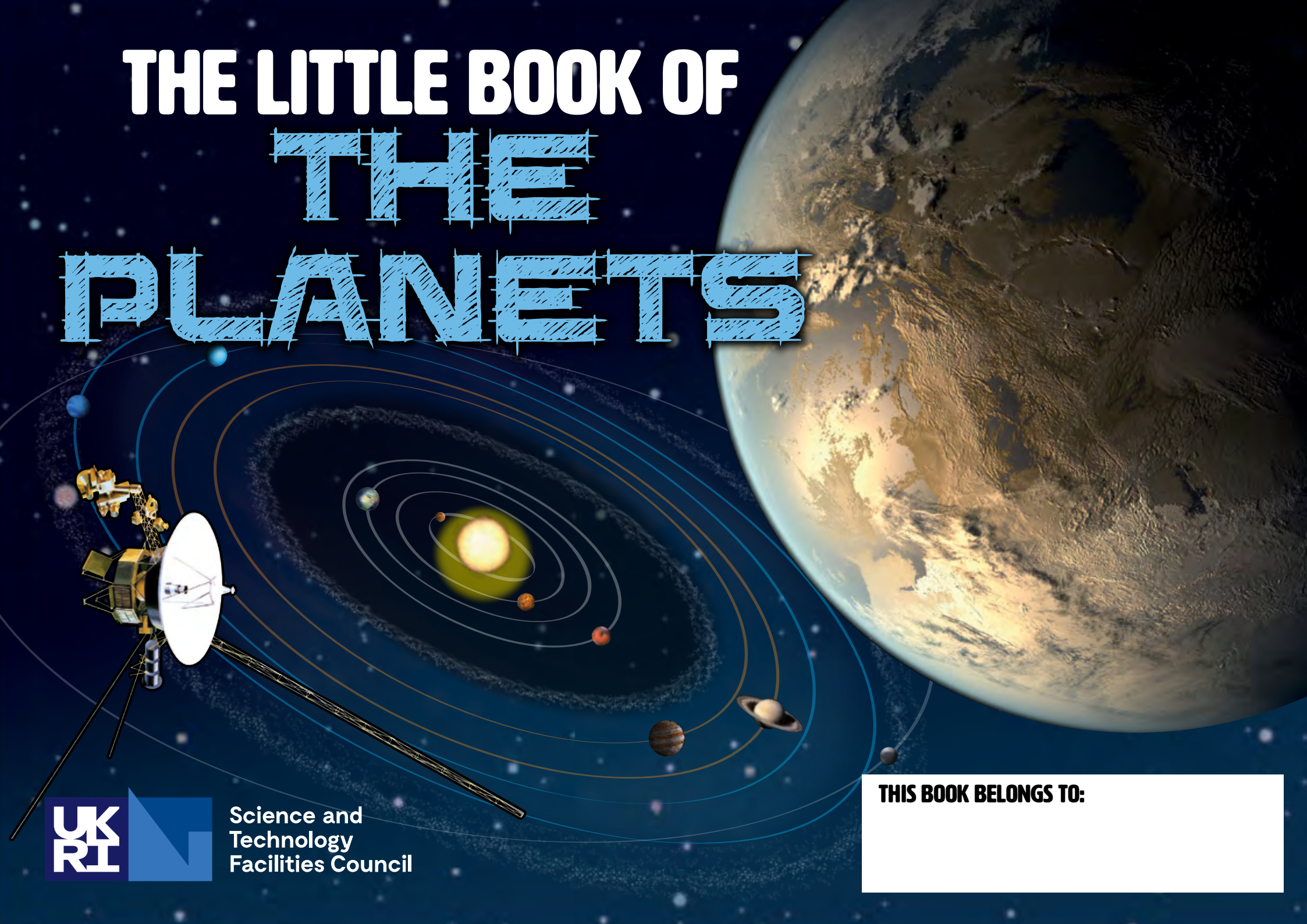
THE LITTLE BOOK OF THE PLANETS



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THIS BOOK BELONGS TO:

What is a planet and what's the difference between a rocky planet, a gas giant and a dwarf planet?

How does distance from the Sun affect the weather?

Which planets have we visited and how did we do it?

You'll find all this out (and lots more) in...

THE LITTLE BOOK OF THE PLANETS

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OTHER IMAGES: NASA, ESA, ESO, JAXA

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1 PLANETS AND THEIR MOONS

The collection of planets, moons and other objects that orbit the Sun are all part of what we called the Solar System, which formed about 4.6 million years ago. The Sun is our nearest star and its gravity holds the Solar system together.

The planets all orbit the Sun in same direction in an almost flat plane. Closest to the Sun's heat are four small rocky world: Mercury, Venus, Earth and Mars. Further out, in the colder reaches of space, are the gas and ice giants: Jupiter, Saturn, Uranus and Neptune. Along with the planets (and their families of moons) there are billions of other lumps of rock and ice that also orbit the Sun.

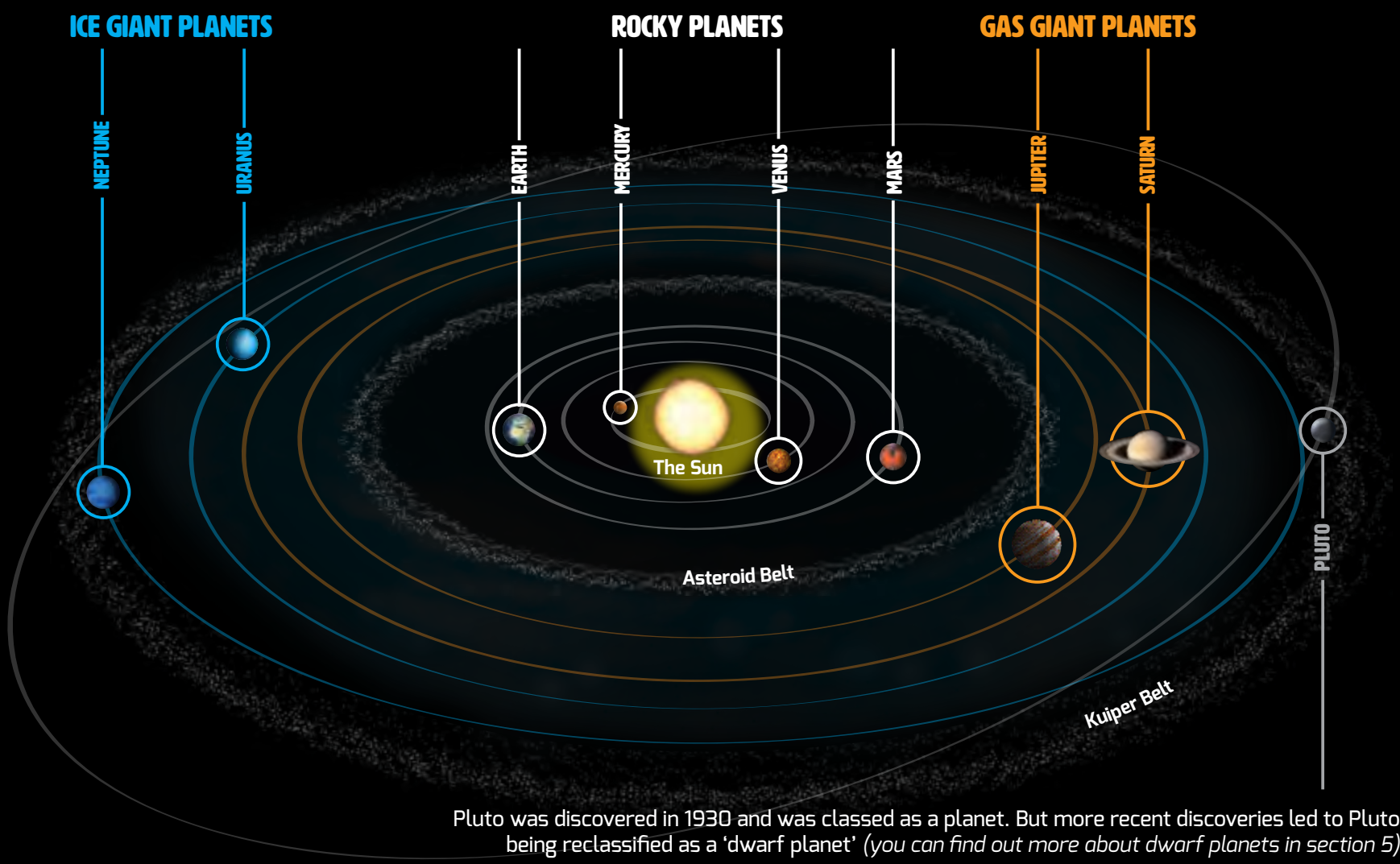
DID YOU KNOW?

Although there are only eight planets, there are more than 170 moons in the Solar System. Earth has only one, but the gas giants have many more. Jupiter and Saturn, for example, have over 120 confirmed moons between them.

1.1 WHAT IS A PLANET?

Before people knew what a planet was, they saw them moving through the night sky like 'wandering stars', so they called them 'planets' from the Greek word for 'wanderer'.

The definition of a planet has changed a bit since then and, in 2006, a planet was finally defined as being 'a body orbiting the Sun that is massive enough for its gravity to make it nearly spherical, and which has cleared other objects out of its path'.



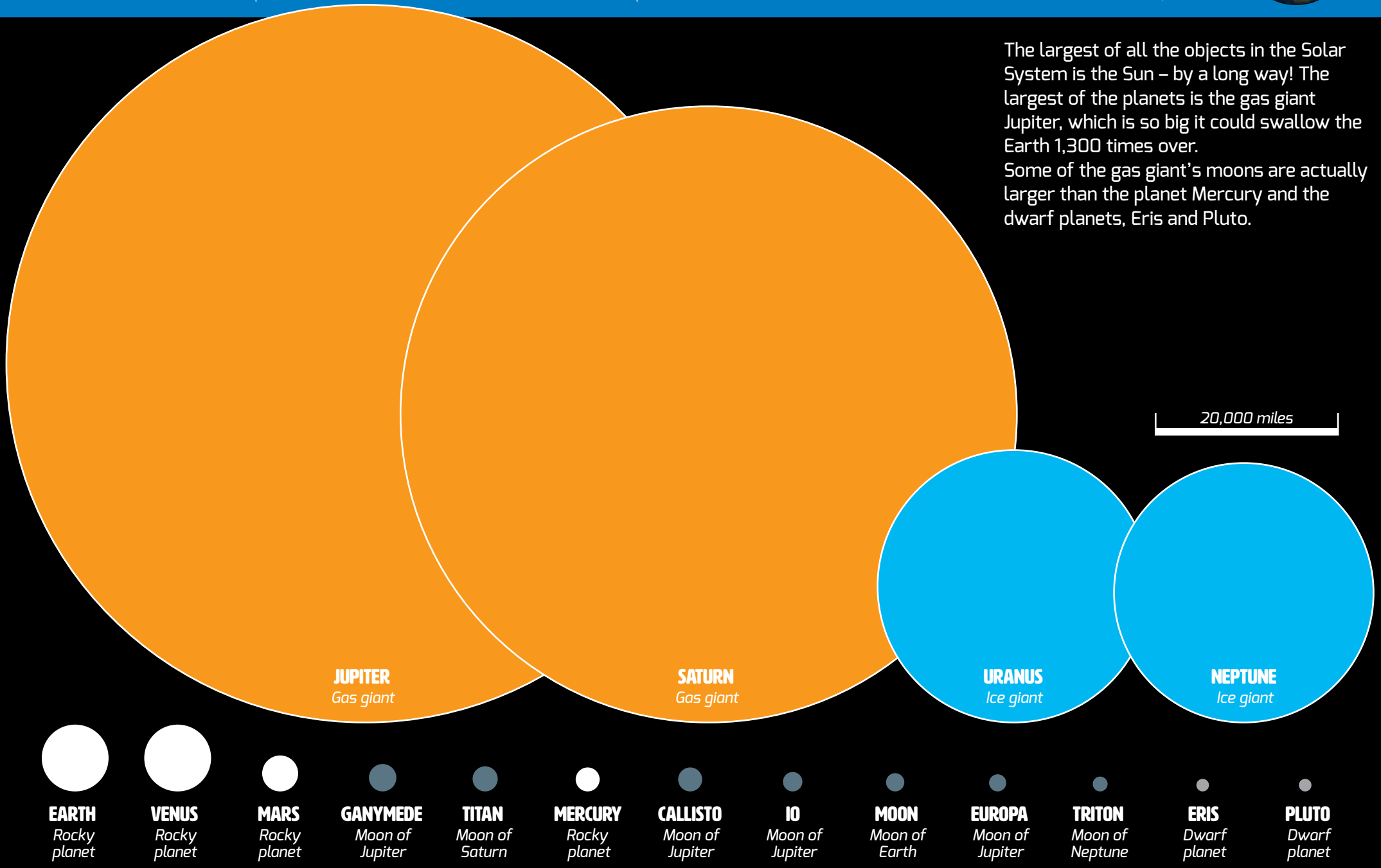
Pluto was discovered in 1930 and was classed as a planet. But more recent discoveries led to Pluto being reclassified as a 'dwarf planet' *(you can find out more about dwarf planets in section 5)*

DID YOU KNOW?

The planets were named in ancient times after Greek or Roman gods. For example, Venus is named after the Roman goddess of love and Jupiter (pictured) after the king of the gods in Roman mythology. Of the two planets discovered in modern times, Uranus is named after the Greek god of the sky, and Neptune after the Roman god of the sea.

1.2 THE PLANETS SIZE & SCALE

The largest of all the objects in the Solar System is the Sun – by a long way! The largest of the planets is the gas giant Jupiter, which is so big it could swallow the Earth 1,300 times over.
Some of the gas giant's moons are actually larger than the planet Mercury and the dwarf planets, Eris and Pluto.



1.3 MOONS OF THE SOLAR SYSTEM

There are more than 200 moons* in the Solar System. Mercury and Venus are the only planets not to have moons of their own and Mars' tiny moons are actually asteroids captured from the asteroid belt.

The gas and ice giants have by far and away the most moons. Most are small, but the four main moons of Jupiter are large and bright enough to be seen from Earth through binoculars.

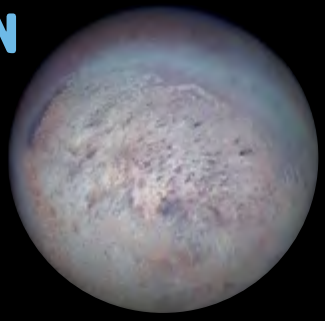
MERCURY	VENUS	EARTH	MARS	JUPITER	SATURN	URANUS	NEPTUNE
0	0	1	2	95	83	27	14

BIGGEST MOON

The biggest moon in the Solar System is Jupiter's moon, **Ganymede**. It is even bigger than the planet Mercury but, thanks to its asteroid-like density, it has less than half of Mercury's mass.

