

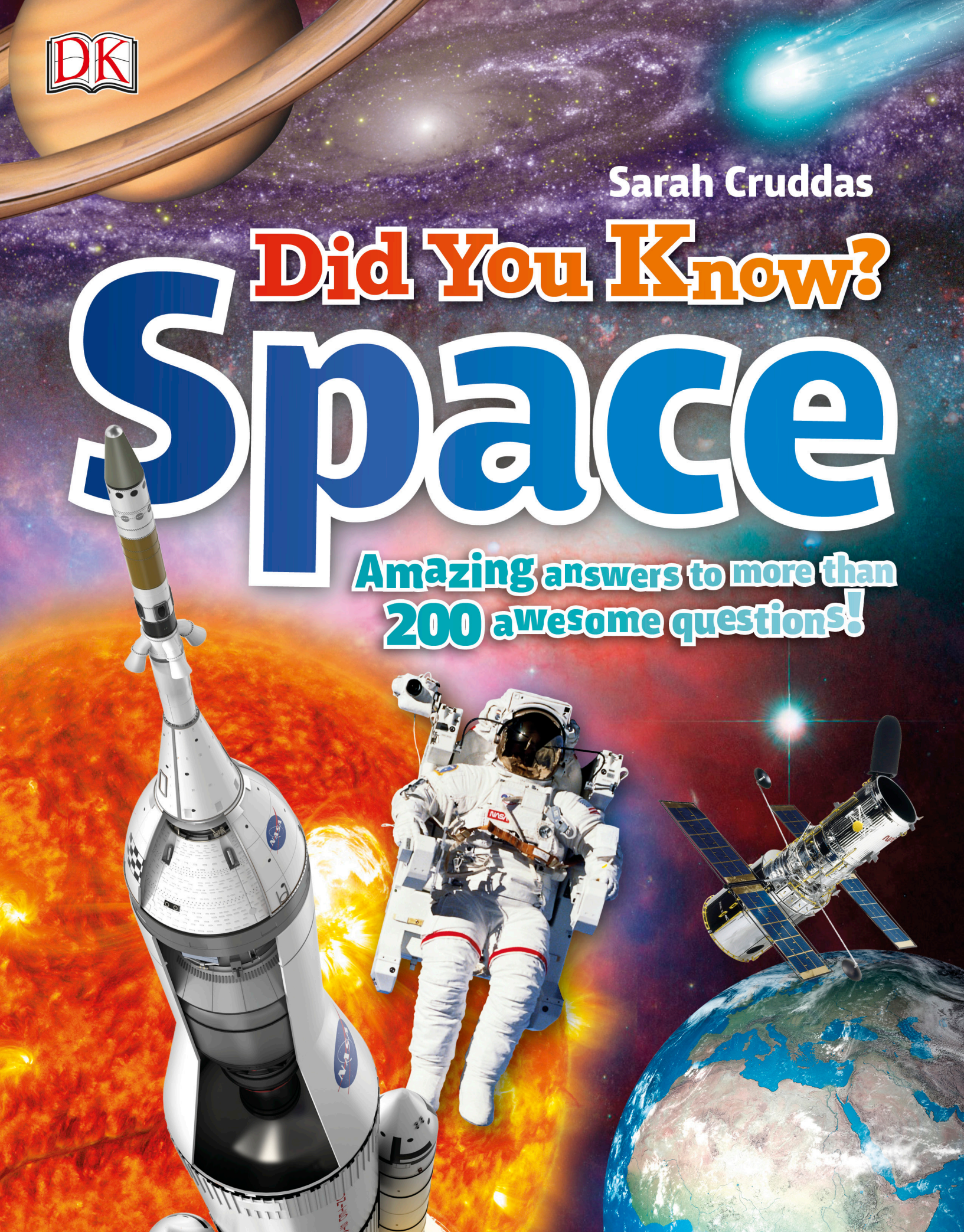


Sarah Cruddas

Did You Know?

Space

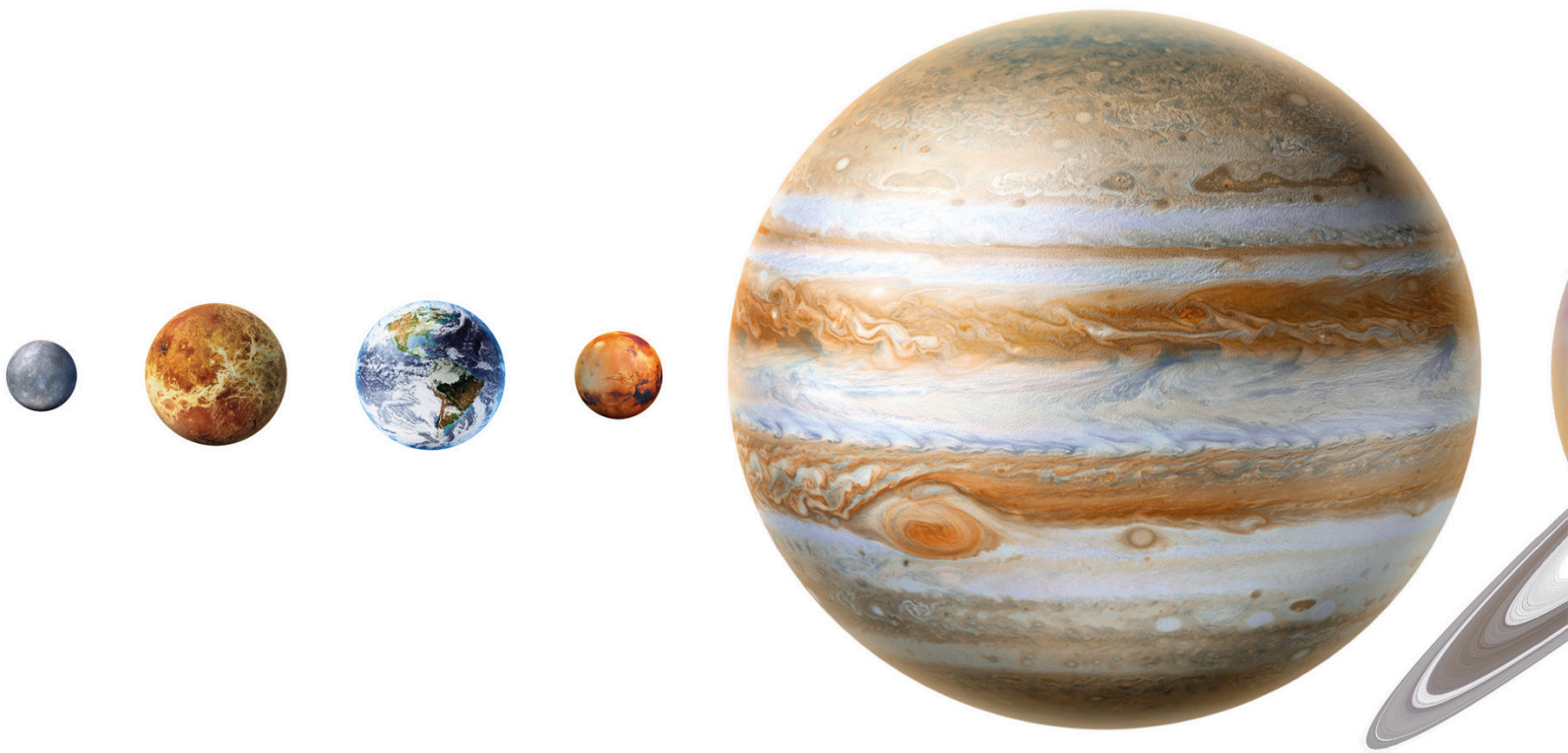
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200 awesome questions!





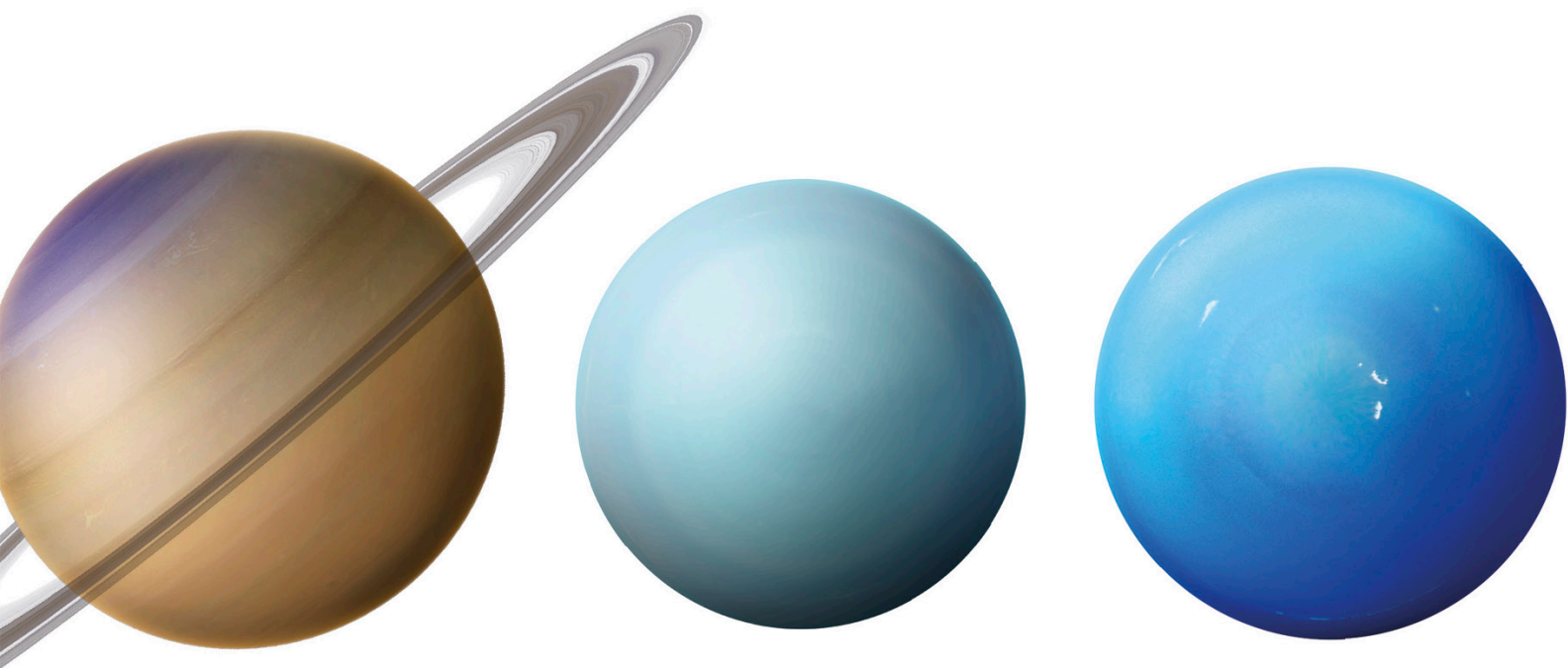
Did You Know?
Space







Did You Know? Space



Sarah Cruddas



Penguin
Random
House

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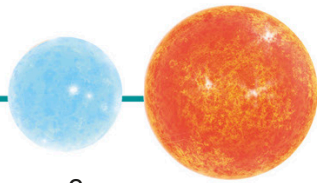
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Find out why I was sent to space on page 88.

Discover when I became the first person to go to space on page 86.







The universe

The universe is an enormous area of space that is always growing. Everything we know, such as planets, galaxies, stars, and living things, are in it.

What is space?

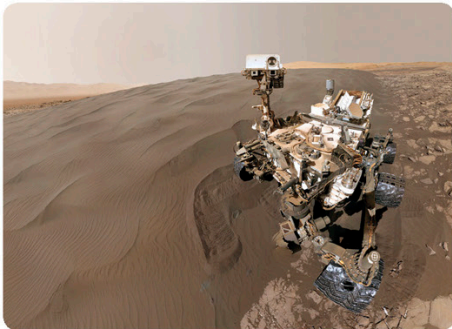
On cloudless nights when you look up at the dark sky, you can see space. It stretches much farther than the eye can see and contains the moon, the sun, all the planets, as well as the Earth, and the stars. Space also contains many things that we haven't yet discovered.

How do we explore space?



Telescopes

Telescopes help us see far into space. They show us images of stars and galaxies too distant to travel to.



Robots

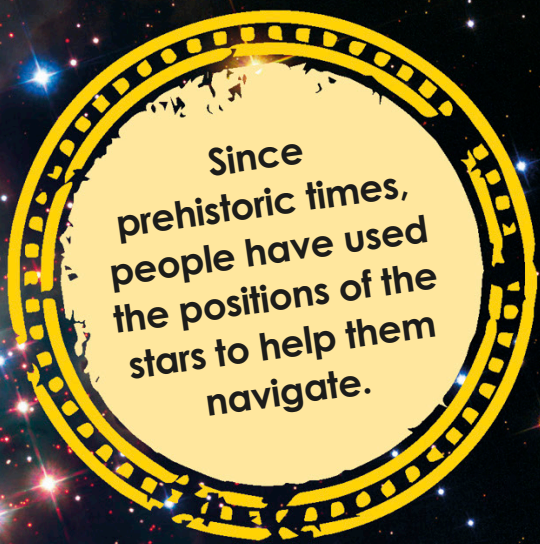
Robots can visit places in space that humans cannot yet reach. They help us understand these places.



People in space

People have been traveling into space since the 1960s. During their trips, they carry out experiments.





Since prehistoric times, people have used the positions of the stars to help them navigate.

Giant star cluster

This giant cluster of about 3,000 stars looks like a firework display. The cluster is called Westerlund 2 and is located in the Milky Way galaxy.

Baby stars

Many newly formed baby stars live in here in an area called a "stellar nursery."



Quick quiz

1. What is a "stellar nursery?"
2. How long have people been going into space?
3. Is the Earth in space?

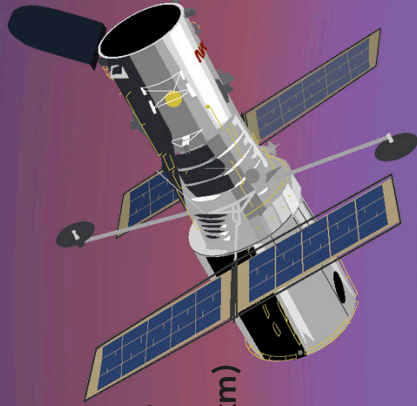
See pages 132–133 for the answers



Quick quiz

1. At what altitude (height) does space begin?
 - a) 62 miles (100 km)
 - b) 310 miles (500 km)
 - c) 373 miles (600 km)
2. What is the second main layer of the Earth's atmosphere called?
 - a) Troposphere
 - b) Thermosphere
 - c) Stratosphere

See pages 132–133 for the answers

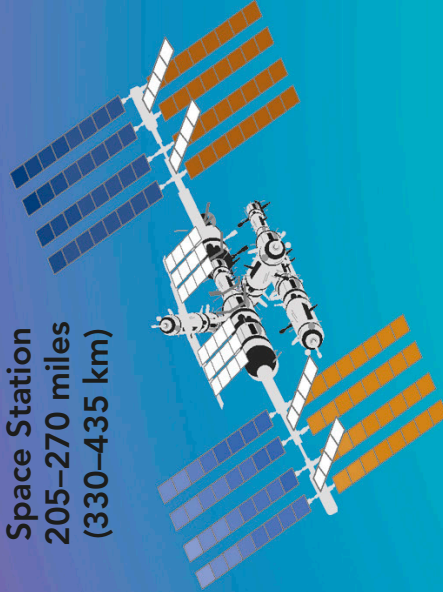


Hubble Space Telescope
339 miles (545 km)

Exosphere

The exosphere is the top part of the Earth's atmosphere. As you go up, the exosphere gradually becomes the airless environment of space.

International Space Station
205–270 miles
(330–435 km)



Thermosphere

The temperature in this layer of the atmosphere can get very high. However, if you were to travel up there, you wouldn't feel hot because the air is really thin and the heat could not transfer to your body.

First man in space
205 miles (330 km)



Aurora Borealis
56–93 miles
(90–150 km)

Mesosphere

This is the highest layer of the atmosphere in which the gases, such as oxygen and nitrogen, are still mixed up. The word "meso" means middle.

Troposphere

This is the lowest layer of Earth's atmosphere. It begins where we live, at the Earth's surface, and is where all our weather takes place.

Stratosphere

This is the second main layer of the atmosphere and is home to the ozone layer. The ozone layer protects us from the sun's rays, which can be dangerous.

Meteor showers
50–75 miles
(80–120 km)

Karman Line 62 miles (100 km)

Highest skydive 25 miles (40 km)

Airplane height 7 miles (11 km)

Earth

Where does space begin?

Space begins at the Karman Line, which is 62 miles (100 km) above the Earth. This is the height you need to reach to become an astronaut. Humans can't survive in space, but are protected by layers of gas that surround the Earth. These layers are called the atmosphere.

What is it like for astronauts in space?



Moon jumper

On the Earth, there is a force called gravity, which keeps everything on the ground. This force is not as strong on the moon, so astronauts can jump really high.



Floating around

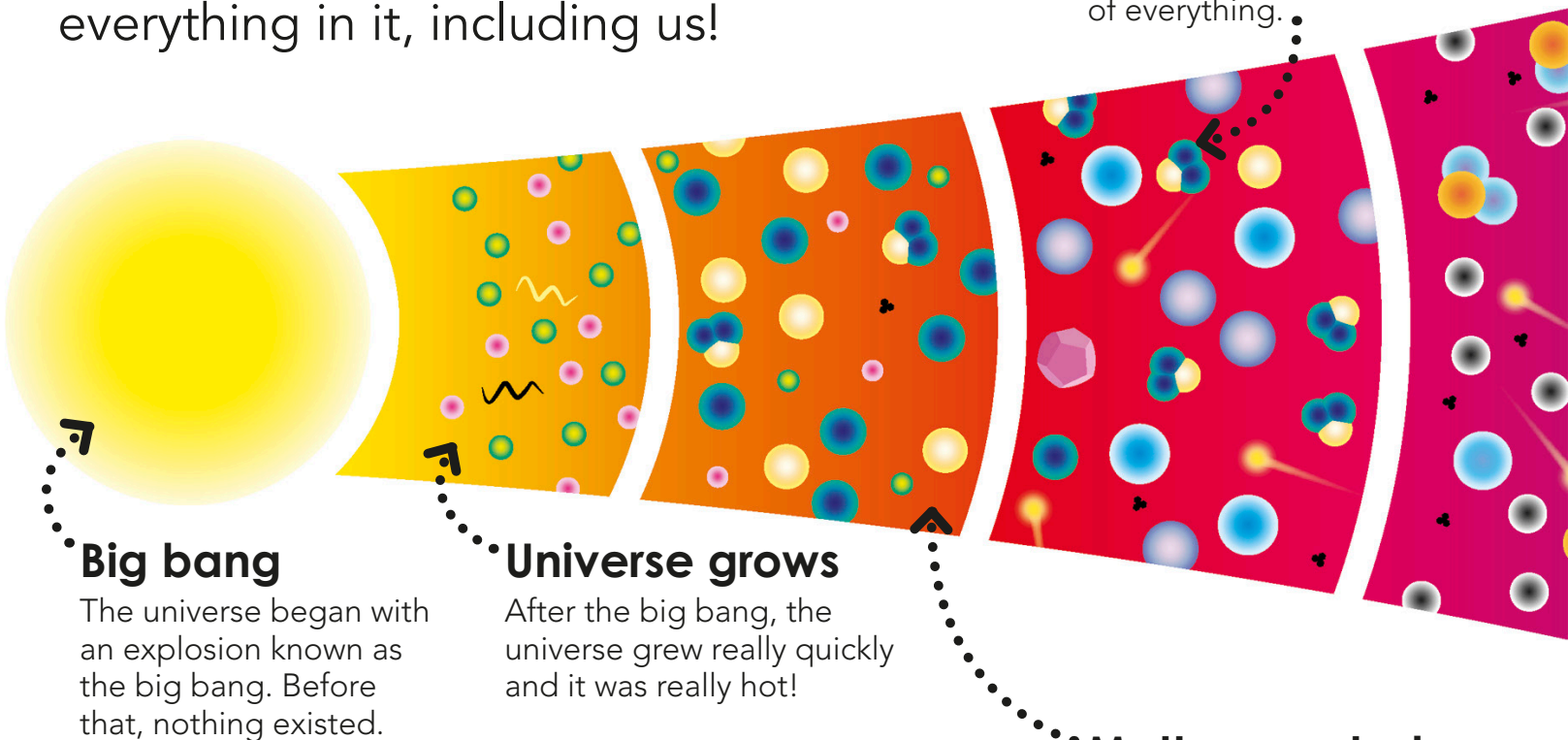
Astronauts float around in the International Space Station because there is no gravity. They can do somersaults and have to push and pull their way around.

Where did the universe come from?

Everything that exists all began to form around 13.8 billion years ago, during an event called the big bang. The big bang started the creation of the universe and everything in it, including us!

Particles form

During the next stage of the universe's creation, tiny particles called protons and neutrons began to form. These make up the center of atoms, which are the building blocks of everything.



Big bang

The universe began with an explosion known as the big bang. Before that, nothing existed.

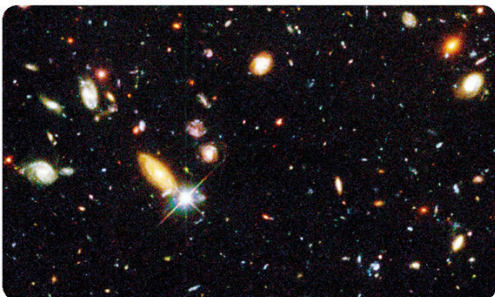
Universe grows

After the big bang, the universe grew really quickly and it was really hot!

Matter created

Within the first second after the big bang, the universe started to cool down and matter began to form. Matter is the stuff that everything is made of.

