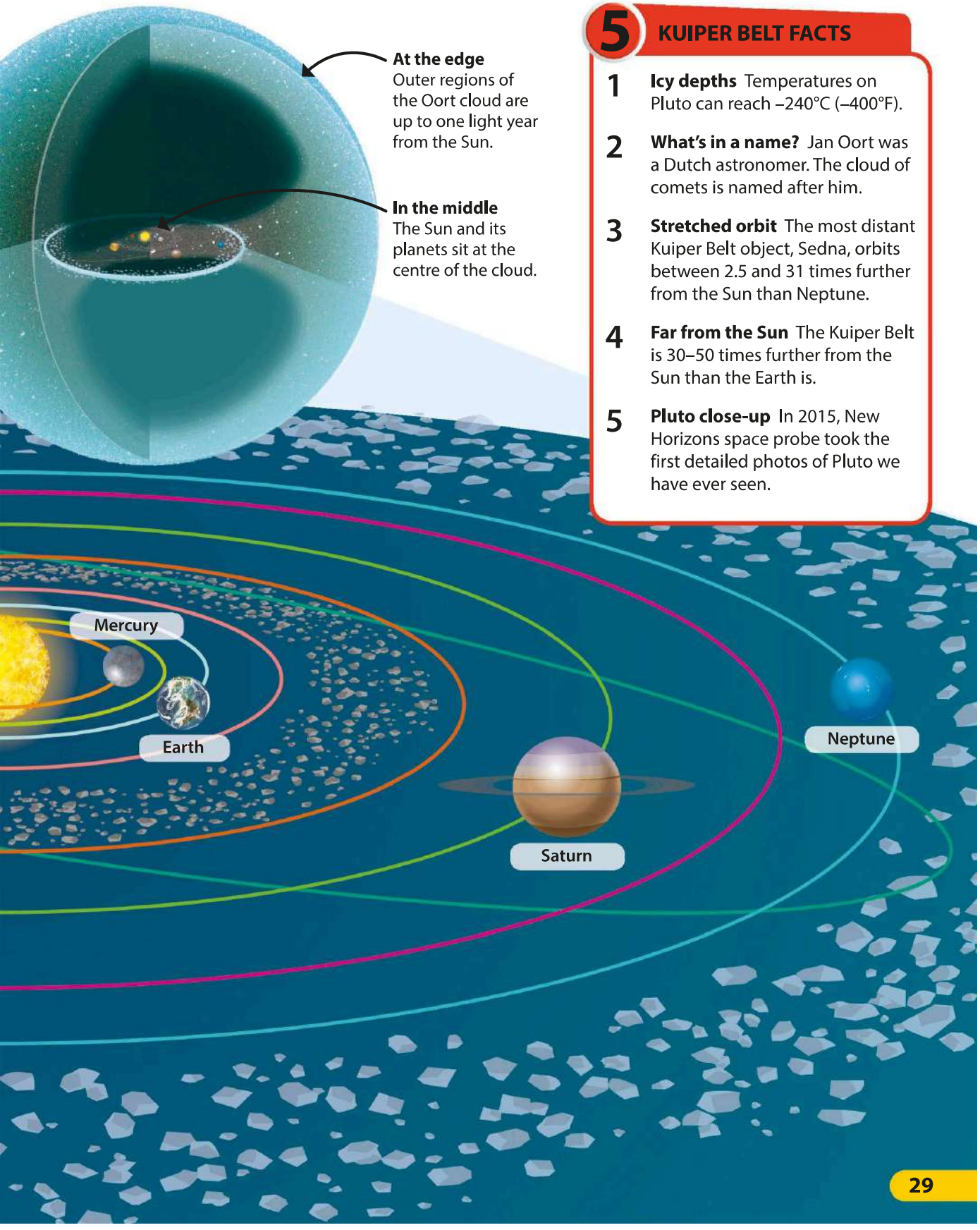
The Solar System is surrounded by a ball-like shell of comets called the Oort Cloud.

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.



5 KUIPER BELT FACTS

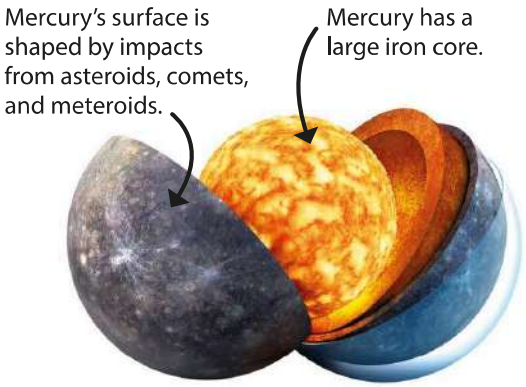
1. **Icy depths** Temperatures on Pluto can reach –240°C (–400°F).
2. **What's in a name?** Jan Oort was a Dutch astronomer. The cloud of comets is named after him.
3. **Stretched orbit** The most distant Kuiper Belt object, Sedna, orbits between 2.5 and 31 times further from the Sun than Neptune.
4. **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.

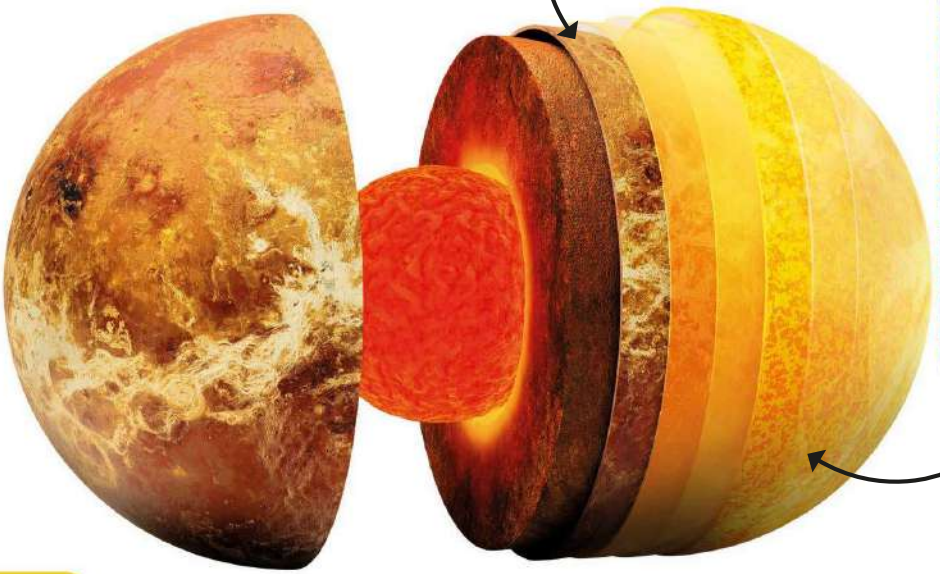


FACT FILE

- **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).