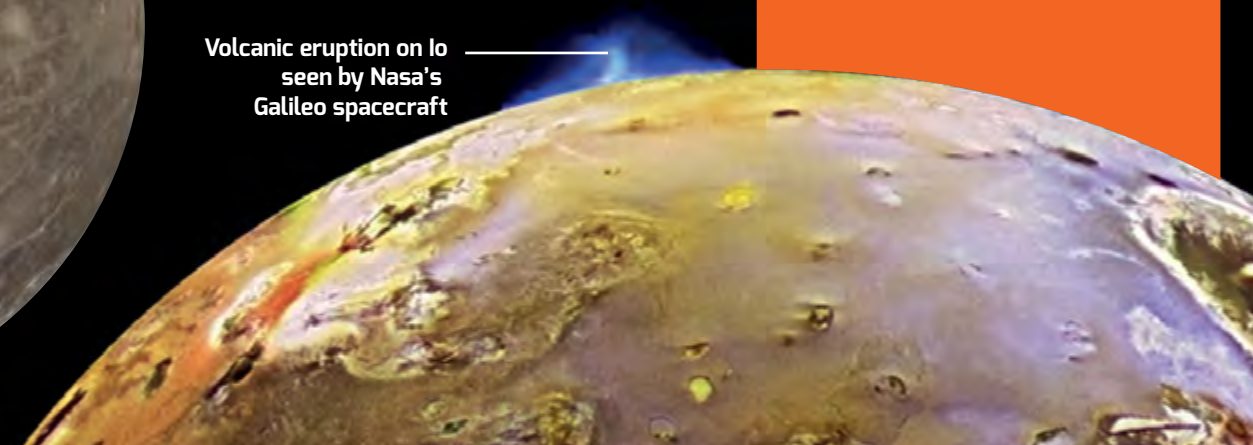
COLDEST MOON

With an average temperature of about -235°C, Pluto's moon **Triton** is one of the coldest places in the Solar System.



MOST VOLCANIC MOON

Covered in hundreds of volcanoes, Jupiter's rocky moon **Io** is the most volcanically active world in the Solar System. Some of its volcanoes erupt lava fountains many kilometres high.



Volcanic eruption on Io seen by Nasa's Galileo spacecraft

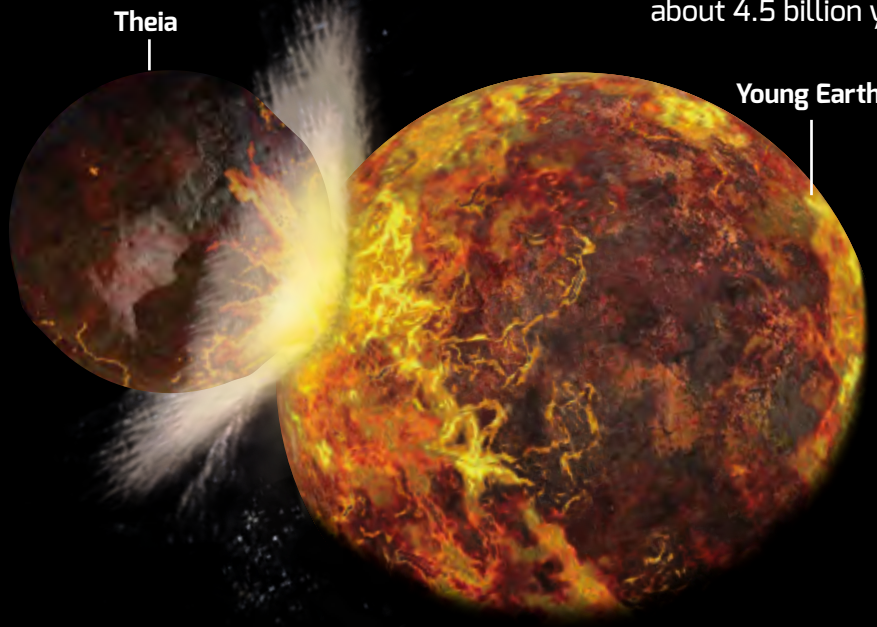
**New moons are always being discovered around the outer planets. Chances are, by the time you read this, many more will have been found.*

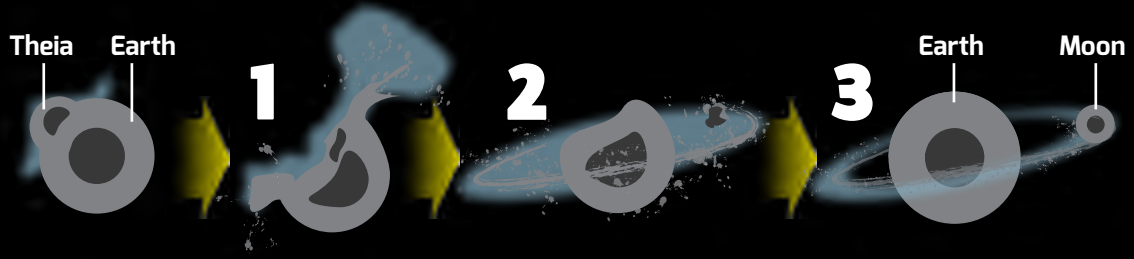
1.4 THE EARTH'S MOON

The Moon is the Earth's largest natural satellite and is the brightest object in the night sky after the Sun. It is the only place in the Solar System, other than Earth, that humans have visited.

HOW THE MOON WAS FORMED

Scientists think that the Moon was formed during a giant collision about 4.5 billion years ago.





1. About 4.5 billion years ago, an object the size of Mars, known as Theia, smashed into the Earth.

2. The collision threw lots of rock from both the Earth and Theia into space.

3. Over time, the orbiting material came together to form the Moon.

DID YOU KNOW?

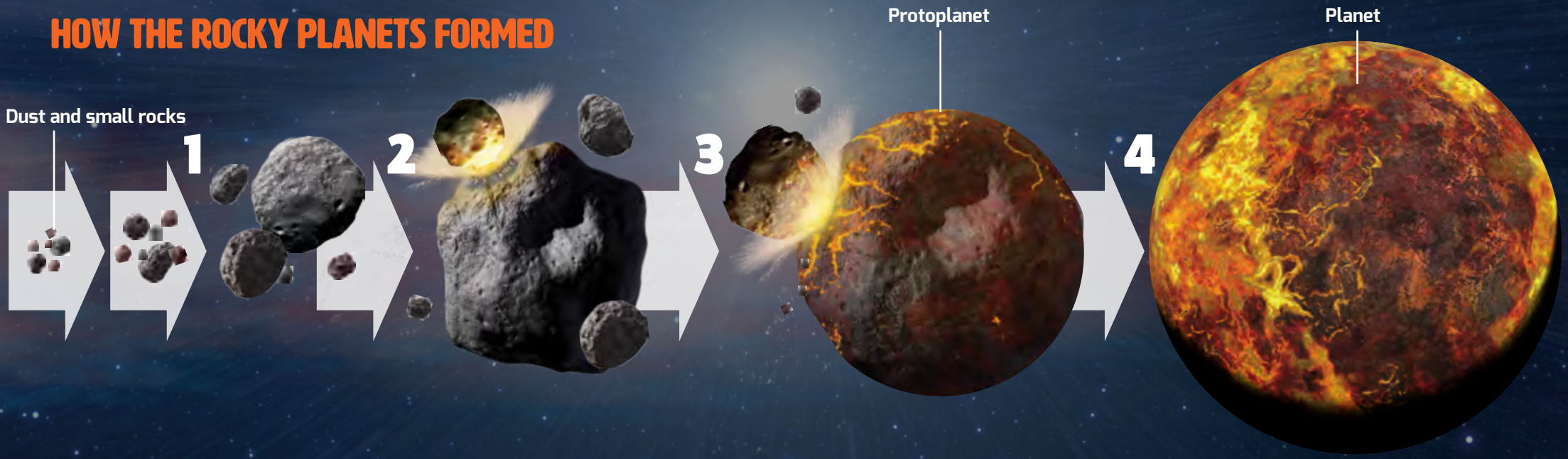
The Moon is about one quarter the diameter of the Earth. This makes it one of the biggest moons in the Solar System and the biggest compared to its host planet.

2 WHAT MAKES A PLANET

When the planets first formed, the Solar System was a very different place than it is today. In fact, it was really just a giant cloud of gas and dust that, over the course of millions of years, collapsed to form the Sun, the planets and everything else that makes up the Solar System.

Even after they formed, the Solar System was a violent place full of chunks of ice and rock that bombarded the young planets. These spacerocks scarred the surfaces of the rocky planets. Over millions of years, volcanism, water, wind, land movement and atmospheric changes continued to shape their landscapes.

HOW THE ROCKY PLANETS FORMED



1. Small particles of gas and dust stick together and form larger chunks.

2. Eventually enough sticks together to form bodies big enough to attract objects with their own gravity.

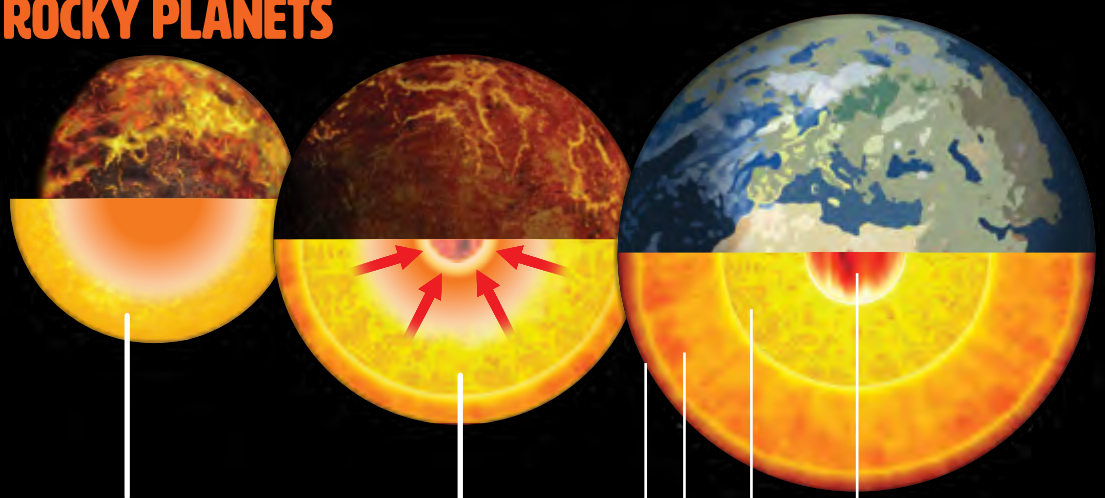
3. The impacts create so much heat that the rock melts – creating a sort of hot 'baby' planet called a protoplanet.

4. By the time a fully grown planet has formed, it is so hot that metals in the rock will sink to centre to create an iron core.

2.1 WHAT'S INSIDE THE PLANETS

The rocky planets are made up of rock and metals. Because metal is denser than rock, it sank toward the centre as the young planets cooled. It is this metallic core that give the Earth its magnetic field.

ROCKY PLANETS



In a newly-formed planet the rock and metals are all mixed together

As the planet cools, metals sink towards the centre

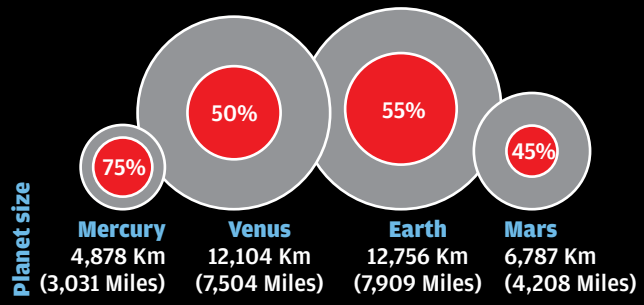
Inner core: A ball of solid iron with a diameter of about 2,400 km (about the size of the Moon)

Outer core: A ball of liquid iron, nickel and sulphur with a diameter of 6,800 km (about the size of Mars)

The mantle: A mixture of solid, semi-molten and molten rock about 2,900 km thick

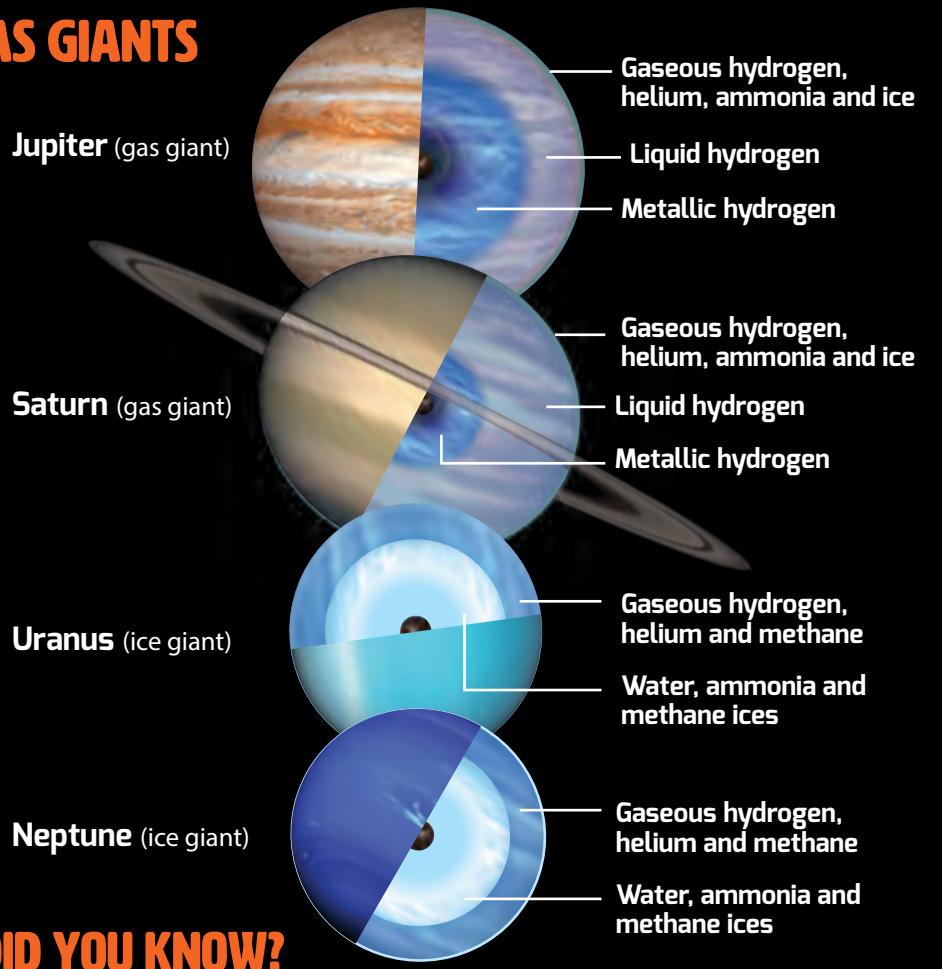
The crust: Earth's rocky surface is just 8-40 km thick and makes up only one per cent of the planet's mass

HOW BIG ARE THEIR CORES?



The gas giants are more atmosphere than planet. They have small rocky, or metallic, cores wrapped in thick layers of gas. What looks like a planet's surface to us is really just the planet's outermost layer of gas and clouds.

GAS GIANTS

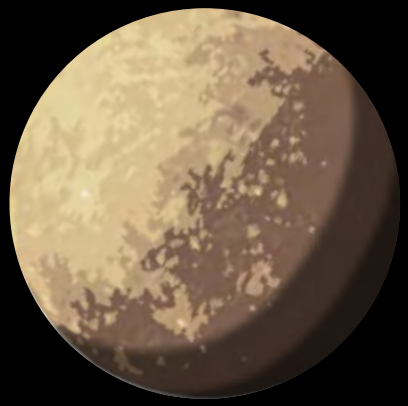


DID YOU KNOW?

All the rocky planets have an atmosphere. Mercury's is very thin because it too small for gravity to keep hold of it. High surface temperatures can cause gases to escape into space. This is why the gas giants are able to have such thick atmospheres – they are cold and extremely massive.

2.2 MEET THE ROCKY PLANETS

MERCURY



Diameter: 4880KM **Moons:** 0

Tiny Mercury is the closest planet to the Sun. A year on Mercury (the amount of time it takes to orbit the Sun) only lasts 88 days but, because it turns very slowly on its axis, a day on Mercury lasts 59 days (that's Earth days of course)!
Because Mercury is so close to the Sun, its surface is very hot – reaching 400°C on its sunlit side (and we think its too hot when it hits 26°C on Earth!).