How do we know how old the universe is?



Universe math

Scientists are able to figure out and guess the age of the universe by studying how fast it is expanding today. They can also look at the oldest objects in space, which helps them to find out how things were made and when.

Atoms form

Many thousands of years after the big bang, the universe had cooled down. This is when atoms began to form.

The present

Even now, in the present day, the universe is still expanding. It is full of many galaxies, stars, and planets.

Stars appear

About 300 million years after the big bang, the first stars formed from clumps of gas and dust.

Galaxies form

The universe continued to expand, and about 500 million years after the big bang, the first galaxies formed.

? True or false?

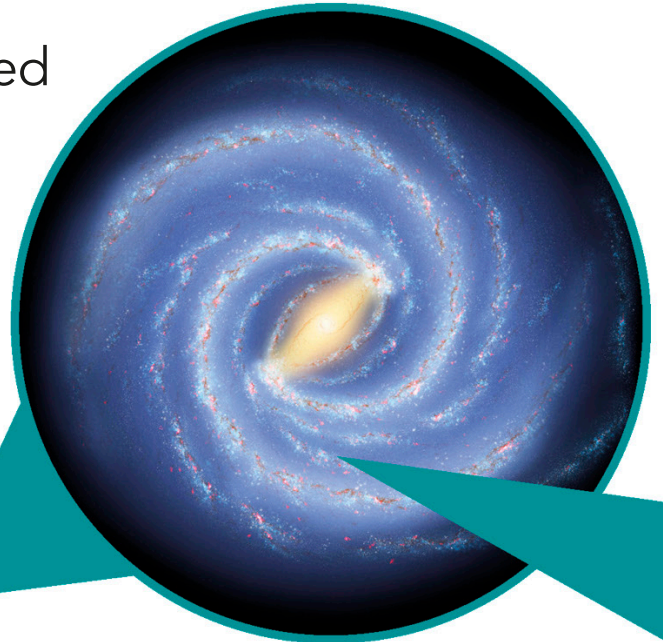
1. The universe is five billion years old.
2. Everything on Earth and in space is made of atoms.
3. The universe has stopped expanding.

See pages 132–133 for the answers

How big is the universe?

The universe is really, really, really big! It is so huge that it is difficult to imagine the size of it. Our sun, which is the biggest object in our solar system, is like a speck of dust when compared with the vastness of the universe.

As far as we know, the universe does not have an edge.

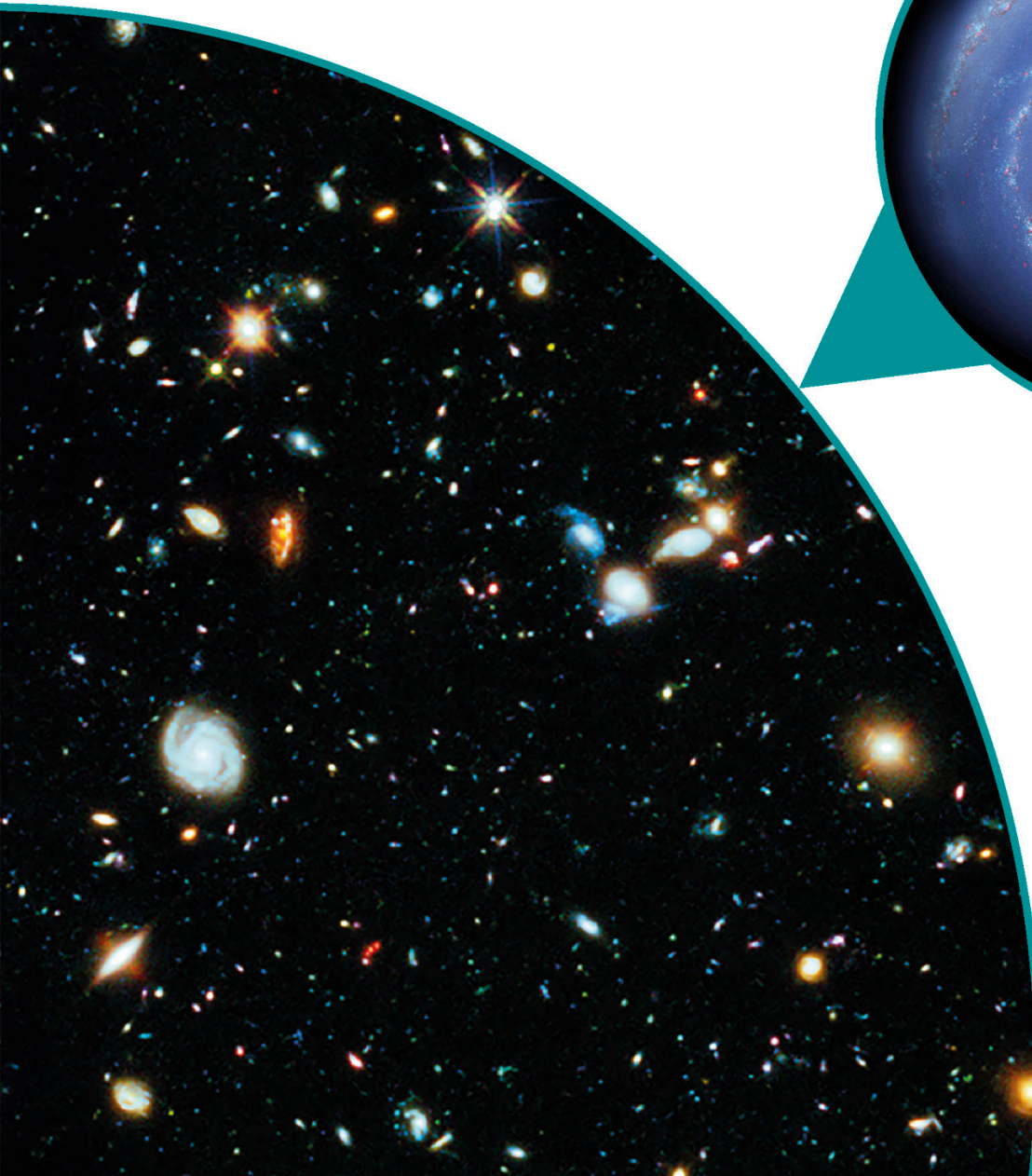


The Milky Way

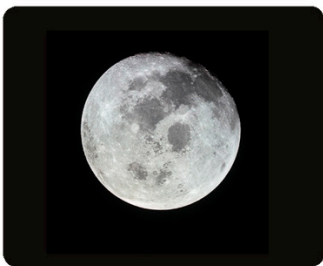
One of the galaxies in our universe is the Milky Way galaxy. There are billions of stars in the Milky Way, most of which have planets that orbit around them.

The universe

Our galaxy is just one of billions of galaxies in the ever-expanding universe. This image shows just a small part of our universe, filled with galaxies.

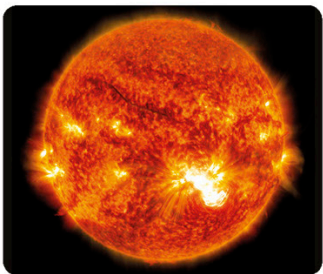


How big is...?



The moon

The moon is our closest neighbor. It might look big in the sky, but it is much smaller than the Earth. It is about a quarter of the Earth's size.



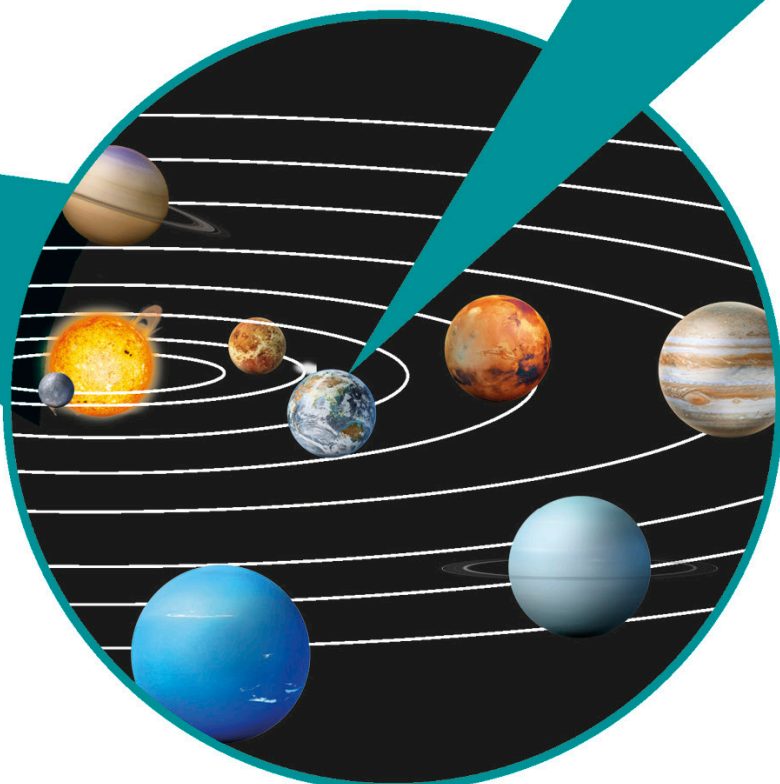
The sun

The sun is the biggest object in our solar system. It is so huge that more than one million Earths could fit inside it.



Earth

To us, the Earth seems huge. More than seven billion people live here! However, compared to the biggest planet in our solar system, Jupiter, the Earth is actually very small.



Our solar system

Our solar system is in the Milky Way galaxy. It is so large that if you were to travel to Mars and look into space, Earth would appear like a small star in the sky.



Quick quiz

1. What is the name of the galaxy that the Earth is in?
2. Roughly, how many Earths can fit inside the sun?
3. What is Earth's closest neighbor in space?

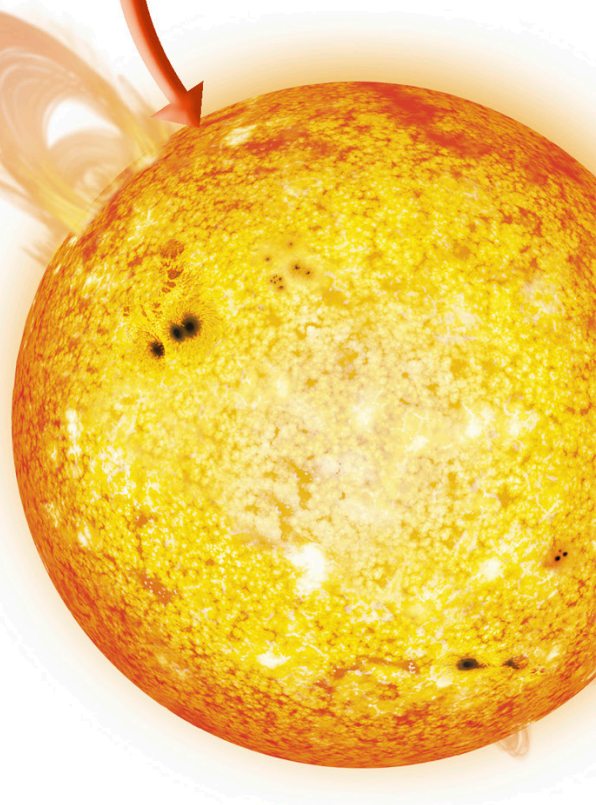
See pages 132–133 for the answers

How cold is it in space?

In the huge areas between the stars and galaxies, space can get very, very cold. In these regions, the temperature can drop as low as -454°F (-270°C). However, the objects in space, such as stars and planets, can be lots of different temperatures.

The sun

This is the hottest object in the solar system. The surface temperature of the sun is around $11,000^{\circ}\text{F}$ ($6,000^{\circ}\text{C}$). Too hot to ever visit!

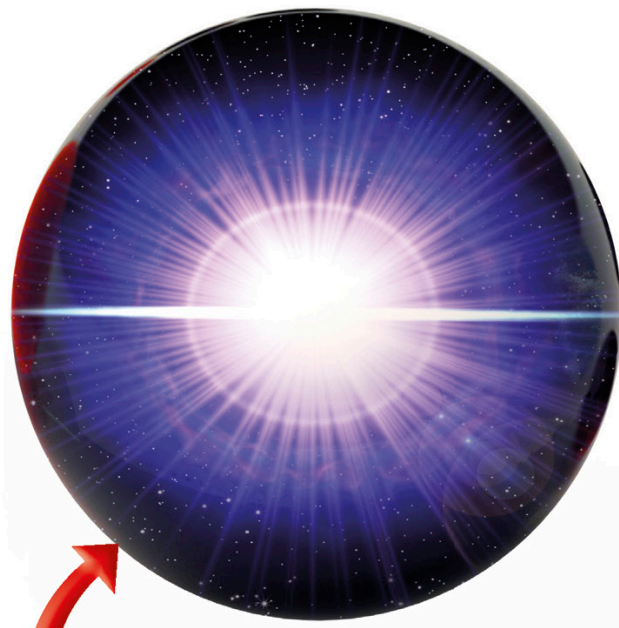


Do other planets have summers and winters?



Uranus

Uranus has four seasons that last around 21 years each. The planet spins on a very tilted axis. This means that during summers and winters, the summer side of Uranus is in daylight for 21 years and the winter side is in darkness for 21 years too.



Supernova

When a huge star explodes, it can become a supernova and temperatures can reach up to $99,000,000^{\circ}\text{F}$ ($55,000,000^{\circ}\text{C}$).



Venus

The hottest planet in the solar system, Venus has a thick atmosphere that helps the surface reach temperatures as high as 880°F (470°C).



Earth

The average temperature on the Earth is around 59°F (15°C). However, this can change depending on the seasons and the location on Earth.



Boomerang Nebula

Thousands of light-years away from the Earth, the Boomerang Nebula is the coldest known object in the universe. Inside this gas cloud, temperatures can be as low as -458°F (-272°C).



The moon

The moon is a world of extreme temperatures. In the sunlight, it can be as hot as 253°F (123°C). The coldest parts can reach -387°F (-233°C).



Neptune

Temperatures on Neptune average about -353°F (-214°C). Its largest moon, Triton, is even colder, with temperatures dropping to -391°F (-235°C)!



? Quick quiz

1. Which is colder—Neptune or its moon, Triton?
2. What is the coldest known object in the universe?

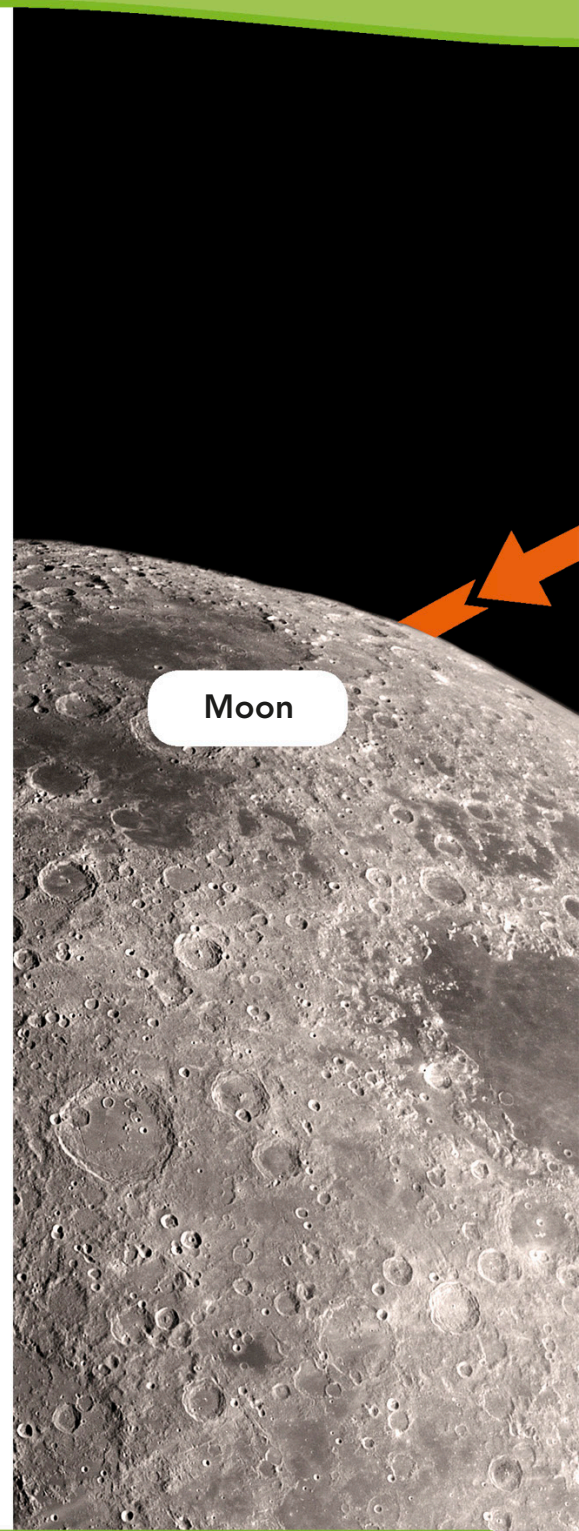
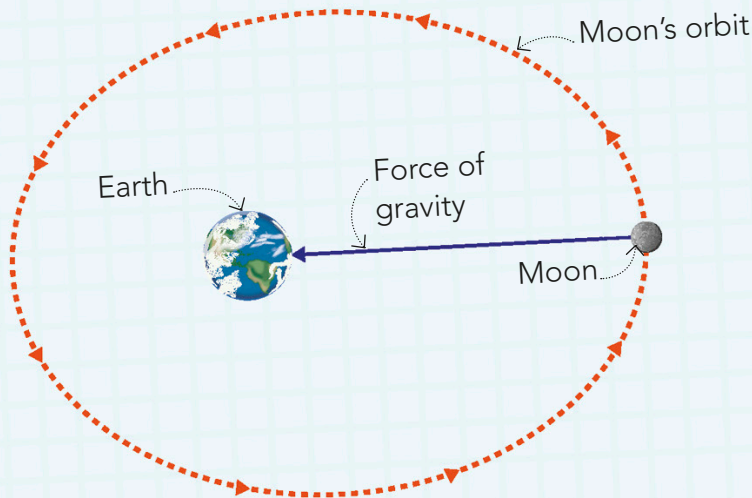
See pages 132–133 for the answers

What is an orbit?

An orbit is a path that one object in space takes around another. In the solar system, the Earth and all the other planets orbit around the sun. Also, many planets, including the Earth, have moons that orbit around them.

What keeps the moon in orbit?

The moon stays in orbit around the Earth because of the force of gravity. The Earth's gravity pulls the moon toward the Earth, stopping it from escaping into space. Without gravity, the universe would not exist—it is the force that made pieces of rock, dust, and ice clump together to form planets, moons, and stars. It also keeps all the planets in orbit around the sun.



What else orbits the Earth?



Satellites

Lots of human-made satellites orbit around the Earth. This includes the International Space Station where astronauts live and work.



Eye in space

The Hubble Space Telescope orbits around the Earth. It can look far into space and takes amazing pictures of distant stars and galaxies.



Earth

... Moon's orbit

The moon travels around the Earth in a counterclockwise direction. It takes the moon 27 days 7 hours and 43 minutes to make one orbit.

? True or false?

1. The moon orbits the Earth.
2. The Earth orbits around the sun.
3. The moon takes a week to orbit the Earth.

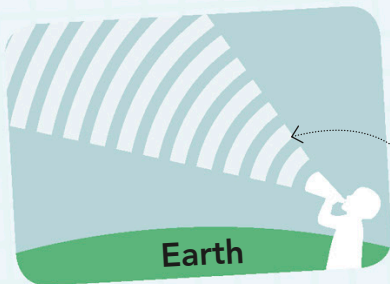
See pages 132–133 for the answers

Can you scream in space?

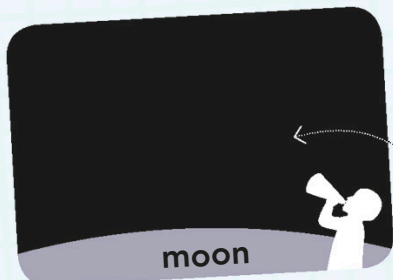
In space, nobody can hear you scream. This is because it is a vacuum, which means that there is no air. Sound can't travel through a vacuum. When astronauts are inside a spacecraft, they can talk and hear sounds because there is air in the spacecraft.

How sound works

Sounds are vibrations that can travel through different materials. The vibrations make the air, or material around it vibrate and the vibrations then travel and enter your ears.