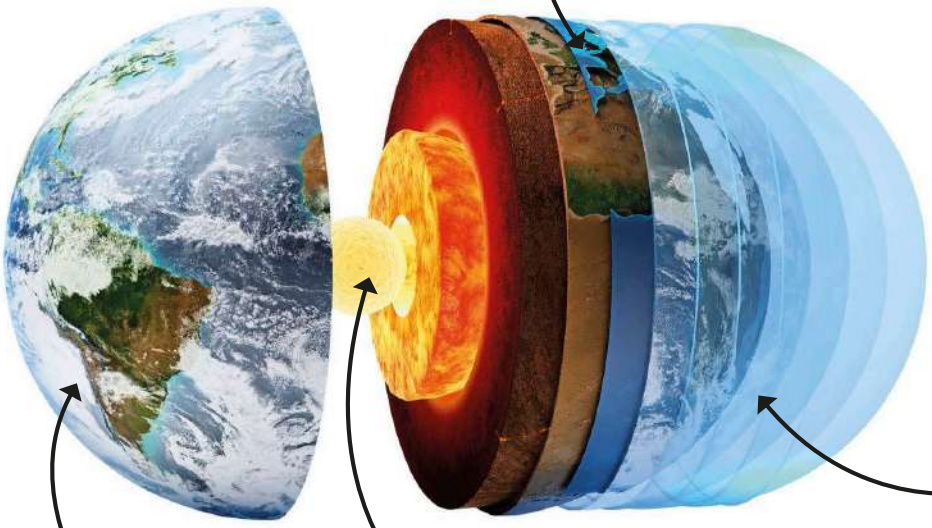


FACT FILE

- **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.



Oceans, seas, rivers, and lakes are on the Earth's surface.

Outer crust is split into slow-moving rocky plates.

Molten core of iron and nickel has a solid center.

Atmosphere keeps temperatures even and allows life to thrive.

FACT FILE

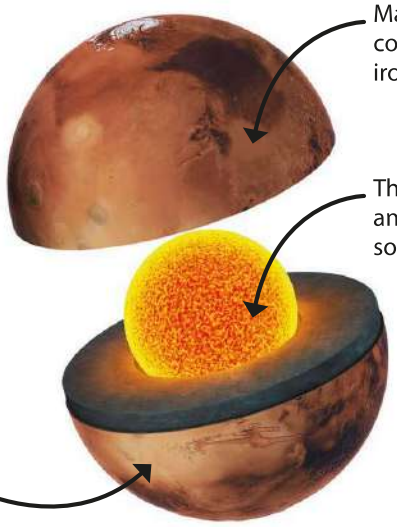
» **Diameter:** 7,900 miles (12,742 km)

» **Distance from the sun:** 93 million miles (150 million km)

» **Number of moons:** 1

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.



Martian crust is covered in red, iron-rich sand.

The core is small and is likely to be solid iron.

Mars has the solar system's deepest canyons and highest mountains.

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

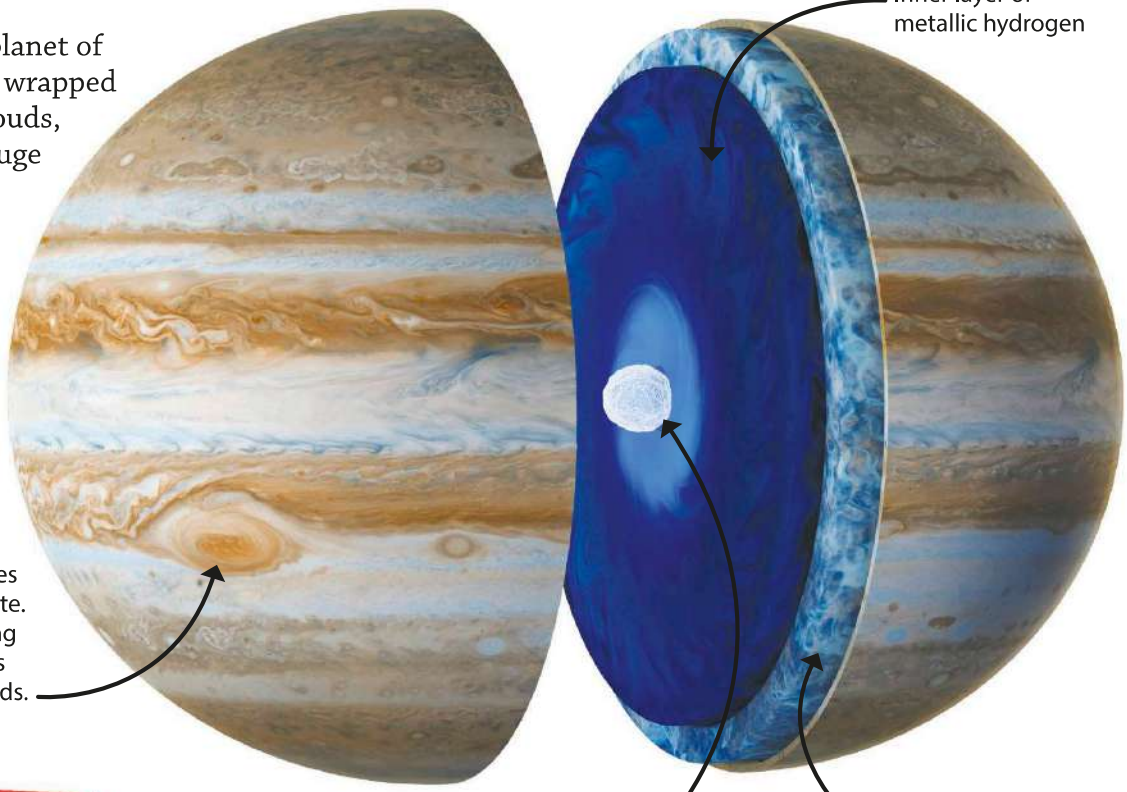
The huge planets of the outer solar system are gas giants or ice giants. They are much larger than Earth, but they are mostly made up of lightweight gases that turn to liquid or slushy ice deep inside. A gas giant's small core is solid and is made of rock.

WOW!

Four of Jupiter's 79 moons are bigger than Pluto!