VENUS

Diameter: 12104KM **Moons:** 0

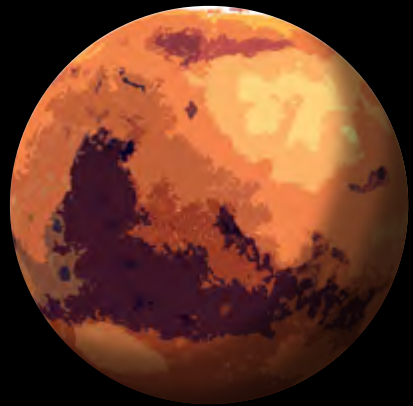
Venus is almost the same size as Earth, but it is very different. It is covered in clouds of water vapour and sulphuric acid that make it impossible to see the surface with ordinary telescopes.
Venus is the hottest planet in the Solar System. Its thick atmosphere is 96.5% carbon dioxide, which traps lots of the heat from the Sun – meaning temperatures reach 475°C. Ouch!

EARTH

Diameter: 12756KM **Moons:** 1

Earth is the planet we call home. About 70% of the Earth's surface is covered in water and it is the only planet in the Solar System that can support complex life like plants, animals and you.
The Earth takes 365.25 days to orbit the Sun and 24 hours to spin on its axis. It's axis is tilted –in the summer it is tilted towards the Sun and in the winter it is tilted away from the Sun.

MARS



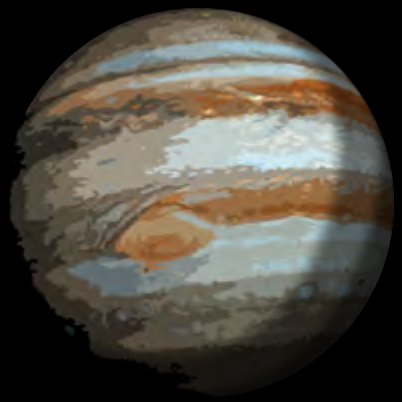
Diameter: 6780KM **Moons:** 2

Mars is red because its surface is covered in iron oxide, which you might know as rust. Today, it has a very thin atmosphere and very little water on its surface, but it once had oceans of liquid water and may once have supported life. Mars is home to the largest volcano in the Solar System, Olympus Mons, which is almost three times higher than Mount Everest!

HOW FAR APART ARE THE PLANETS?

2.3 MEET THE GAS GIANTS

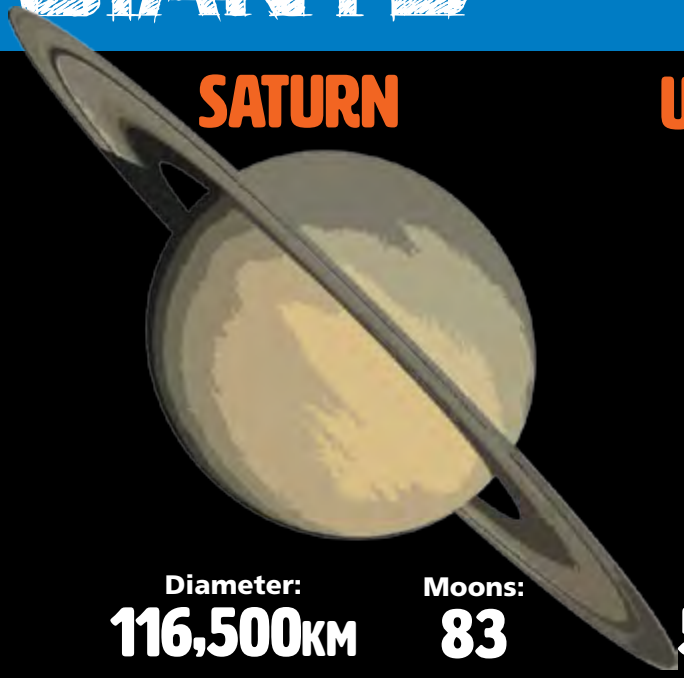
JUPITER



Diameter: 142,900KM **Moons:** 95

Jupiter is the biggest planet in the Solar System. Its mass is 318 times that of Earth. In some ways it is more like a star than a planet because it is a giant ball of gas. It doesn't have a rocky surface – just lots of layers of compressed gases. Jupiter is very stormy. Its famous 'Great Red Spot' is a giant storm that has been raging for 350 years. The storm is so big that three Earths could fit inside it!

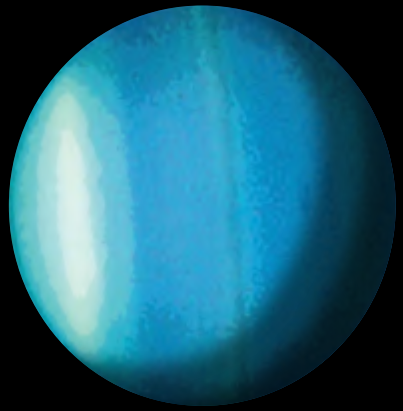
SATURN



Diameter: 116,500KM **Moons:** 83

With a mass 95 times that of the Earth, Saturn is the second largest planet. Like Jupiter, it is a gas giant planet.
Saturn's most famous feature is its system of rings, which are made up of ice and dust. Its rings measure 282,000 km in diameter. Although Saturn has 83 moons, it actually has many more smaller moons, called 'moonlets'.

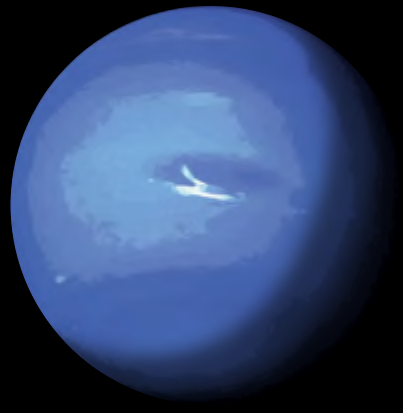
URANUS



Diameter: 51,000 KM **Moons:** 27

With temperatures reaching as low as -224ºC, Uranus is one of the coldest planets. It has two sets of very thin rings made up of ice and dust. At some point in its past, Uranus was knocked on its side by some great disaster. It also spins on its axis in the opposite direction to all the other planets. Like Neptune, Uranus contains much more ice than the other gas giants, so both are now called an 'ice giants'.

NEPTUNE



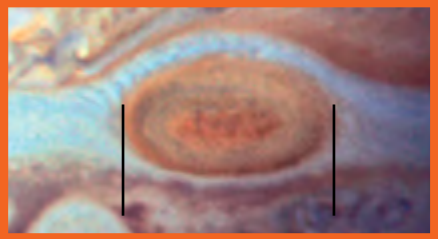
Diameter: 49,300 KM **Moons:** 14

Neptune is the most distant planet. It is so far away that it takes 165 years to complete one orbit. It was discovered in 1846 after mathematicians told astronomers where to look for it – because it was too far away to be seen easily by the telescopes of the day.
Neptune's atmosphere is very stormy. One storm, discovered in 1989, lasted five years and had winds reaching speeds of 1,300 mph!

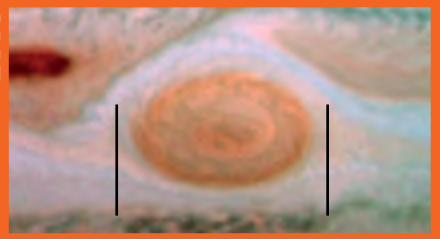
JUPITER'S SHRINKING STORM

Jupiter's storm may have been blowing for 350 years but it slowly blowing itself out. The famous red spot has been shrinking by at least 200 km (124 miles) each year.

1995



2009



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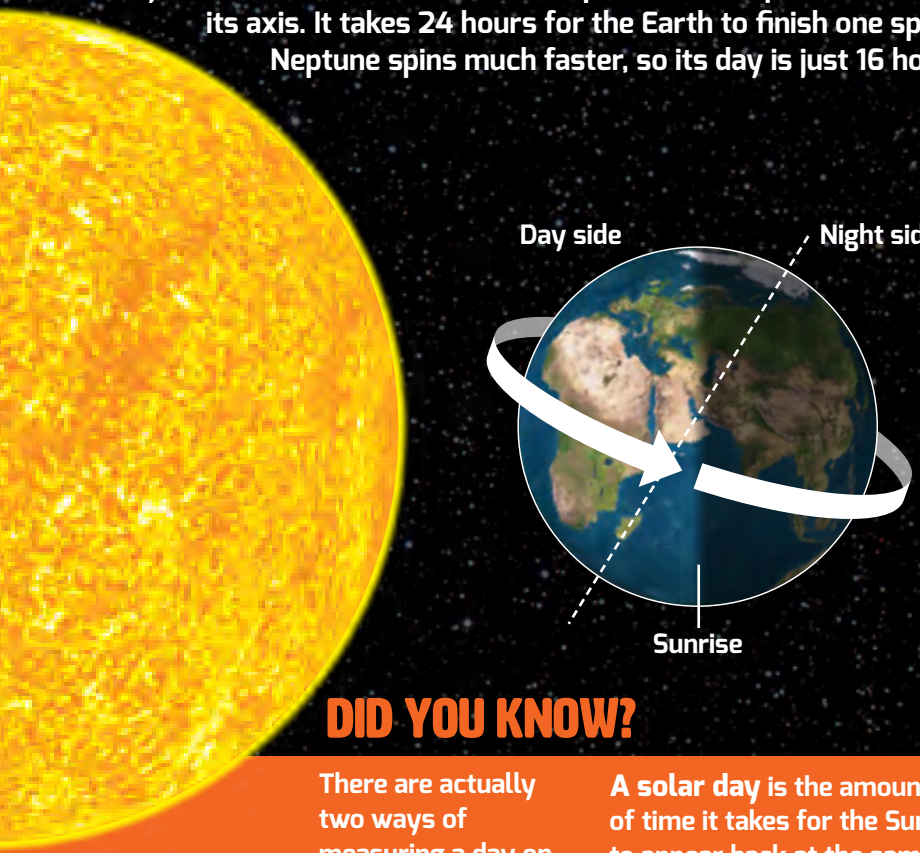
3 DAYS, YEARS & SEASONS

As residents of planet Earth, we are used to thinking of a day being 24 hours long and a year being 365 days. But if you were on Mercury you'd find that a day lasts 59 Earth days and year last just 88 days!

The length of a planet's day depends on how fast it is spinning and the length of a planet's year depends on how long it takes to orbit the Sun. So what causes a planet to have seasons? Do all planets have winter or summer?

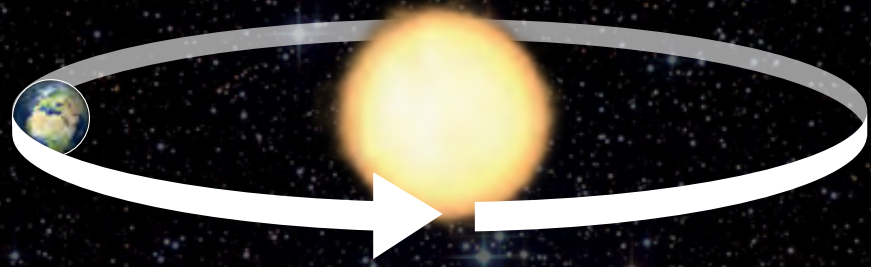
HOW LONG IS A DAY?

A day is the amount of time it takes a planet to complete one rotation on its axis. It takes 24 hours for the Earth to finish one spin. Neptune spins much faster, so its day is just 16 hours long.



HOW LONG IS A YEAR?

A year is the amount of time it takes a planet to complete one orbit of the Sun. It takes 365 days for the Earth to orbit the Sun, but it takes distant Neptune 165 Earth years to complete the journey.



It actually takes a little more than 365 days for the Earth to complete one orbit. It actually takes 365.24 days.

To make up for the extra quarter day, we add an extra day to the calendar at the end of February every 4 years. This is a called a **leap year**.

DID YOU KNOW?

There are actually two ways of measuring a day on Earth: a solar day, and a sidereal day.

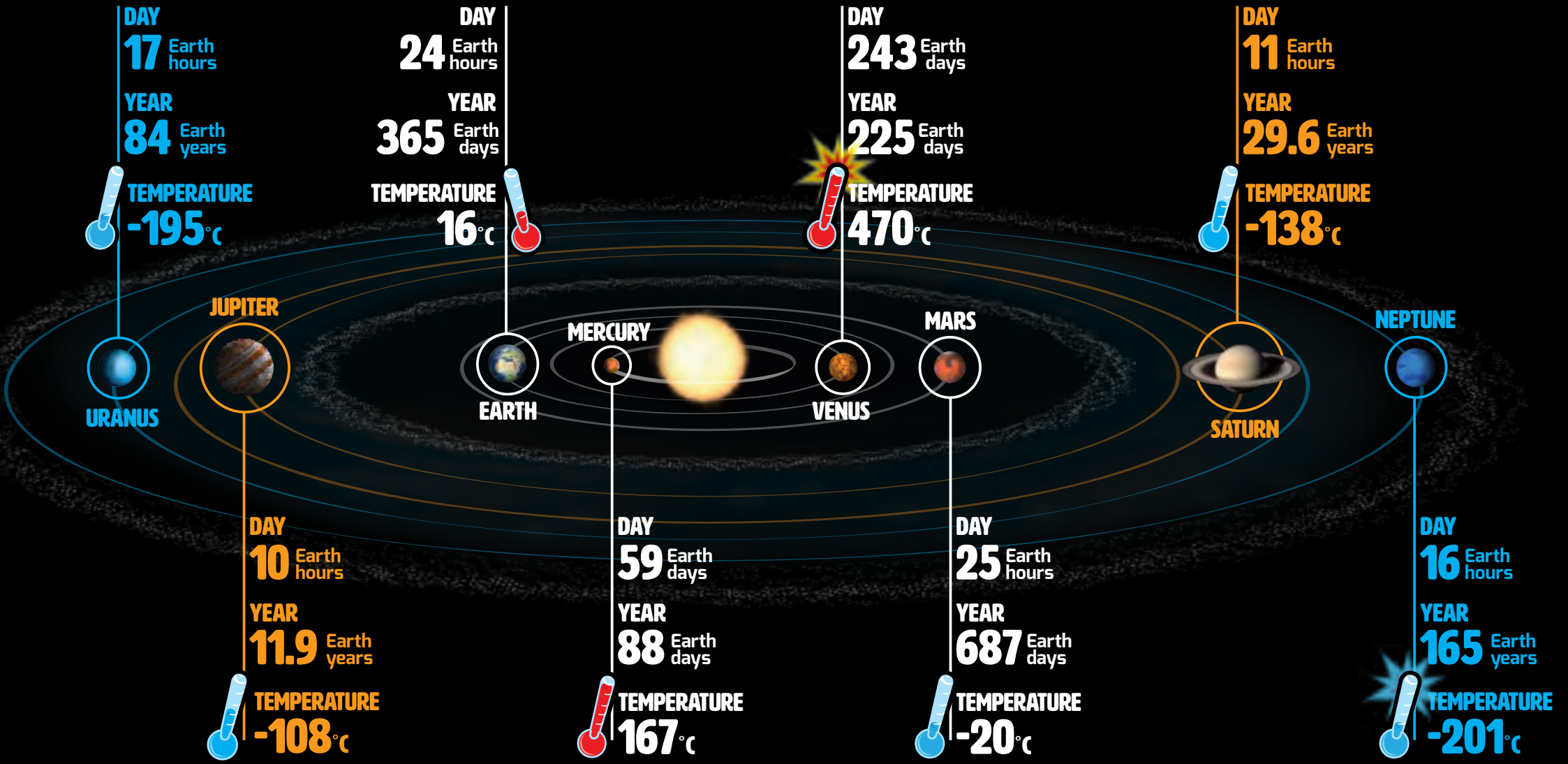
A solar day is the amount of time it takes for the Sun to appear back at the same point in the sky from one day to the next.