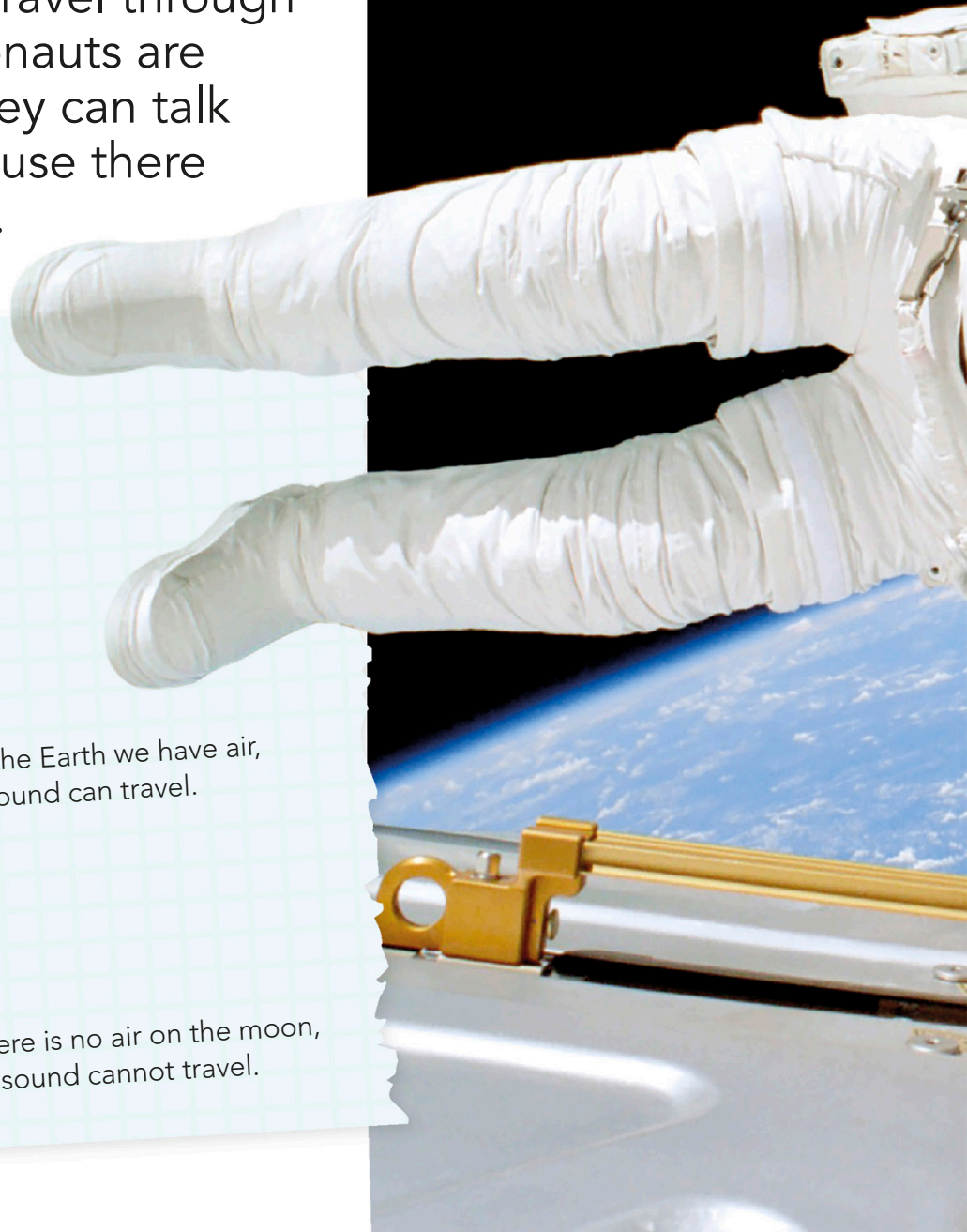
On the Earth we have air, so sound can travel.



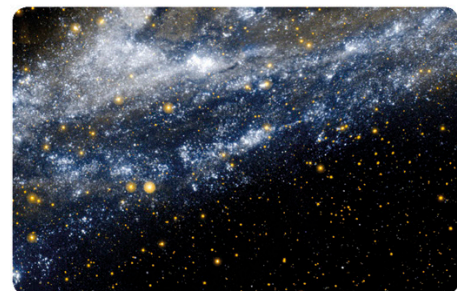
There is no air on the moon, so sound cannot travel.

Vacuum

A vacuum is an area with nothing in it, not even air! If there is a vacuum between an object making sound and your ear, you won't hear the sound.



What does it smell like in space?



The smell of space

Astronauts who have returned from space have struggled to describe the smell of their space suits after a space walk. Some say the space suits smell a bit burned and metallic, like the smell of hot metal.

Radio microphone

Spacewalking astronauts wear microphones so they can talk to each other by radio. Their space suits protect them from the vacuum of space.

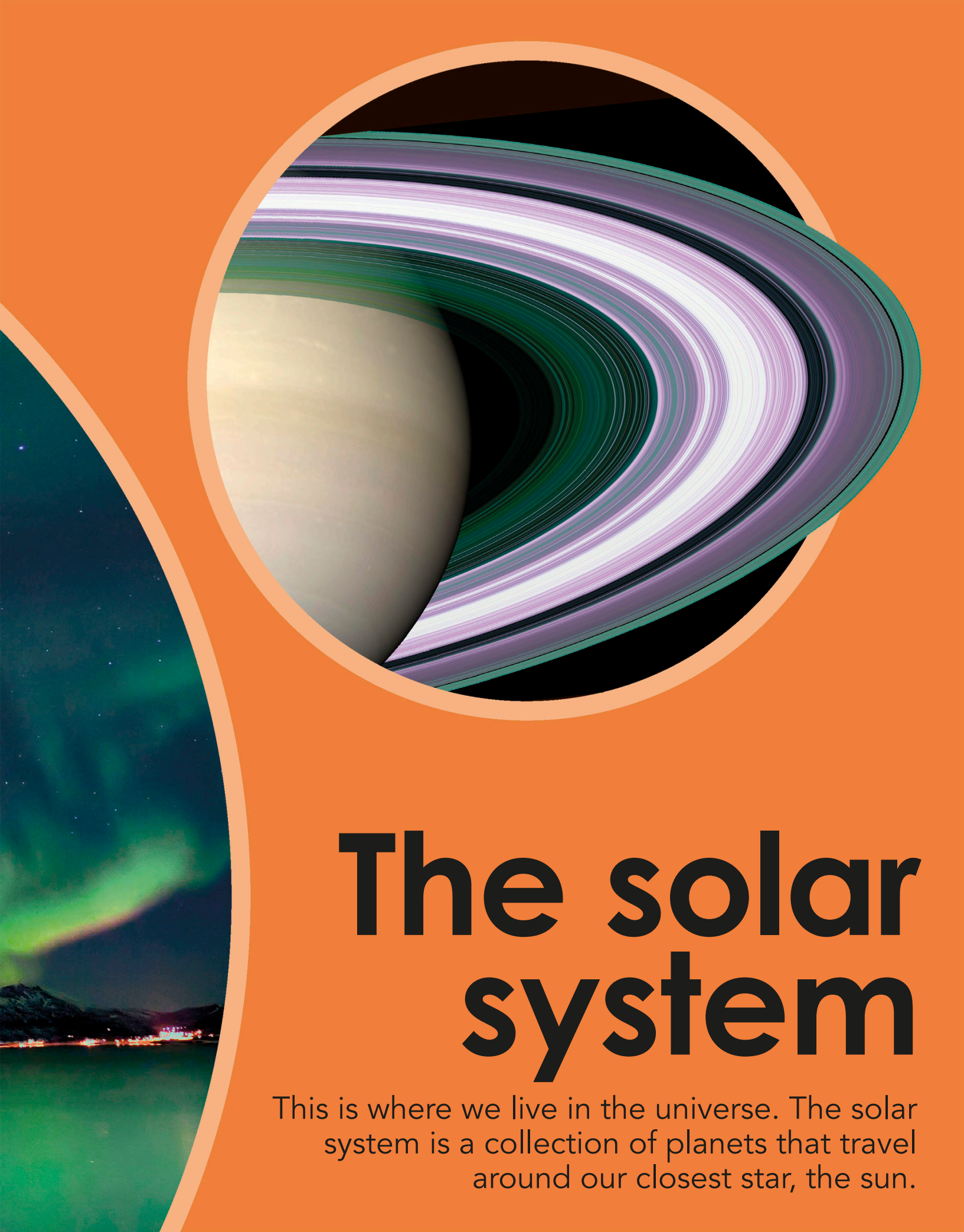


Quick quiz

1. Why do spacewalking astronauts wear microphones?
2. What is a vacuum?
3. Is there air in space?

See pages 132–133 for the answers





The solar system

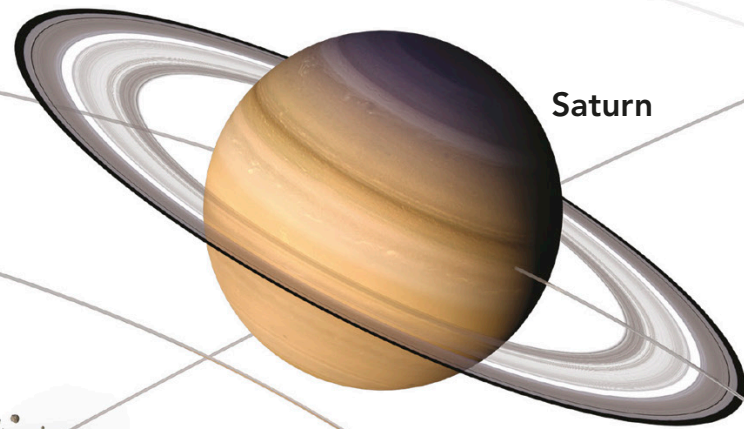
This is where we live in the universe. The solar system is a collection of planets that travel around our closest star, the sun.

What is the solar system?

The solar system is our home in the universe. It is made up of our sun at the center, with planets, dwarf planets, asteroids, and comets orbiting around it. Our solar system is just one of many similar systems in space.

Asteroids

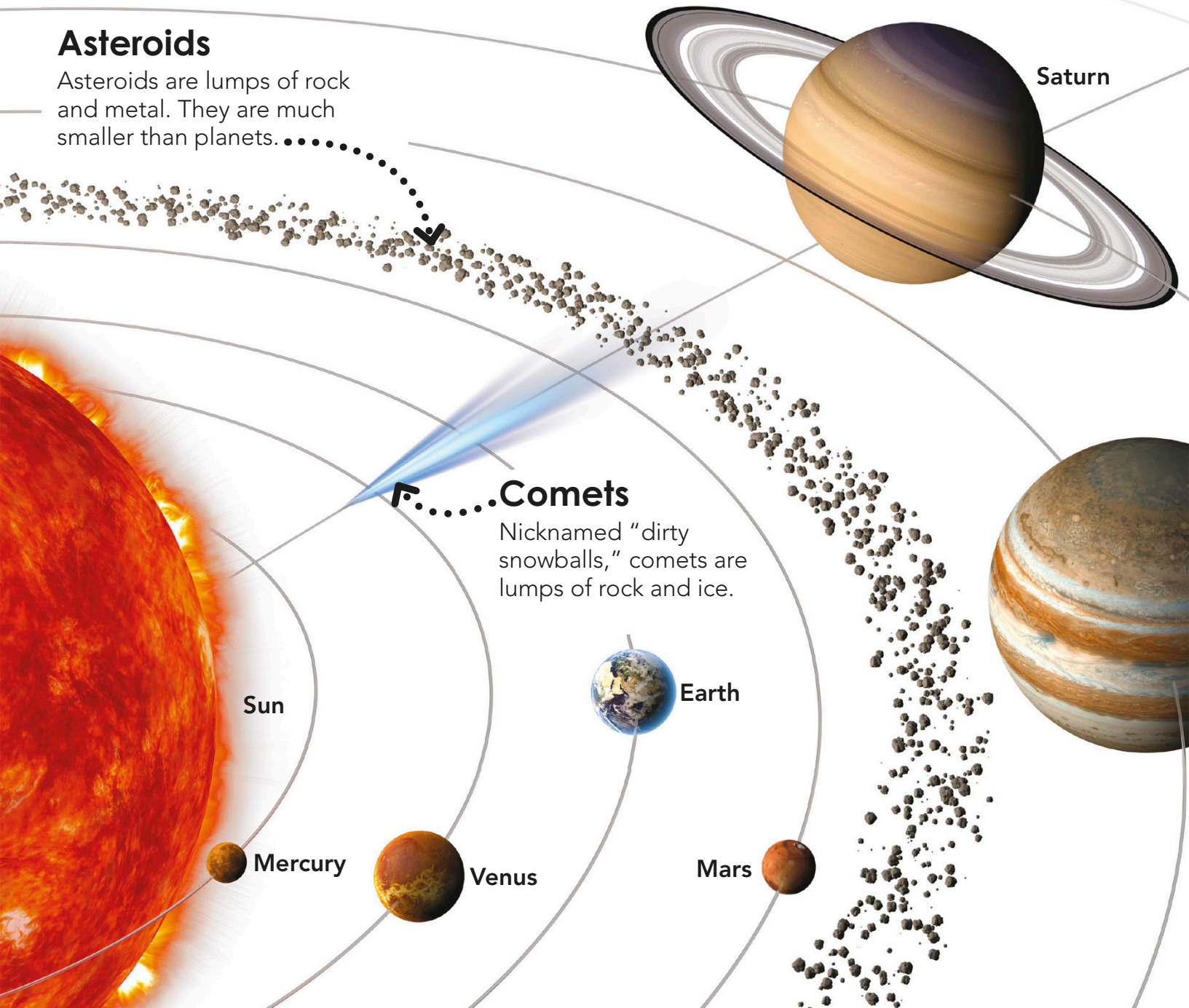
Asteroids are lumps of rock and metal. They are much smaller than planets.



Saturn

Comets

Nicknamed "dirty snowballs," comets are lumps of rock and ice.



Sun

Mercury

Venus

Earth

Mars

Where did the solar system come from?



The sun

The solar system began 4.6 billion years ago when the sun was formed. A cloud of gas and dust became squashed together by gravity. It began to draw more material toward it until it became the sun.



Everything else

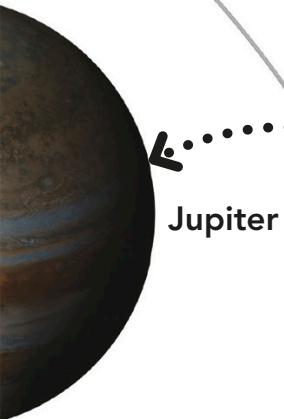
The bits of material left over after the sun formed clumped together into bigger and bigger pieces. These clumps became planets, dwarf planets, asteroids, comets, and moons.

Kuiper Belt

Toward the edge of the solar system is the Kuiper Belt. It is home to frozen objects, such as comets and dwarf planets.

Orbits

An orbit is the curved path that an object follows in space. The planets and everything else in our solar system orbit the sun.



Planets

There are eight planets in our solar system. Some planets are rocky, such as Earth and Mars, and others are made mostly of gas, such as Jupiter and Saturn.



Quick quiz

- Which planet is the biggest in our solar system?
 - Jupiter
 - Neptune
 - Earth
- Which planet is closest to the sun?
 - Venus
 - Mercury
 - Mars

See pages 132–133 for the answers

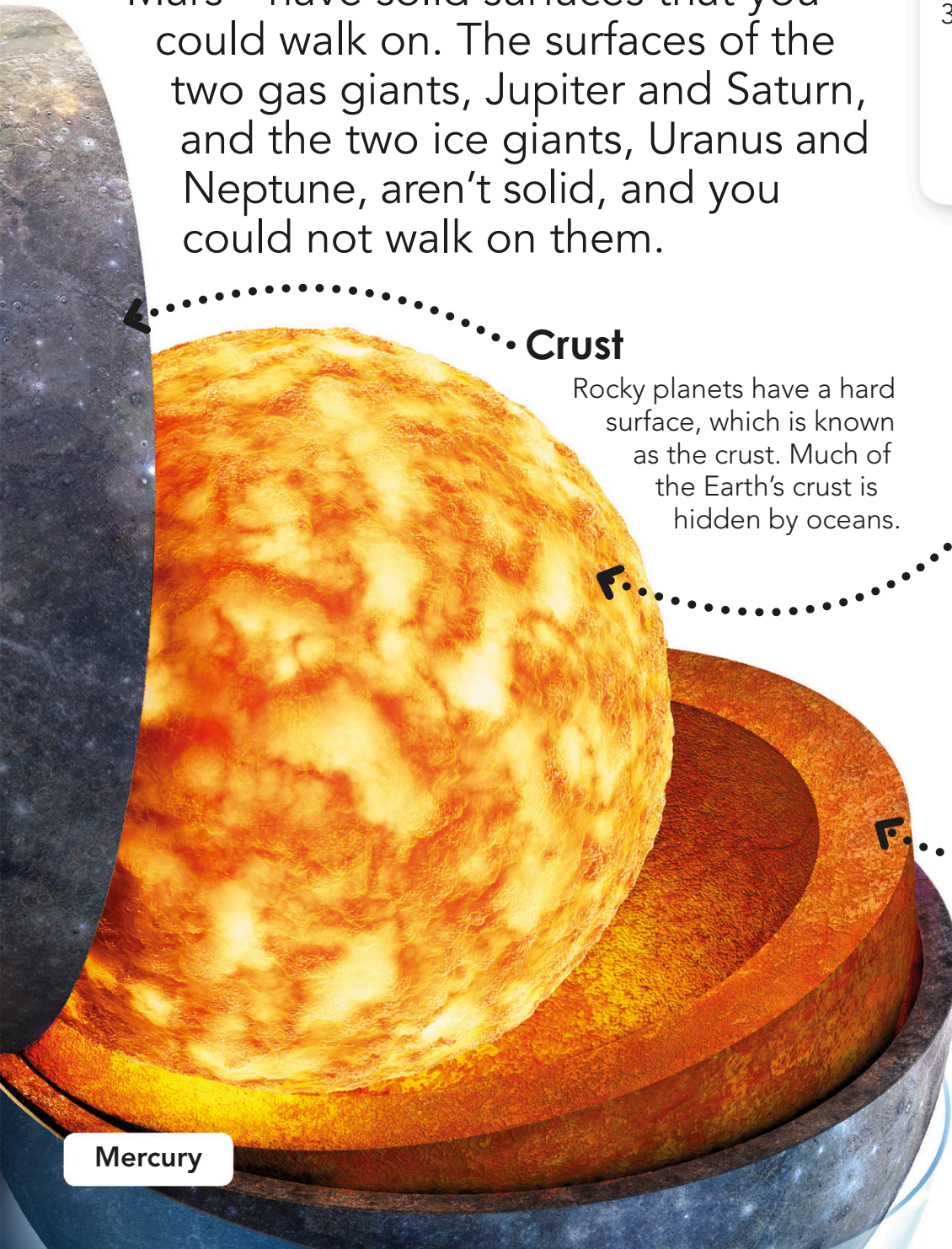
What are planets made of?

In our solar system, the four inner rocky planets—Mercury, Venus, Earth, and Mars—have solid surfaces that you could walk on. The surfaces of the two gas giants, Jupiter and Saturn, and the two ice giants, Uranus and Neptune, aren't solid, and you could not walk on them.

? True or false?

1. There are eight rocky planets in the solar system.
2. Gas giants have a small, rocky core.
3. The surface of the Earth is called the crust.

See pages 132–133 for the answers



Crust

Rocky planets have a hard surface, which is known as the crust. Much of the Earth's crust is hidden by oceans.

Core

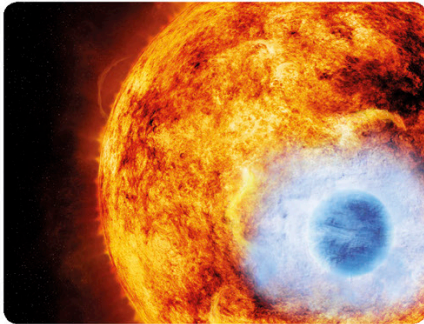
All rocky planets have a similar structure. Each has a metallic core, or center, which is mostly made of iron.

Mantle

The part of the planet between its crust and core is called the mantle. It is made of many rocky layers.

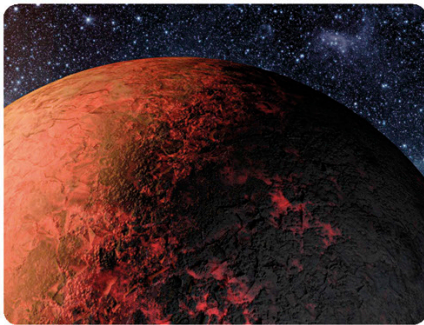
Mercury

What are planets outside our solar system made of?



HD 189733b

Planets that orbit other stars are made of the same kind of stuff—rocks and gases—as the planets in our solar system. HD 189733b is a huge gas giant like Jupiter. It is blue and rains liquid glass!



Kepler-186f

This is the most “Earthlike” planet discovered so far. It is a similar size as our planet, and scientists think that, like Earth, it might be rocky and have water on its surface.

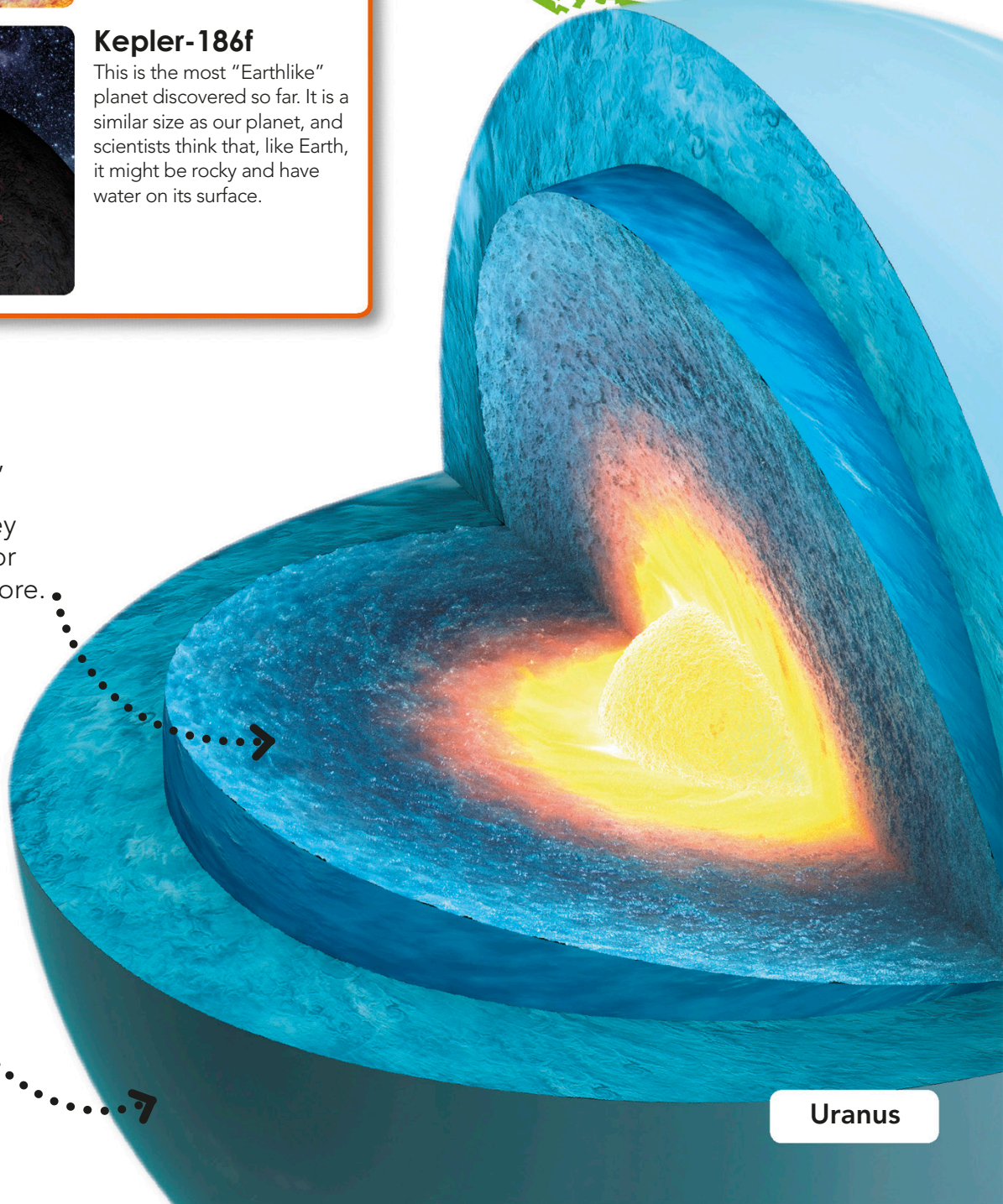
Scientists do not know the size of Jupiter's rocky core because it is hidden below layers of gas and liquid.