Jupiter

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



FACT FILE

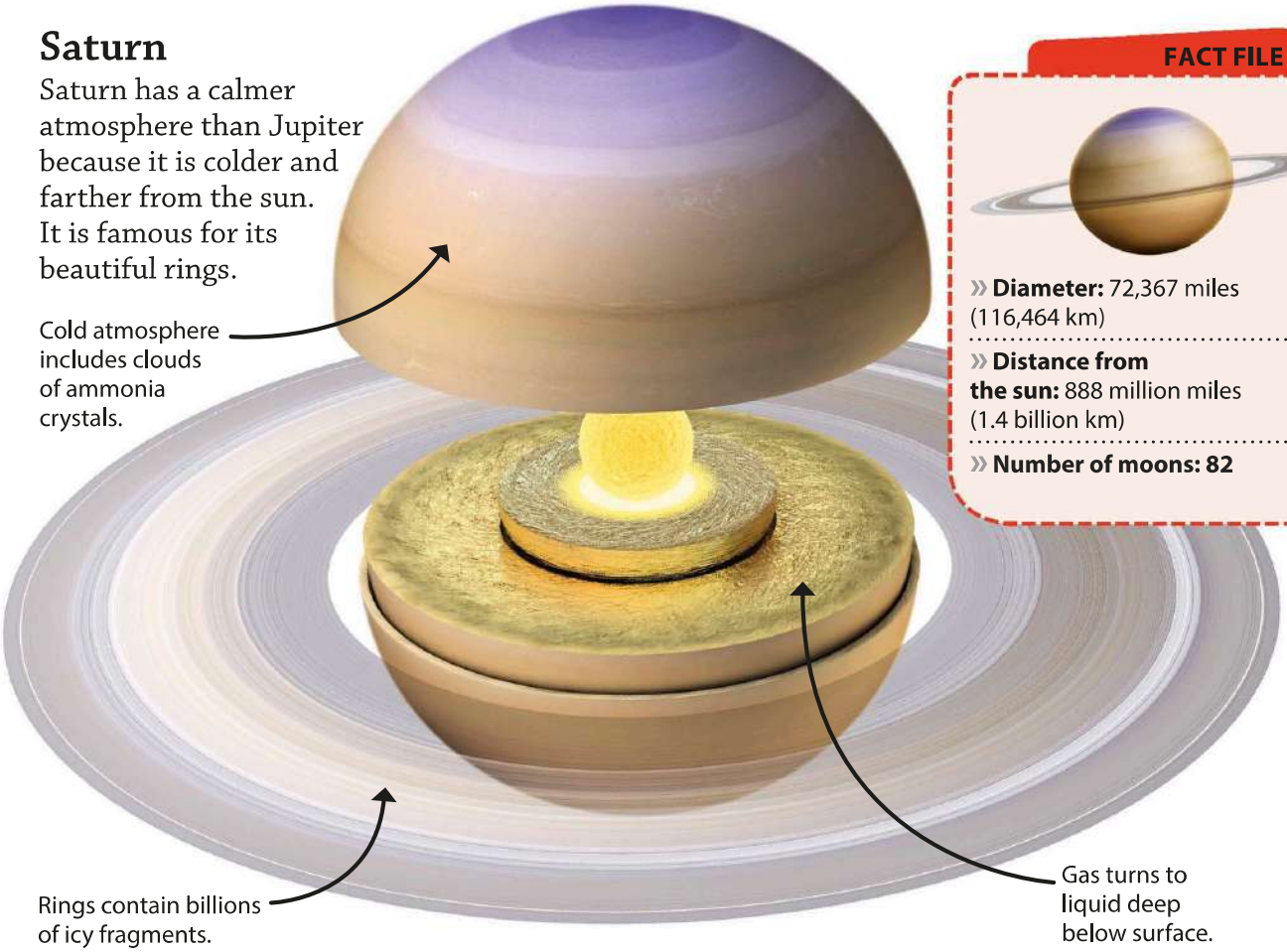
» **Diameter:** 88,765 miles (142,984 km)

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

» **Number of moons: 79**

Saturn

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



FACT FILE

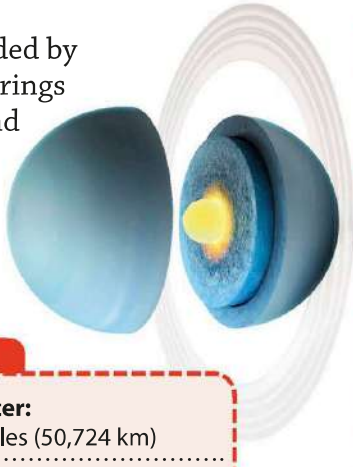
» **Diameter:** 72,367 miles (116,464 km)

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

» **Number of moons: 82**

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)

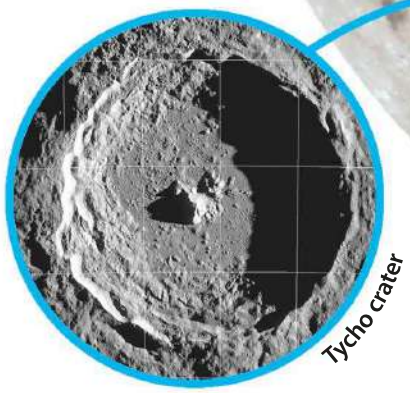
» **Number of moons:** 14

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.