A sidereal day is the amount of time it takes the Earth to complete a full rotation. This actually takes just 23 hours and 56 minutes.

3.1 DAYS, YEARS AND TEMPERATURES

WHAT A DIFFERENCE SOME DISTANCE MAKES

How far away a planet is from the Sun makes a huge difference what that planet is like. Look closely at this diagram. What do you notice about how a planet's distance from the Sun affects the length of its year or its temperature? All the temperatures shown are averages.

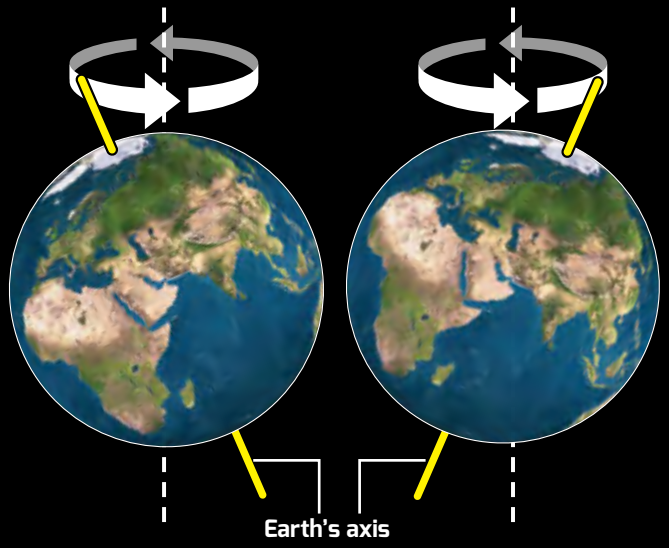


3.2 WHAT CAUSES THE SEASONS?

Each planet in the solar system has seasons. Earth has four seasons – winter, spring, summer and autumn. Most planets also have four seasons, but they can be wildly different – on Venus, seasons are short.

WHAT CAUSES THE SEASONS?

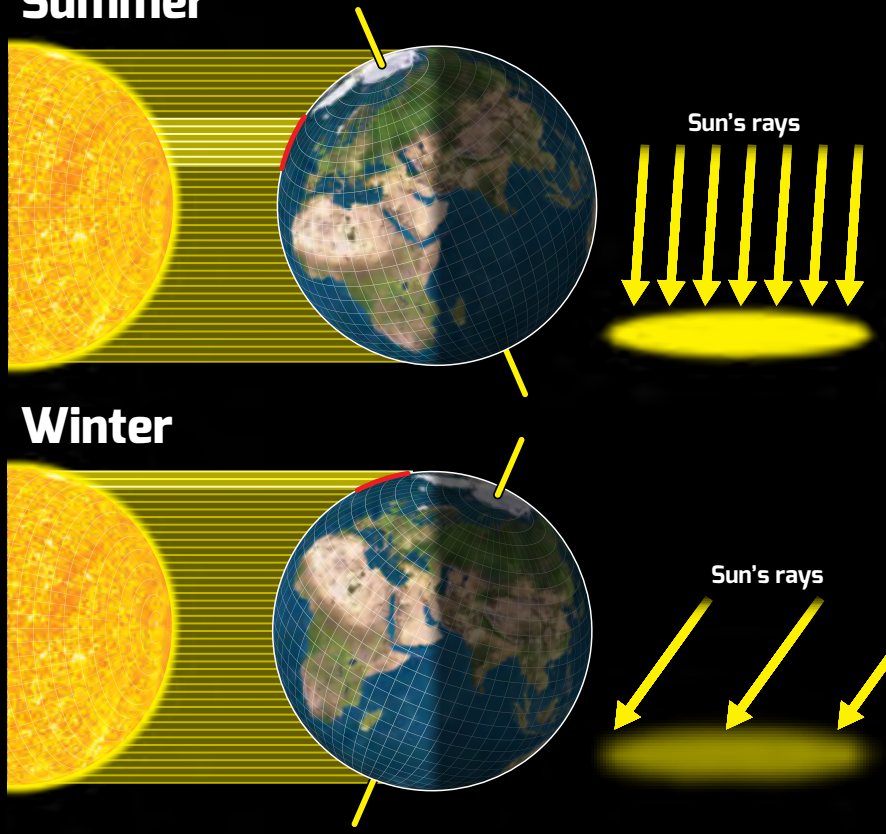
Although the distance between a planet and the Sun does vary throughout the year, this is not the main cause of the seasons. Most seasonal changes are determined by how much a planet is tilted on it's axis.



The Earth's axis is actually tilted at an angle of 23.45 degrees. This causes the Earth to wobble from side to side as it orbits the Sun.

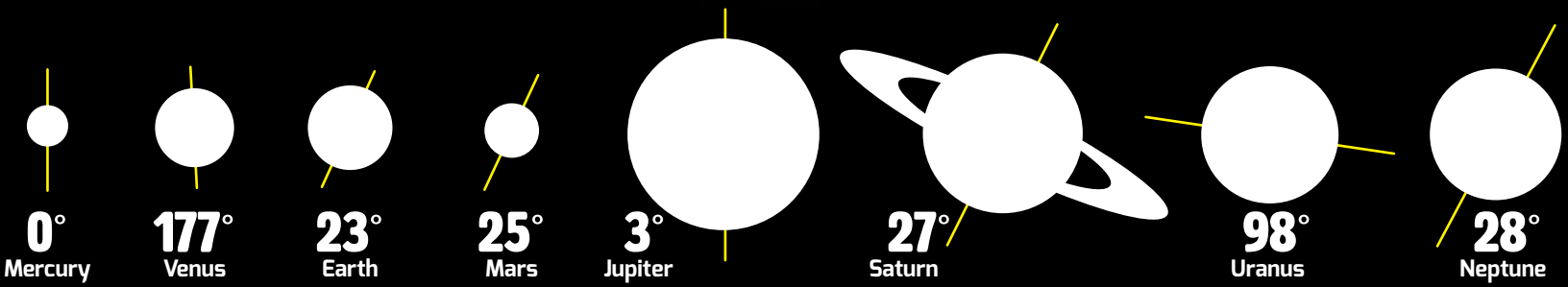
In the summer, the northern hemisphere tilts towards the Sun. The Sun's rays hit the Earth at a more direct angle – meaning more sunlight can fall on a smaller area than it does during winter.

On Saturn, a season can last for seven years. And on Mercury, you can't even tell when one season ends and the next one begins.



TILTED PLANETS

Have a look at how all the planets are tilted. How do you think this affects their seasons?

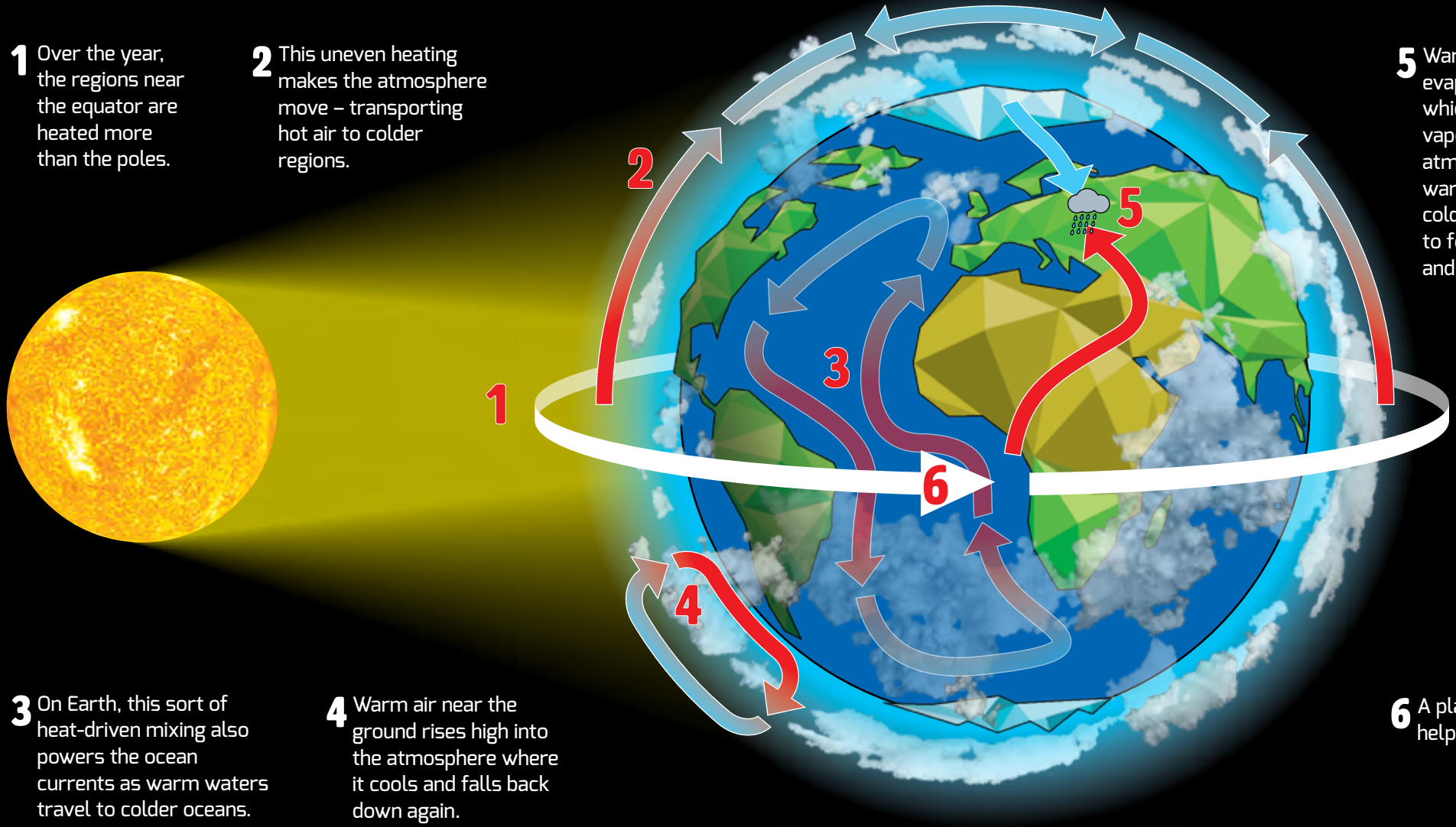


3.3 SOLAR-POWERED WEATHER

Weather systems are driven by energy in the form of heat. On the rocky planets, that heat come from the Sun. But the gas giants are much too far from the Sun to get much energy from sunlight. The weather systems on gas giants are driven by heat that rises from internal heat sources within their cores.

1 Over the year, the regions near the equator are heated more than the poles.

2 This uneven heating makes the atmosphere move – transporting hot air to colder regions.



5 Warmer waters also evaporate more readily, which moves water vapour into the atmosphere. When warm moist air meets colder air, it condenses to form clouds and fall and rain or snow.

3 On Earth, this sort of heat-driven mixing also powers the ocean currents as warm waters travel to colder oceans.

4 Warm air near the ground rises high into the atmosphere where it cools and falls back down again.

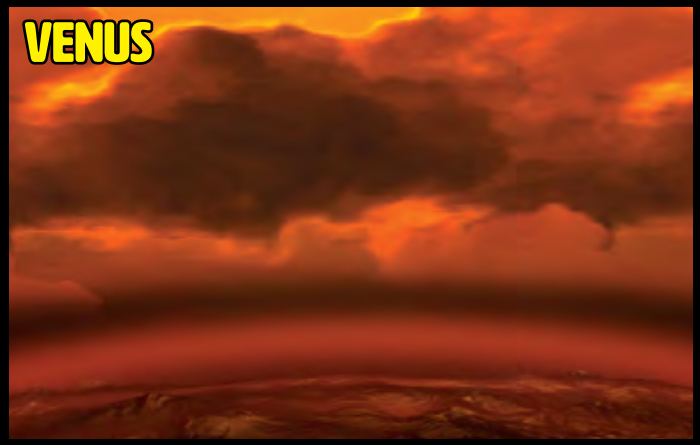
6 A planet's rotation also helps to stir up winds.

3.4 WEATHER ON THE ROCKY PLANETS

MERCURY

Mercury is the only planet in the solar system to have almost no atmosphere. This is partly because of Mercury's tiny size, which means it doesn't have the gravitational pull to hold on to its atmosphere, and partly because it is so close to Sun that its atmosphere gets blasted away into space by the solar wind. Because it doesn't really have an atmosphere, Mercury doesn't really have any weather to speak of.

VENUS

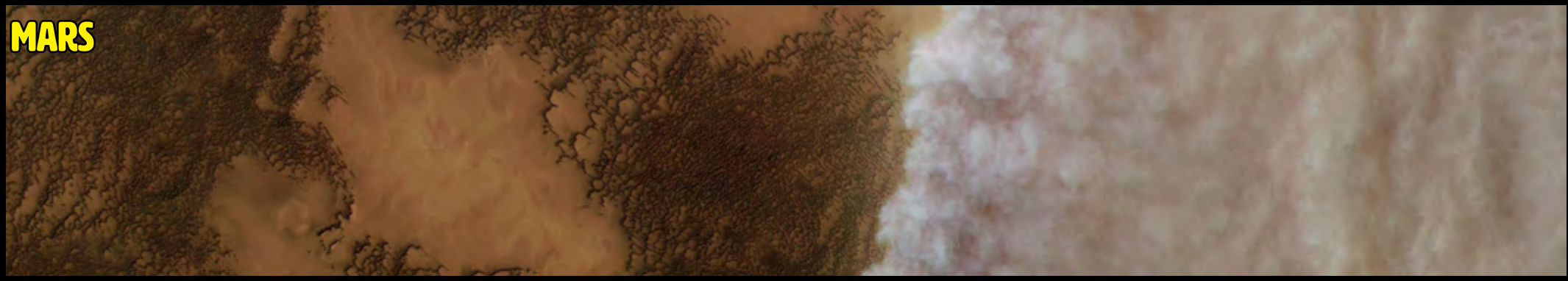


Although similar in size to Earth, Venus is a very unpleasant place to be. It has a dense, toxic atmosphere filled with carbon dioxide. Its thick, yellow clouds are made of sulphuric acid and trap so much heat that Venus' surface is hot enough to melt lead. Also, the atmosphere is so thick that, on the surface, it is 70-100 times the pressure on Earth... now that will make your ears pop!

EARTH

The Earth and Venus might have started out as very similar worlds but, unlike Venus, Earth is just the right distance from the Sun – orbiting the Sun in a 'Goldilocks zone' where it isn't too hot or too cold for life to thrive. Although it might seem to us that weather can be quite extreme on Earth, compared to the rest of the solar system we have it easy.

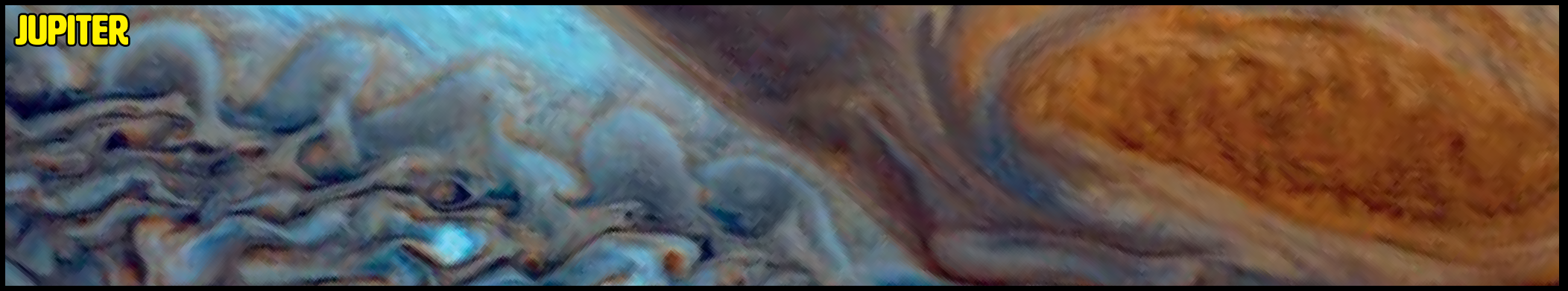
MARS



Mars has seasons very much like those of the Earth, but it has a very thin atmosphere that means that surface pressure is over one hundred times lower than it is on Earth. This means that, when the wind does blow, there isn't much air to move around so you'd barely feel it. Mars has dust storms that can last for months and, in the winter, it can become cold enough for the carbon dioxide in the atmosphere to freeze and fall as snow at the poles.