Layers

Unlike the rocky planets, ice and gas giants don't have a hard surface. They are made mostly of ice or gas with a small, rocky core.

Atmosphere

Ice and gas giants have many layers of clouds. Underneath the cloud tops, the atmosphere gets thicker and thicker.



Uranus

Why is there life on Earth?

Earth is at just the right distance from the sun for it to be not too hot and not too cold for life to exist. This is called the habitable zone. Our planet also has all the ingredients needed for life to begin and survive. These include liquid water, raw materials such as soil, and energy from the sun.

Energy

For life to exist, there needs to be a constant source of energy. On Earth, that energy comes from the sun.

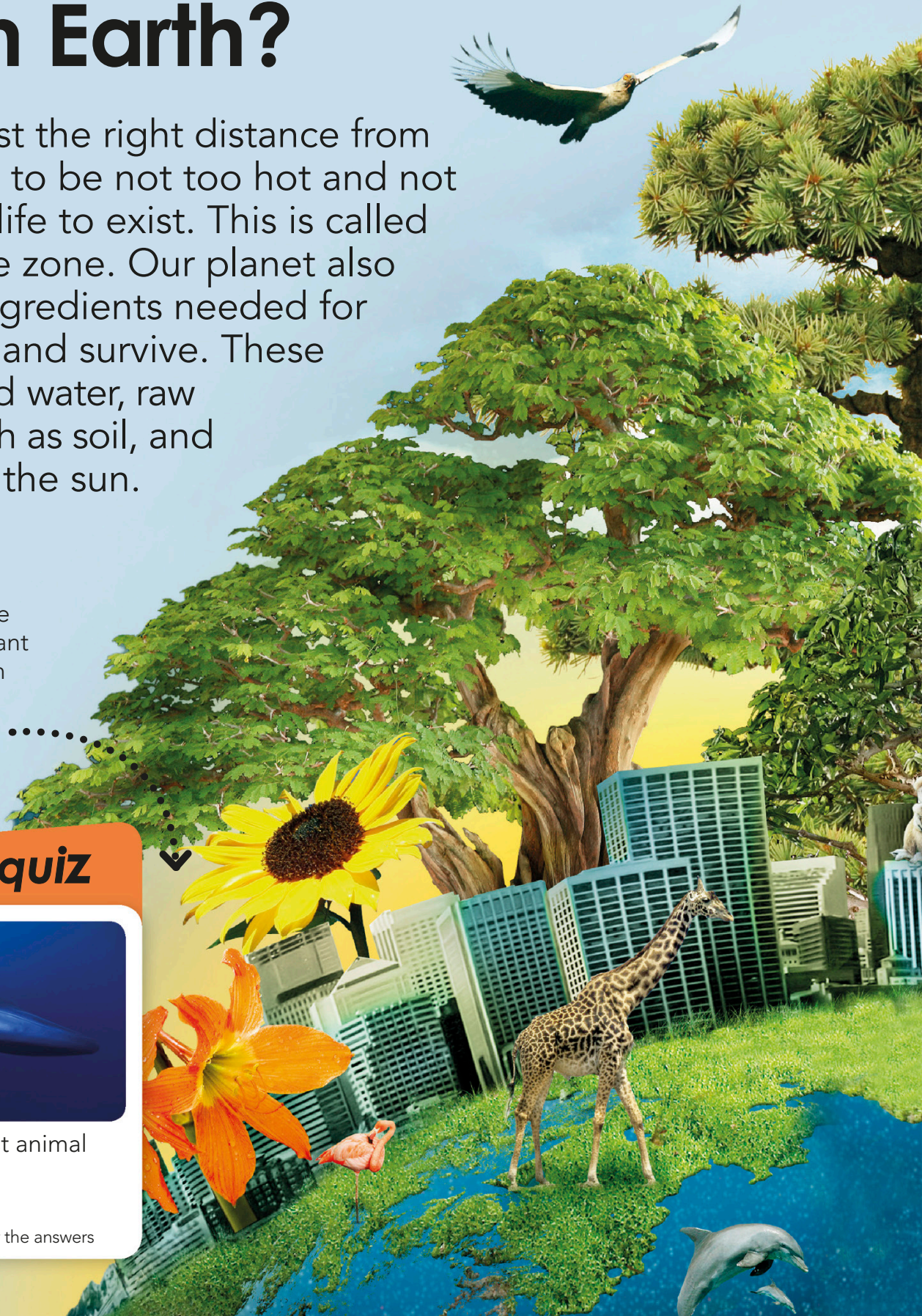


Picture quiz



What is the biggest animal on Earth?

See pages 132–133 for the answers



Raw materials

The raw materials that make up all living things can be found almost anywhere on Earth. Add water and energy to these materials and life can appear. This is how all plants, animals, and everything living on Earth began.

Where does life come from?



Stardust

All the ingredients that made the Earth and everything on it came from stardust. This was created when dying stars exploded. This means that we are all made from stardust! This dust later made more stars and planets like Earth.

Life began
on Earth more
than 3.5 billion
years ago!

Water

Planet Earth has plenty of liquid water, unlike the other planets in our solar system. Water is essential for life—without it, life would not exist.



Why is Jupiter striped?

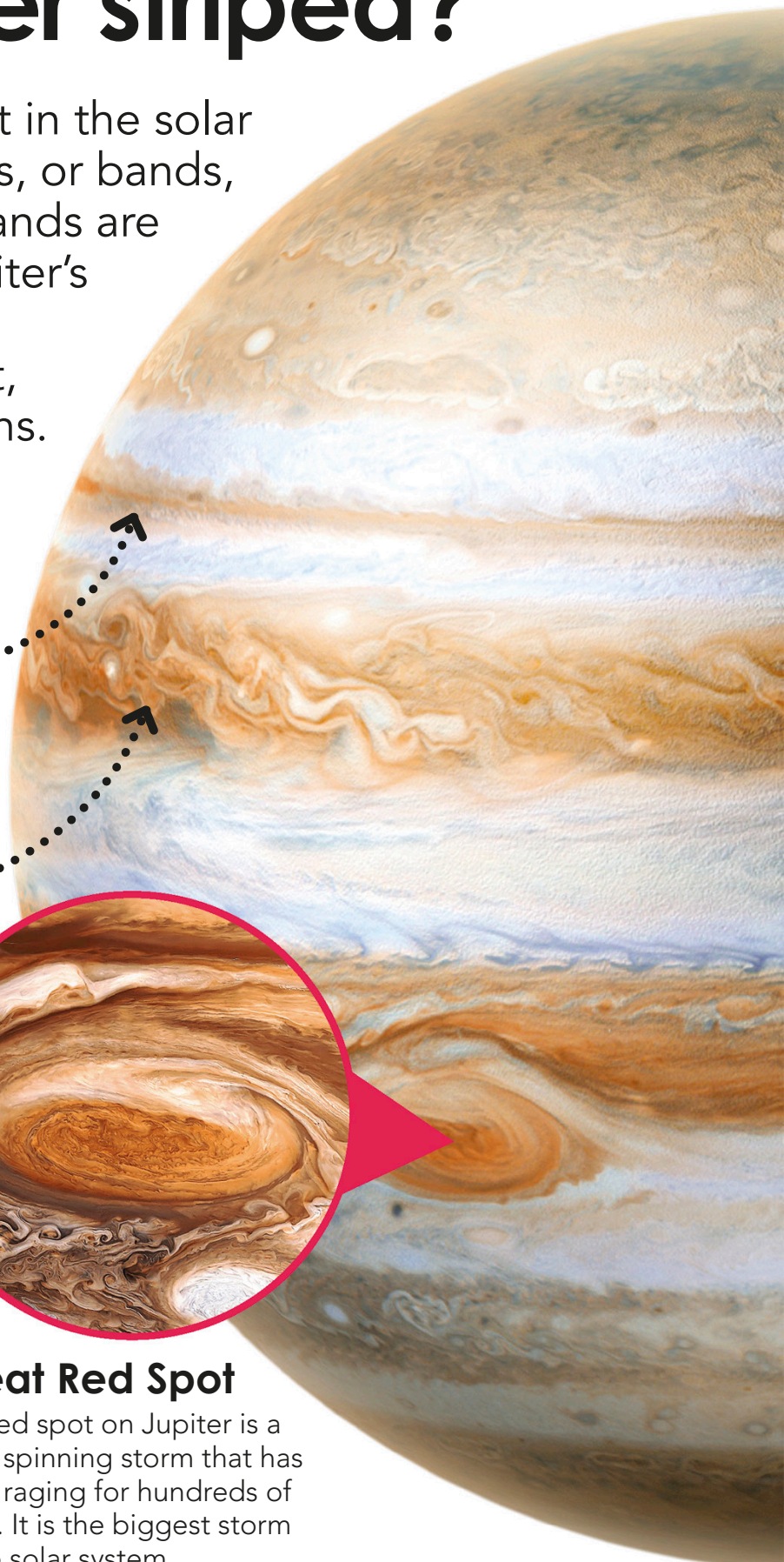
Jupiter is the biggest planet in the solar system. It has several stripes, or bands, of different colors. These bands are caused by chemicals in Jupiter's clouds and also by winds that whip around the planet, moving in different directions.

Rapid rotation

Jupiter is the fastest spinning planet in the solar system. It takes less than 10 hours to make one complete turn, or rotation.

Strong winds

Jupiter is a very windy and stormy planet. Its winds are created deep inside the planet and blow across it at hundreds of miles an hour.



Picture quiz



On which planet was this giant storm spotted?

See pages 132–133 for the answers

Great Red Spot

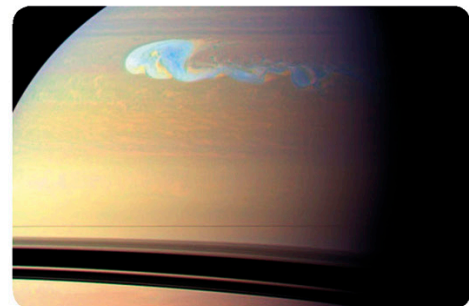
The red spot on Jupiter is a huge spinning storm that has been raging for hundreds of years. It is the biggest storm in the solar system.

Icy clouds

Jupiter's north pole is covered in icy storm clouds. The pole also has massive light shows, which are similar to the auroras that are seen on Earth.

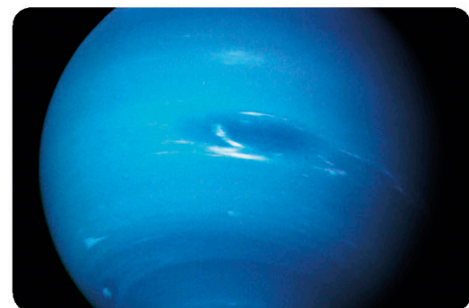


Which other planets are stormy?



Great White Spot

Huge thunderstorms raging on Saturn show up every few years as the Great White Spot. They often spread right around the planet.



Great Dark Spots

Neptune is the windiest planet in the solar system. It has giant dark spots, which are gigantic spinning storms, like hurricanes. These spots will often suddenly appear and then disappear again.

In 2010,
one of Jupiter's big
stripes disappeared.
It then reappeared
a few months
later.

Is there life on Mars?

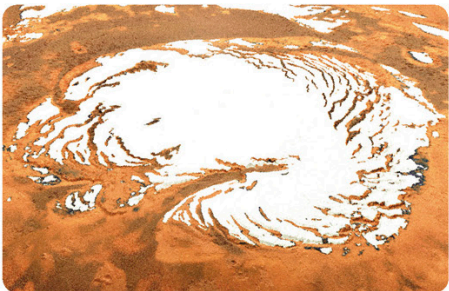
Long ago, Mars was warmer and wetter than it is now, with a thicker atmosphere, or layer of gas, surrounding the planet. This means there could once have been life on it. There may even be tiny life forms there today.

What is the weather like on Mars?



Dust storms

Mars often has huge dust storms. These storms are sometimes so big that they can be seen by telescopes on Earth.



Cold weather

Mars is a cold world, with a much thinner atmosphere than Earth. Its average temperature is a chilly -76°F (-60°C).

Olympus Mons

The largest volcano in the solar system is on Mars. It is called Olympus Mons, and it is 16 miles (25 km) high, which is nearly three times the height of Mount Everest.



Frozen poles

Just like Earth, Mars has ice caps covering its north and south poles. The ice is made of frozen water and frozen carbon dioxide.

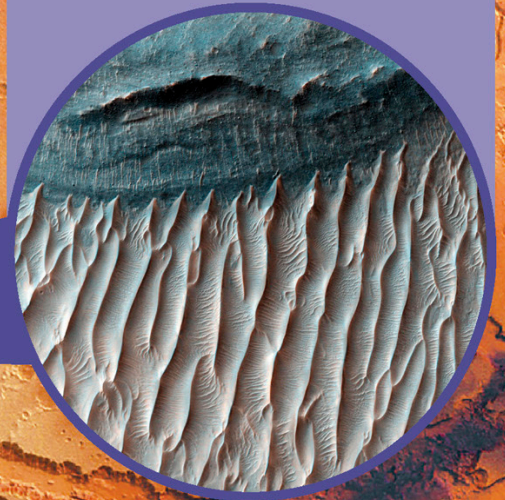
? True or false?

1. Mars is a smaller planet than Earth.
2. Mars does not have a south pole.
3. Mars may have once had life.

See pages 132–133 for the answers

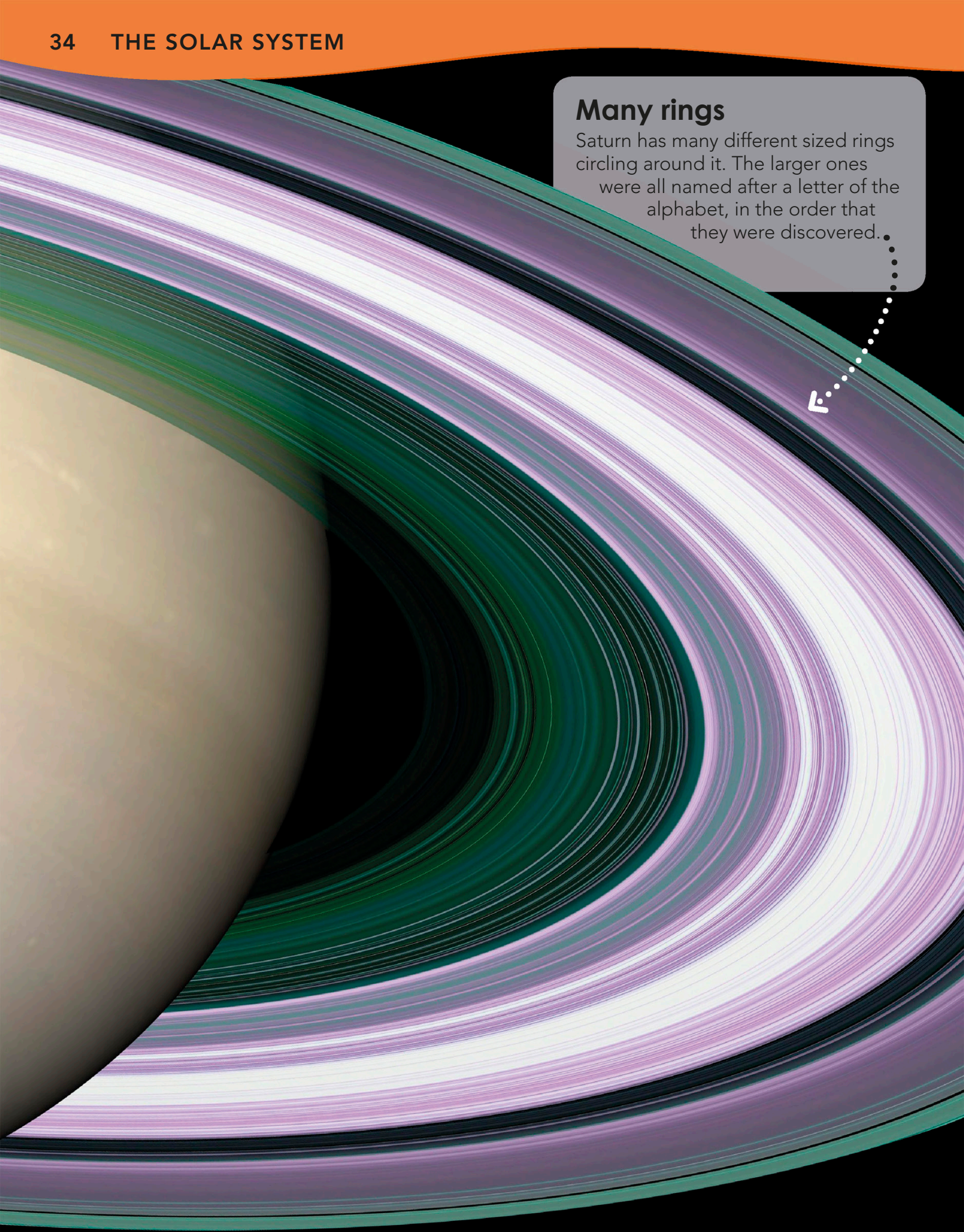
Signs of water

The rule used by scientists who are looking for life elsewhere in the universe is to follow the water! Streaks on Mars's surface are thought to have been made by the flow of very salty water.



Many rings

Saturn has many different sized rings circling around it. The larger ones were all named after a letter of the alphabet, in the order that they were discovered.



What are Saturn's rings made of?

When you look at Saturn through a telescope, you can see beautiful rings circling the planet. They are made of icy rock and dust. No one knows for sure why Saturn has rings. They may be the remains of a moon that was destroyed or material left over from when Saturn formed.

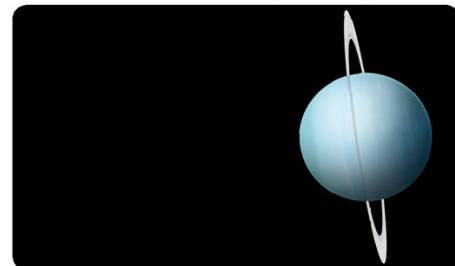
Gaps in the rings

The dark areas are gaps in between Saturn's rings. The biggest gap is called the Cassini Division and is thought to have been made by Mimas, one of Saturn's moons. As Mimas orbits Saturn, its gravity pulls rocks out of the rings.

Close-up

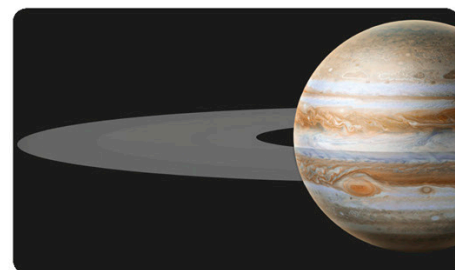
There are billions of pieces of ice, rock, and dust in Saturn's rings. The rings are as wide as the gap between the Earth and the moon.

Do any other planets have rings around them?



Uranus

Ice giant Uranus has rings that circle it. The rings are much smaller than those around Saturn. Uranus's neighbor Neptune has similar rings, too.



Jupiter

The rings that circle Jupiter are mostly made of dust. This dust was formed when space rocks, or meteoroids, crashed into some of Jupiter's moons.

? True or false?

1. Saturn is the only planet in the solar system with rings.
2. Saturn has more than one ring.
3. Jupiter has rings made of dust.

See pages 132–133 for the answers

Is Pluto a planet?

For many years Pluto was known as a planet, but this is no longer the case. Pluto is now called a dwarf planet. It is much smaller than other planets, but it does still have a lot in common with them—it is round, has moons, and orbits the sun.