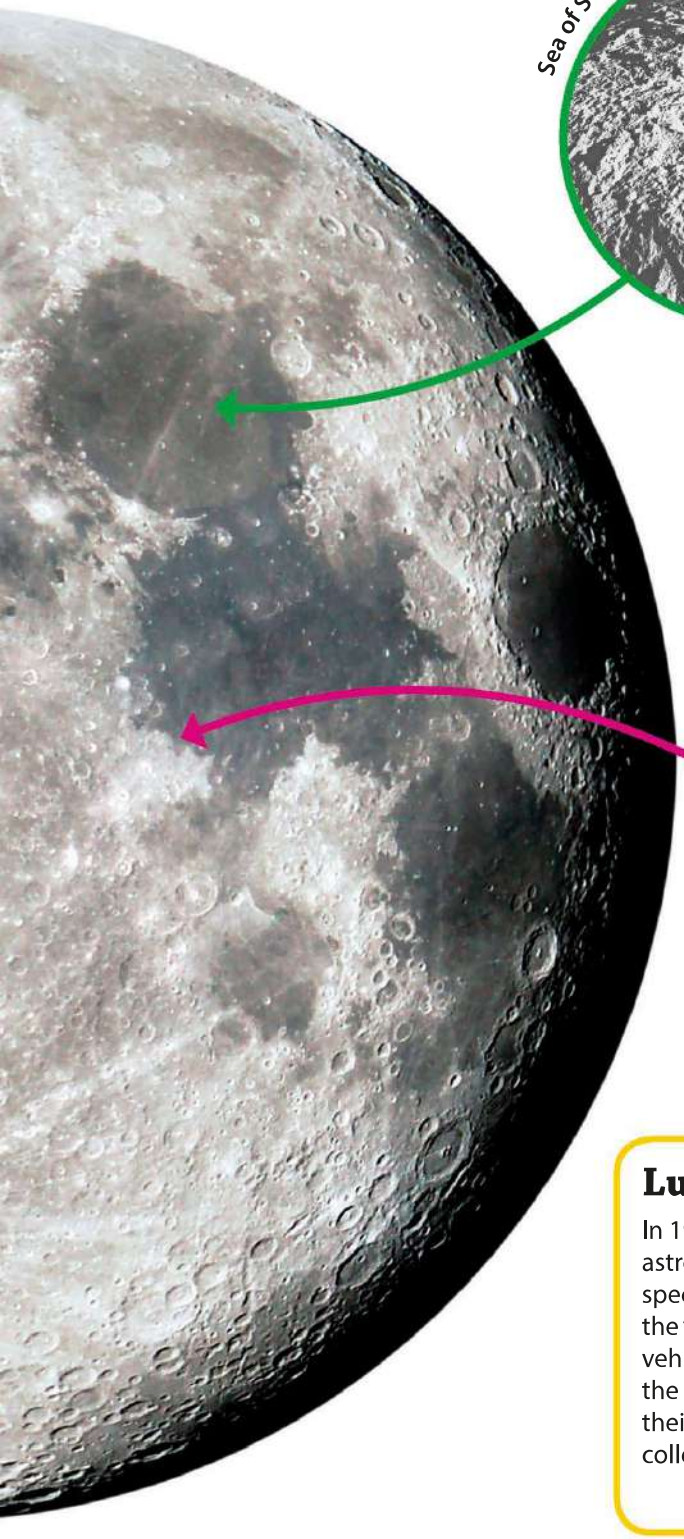
Mountains

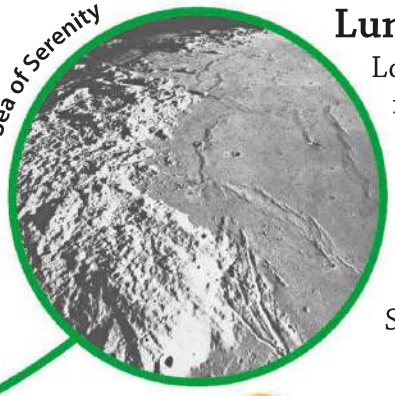
Many of the moon's mountain ranges are actually the raised edges of huge craters formed from the largest impacts.



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.





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.

Moon landing

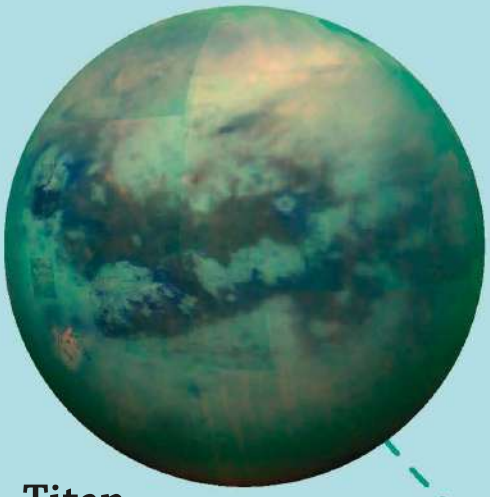
Apollo 11 landed on the edge of the Sea of Tranquility in 1969. It was the first space mission in which astronauts, including Buzz Aldrin, walked on the moon!

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.

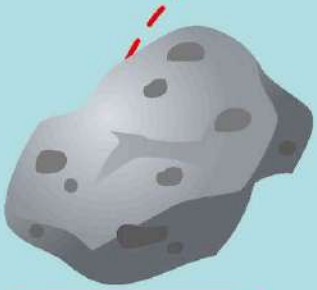


Dactyl

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.

Titan

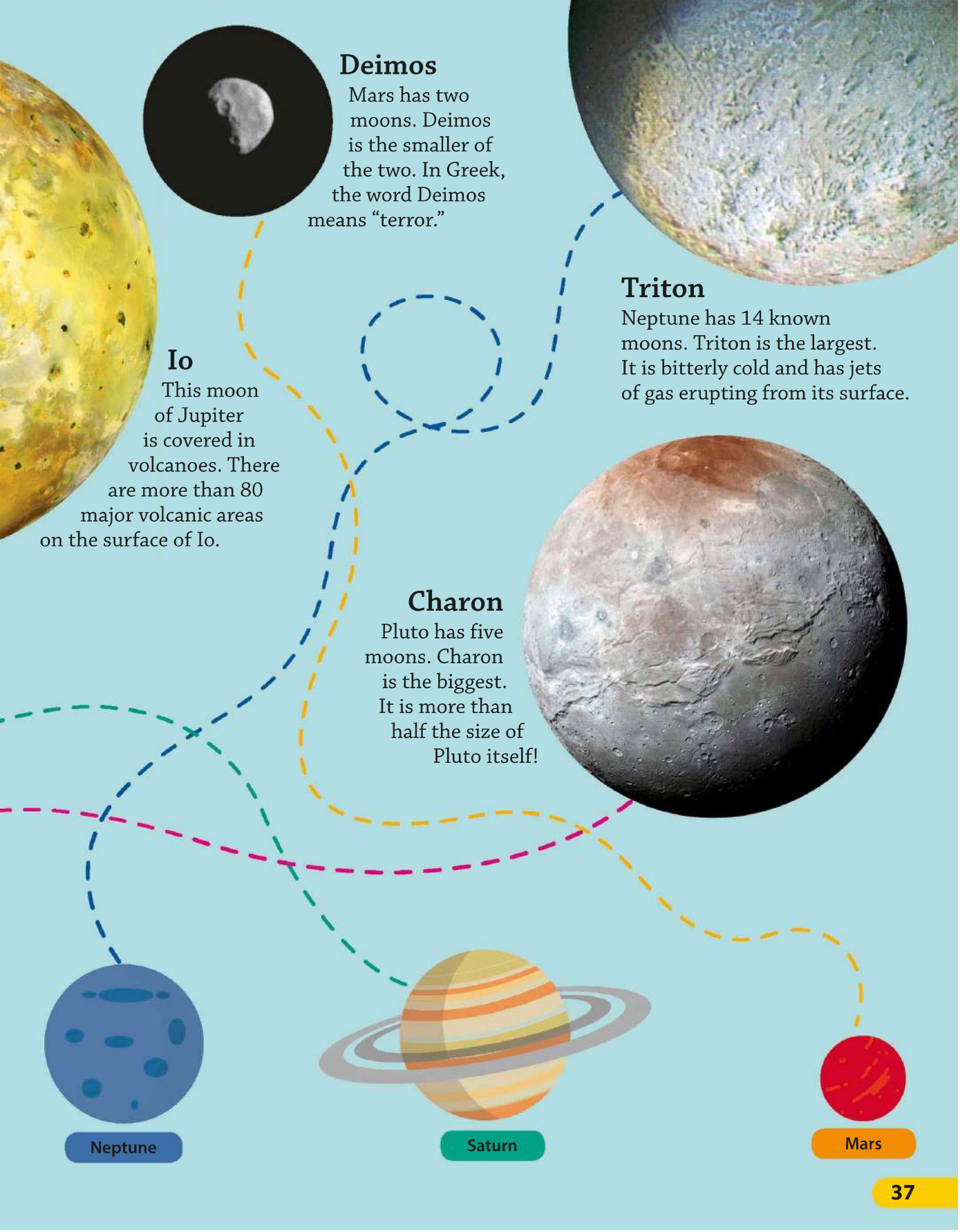
One of Saturn's moons, Titan, is 50 percent larger than the Earth's moon. This moon has a thick atmosphere and oily lakes on its surface.