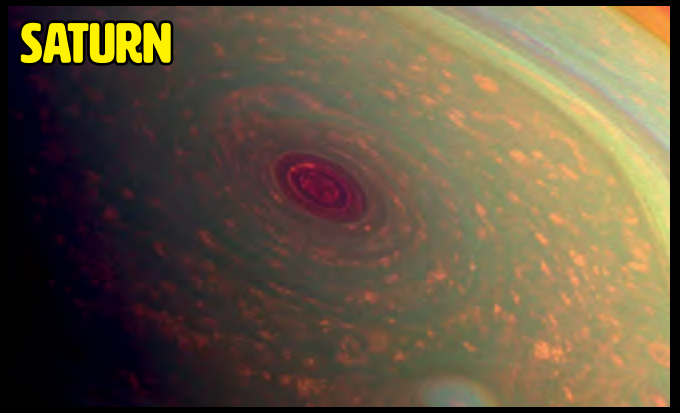
3.5 WEATHER ON THE GAS GIANTS

JUPITER



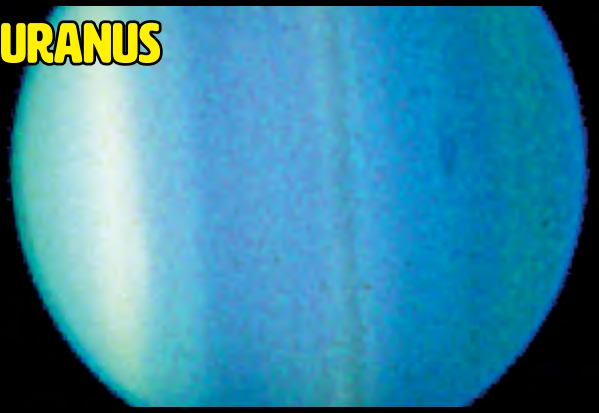
Despite its size, Jupiter spins very quickly and being made almost entirely of ammonia gases, this means that Jupiter can have some very exciting weather indeed. Wind speeds can reach more than 370 mph. Jupiter's swirling clouds are what gives the planet its beautiful appearance. These are long-lived storms that can last for hundreds of years. Jupiter's 'Great Red Spot' is actually a storm bigger than the Earth with winds of up to 270 mph and that has been ranging for more than 300 years.

SATURN



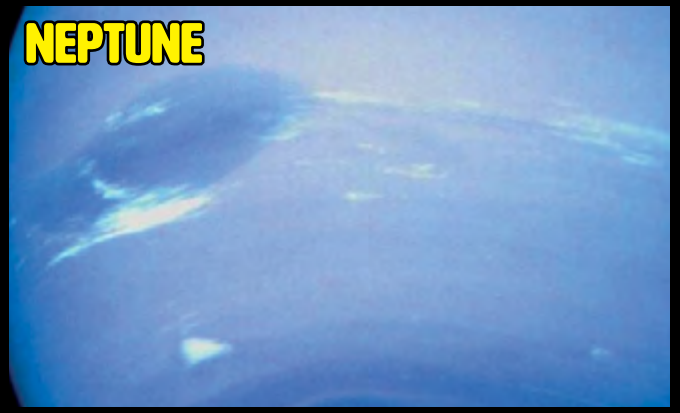
Saturn's atmosphere is similar Jupiter's, but with even faster winds – winds at the equator can reach more 1,000 mph! Saturn has huge electrical storms covering thousands of miles and creating lightening 1,000 times stronger than on Earth. These lightning storms can create diamonds that rain down through the atmosphere – in fact, storms can create up to 1,000 tonnes of diamond rain each Earth year.

URANUS



Unlike the ammonia clouds of Jupiter and Saturn, Uranus and Neptune have clouds of methane ice in their cold atmospheres. Winds on Uranus can reach speeds of up to 360 mph which is strange because, unlike its bigger brothers, Uranus doesn't have an internal heat source to help power strong winds. Weirdly, Uranus lies almost on its side, rotating about an axis tilted at 98°, which means summer on Uranus lasts about 21 Earth years.

NEPTUNE



As unpleasant as the weather on Uranus might be, it is nothing compared to Neptune which has the highest winds every recorded in the solar system, reaching more than 1,300mph. It also has huge storm systems, rather like Jupiter. The most famous storm, called the 'Great Dark Spot' was spotted by Voyager 2 when it flew past in 1989 – although when the Hubble Space Telescope looked for it 5 years later the storm had vanished.

4 EXPLORING THE PLANETS

We can learn a lot about a planet using telescopes but, if you really want to get to know an alien world, you need to visit it. We haven't been able to put astronauts onto any of the planets yet, but we have been able to send robotic explorers.

Robotic spacecraft have been exploring the Solar System since 1959. About the size of a family car, they carry scientific instruments that allow us to investigate distant worlds and send the data back to Earth.

TYPES OF ROBOTIC EXPLORER

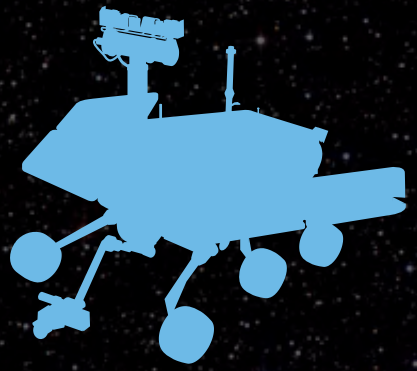
Flyby

Flyby spacecraft, such as Voyager (launched in 1977), didn't stop to visit a particular planet. Instead they use their instruments to photographic and take readings as they fly past.

Lander

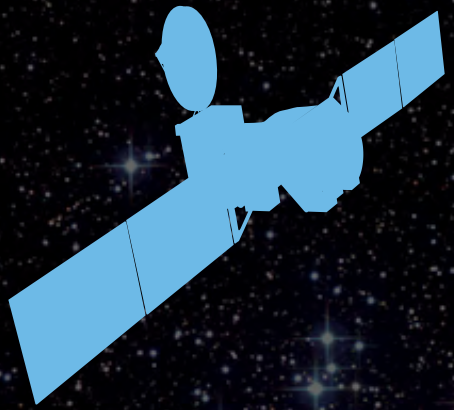
Landers do touch down on a planet's surface. They don't have wheels so can't move around but they can take readings of a planet's atmosphere and even drill down into surface.

Rover



Rovers can do everything a lander can but has the advantage of being able to move around the surface of a planet. This allows them to spot interesting features and then travel to explore them.

Orbiter



Orbiters are satellites that stay in space and circle around a planet. They are full of cameras and science equipment and some can release landers or rovers to the surface. Their little robotic buddies then transmit their findings to the orbiter, which then sends the data back to Earth.

Helicopter

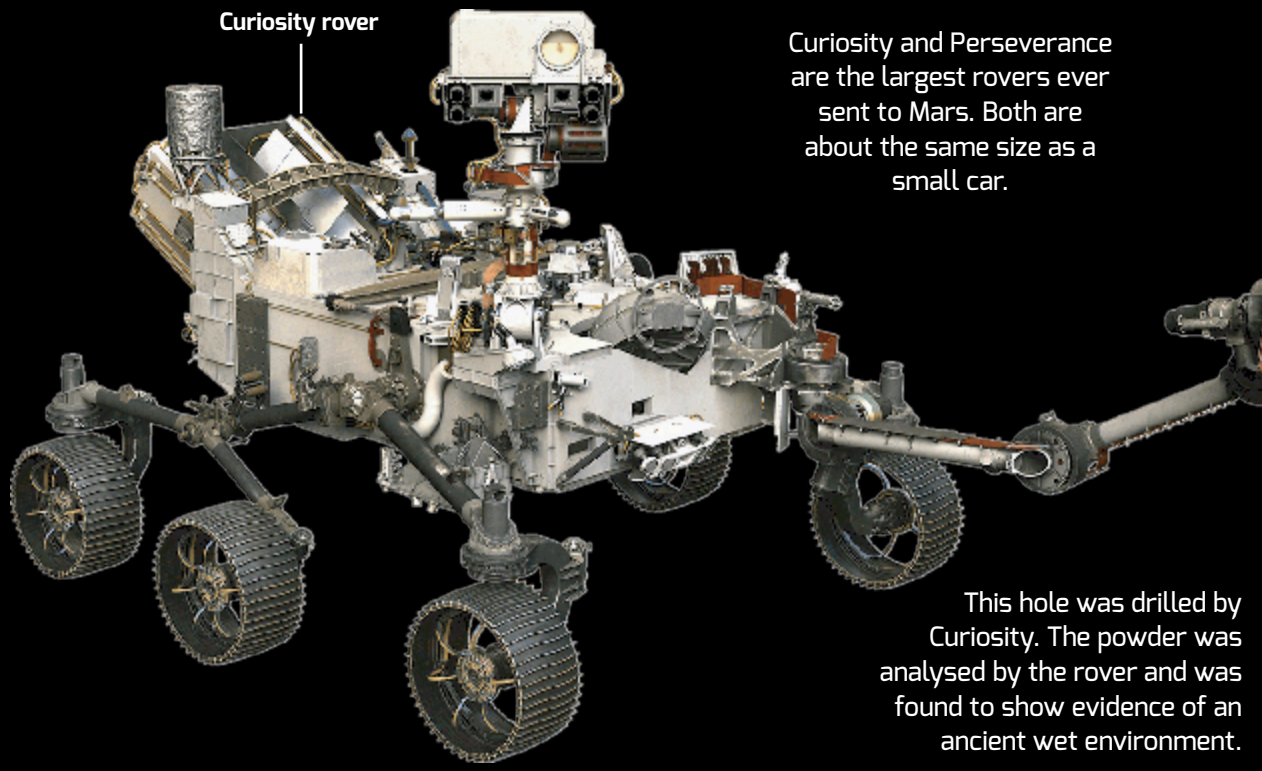
Helicopters are latest addition to robot explorer club. The first, called Ingenuity, was released by Nasa's Perseverance rover and made its first flight above the surface of Mars in 2021. The tiny helicopter was the first aircraft to fly in the sky of another world.

4.1 EXPLORING MARS WITH ROVERS

Since the start of the space age, there have been nearly 50 robotic explorers sent to Mars – although nearly half of those didn't make it safely to the Red Planet. Today, there are more spacecraft operating at Mars than on any other planet beside Earth.

ROVERS

Unlike landers, which can't move, rovers have wheels and can drive around to visit different areas and study the different chemicals in each rock. These chemicals can tell scientists something about the environments that changed that rock over time.
Rovers use many scientific instruments to study rocks.



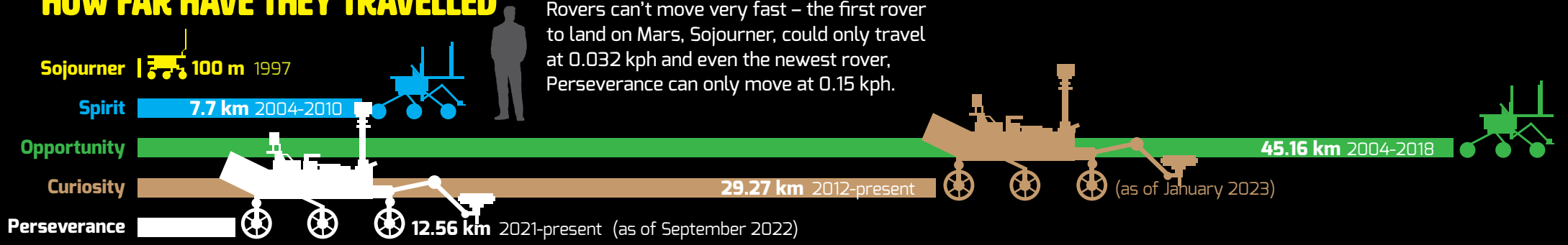
Curiosity and Perseverance are the largest rovers ever sent to Mars. Both are about the same size as a small car.

Curiosity has a drill that can take rock samples and even has a laser it can use to vaporise rocks.

This hole was drilled by Curiosity. The powder was analysed by the rover and was found to show evidence of an ancient wet environment.

HOW FAR HAVE THEY TRAVELLED

Rovers can't move very fast – the first rover to land on Mars, Sojourner, could only travel at 0.032 kph and even the newest rover, Perseverance can only move at 0.15 kph.

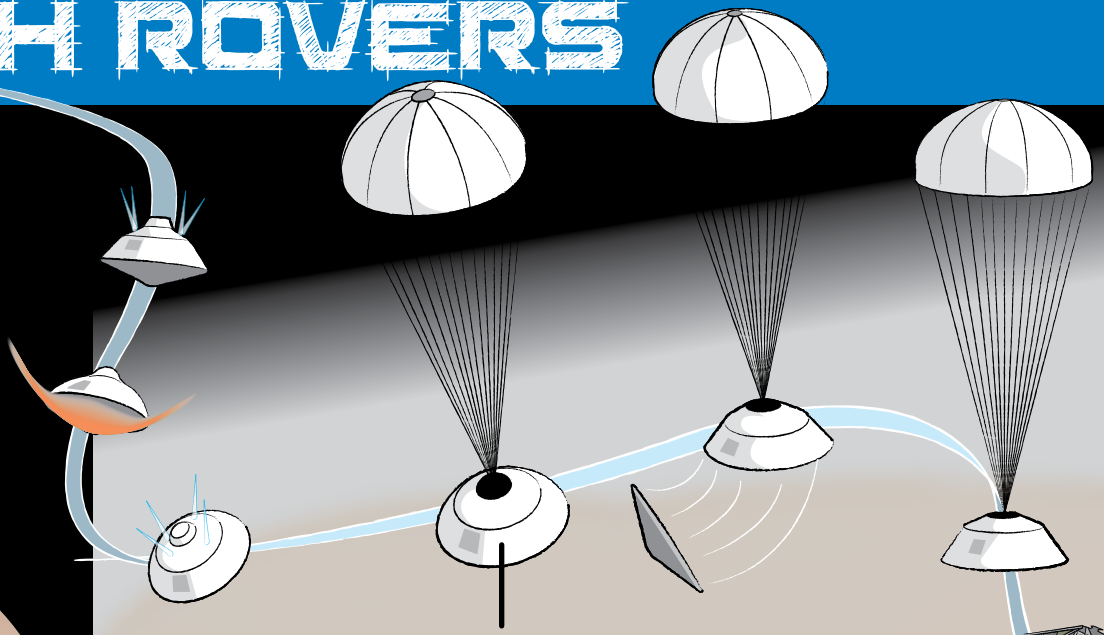


4.2 EXPLORING MARS WITH ROVERS

LANDING ON MARS

Landing on Mars is tricky. When a spacecraft enters the atmosphere, it can be travelling at more than 13,000 mph. On Earth, we use parachutes to slow down, but on Mars the air is too thin to slow down a heavy vehicle like a lander or a rover.

Smaller rovers like Spirit and Opportunity could use airbags to soften their landing and bounce safely onto the surface, but Curiosity and Perseverance were much too heavy for this to work so scientists had to design something new: a sky crane.