Small size

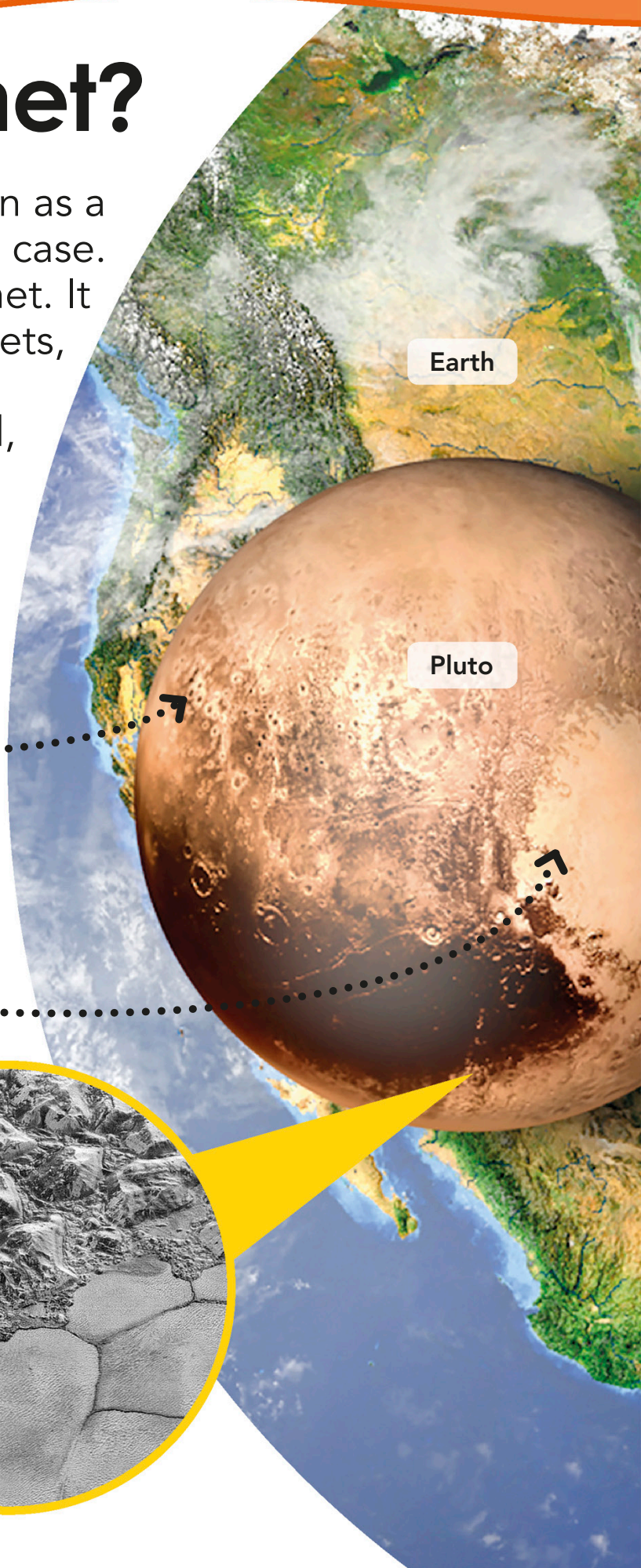
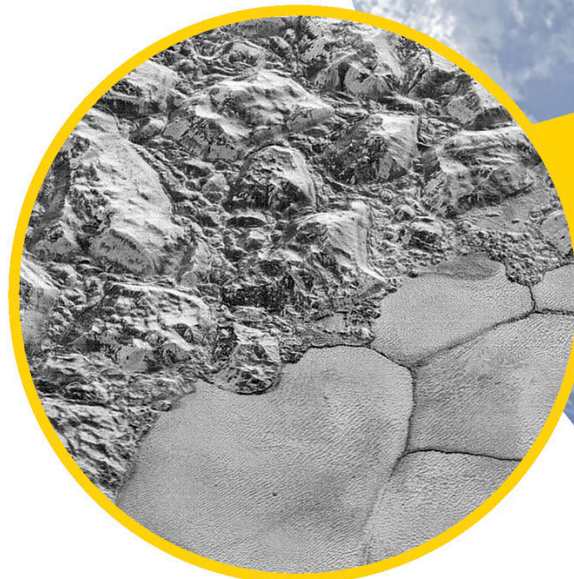
Pluto is smaller than Earth's moon. It is far away from the sun in a region of the solar system called the Kuiper Belt, which lies beyond the planet Neptune.

Pluto's heart

This part of Pluto's surface is shaped like a heart. It is smooth and doesn't have craters. Its name is Tombaugh Regio, after Clyde Tombaugh, the American astronomer who discovered Pluto in 1930.

Pluto's surface

There are craters, gigantic rivers of ice called glaciers, and mountains on Pluto's surface. Scientists think there may also be volcanoes that spew out ice instead of lava.





Quick quiz

1. What is Pluto?
2. How many dwarf planets have been discovered so far?
3. Does Pluto have moons?

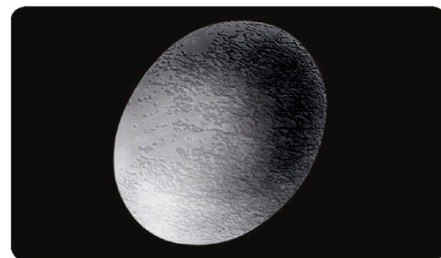
See pages 132–133 for the answers

Are there other dwarf planets?



Makemake

Makemake is a cold dwarf planet and it has at least one moon. So far, there are five known dwarf planets, and four of them are in the Kuiper Belt. There are probably many more waiting to be discovered.



Haumea

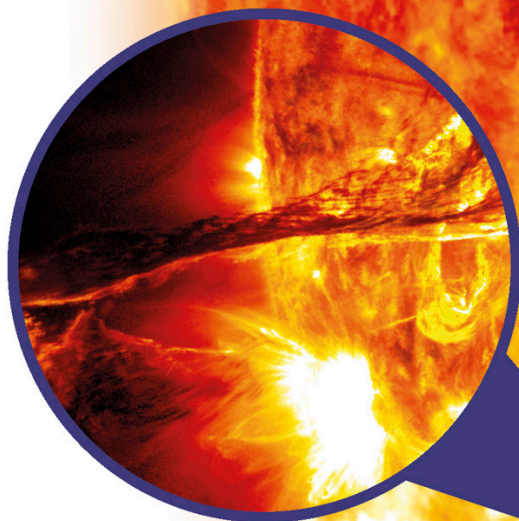
This dwarf planet takes 283 Earth years to complete one orbit around the sun. Haumea is shaped like a football and has two moons. A space probe has not yet visited Haumea.

Corona

The second-hottest part of the sun is its outer atmosphere (layer of gas), called the corona. Scientists do not yet understand why it is hotter than the surface.

Solar flare

Solar flares are gigantic eruptions of energy from the surface of the sun. They can take days to build up before exploding in a dramatic fashion. They are the biggest explosive events in the solar system, and they can last from a few minutes to several hours.



How hot is the sun?

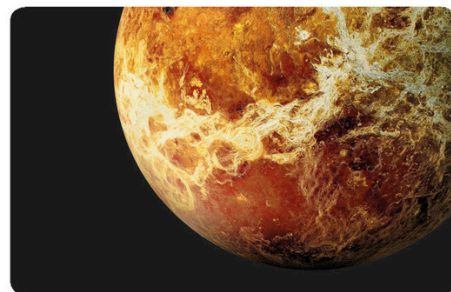
The sun is a sizzling ball of gas. It is our closest star and the hottest thing in our solar system. If you were able to stick a thermometer on its surface, it would read a scorching 11,000°F (6,000°C). The hottest part of the sun, however, is its center, or core.

Which planets are the hottest?



Mercury

Temperatures on tiny Mercury can reach a searing 790°F (420°C). It is the closest planet to the sun.



Venus

Even though Venus is farther away from the sun than Mercury, it is actually hotter. Venus has a thick atmosphere covered by clouds that trap in the sun's heat.

Sunspots

Sunspots are dark spots that appear on the sun's surface. They are the coolest parts of the sun and often appear in pairs.



Quick quiz

1. Which is the hottest part of the sun?
2. What are solar flares?
3. Can you guess how far away the Earth is from the sun?

See pages 132–133 for the answers

Why does the moon change its shape?

The moon can be seen in the night sky from almost anywhere on Earth. Sometimes it is a bright, round circle, and other times it is a crescent shape. The moon itself isn't really changing, it just looks different from Earth. This is because we see different amounts of the sunlit side of the moon as it orbits Earth.

1. New moon

In this phase, we cannot see the moon from Earth because its lit face is directly toward the sun.

2. Waxing crescent

As the moon moves away from the sun, we see sunlight reflected off a tiny part of it. We see a sliver, or crescent.

3. First quarter

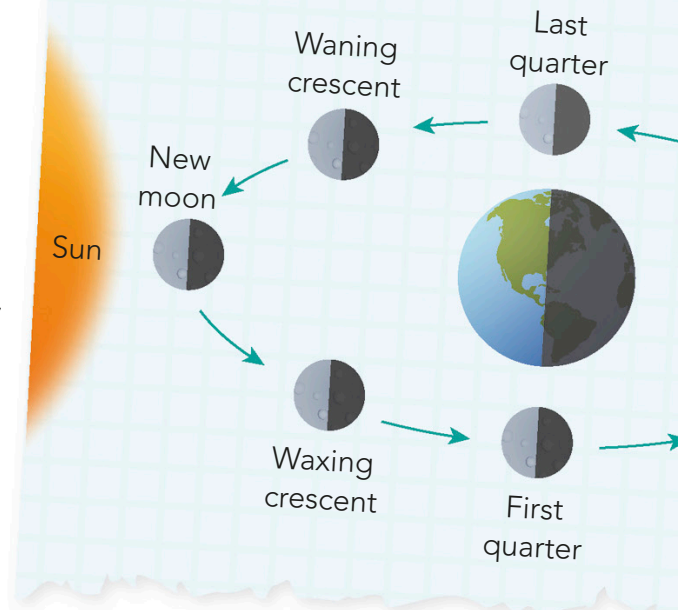
The moon has now traveled a quarter of its orbit. We can see about half of it.

4. Waxing gibbous

The moon becomes bigger each night. It's described as "gibbous," which means it looks swollen on one side.

Phases of the moon

The moon takes just less than 28 days to orbit the Earth. The different shapes that the moon appears to be are known as phases. This is what the moon's orbit looks like from space.



1



2



3



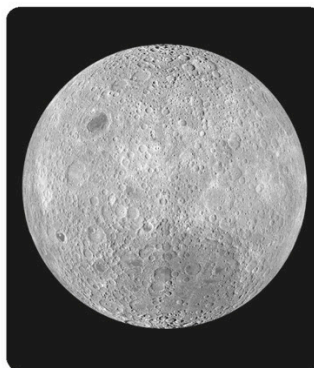
4

What are the two sides of the moon?



Near side

The near side of the moon is the side that always faces Earth. The Earth helps to shield it from collisions with space rocks, but some do still hit it and make craters.



Far side

The far side of the moon never faces the Earth. The only people who have ever seen the far side are astronauts who have flown over it. There are many craters on this side.

The moon is the brightest object that you can see in the night sky!

? True or false?

1. Earth orbits the moon.
2. The far side of the moon has many craters.
3. There are eight phases of the moon.

See pages 132–133 for the answers

5. Full Moon

The complete face of the moon reflects the sun's light. We can now see a full moon.

6. Waning gibbous

The moon is now waning, or shrinking. It will keep waning until there's another new moon.

7. Last quarter

The moon is now three-quarters of the way around the Earth.

8. Waning crescent

We can now see just a sliver of the moon. It has almost completed a full orbit of the Earth.



5



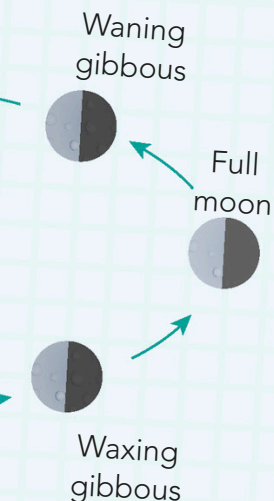
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7



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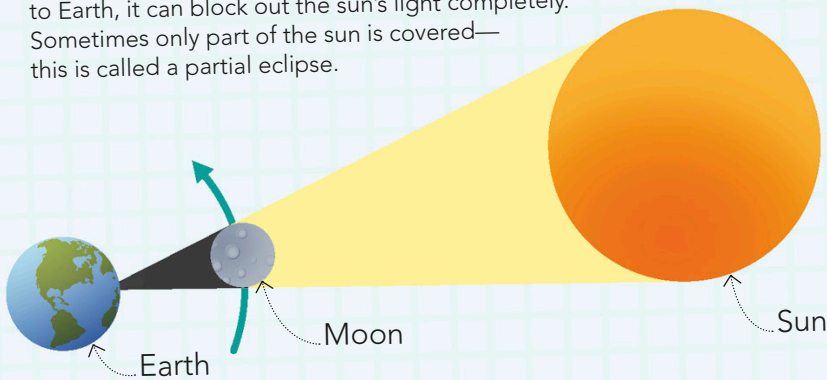


Can it be dark in the daytime?

A solar eclipse can cause it to be dark on Earth during the daytime. This is when the moon passes directly between the Earth and the sun. The moon blocks out the sunlight, making some places on Earth become dark.

How a solar eclipse works

When the moon reaches a certain point in its orbit, it sometimes passes directly between the Earth and the sun. The moon is smaller than the sun, but, because it is closer to Earth, it can block out the sun's light completely. Sometimes only part of the sun is covered—this is called a partial eclipse.

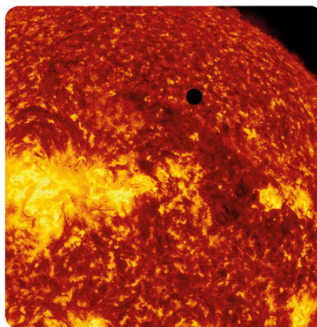


Are there other types of eclipses?



Lunar eclipse

A lunar eclipse is when the Earth passes between the moon and the sun. Earth's shadow makes the moon go dark, but some sunlight reaches the moon and causes it to appear red.



Venus transit

Sometimes Venus and Mercury pass between the Earth and the sun. This is called a transit. The black dot here shows Venus crossing the sun.



During a solar eclipse, birds will often stop singing because they think it's nighttime.

Sun's corona

When the moon covers the sun, the sun's atmosphere can be seen. This is known as the "corona."



Quick quiz

1. Can you guess how long a solar eclipse takes?
2. Why should people wear special glasses to watch a solar eclipse?
3. What is it called when the moon only covers part of the sun?

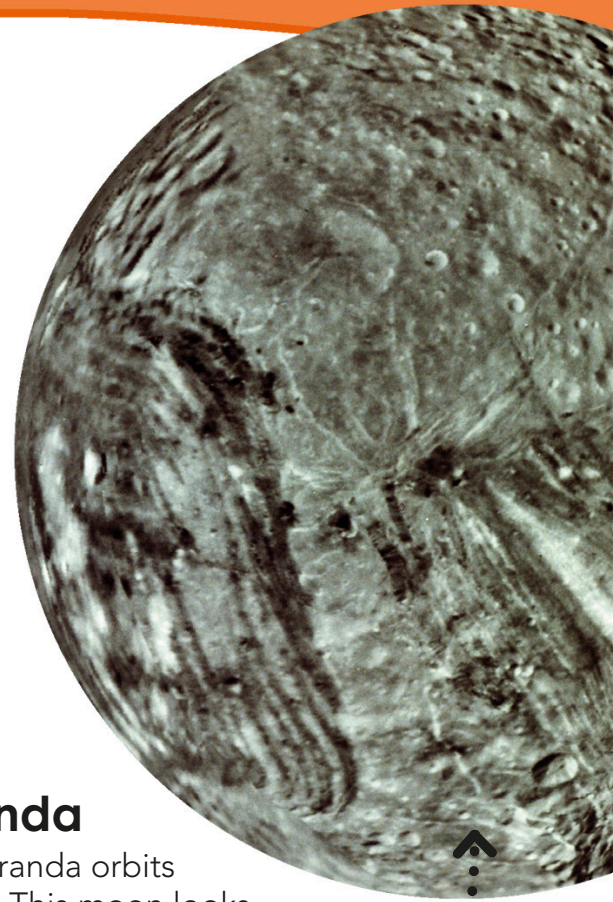
See pages 132–133 for the answers

Diamond ring

Just at the point when the moon covers the sun, a beautiful flash of light can be seen. This is called the "Diamond Ring."

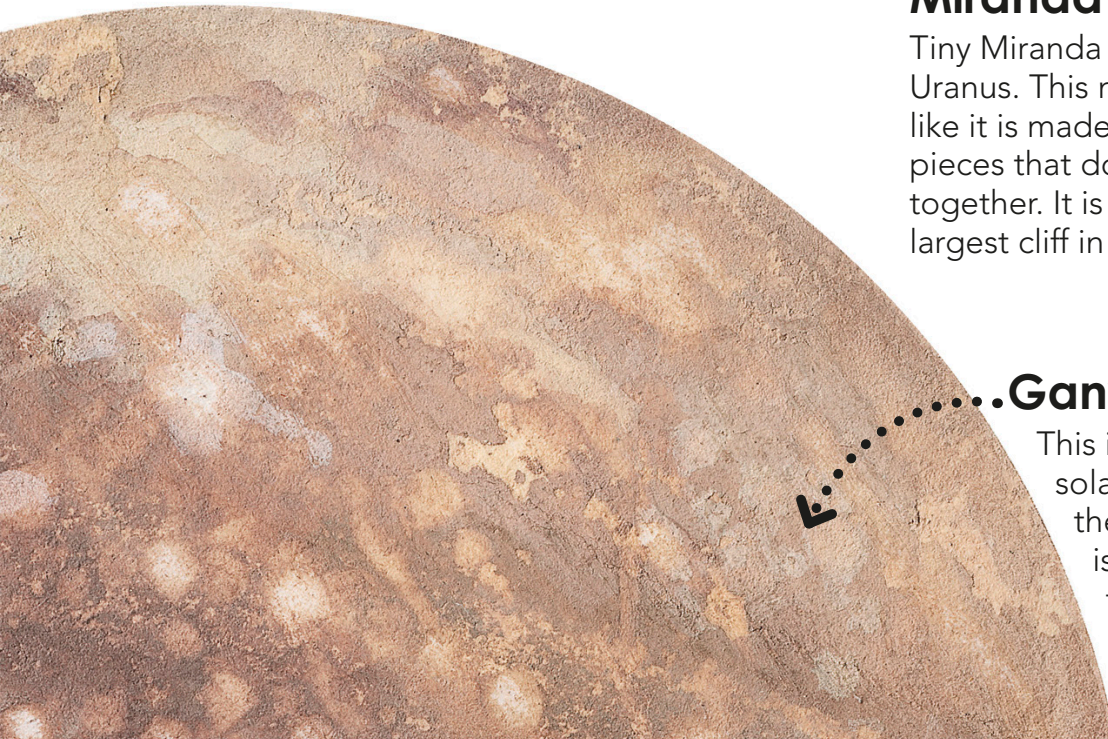
Do other planets have moons?

Our moon is not the only one in the solar system. Except for Venus and Mercury, all of the other planets have moons. Some asteroids have moons and the dwarf planet Pluto has five moons.



Miranda

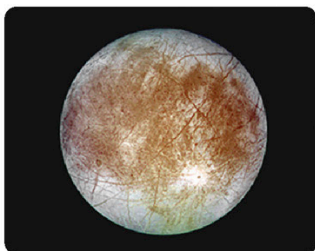
Tiny Miranda orbits Uranus. This moon looks like it is made of lots of different pieces that don't quite fit together. It is home to the largest cliff in the solar system.



Ganimede

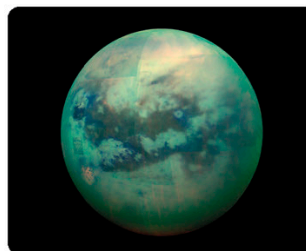
This is the biggest moon in the solar system—even bigger than the planet Mercury! Ganimede is one of the 67 moons that orbit Jupiter.

Could there be life on any moons?



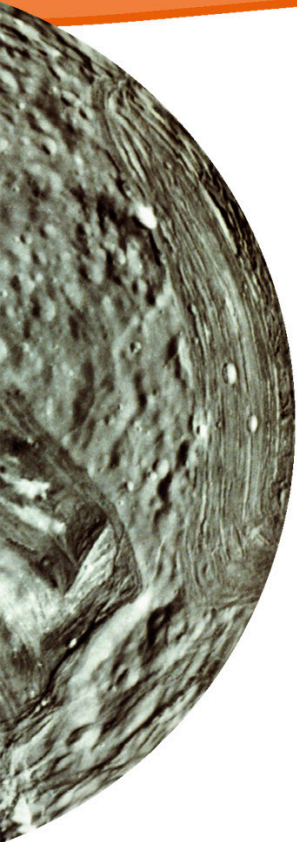
Europa

This moon orbits Jupiter. It has a liquid ocean lurking beneath its frozen surface. Scientists think it is possible that there could be life in Europa's ocean.