Ida (an asteroid)

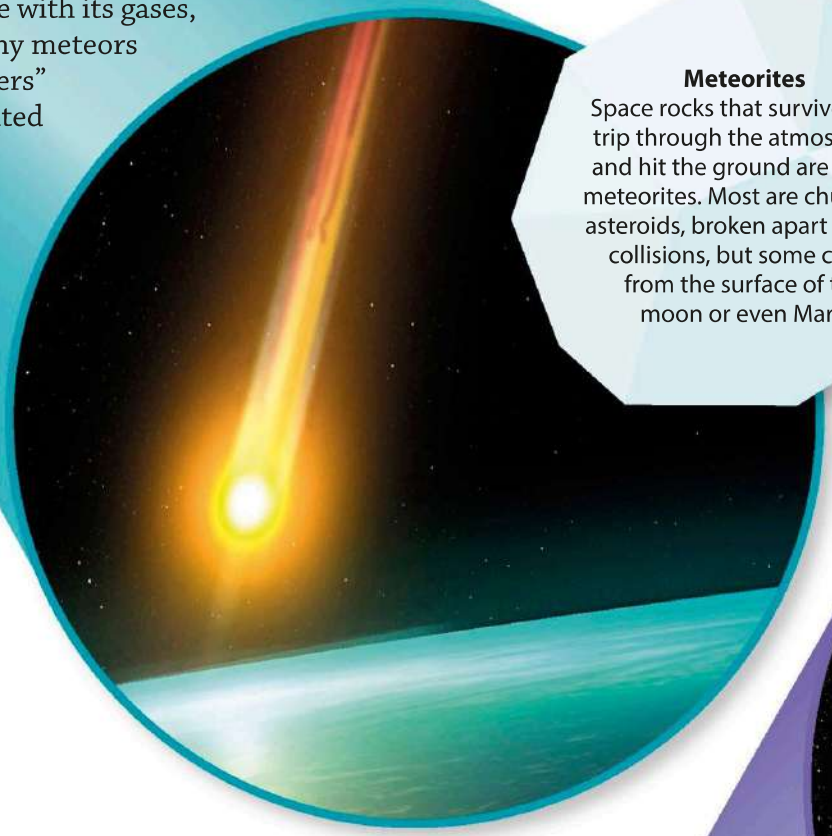
Jupiter

Pluto


Deimos
Mars has two moons. Deimos is the smaller of the two. In Greek, the word Deimos means "terror."
Triton
Neptune has 14 known moons. Triton is the largest. It is bitterly cold and has jets of gas erupting from its surface.
Io
This moon of Jupiter is covered in volcanoes. There are more than 80 major volcanic areas on the surface of Io.
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

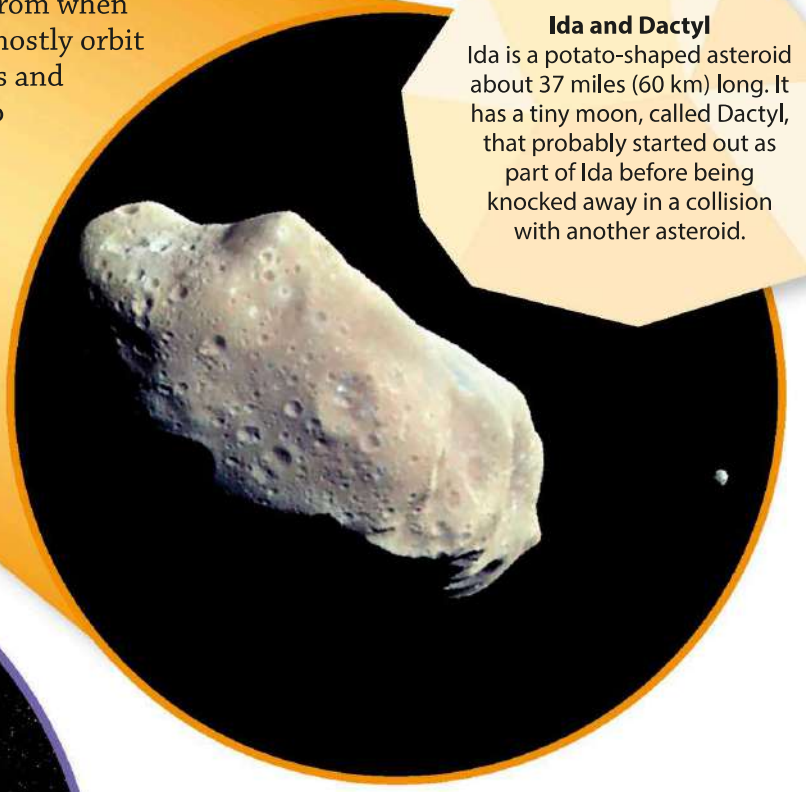
As well as planets and the sun, our solar system is filled with countless smaller objects that have changed little since the birth of the solar system. They range from country-sized asteroids and city-sized comets to tiny flecks of dust.

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.