Parachutes slow the craft from more than 13,000 mph to about 200 mph.

The rover and sky crane separate from the parachute and thrusters slow them down to less than 2 mph.

The sky crane lowers the rover gently onto the surface on a set of cables

To avoid crashing into the rover, the sky crane fires its thrusters one last time and flies clear

SEVEN MINUTES OF TERROR

The time it takes for a spacecraft to land on Mars is known as 'seven minutes of terror'. This because the spacecraft has to slow from 13,000 mph to zero all by itself with no help from humans on Earth. If any one of the stages goes even slightly wrong, the rover will crash into the surface and be destroyed.

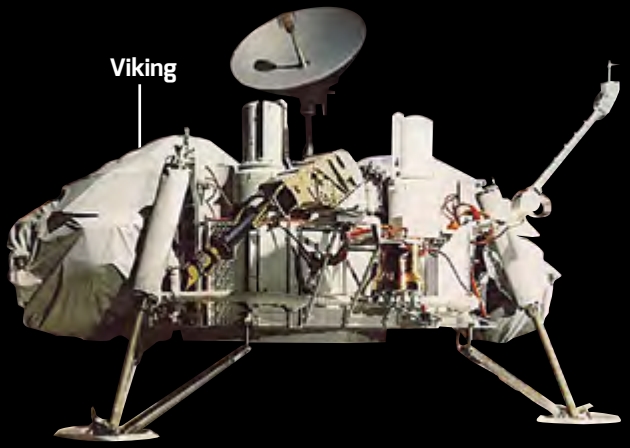
Lots of Mars missions have not survived the 'seven minutes of terror'. So many have ended in failure that scientists sometimes call it the 'Mars Curse', or the 'Great Galactic Ghoul!'

4.3 EXPLORING MARS WITH LANDERS

Being unable to move around isn't necessarily a bad thing. Driving around requires complicated computers, motors and cameras that take up space that can be used for science experiments. Landers can't move, but are fully-loaded with equipment dedicated to science.

THE FIRST LANDER

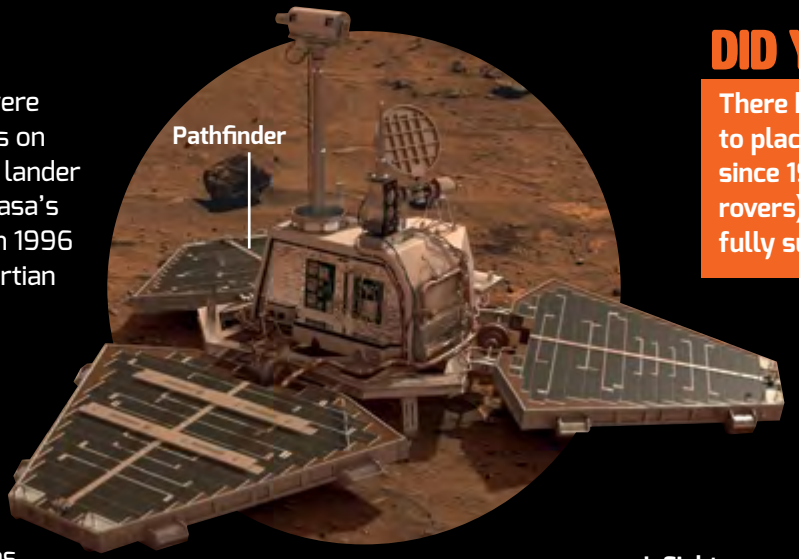
Nasa's Viking 1 and 2 were the first robotic explorers to safely land on Mars. Each spacecraft was made of an orbiter and a lander. The orbiters took pictures of Mars from their orbit and sent information to Earth. The landers gathered scientific data on the surface of the planet. They were launched in 1975 and landed in 1976.



The Viking probes analysed gases in the Martian atmosphere and chemicals in the soil for evidence of life. They also measured wind speed, wind direction, atmospheric temperature and pressure. The Viking orbiters mapped the Martian surface.

A 20 YEAR GAP

After the Viking missions there were several attempts to place landers on Mars but they all failed. The next lander to survive the trip to Mars was Nasa's Pathfinder lander, which landed in 1996 and also carried the first ever Martian rover: Sojourner.

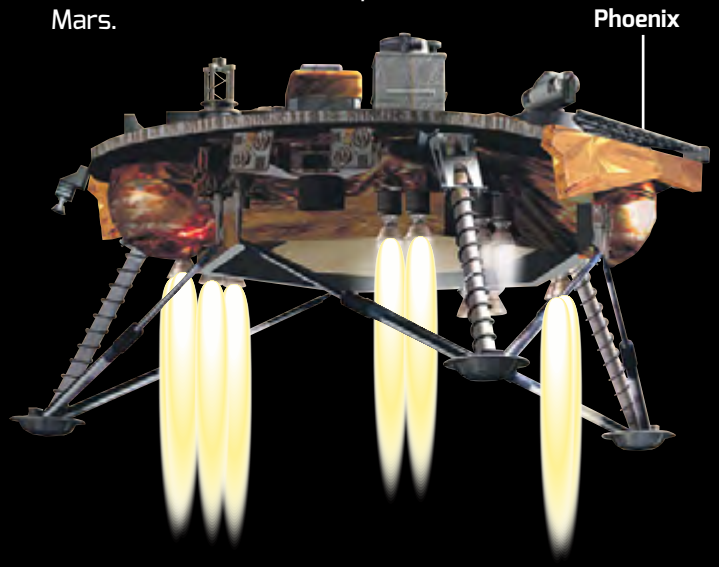


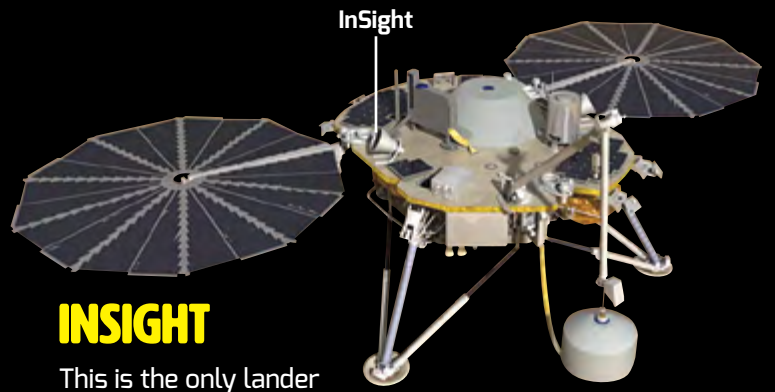
DID YOU KNOW?

There have been 15 attempts to place landers on Mars since 1962 (not counting rovers). Only 4 have been fully successful.

PHOENIX

The next lander to safely land was Nasa's Phoenix lander. It landed in 2008 and made history as its robotic arm was the first to touch and sample water on Mars.





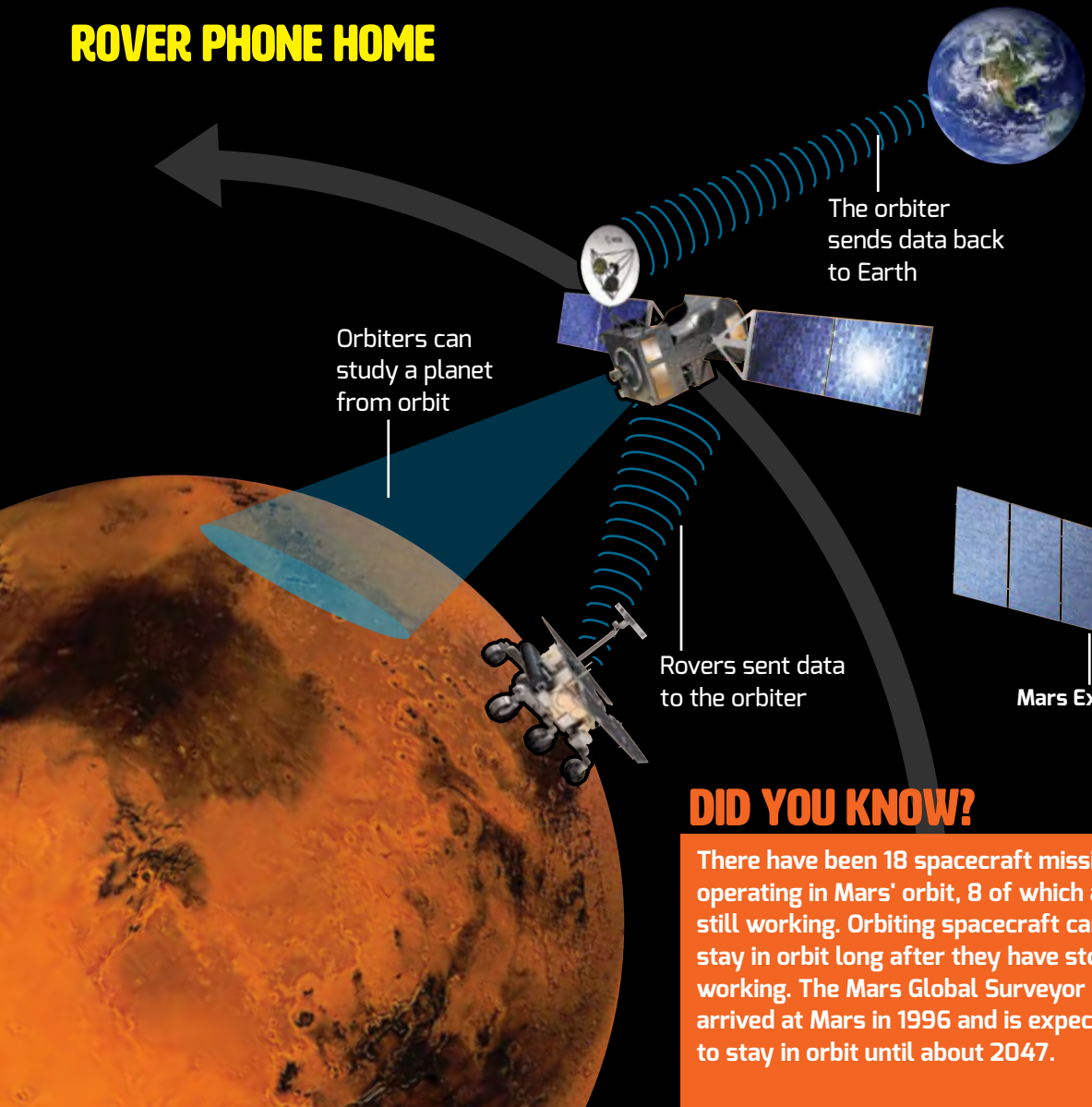
INSIGHT

This is the only lander currently working on the Martian surface. Insight landed in 2018 and used a lot of the same parts as the Phoenix lander. It was designed to study the inside of Mars by listening for 'marsquakes' and meteorite impacts.

4.4 EXPLORING MARS FROM ORBIT

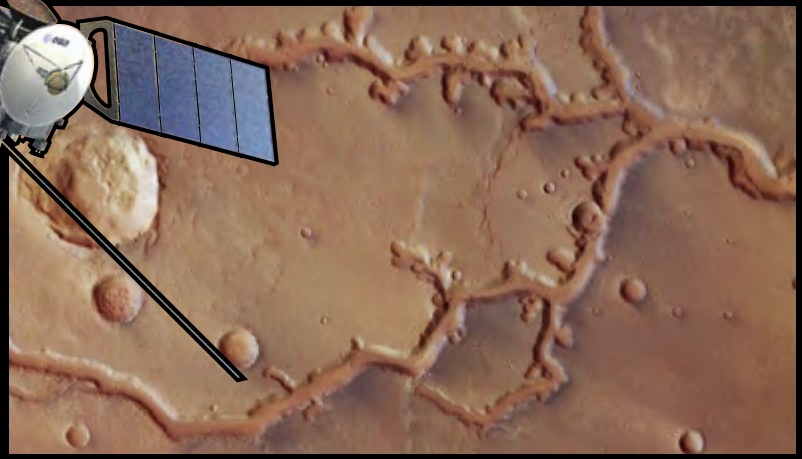
Orbiting spacecraft are very important tools for exploring distant planets. As well as delivering rovers and landers to the surface, they have their own scientific equipment that allows them to photograph a planet, study its surface, atmosphere and weather. They also allow robotic explorers on the surface to 'phone home' by transmitting their data back to Earth.

ROVER PHONE HOME



OLD VERSUS NEW

This is one of the first images ever taken of the surface of Mars. It was taken by Nasa's Mariner 9 orbiter in 1971, which was the first spacecraft ever to orbit another planet.



This is the same region photographed by ESA's Mars Express orbiter in 2018.

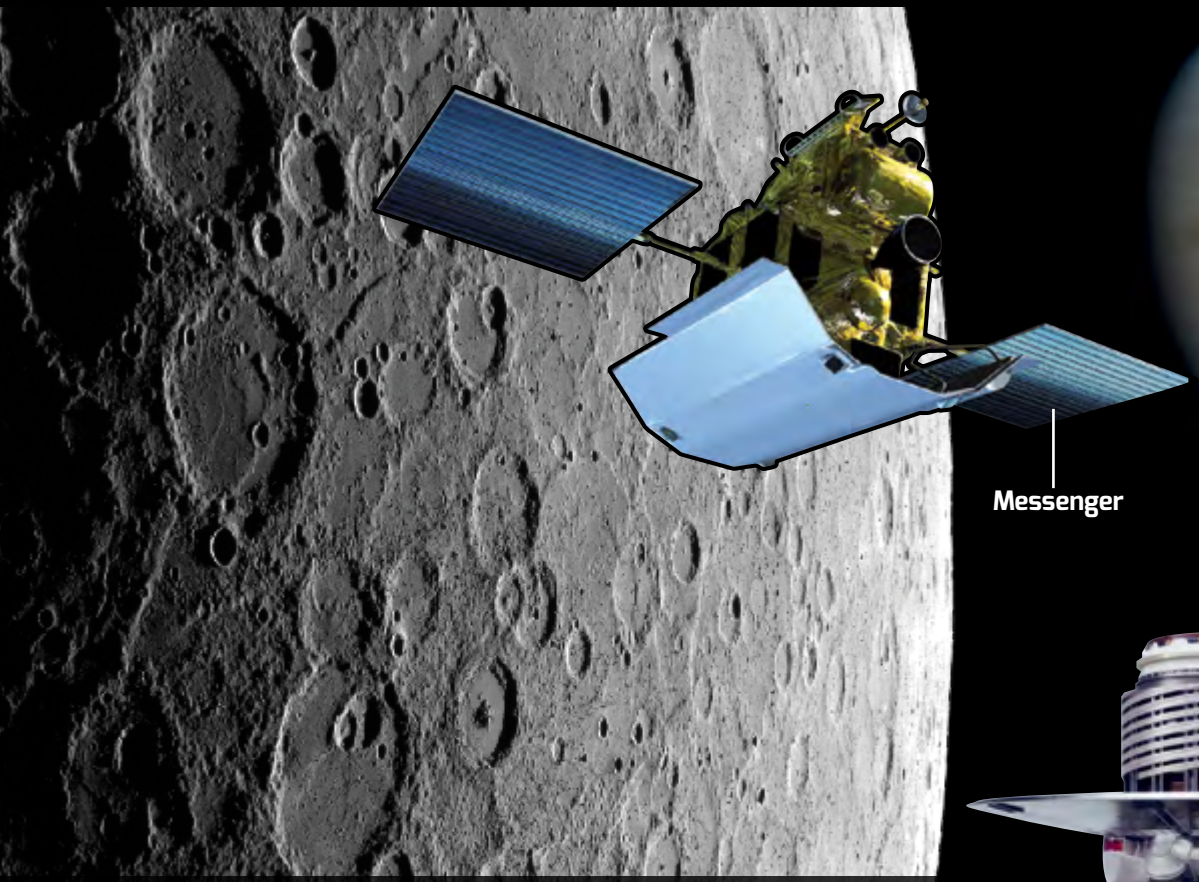
DID YOU KNOW?