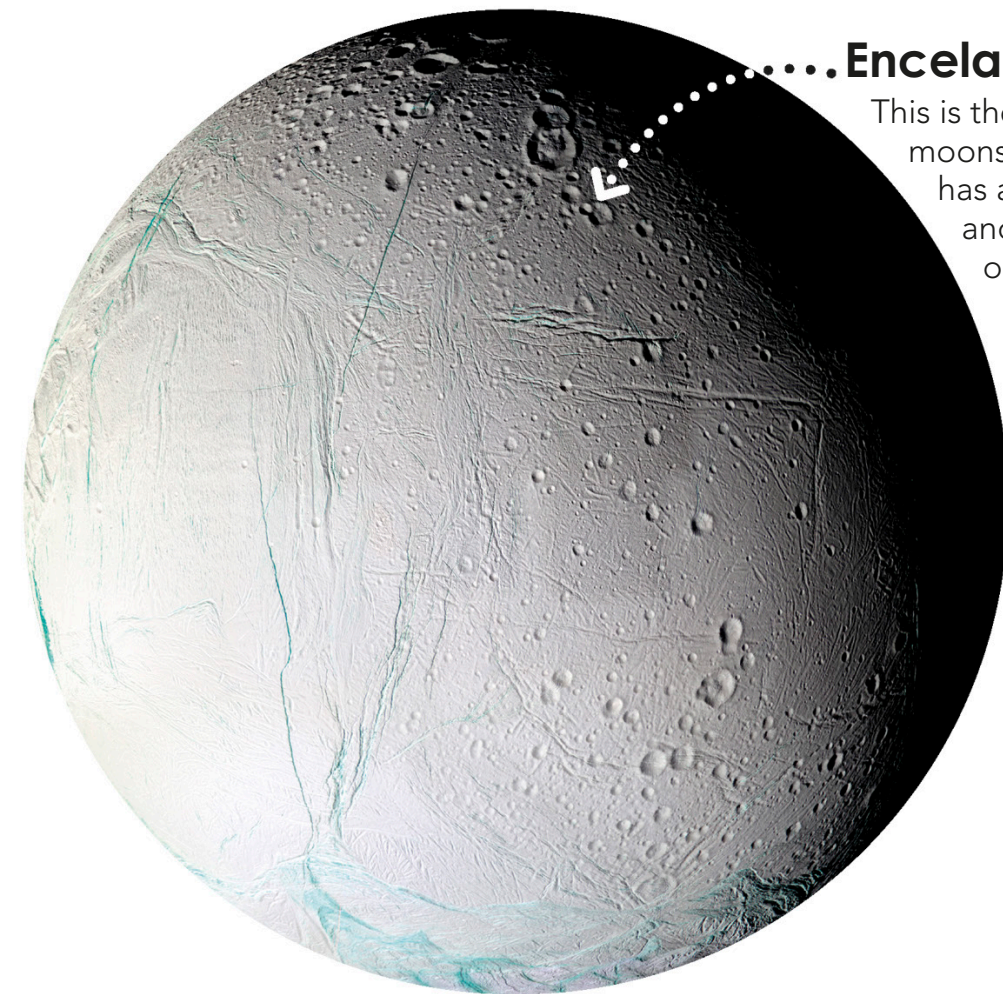
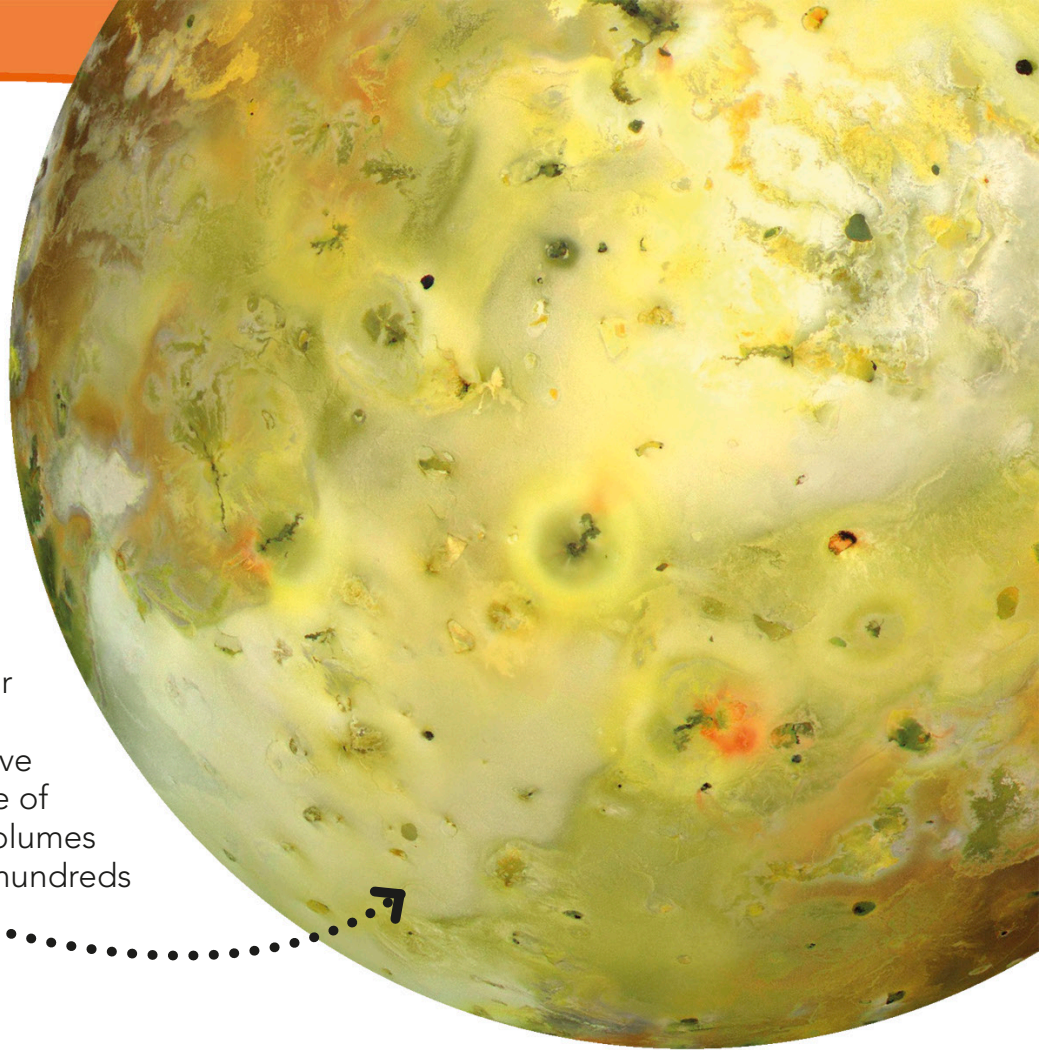
Titan

This moon of Saturn is the only one in our solar system with an atmosphere. Scientists think Titan could be like a young Earth, and that some form of life may exist there.



Io

This moon of Jupiter is the most volcanic place in our solar system. Io has hundreds of active volcanoes. Some of them spew out plumes of lava that rise hundreds of miles high.

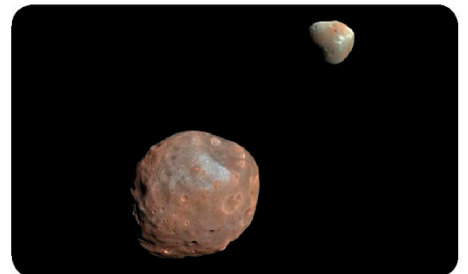


Enceladus

This is the sixth largest of Saturn's 62 moons. It is covered in an icy crust that has an ocean below it. Eruptions of rock and dust from Enceladus have formed one of Saturn's outer rings.



Picture quiz



Which rocky, red planet do these two oddly shaped moons belong to?

See pages 132-133 for the answers

What would happen if a meteor hit the Earth?

Many pieces of space rock and dust enter the Earth's atmosphere every day, but most burn up before they reach the surface. Sometimes small pieces survive and hit the ground. Very rarely, large rocks hit the Earth, and they can make big craters, such as Barringer Crater in Arizona.

Meteoroid



Meteor



Meteorite

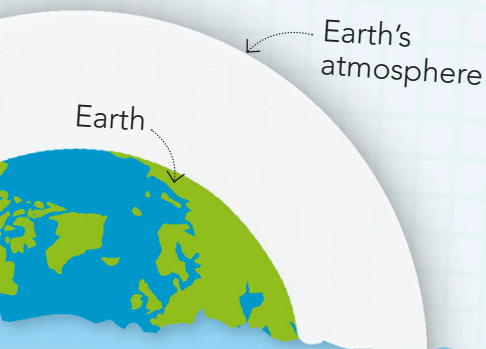


Viewing platform

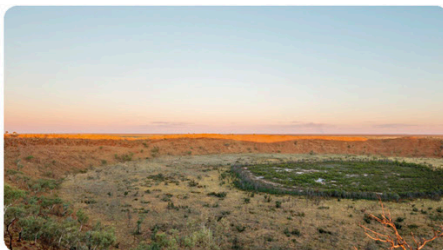
This specially built viewing platform lets visitors peer down into the huge crater.

Meteoroids, meteors, and meteorites

Meteoroids, meteors, and meteorites are practically the same thing—the only difference is their location. A meteoroid is a piece of rock or metal that is moving through space. If it enters Earth's atmosphere, it is then a meteor. If it doesn't burn up and lands on the Earth, it is then a meteorite.



How can you find a meteorite?



Choose your location

Meteorites are easiest to spot in places that have few earth rocks. These places are deserts, dry lake beds, or on the frozen continent of Antarctica.



Use a metal detector

Some meteorites are rocks that contain a lot of metal. This means that you can use a metal detector to help you find meteorites that might be buried underground.

Barringer Crater

Barringer Crater was named after Daniel Barringer. He was the first person to suggest that the crater was made by a meteorite that had hit the Earth.

Deep crater

This crater was made by a meteorite that crashed to Earth about 50,000 years ago. It is 560 ft (170 m) deep and 3,900 ft (1,200 m) wide.



Quick quiz

1. Where would you find a meteoroid?
2. Where is Barringer Crater?
3. What is a meteorite?

See pages 132–133 for the answers

What is a shooting star?

A shooting star isn't really a star, it is a meteor. This is a piece of rock or dust from space that enters the Earth's atmosphere. As it moves through our atmosphere, it heats up and leaves a streak of hot gas behind it in the sky. When there are lots of shooting stars, it is called a meteor shower.

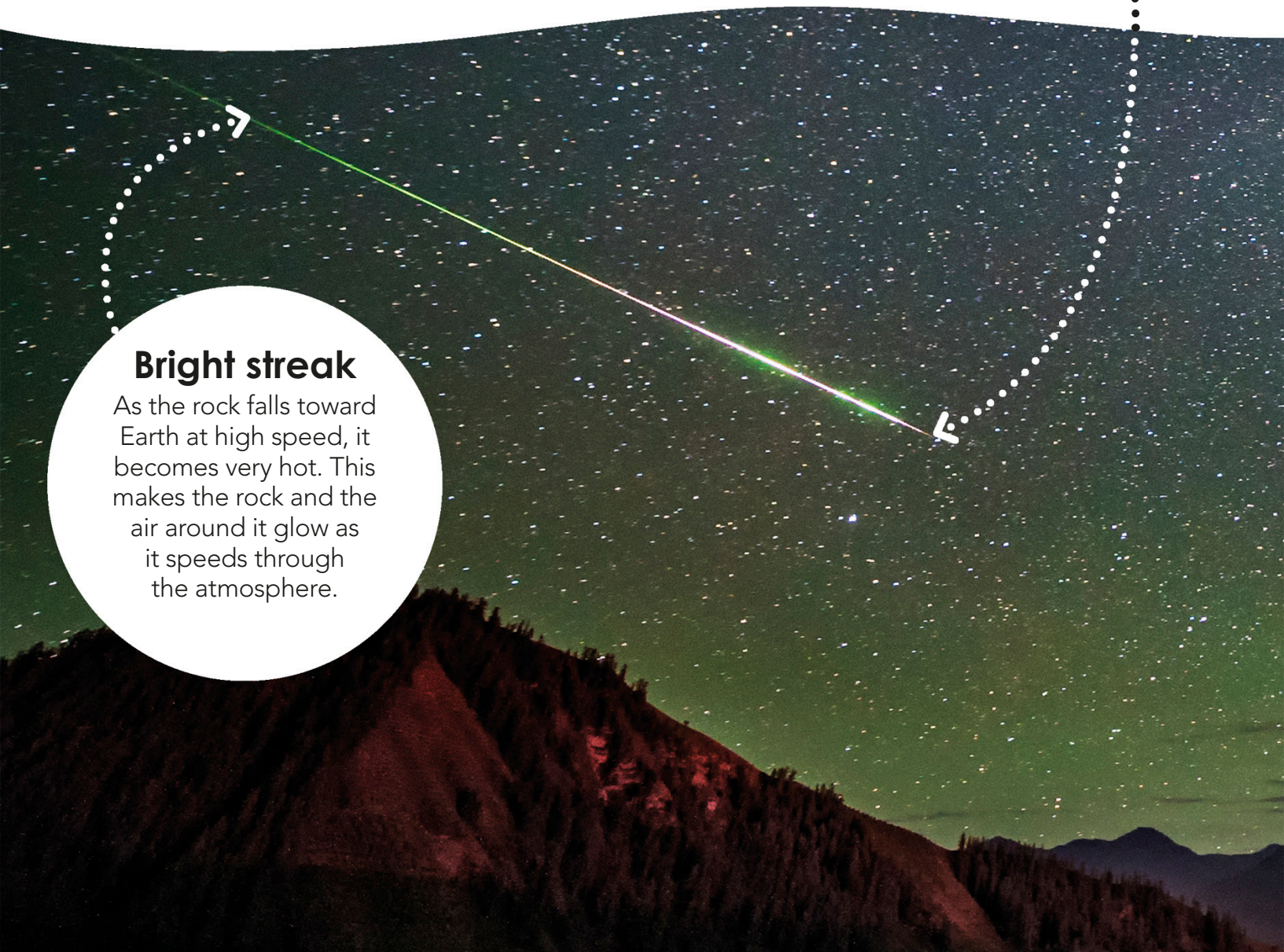
Most meteor showers don't make a sound, but sometimes a hissing noise can be heard.

Burning up

The pieces of rock and dust are normally very small. They will usually burn up before they reach the Earth.

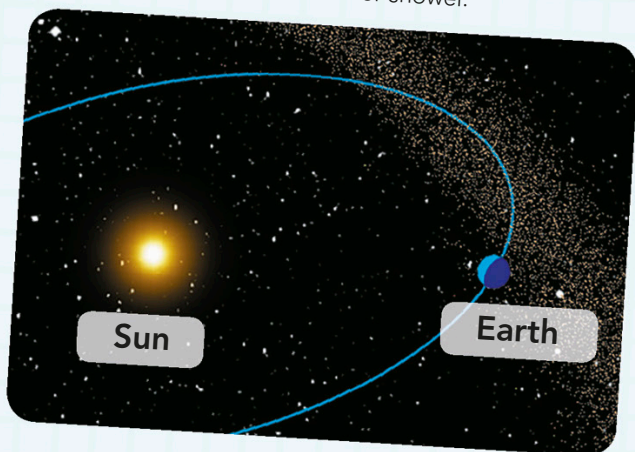
Bright streak

As the rock falls toward Earth at high speed, it becomes very hot. This makes the rock and the air around it glow as it speeds through the atmosphere.



What is a meteor shower?

Comets give off lots of pieces of rock and dust when they travel through space. When Earth's orbit takes it through this trail, the particles enter the Earth's atmosphere and create a meteor shower.



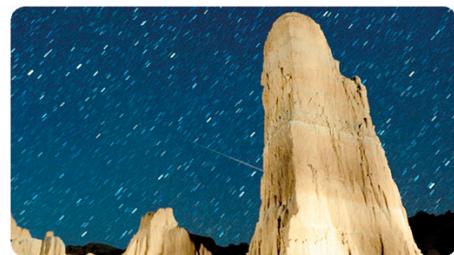
Earth passing through comet dust

Which are the best meteor showers to look out for?



Leonid meteor shower

The Leonids are caused by the comet Tempel-Tuttle. They can be seen every November, around the middle of the month.



Perseid meteor shower

This is one of the most popular meteor showers of the year. The Perseid meteor shower is known for its many fast and bright "shooting stars." It can be seen around the middle of August.

? True or false?

1. You can see the Perseid meteor shower in August.
2. Halley's Comet causes the Leonids.
3. A shooting star is a star falling to the Earth.

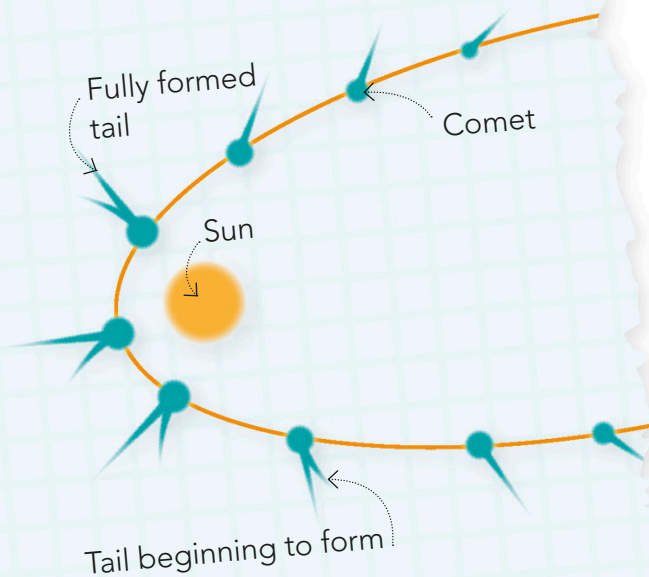
See pages 132–133 for the answers

Why do comets have tails?

Comets are made of gas, dust, and ice that was left over from when the solar system formed. Comets do not have tails all the time. When a comet passes close to the sun, it heats up, causing its surface to boil away and create a tail.

How comet tails form

Comets travel around the sun in an oval-shaped path. As a comet passes close to the sun, it starts throwing out dust and gas because the nucleus is heated by the sun. This forms a tail that points away from the sun.

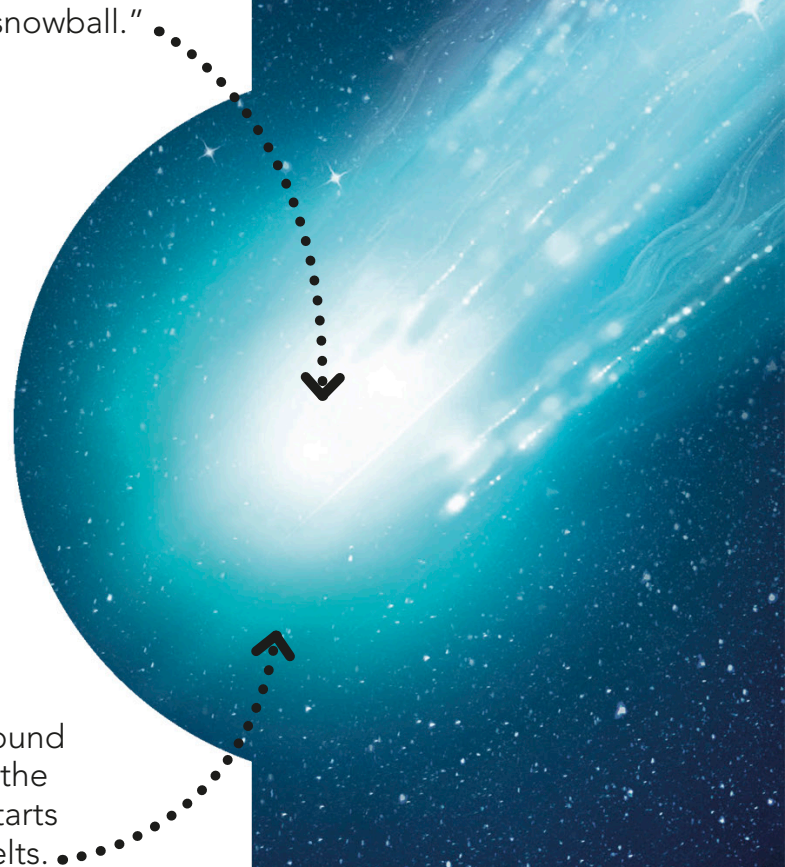


Comet's nucleus

The head of a comet is called the nucleus. It is often known as a "dirty snowball."

Coma

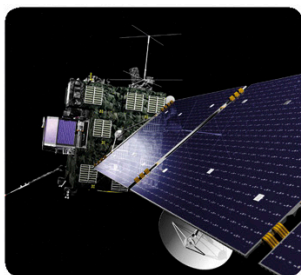
This cloud of dust and ice around the comet's nucleus is called the coma. This is where the tail starts to form as the "snowball" melts.



Comet's tail

The comet's dust tail streaks across the sky for many millions of miles. The tail always points away from the sun.

Is it possible to land on a comet?



Philae

After a 10-year journey across our solar system, the *Rosetta* spacecraft successfully sent a lander, called *Philae*, onto the surface of a comet in 2014.

? True or false?

1. Comets always have tails.
2. The head of a comet is sometimes known as a "dirty snowball."
3. A lander called *Rosetta* has visited the surface of a comet.

See pages 132–133 for the answers

What is the asteroid belt?

The asteroid belt is a ring of big rocks, called asteroids, that orbit the sun. It is found between the planets Mars and Jupiter. There are hundreds of thousands of asteroids in the belt, and they come in many different shapes and sizes.

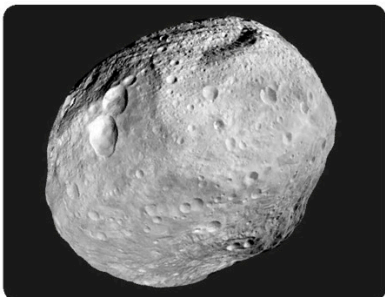
Trojans

These asteroids travel around the sun in the same orbit as Jupiter. They travel in two groups—one group ahead of Jupiter and the other trailing behind it.