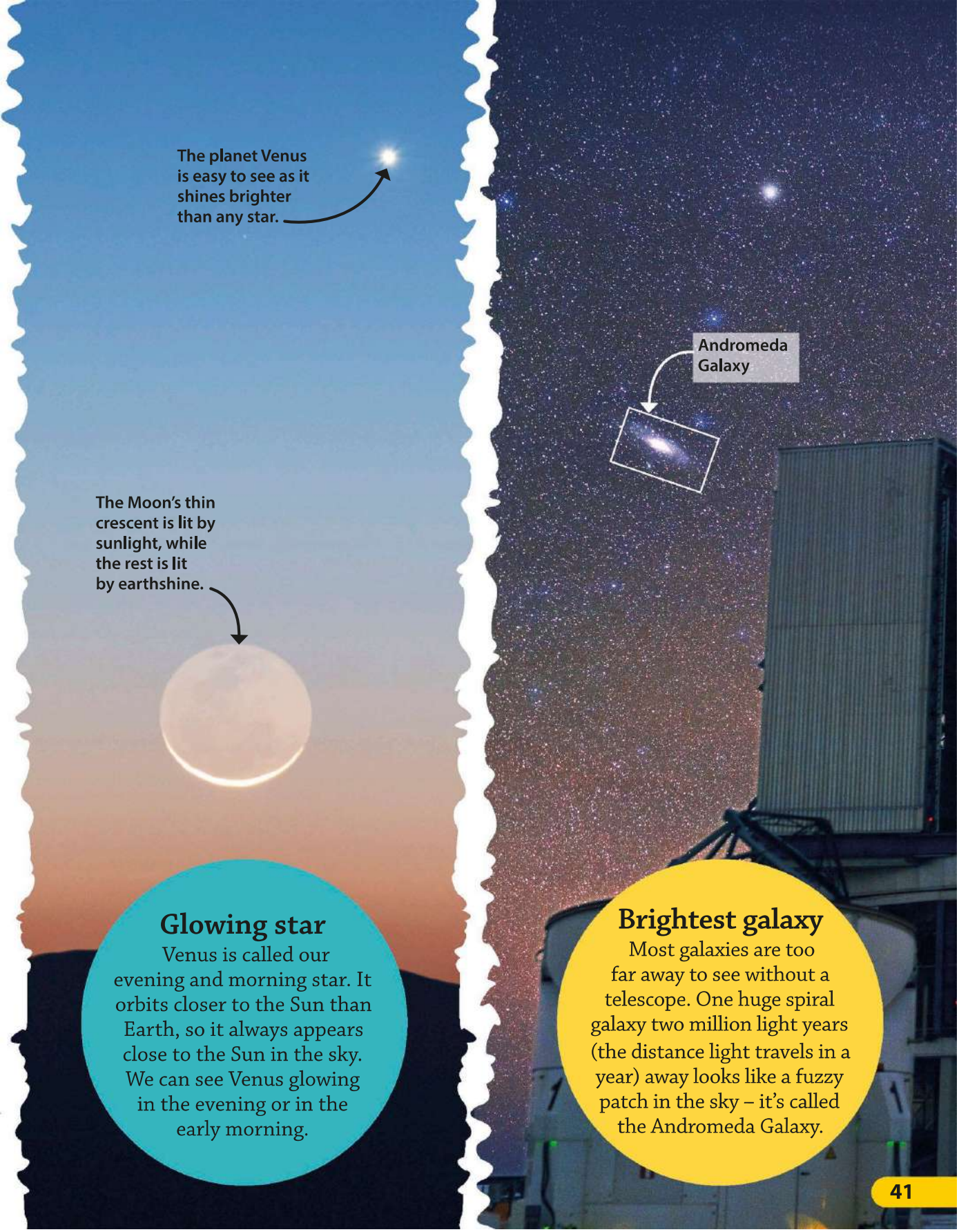
Near-Earth Objects

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.



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.

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.

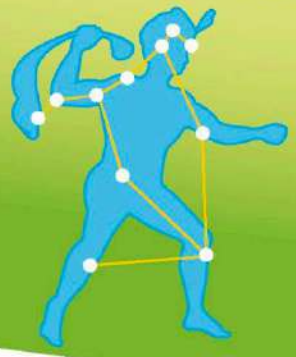
Constellations

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

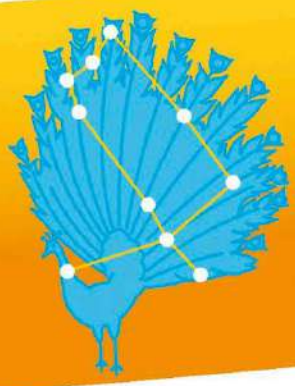
Southern hemisphere

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.

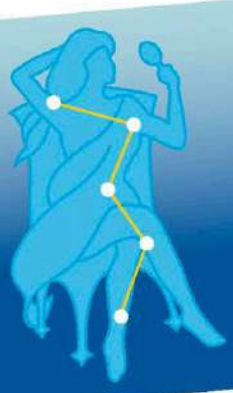
Northern and Southern stars

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

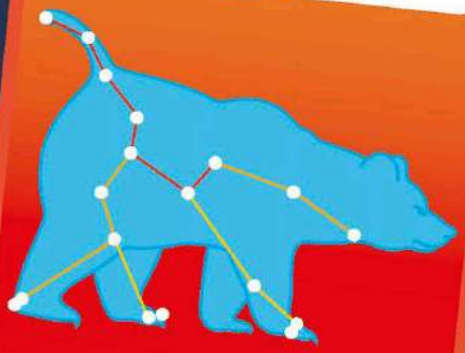
Southern hemisphere

CASSIOPEIA



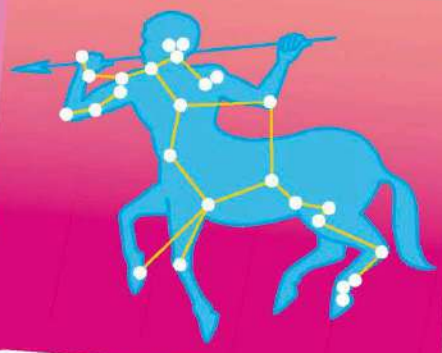
Cassiopeia is the name of a queen in an ancient Greek myth. This constellation links five bright stars to form a W-shaped pattern on its side. It can be seen throughout the year in the northern night sky.

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

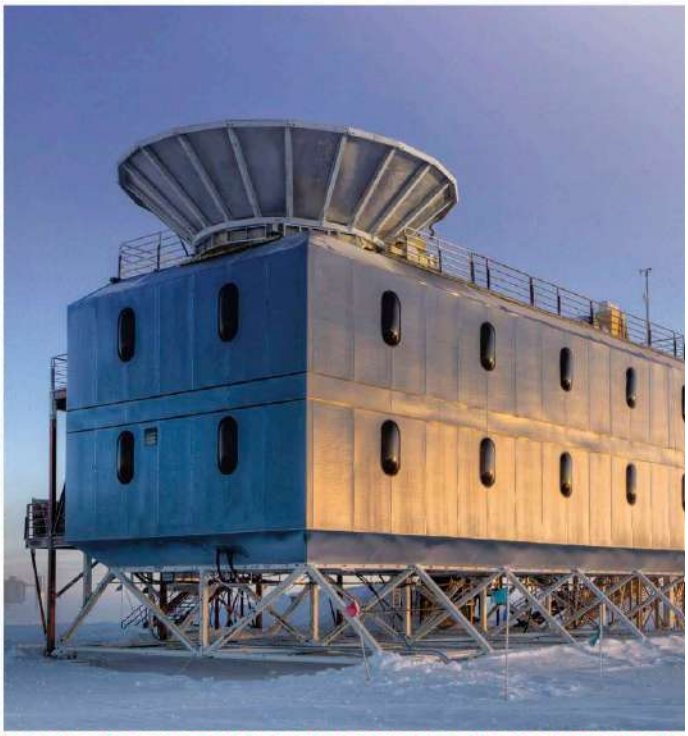
The cross in the southern night sky is the smallest constellation, but it is one of the easiest to spot. It is best seen in May. Four main stars create the cross pattern. There is also a bright cluster of stars within the constellation that is called the Jewel Box.

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

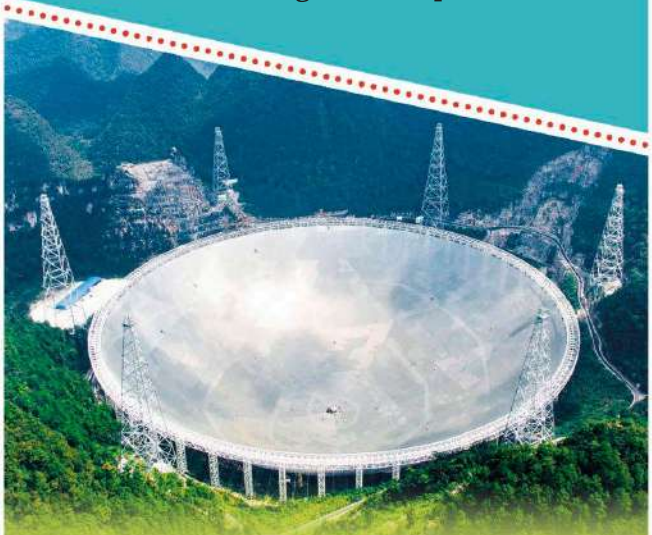
Many space objects create invisible rays as well as light, but these are mostly blocked by Earth's atmosphere. This telescope collects "microwave" rays that make it through the thin Antarctic air.

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.

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.



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).

Atacama Large Millimeter/submillimeter Array

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 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?