There have been 18 spacecraft missions operating in Mars' orbit, 8 of which are still working. Orbiting spacecraft can stay in orbit long after they have stopped working. The Mars Global Surveyor arrived at Mars in 1996 and is expected to stay in orbit until about 2047.

4.5 EXPLORING THE OTHER ROCKY PLANETS

We may have sent more explorers to Mars than any other planet, but that doesn't mean we've ignored the others. Mars and the Moon are still the only worlds we have sent rovers to, but we have sent landers and orbiters to visit other planets and there have been a few flybys that have snapped pictures as they few past.

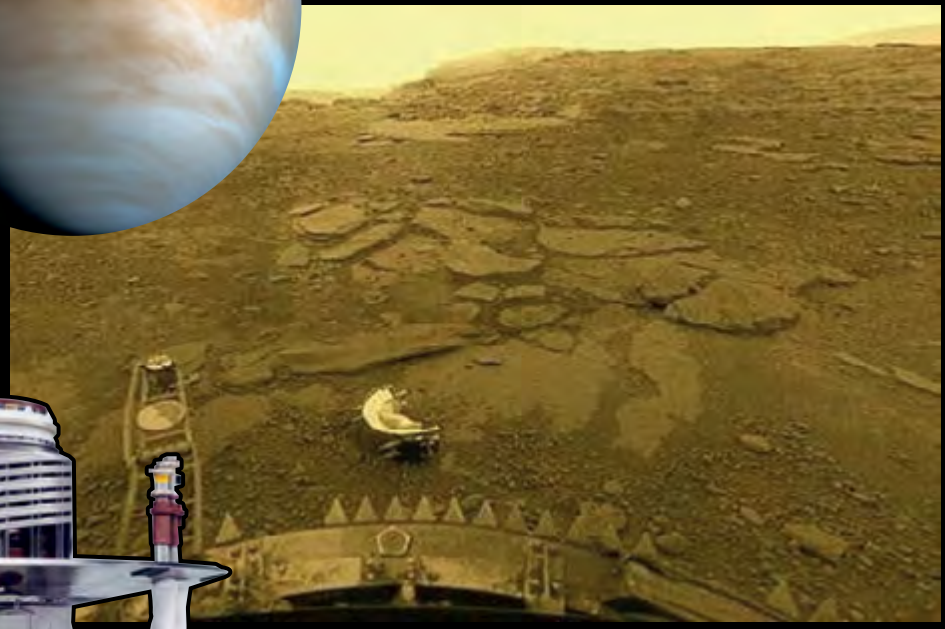
EXPLORING MERCURY



Mercury is so close to Sun that it is very difficult to study – in fact, it is the least explored of the inner planets. Only three spacecraft have visited Mercury. Nasa's Mariner 10 did a flyby in 1972, but the first to orbit the planet was Messenger, which stayed in orbit from 2011 to 2015. The next mission to visit will be BepiColombo, which has already performed a flyby and will arrive in orbit in 2025.

EXPLORING VENUS

Venus was one of the first planets to be visited by spacecraft from Earth. Probes do not last long on the surface, where the atmosphere is 50 times denser than Earth's and temperatures are hot enough to melt lead. Of all the landers sent to Venus, the only one to survive more than 2 hours was Russia's Venera 13.



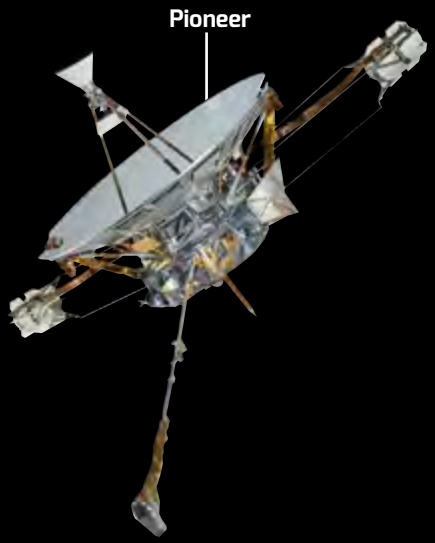
This is one of the few pictures we have of the surface of Venus. It was taken by Venera 13 in 1982.

Venera 13: Built to survive the heat and pressure of Venus as long as possible, it looks very different to a Mars lander.

4.6 EXPLORING THE GAS GIANTS

If you thought visiting the inner rocky planets was difficult, then visiting the gas giants is much, much harder. Not only are they much further away, they are so huge that their gravitation pull is enormous and they can be surrounded by powerful magnetic fields and dangerous radiation that can damage orbiting spacecraft. And, because they don't have a solid surface, rovers and landers have nothing to land on. Most of what we know about the gas giants comes from images and data collected by flyby spacecraft as they shoot past.

JUPITER

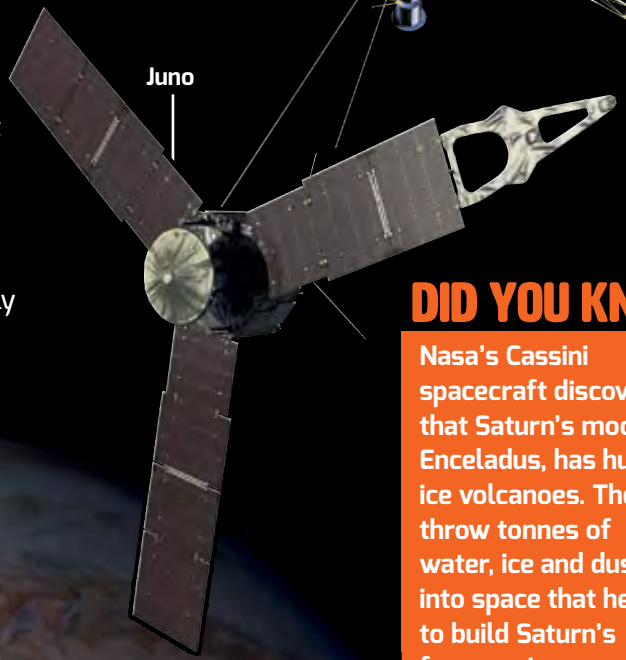


FLYBYS

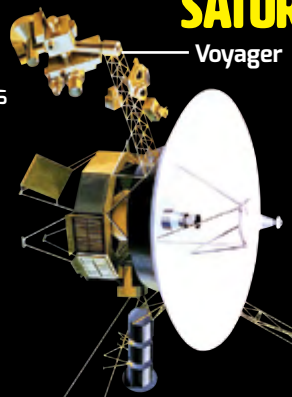
The first successful mission to Jupiter was a flyby in 1973 by **Pioneer 10**. **Pioneer 11** flew past in 1974, followed by **Voyager 1 and 2** in 1979. **Ulysses** did a flyby in 1992 and 2000 and **Cassini** took photographs on its way to Saturn in 2000. The last flyby was by **New Horizons** in 2007 as it headed off to study Pluto.

ORBITERS

Nasa's **Galileo** was the first spacecraft to orbit Jupiter (1996 to 2003). **Juno**, which arrived in 2016 is the only spacecraft currently orbiting Jupiter.

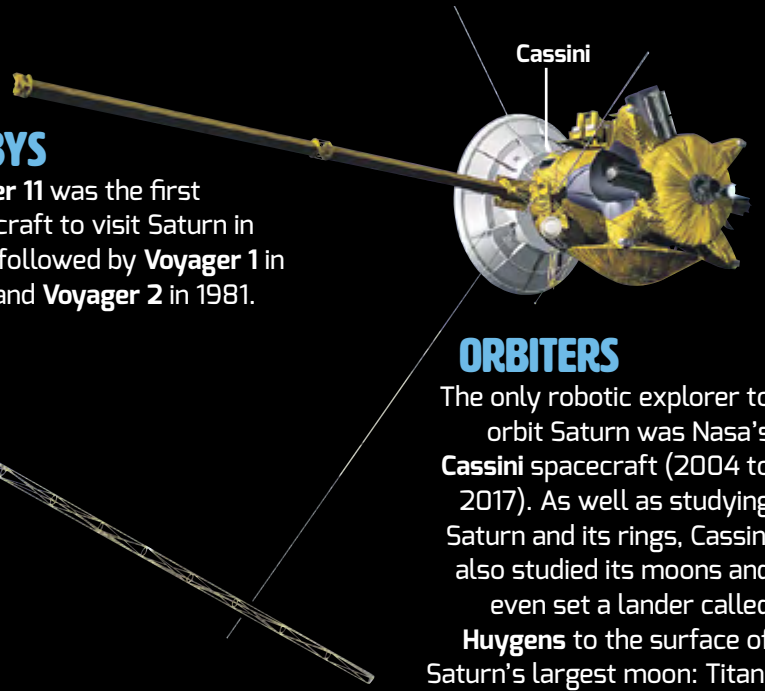


SATURN



FLYBYS

Pioneer 11 was the first spacecraft to visit Saturn in 1979, followed by **Voyager 1** in 1980 and **Voyager 2** in 1981.



ORBITERS

The only robotic explorer to orbit Saturn was Nasa's **Cassini** spacecraft (2004 to 2017). As well as studying Saturn and its rings, Cassini also studied its moons and even set a lander called **Huygens** to the surface of Saturn's largest moon: Titan.

DID YOU KNOW?

Nasa's Cassini spacecraft discovered that Saturn's moon, Enceladus, has huge ice volcanoes. They throw tonnes of water, ice and dust into space that helps to build Saturn's famous rings.

URANUS & NEPTUNE

So far, the only spacecraft to visit Uranus and Neptune is **Voyager 2**, which flew past Uranus in 1986 and Neptune in 1989.

5 DWARF PLANETS & EXOPLANETS

Not everything that looks like a planet can be called a planet. When Pluto was discovered scientists thought it was actually bigger than Mercury so it was counted as being the ninth planet. We now know that Pluto is actually much smaller than we thought so it was renamed as a 'dwarf planet',

DID YOU KNOW?

To be called a 'planet' it must do three things:

1. It must orbit a star.

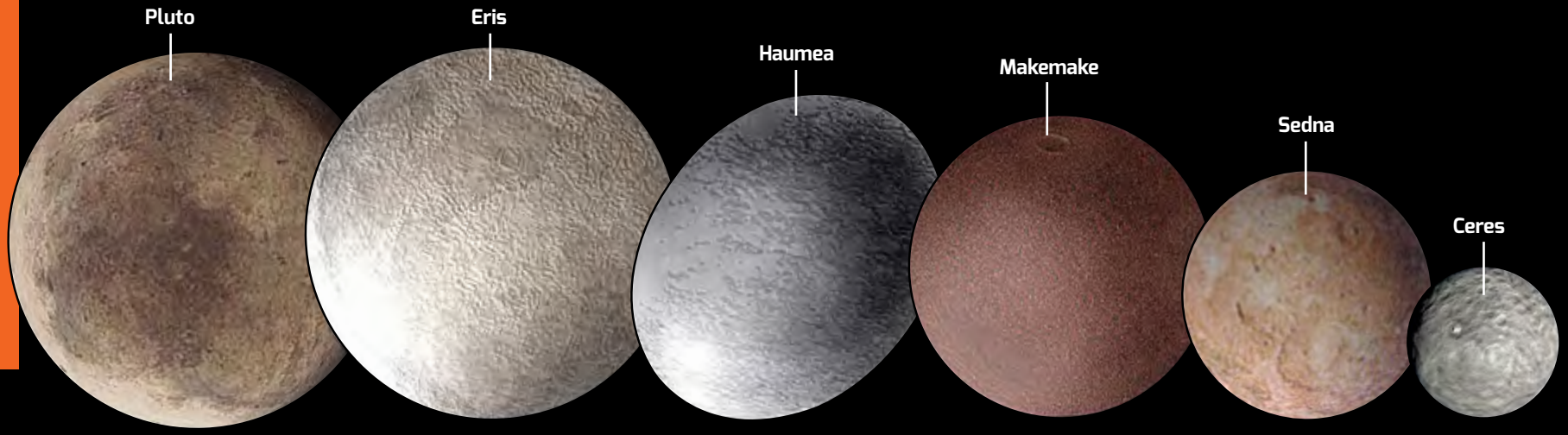
2. It must be big enough to have enough gravity to force a spherical shape.

3. It must be big enough that its gravity has cleared away any objects of a similar size near its orbit.

THE DWARF PLANETS

The five best-known dwarf planets are Ceres, Pluto, Makemake, Haumea, Sedna, and Eris. Except for Ceres, which lies in the main asteroid belt, these small worlds are located in the Kuiper Belt. They're considered dwarfs because they are massive, (mostly) round, and orbit the Sun, but they haven't cleared their orbit.

Astronomers think there might be thousands of dwarf planets waiting to be discovered beyond Neptune.

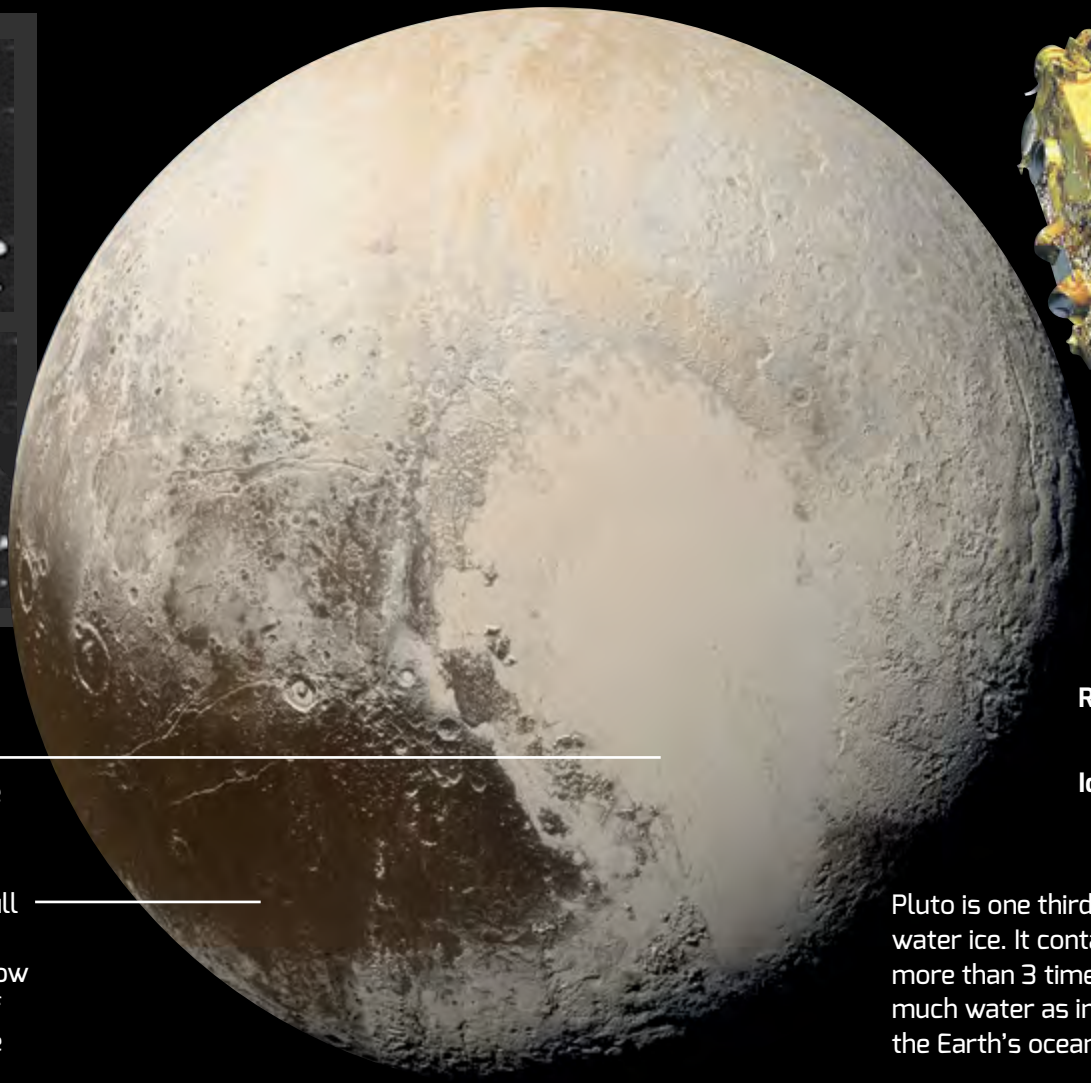


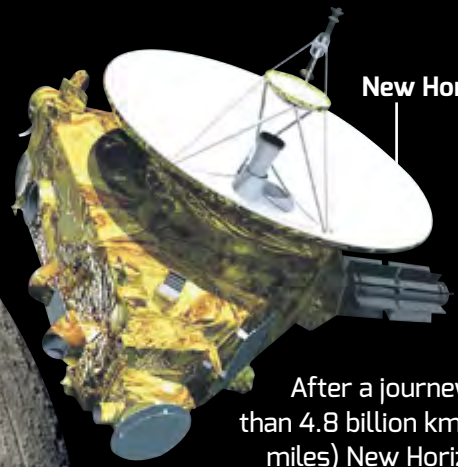
If you compare them with the Earth you can see why they are called dwarf planets. Pluto is even smaller than the Moon.