Dividing belt

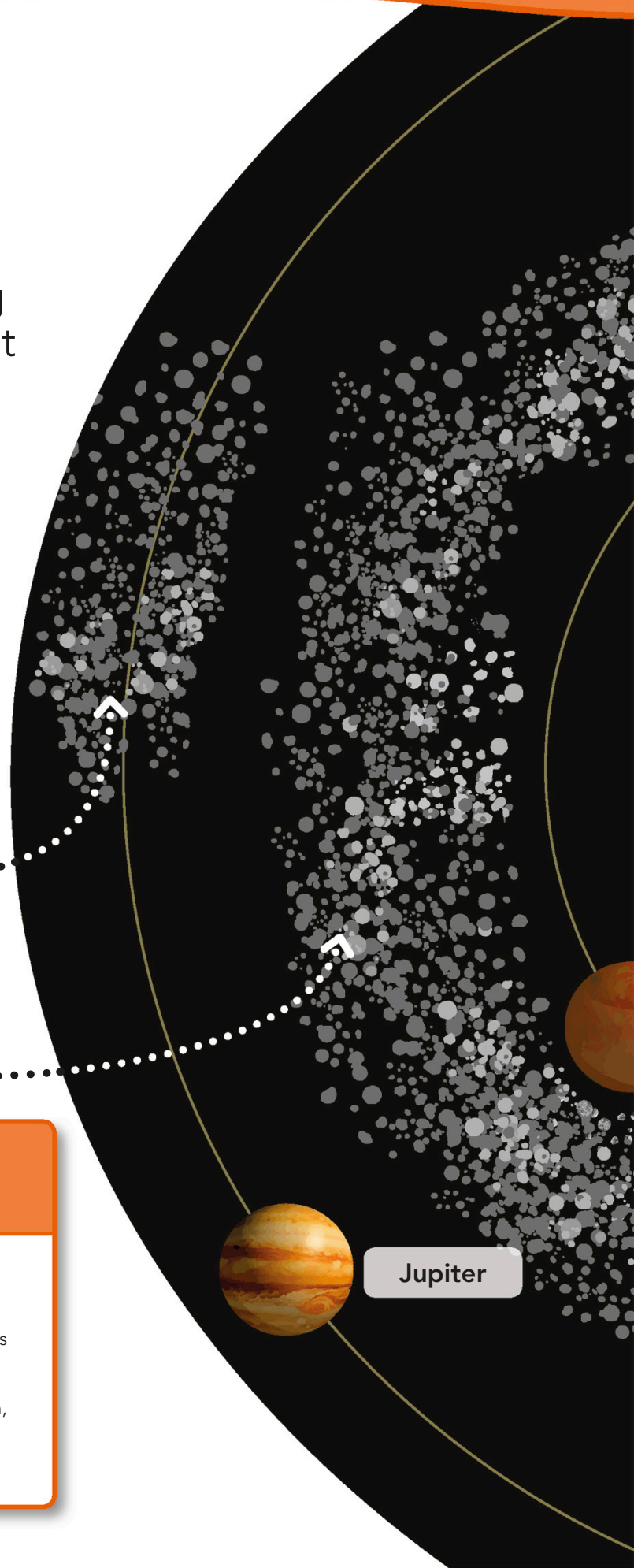
The asteroid belt separates the four inner, rocky planets from Jupiter and the other outer planets.

What can we learn from asteroids?



Vesta

Asteroids, such as Vesta, were left over from when the solar system formed billions of years ago. Studying asteroids can help scientists understand how planets, such as the Earth, were made.



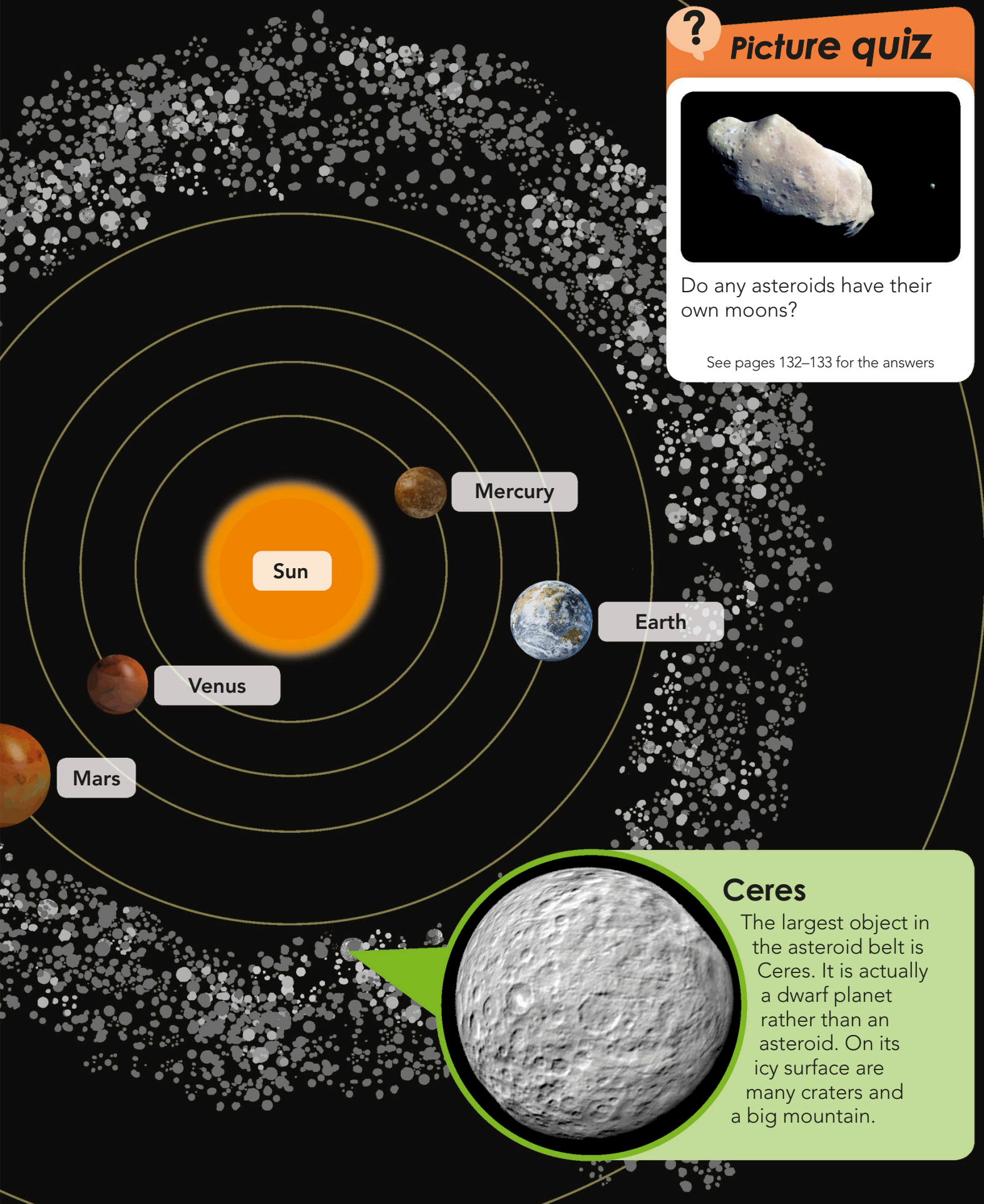


Picture quiz



Do any asteroids have their own moons?

See pages 132–133 for the answers



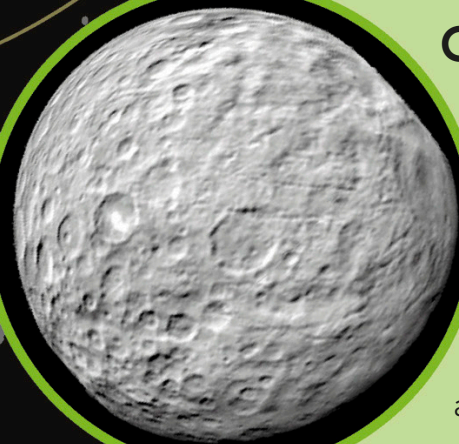
Sun

Mercury

Earth

Venus

Mars



Ceres

The largest object in the asteroid belt is Ceres. It is actually a dwarf planet rather than an asteroid. On its icy surface are many craters and a big mountain.

Can you see the Earth from other planets?

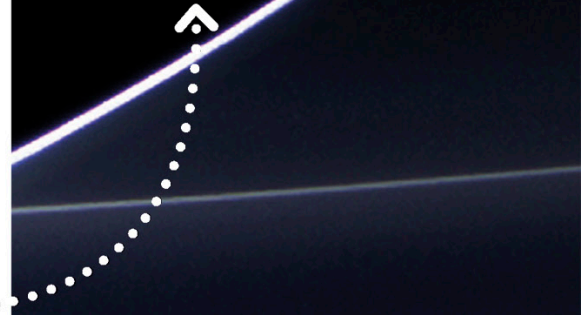
Sometimes when you look up at the night sky, you can see some of the other planets in the solar system. If you could visit these planets, you'd be able to see the Earth in a similar way.

Saturn

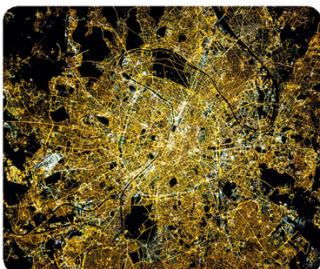
In the corner of this picture is the planet Saturn. It looks dark because the sun is behind it.

Cassini-Huygens

This photograph was taken by the *Cassini* spacecraft. *Cassini* and its companion spacecraft, *Huygens*, visited Saturn to help us learn more about the planet and its largest moon, Titan.



What does the Earth look like from space?



Paris at night

Astronauts living in space and orbiting the Earth can see whole cities from above. The bright lights of Paris look like a beautiful painting in this photograph taken from the International Space Station (ISS).



Erupting volcano

Volcanoes erupting plumes of smoke and ash can be seen from space. The astronauts in the ISS were the first to see the eruption of this volcano, called Mount Cleveland, in Alaska.

A tiny dot

This pale blue dot is the Earth. It is 746 million miles from Saturn. In the future, people may travel far enough into space to see the Earth looking just like this.



? True or false?

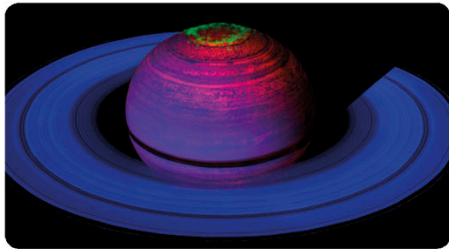
1. You can see the Earth from other planets.
2. You can't see volcanoes from space.
3. From far away, the Earth looks like a pale blue dot.

See pages 132–133 for the answers

What are auroras?

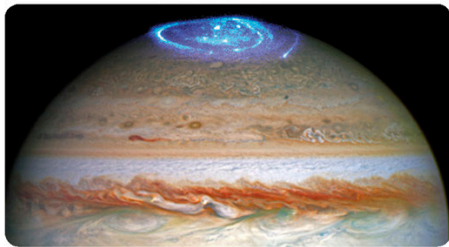
Auroras are naturally occurring light displays that can be seen near the north and south poles. Auroras are formed when particles from the sun enter the Earth's atmosphere at high speed and hit the gases there. This creates colorful curtains of light that appear to float in the sky.

Are there auroras on other planets?



Saturn

Auroras sometimes appear at Saturn's north and south poles. This false-color image shows a dazzling green aurora display around the gas giant's south pole.



Jupiter

Auroras on Jupiter are the most incredible in the whole solar system. This aurora over Jupiter's north pole covers an area bigger than planet Earth!

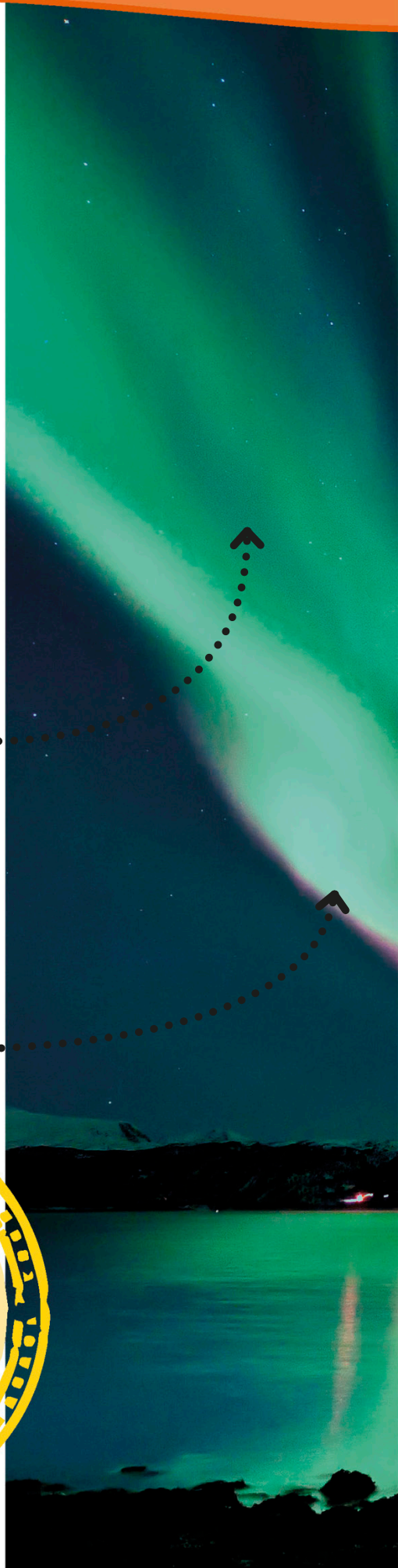
Different patterns

Auroras paint amazingly beautiful patterns in the sky. Sometimes the patterns are swirly or shaped like spirals.

Different colors

You can spot a lot of different colors during an aurora display. The most common color is green, but you may also see purple, pink, red, and yellow.

Astronauts
in space can
sometimes see
auroras as they
orbit the Earth.





? True or false?

1. The best places to see auroras on Earth are near the north and south poles.
2. Auroras can include a lot of different colors.
3. Jupiter has the biggest aurora in the solar system.

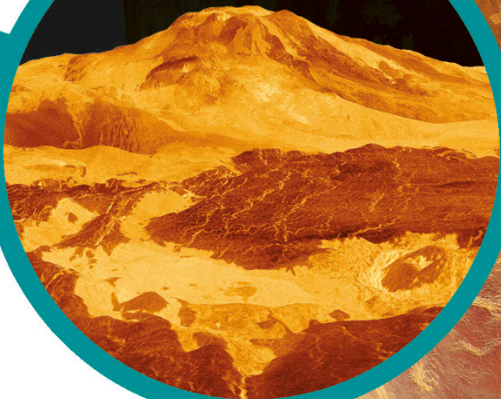
See pages 132–133 for the answers

Could you live on Venus?

Venus is roughly the same size and shape as Earth, but you wouldn't want to live there. It has a thick, toxic atmosphere and temperatures can get as hot as 880°F (471°C). If an unprotected spacecraft landed on the surface of Venus, it would begin to melt in minutes!

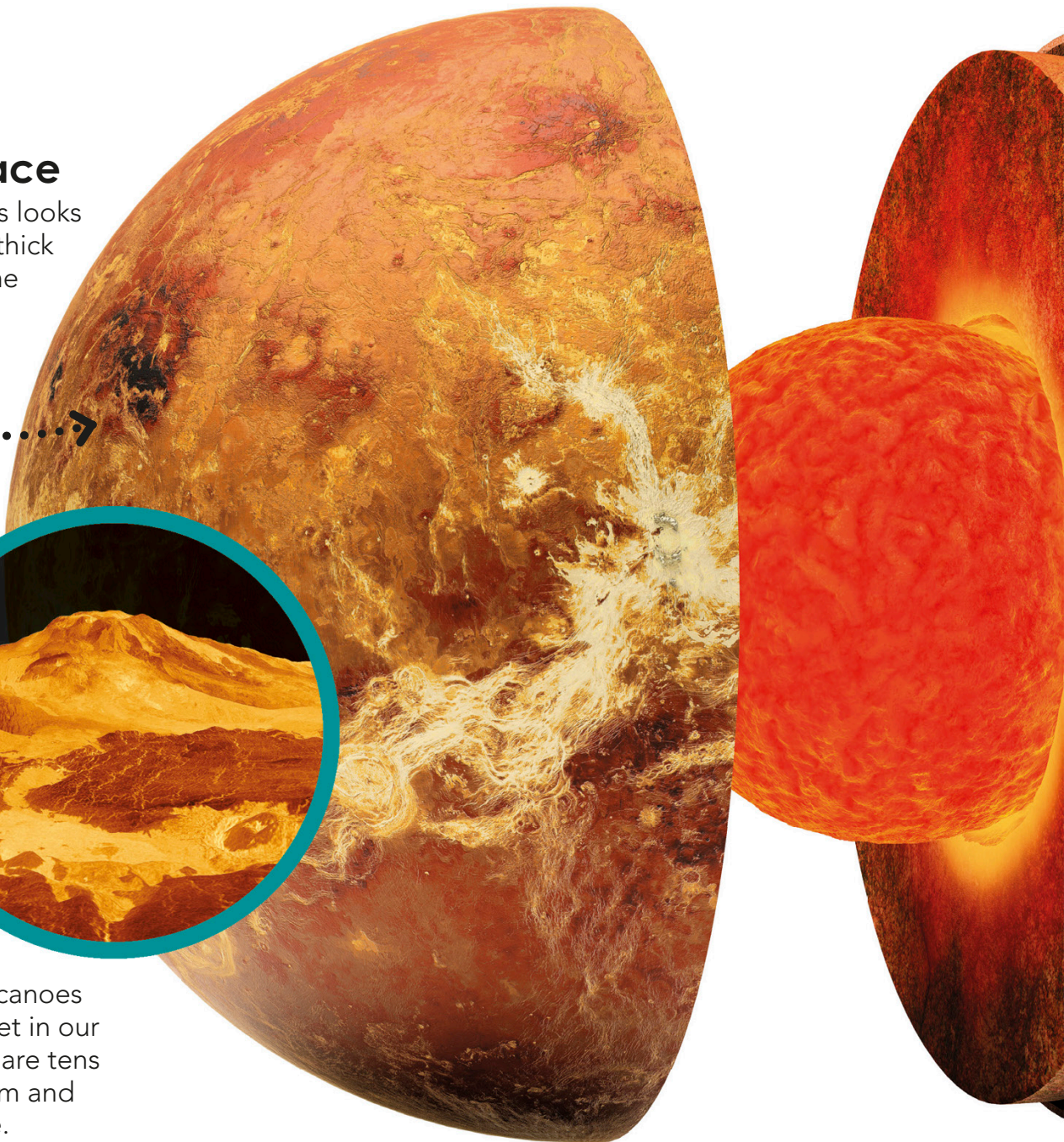
Hot, dry surface

The surface of Venus looks orange because its thick atmosphere traps the sunlight. However, at the surface, there are gray rocks like on the Earth.



Volcanoes

Venus has more volcanoes than any other planet in our solar system. There are tens of thousands of them and some may be active.

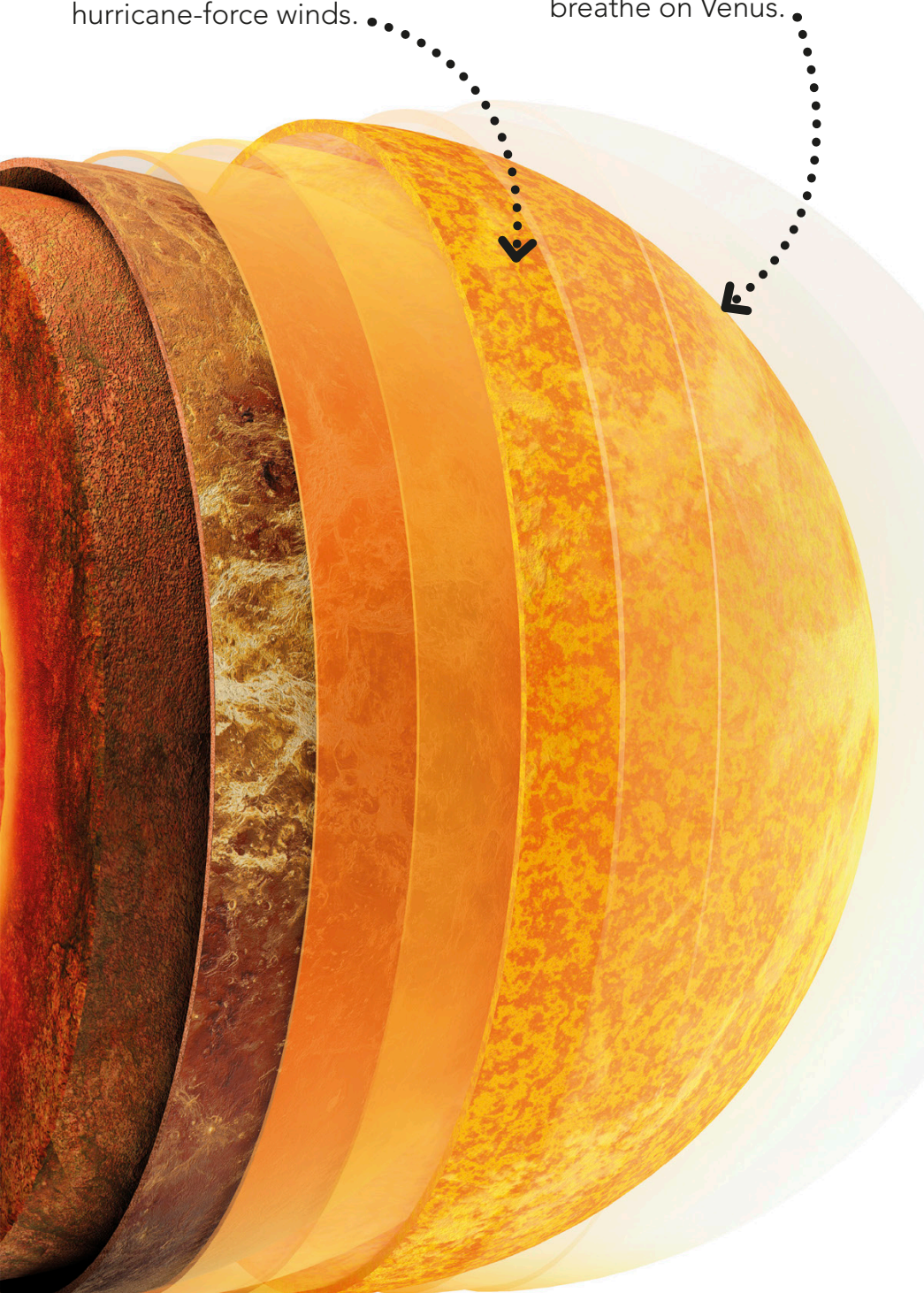


Thick clouds

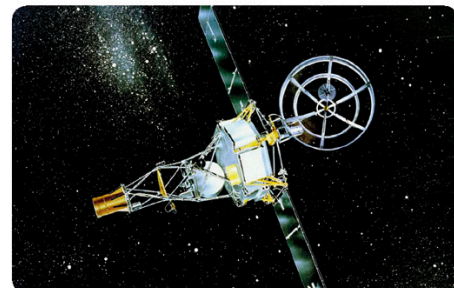
Venus has a thick layer of clouds that are made of droplets of acid. These dangerous clouds speed around the planet, driven by hurricane-force winds.