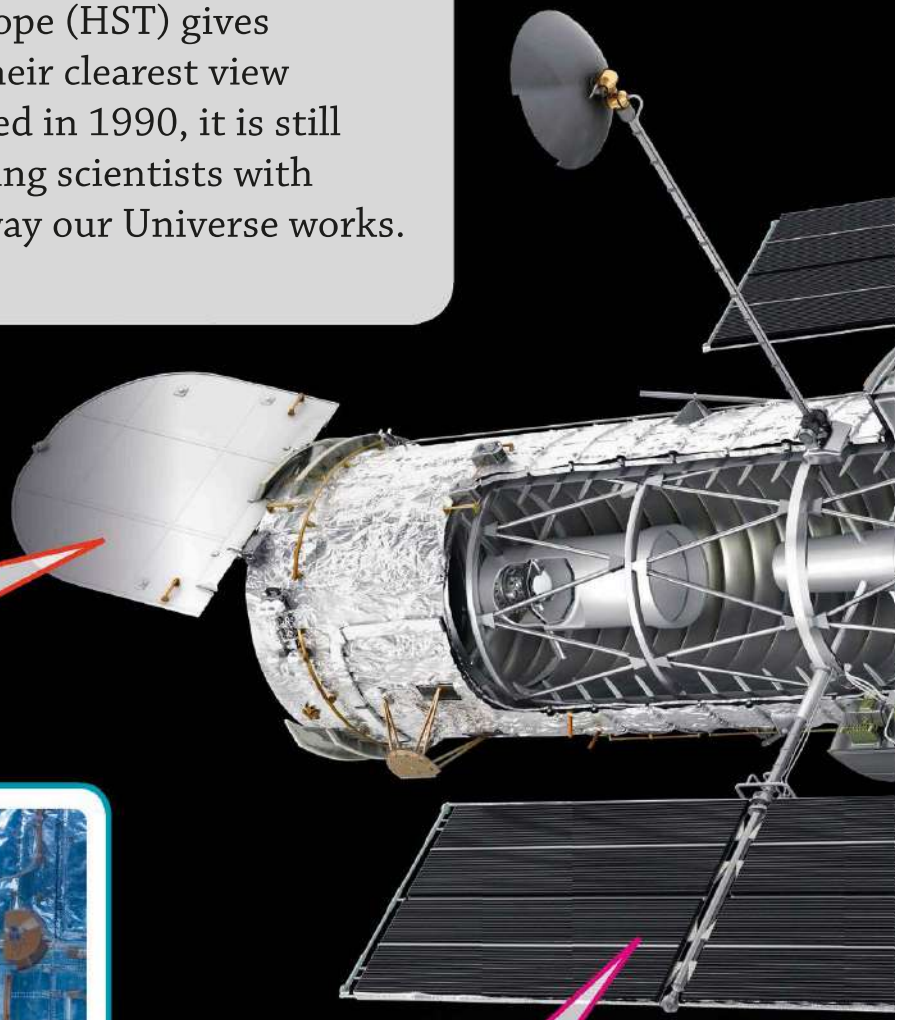
A: I became fascinated with space at a young age, reading everything I could get my hands on about the subject and going stargazing in my backyard on clear nights. My dream was always to travel to space, but since that seemed completely out of reach, I decided to become an astronomer and study the universe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

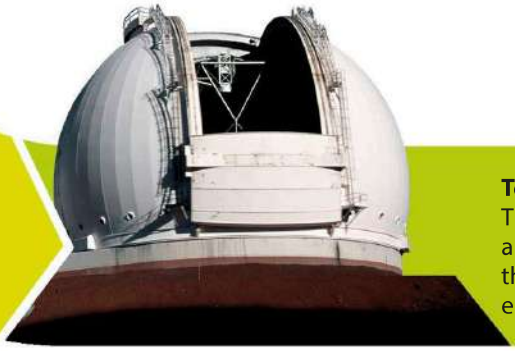
Exploring space

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.

"Buzz" Aldrin

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

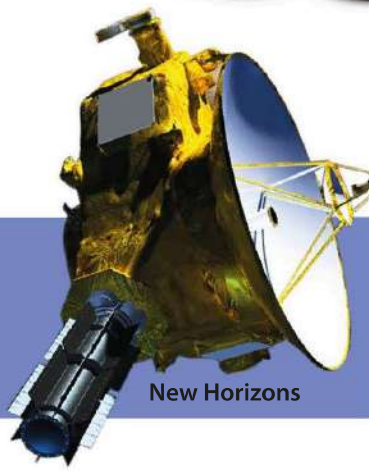


Keck Observatory

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

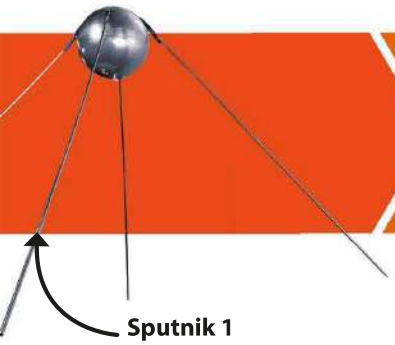
Cassini-Huygens near Saturn

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



New Horizons

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



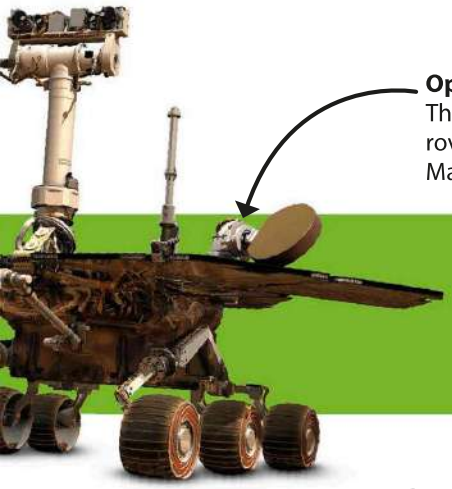
Sputnik 1
This battery-powered satellite was very basic, with four antennae and a radio transmitter.

Yuri Gagarin

Laika

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

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

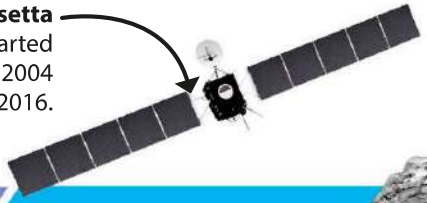


Opportunity
This 5 ft (1.5 m) tall rover has explored Mars since 2004.

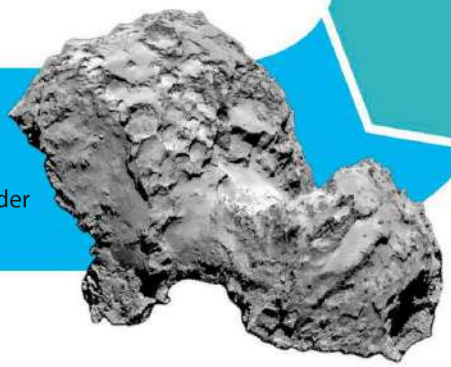
Mars rover
In 2004, NASA landed a pair of wheeled robot explorers, Spirit and Opportunity, on Mars.