5.1 EXPLORING PLUTO

Pluto was discovered in 1930 by astronomers searching for a mysterious 'Planet X' though to exist beyond Neptune. For 76 years Pluto was known as the ninth planet but it was reclassified as a dwarf planet in 2006. The first spacecraft to visit Pluto was New Horizons in 2015. It took New Horizons nine years to reach Pluto and was launched when it was still classified as a planet. New Horizons took the first close-up images of Pluto and its moons. It discovered that Pluto has blue skies, huge mountains, five moons, and it snows red snow!

This is the first image ever taken of Pluto when it was discovered in 1930. By comparing the two images, astronomers could see one of 'stars' (circled) moving. It could only be the 'Planet X' they had been searching for.

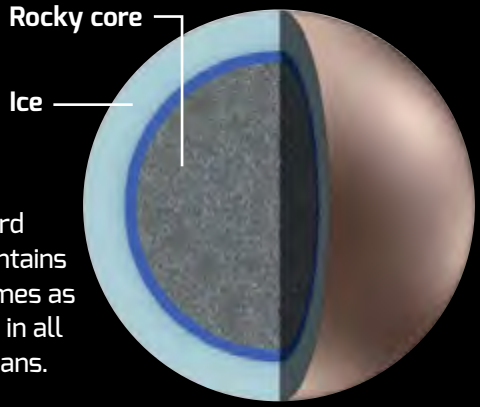




After a journey of more than 4.8 billion km (3 billion miles) New Horizons flew by Pluto in 2015 and took a series of images and other measurements. The spacecraft is now on its way to the Kuiper Belt to explore even more distant objects.

DID YOU KNOW?

After Pluto was discovered, in 1930, a competition was held to name the planet. Venetia Burney, an eleven-year-old schoolgirl from Oxford won by suggesting the name Pluto. Pluto was the Roman god of the underworld.



Pluto is one third water ice. It contains more than 3 times as much water as in all the Earth's oceans.

5.2 DISCOVERING EXOPLANETS

Their might be only eight planets in our Solar System, but the galaxy contains billions of stars and we now believe that many of those stars have their own planets.. We call these distance alien worlds 'extrasolar planets', or 'exoplanets' for short. The first confirmed exoplanet discovery was in 1992. Since then, astronomers have discovered almost 5,000 exoplanets. We now know that there are more exoplanets than there are stars in sky.

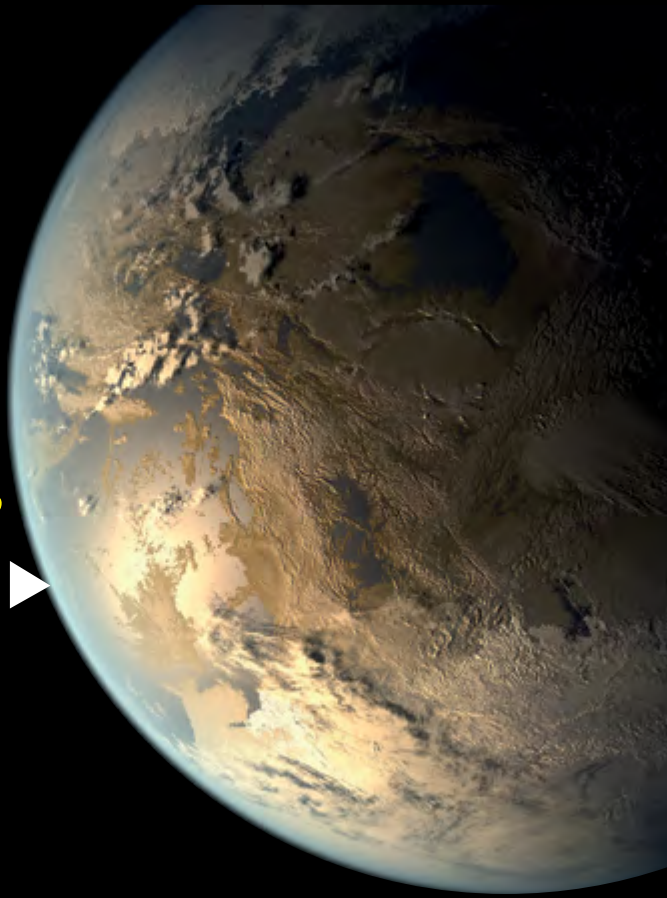
Kepler was a space telescope designed to find exoplanets. From 2009 to 2013, it watched 100,000 stars for the tell-tale signs that an exoplanet is orbiting one of the stars. Most of the exoplanets we know about were discovered by Kepler.

THE FIRST EXOPLANET

The first exoplanet found around a Sun-like star was 51 Pegasi b, in 1995. It is called a hot-Jupiter planet because it is massive like Jupiter and hot because it is so close to its star.

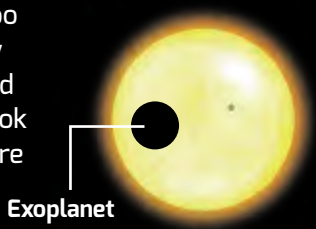
ANOTHER EARTH?

The first Earth-size planet was discovered in 2014. Kepler-186f orbits in the habitable zone of its star, which means it might have oceans and perhaps even alien life

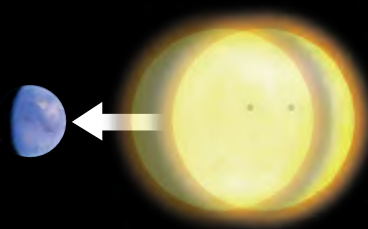


HOW DO YOU SPOT A PLANET YOU CAN'T SEE?

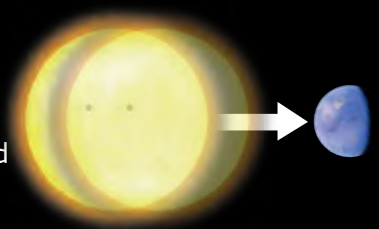
Exoplanets are much too far away to see directly with a telescope. Instead astronomers have to look for other clues that there is a planet orbiting a distant star.



One way to spot an exoplanet is to look at a distant star and wait to see if it's light gets dimmer. If it does, it might mean there is a planet passing in front of it. This is called a 'transit'.

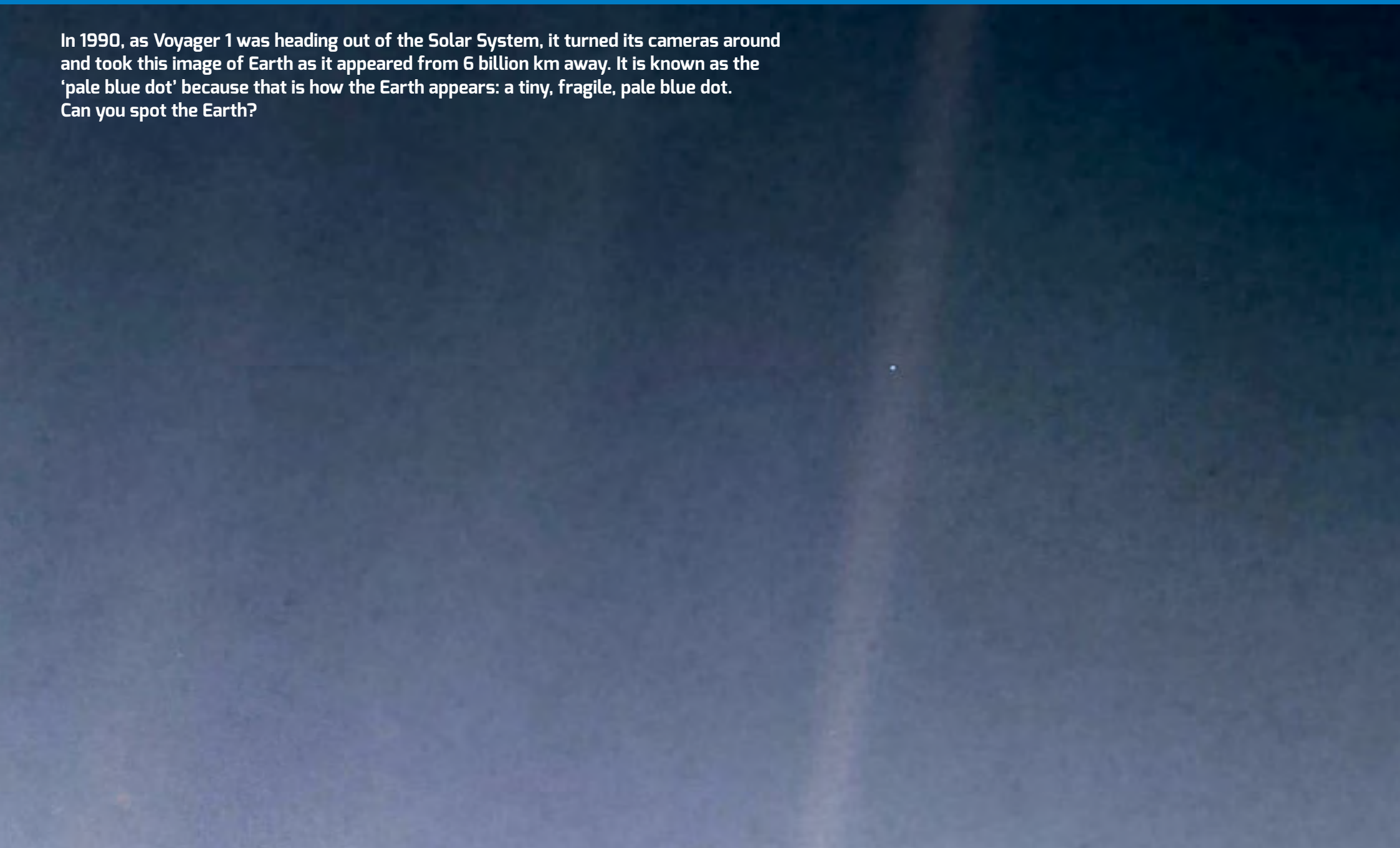


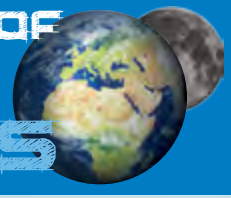
Another way is to see if the star is wobbling slightly. If it is, then it might be because there is a planet orbiting it and its gravity is tugging at the star.



THE FAMOUS 'PALE BLUE DOT'

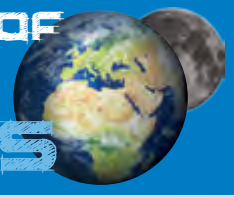
In 1990, as Voyager 1 was heading out of the Solar System, it turned its cameras around and took this image of Earth as it appeared from 6 billion km away. It is known as the 'pale blue dot' because that is how the Earth appears: a tiny, fragile, pale blue dot. Can you spot the Earth?





NOTES

Need to make some notes or doodle some ideas?
This is the place to do it!



NOTES

Need to make some notes or doodle some ideas?
This is the place to do it!

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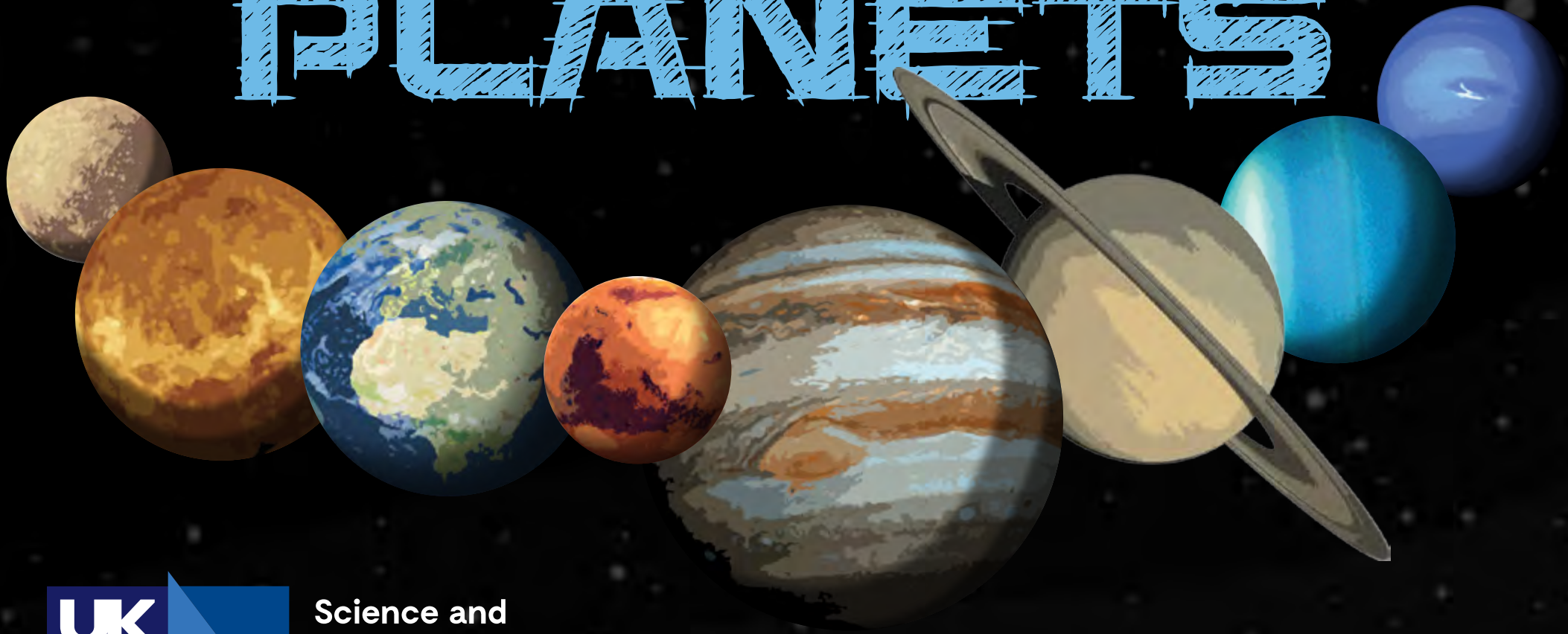
100-01-01

THE LITTLE BOOK OF THE PLANETS



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