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

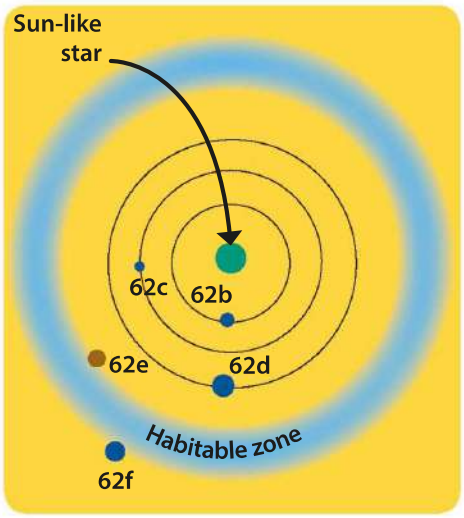
Most exoplanets are too faint to see directly—their dim light is easily drowned out. So astronomers find them by looking for the ways they affect their stars.

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.

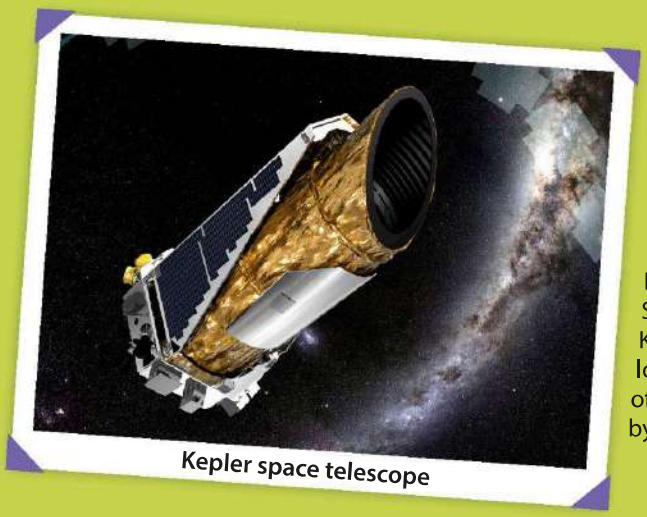


Kepler-62 System

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

Pioneer 10

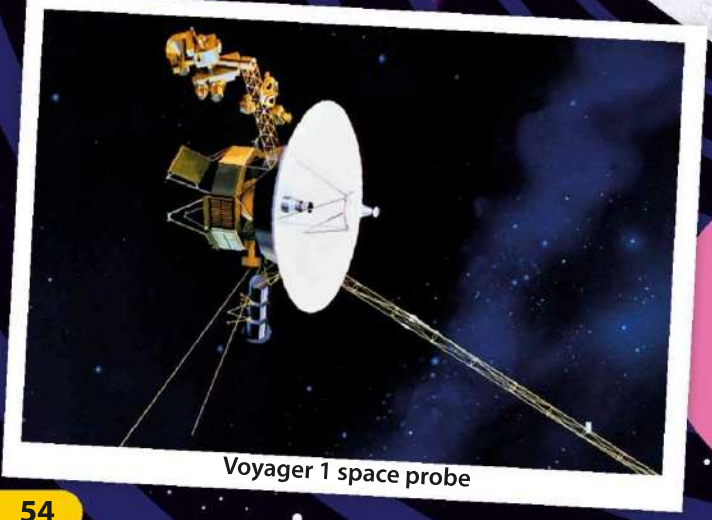
Robot space probes such as Pioneer 10 will take thousands of years to reach nearby stars, but they will keep traveling forever. They carry messages from humanity for anyone who eventually finds them.

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.

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.



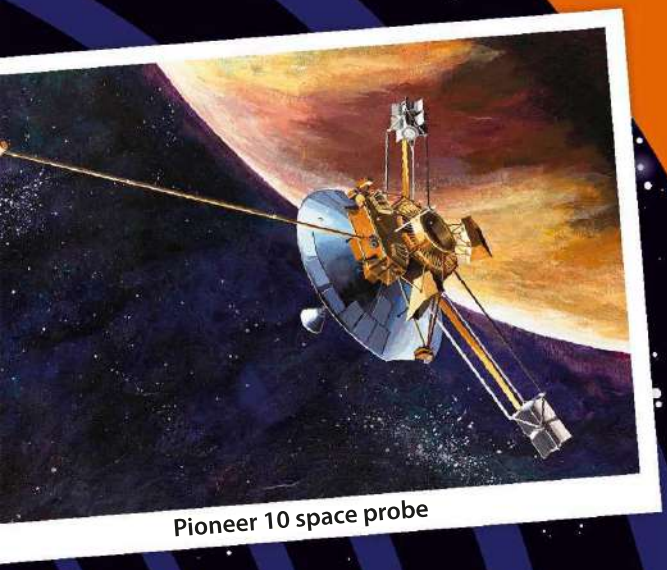
Voyager 1 space probe

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.

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.



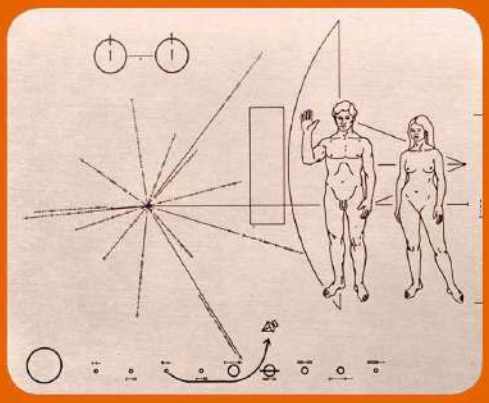
Pioneer 10 space probe

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



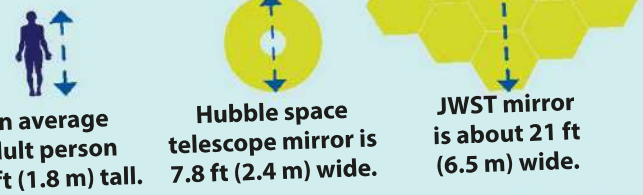
Pioneer plaque
A plaque fixed to Pioneers 10 and 11 shows two humans and the location of our solar system.

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.

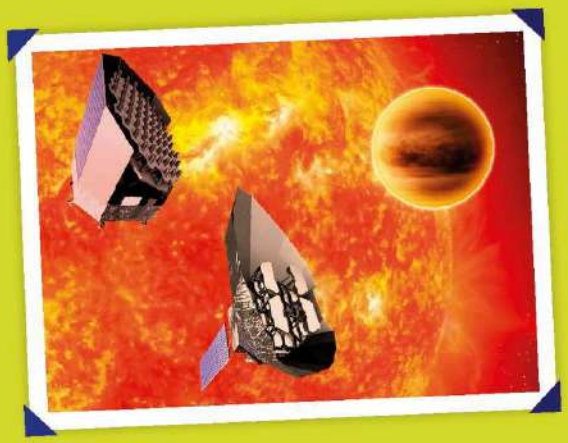
» **7 Communications antenna** JWST receives instructions from NASA and sends images and data back to the Earth.

» **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.