Toxic air

Venus's atmosphere is made of toxic carbon dioxide gas. It traps in heat, making the planet very hot. There is no oxygen for humans to breathe on Venus.

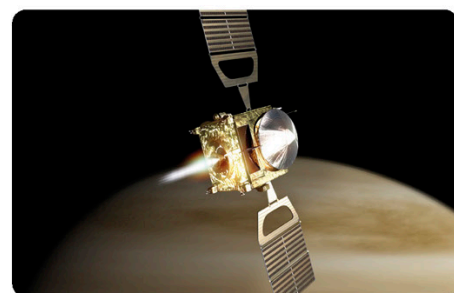


How do we know what Venus is like?



Mariner 2

The first spacecraft to fly around Venus was NASA's *Mariner 2* in 1962. Since then, many spacecraft have been to Venus.



Venus Express

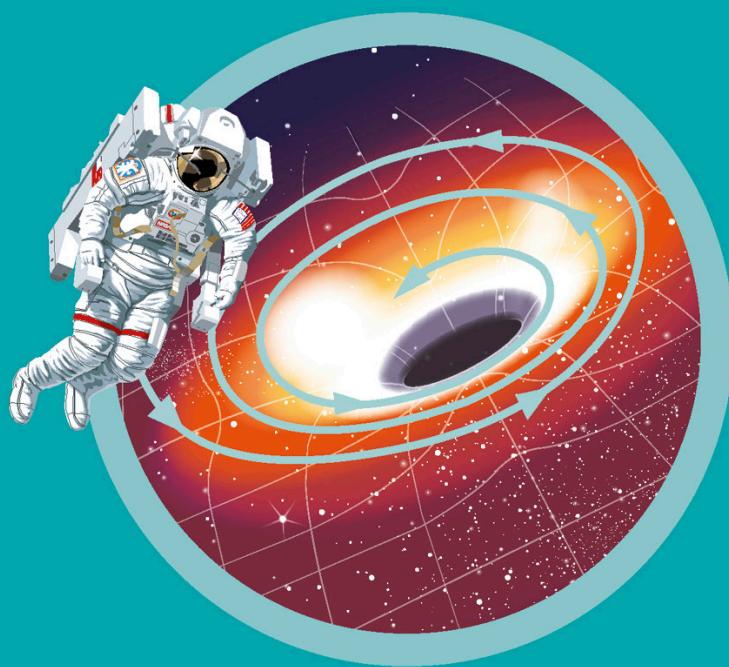
Venus Express was a spacecraft that was sent to learn more about Venus's atmosphere. It was launched in 2005.

? True or false?

1. Venus is the closest planet to the sun.
2. Venus has lots of volcanoes.
3. Venus is covered in lots of orange rocks.

See pages 132–133 for the answers





Deep space

Deep space is the universe beyond our Earth. Many amazing planets, stars, and galaxies are made and can be found there.

How many stars are there in the universe?

From Earth, we can see thousands of stars in the night sky, but there are many more farther out in space. In fact, there are more stars in the universe than grains of sand on all the beaches and deserts on Earth.

What is the closest star to our sun?



Proxima Centauri

The closest star to our sun is called Proxima Centauri. It is very far away from the sun and from Earth—so far that light from it takes more than four years to reach us on Earth.

Scientists think
there are about
1,000 billion trillion
stars in the universe!

Counting stars

To figure out the number of stars in the universe, scientists multiply the number of stars in a galaxy by the number of galaxies they think there are.

? Picture quiz



Most stars live together in galaxies. Can you guess what type of galaxy this is?

See pages 132–133 for the answers

..Young stars

This picture was taken by the Hubble Space Telescope. It shows a place in space where stars are formed.

Where do stars come from?

Stars are big balls of gas that give off heat and light. They begin their lives in huge, cold clouds of gas and dust that are called nebulae. There are many different nebulae scattered throughout most galaxies.

How stars are born

New stars are being born every day and they all go through the same growing process. The sun was created in this way 4.6 billion years ago.



Clumps of gas form

Inside a nebula, clumps of gas start to come together inside a molecular cloud.



The clumps contract

These clumps of gas and dust contract, or become smaller. The gravity of this new clump pulls in more dust from around it.



A spinning disk

The clump shrinks to form a hot, dense core. It is surrounded by a spinning disk of matter with jets of gas that shoot out from the top and bottom.



The star lights up

When the center is hot enough, energy is released and a star is born. A disk of extra matter still orbits the young star.



The disk moves on

The leftover disk material can become planets, moons, asteroids, or comets—or may just remain as dust.

Eagle Nebula

The Eagle Nebula is a region of gas and dust in space where stars form. It is more than 5.5 million years old!



Have other nebulas been discovered?



Horsehead Nebula

The Horsehead Nebula was discovered by astronomers in 1888. It makes a beautiful picture in space.



Carina Nebula

The Carina Nebula is about 7,500 light-years from the Earth. It is thought to be home to more than 14,000 stars!

? True or false?

1. Stars form in clouds of gas and dust.
2. The sun is six billion years old.

See pages 132–133 for the answers



Pillars of Creation

These columns of gas and dust are called the Pillars of Creation, because stars are born inside them. They are about 57 trillion miles (92 trillion km) high. That is twice the distance from the sun to the closest star.

Are all stars the same?

Stars come in lots of different sizes and colors. Some are gigantic, many times bigger than the sun. Other stars are tiny and not very bright. Here are some of the types of star that have been discovered in the universe so far.

Most stars that you can see in the night sky without a telescope are bigger than the sun.

Red supergiant

These stars are huge! If you were to put the sun next to a red supergiant you would hardly be able to see it. These massive stars have much shorter life spans than smaller stars.

Blue supergiant

In space, the hottest stars are blue. Blue supergiants are extremely hot and bright, but are smaller in size than the red supergiants.

Blue giant

Large and compact, blue giants burn fuel quickly. This means they reach really high temperatures and are very bright.

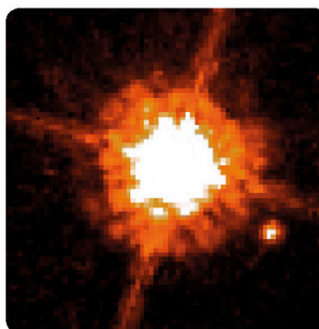
Red giant

Red giants are stars that are near the end of their life. They are much cooler and larger than the sun.

Orange subgiant

Between a red giant and a star like the sun, is the orange subgiant. Our sun will turn into an orange subgiant toward the end of its life, before it becomes a red giant.

Are there stars that are smaller than the sun?



Red dwarf

Stars that are small are known as dwarf stars. A red dwarf is a star that is much smaller and cooler than the sun.



White dwarf

A white dwarf is what is left over from a star like our sun, when it has come to the end of its life. It is very heavy and small, about the same size as the Earth.

The sun

The sun is an average star, also known as a main sequence star. There are many stars similar to our sun in the universe.

? True or false?

1. Some stars are giants.
2. Some stars are dwarfs.
3. Our sun is a giant star.

See pages 132–133 for the answers

What is a light-year?

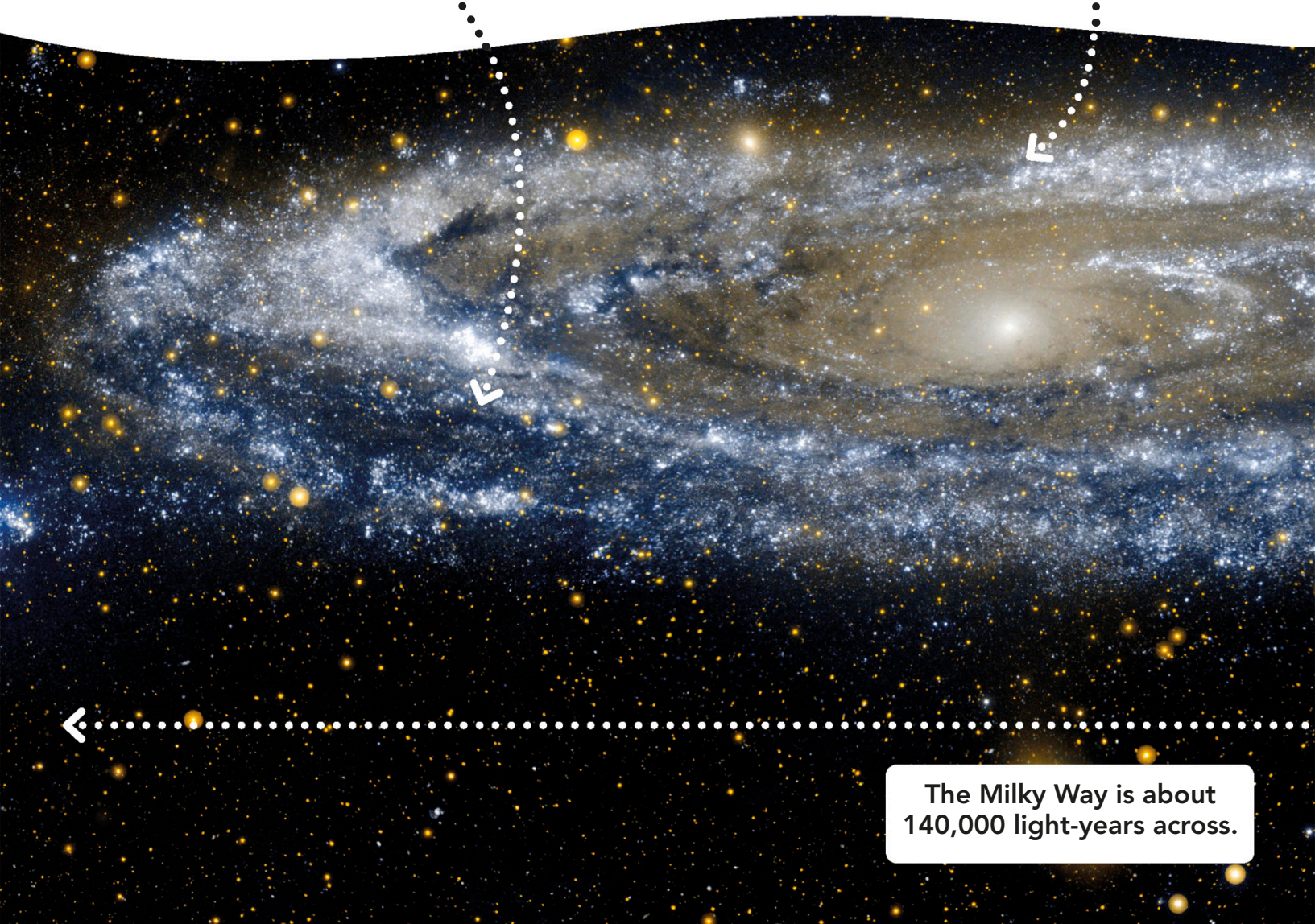
A light-year is the distance light is able to travel in a year. In space, things are very far apart, so astronomers use light-years to measure how far away things are from each other. In one year, light can travel nearly 6.2 trillion miles (10 trillion km).

Closest neighbor

The closest star to our sun is more than four light-years away. This means light from that star takes more than four years to reach the Earth.

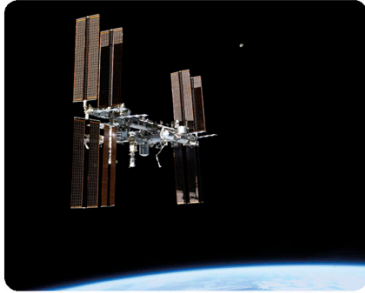
Speed of light

In one second, light can travel 186,500 miles (300,000 km) through space. This means light from the sun takes more than eight minutes to reach the Earth.



The Milky Way is about 140,000 light-years across.

How fast can we travel in space?



A fast orbit

The International Space Station orbits the Earth at a speed of around 17,400 mph (28,000 kph). At this speed it travels around the Earth once every 90 minutes.



Speedy spacecraft

The NASA spacecraft *Juno* reached a top speed of about 165,000 mph (265,000 kph) as it traveled to the planet Jupiter in 2016.

The Milky Way

The Milky Way galaxy has hundreds of billions of stars. Light from these stars takes many years to reach us on the Earth.

Nothing on Earth
or in space can
travel faster than the
speed of light.



Quick quiz

1. What is the speed of light?
2. How long does it take light from the sun to reach the Earth?
3. How long does it take the International Space Station to orbit the Earth?

See pages 132–133 for the answers

What is a black hole?

Black holes are among the most mysterious and incredible things in the universe. They aren't real holes, but are areas where matter has been squashed into a tiny space. It is thought that black holes have strange powers...

Keep your distance!

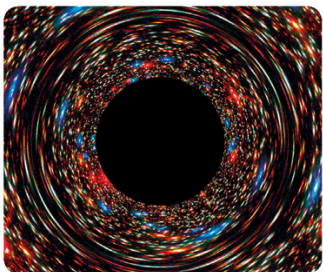
Don't get too close to a black hole or you'll be swallowed up! The pulling force, or gravity, of a black hole is so powerful that nothing can escape it.

Invisible

Black holes are invisible to the human eye because no light can escape from them. Scientists use telescopes with special tools to find them.

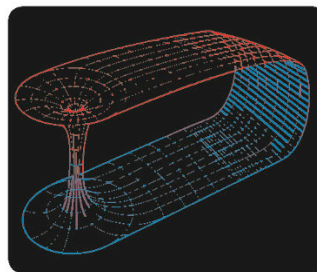


What else can black holes do?



Bend space and light

The gravity of a black hole is so strong that it bends the space around it. Light passing near a black hole follows a curved path and eventually enters it.



Stretch time

Black holes can stretch time! The closer you get to a black hole, the slower time goes. Some scientists even think black holes bend the shape of the universe and make shortcuts, called wormholes, between different parts of it.



Different sizes

Black holes can vary in size. Some are gigantic. Others are incredibly tiny.



Quick quiz

1. What does a black hole look like?
2. What is the name of the force that pulls things into a black hole?
3. Does time go faster or slower near a black hole?

See pages 132–133 for the answers



Stellar nursery

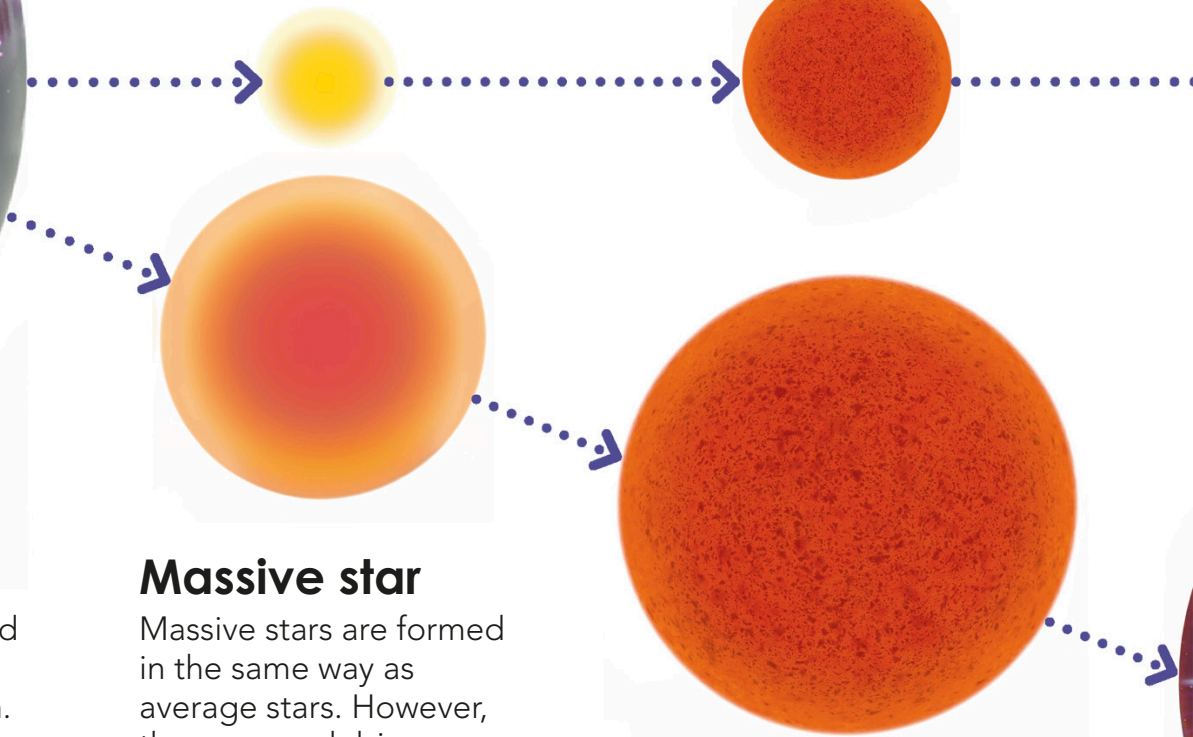
A stellar nursery is a cloud of very hot gas. This is where new stars are born. Stars are made from gas and dust. Stars with more gas and dust will be larger.

Average star

An average star is a star like our sun. This kind of star stays the same size and shape for about 10 billion years before it begins to die.

Red giant

As an average star nears the end of its life, it slowly begins to get bigger and cooler. It is then known as a red giant.



Massive star

Massive stars are formed in the same way as average stars. However, they are much bigger and use up energy faster, so they don't live as long.

Red supergiant

This is the largest type of star in the universe. Red supergiants are massive stars that have become bigger and cooler toward the end of their life.

What happens when stars die?

Just like everything else in our universe, stars are born and eventually die. Some stars have very quiet deaths, and others end with massive explosions. Follow this diagram to see how different stars change throughout their lives.

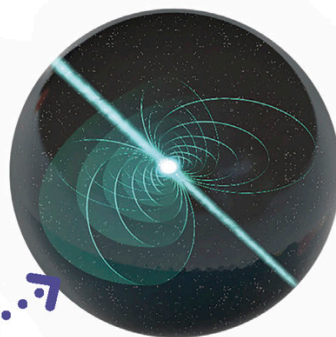
Planetary nebula

As the star starts to run out of fuel, its core, or center, collapses and it loses its outer layers. It is now known as a planetary nebula.



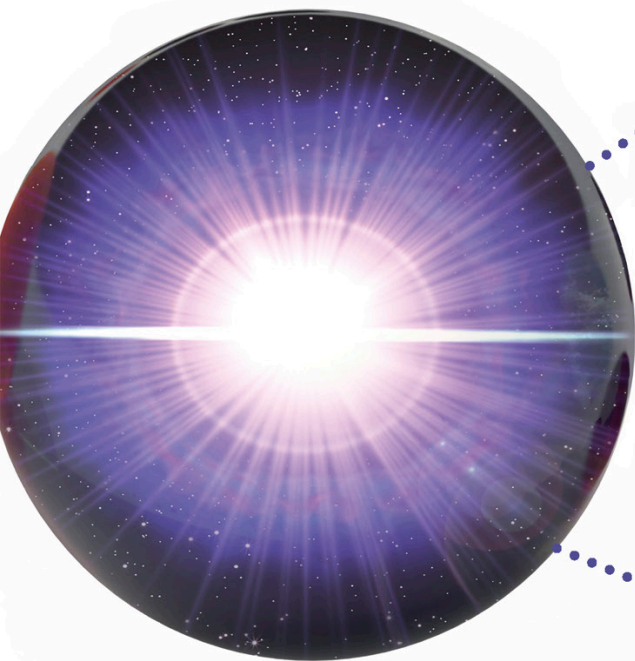
White dwarf

The leftover core of the star is called a white dwarf. This will eventually cool to become a black dwarf.



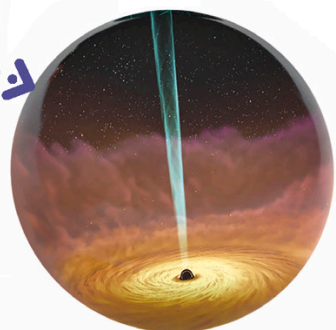
Neutron star

These are tightly packed, tiny stars. They measure no more than 10 miles (16 km) across.



Supernova

At the end of the red supergiant's life, there is a massive explosion called a supernova. This throws the outer layers of the star out into space. The core of the star may become a neutron star or a black hole.



Black hole

A black hole forms when the core of a dying star becomes so tightly packed into a tiny space that nothing can escape—not even light.

When did we last see a supernova in the Milky Way?



Kepler's Supernova

The last time we saw a supernova in our galaxy was just over 400 years ago. The explosion, now called Kepler's Supernova, was brighter than any other star in the night sky for a few weeks.



Quick quiz

1. What does an average star become when it dies?
 - a) A supernova
 - b) A black hole
 - c) A white dwarf
2. What is the biggest type of star?
 - a) White dwarf
 - b) Average star
 - c) Red supergiant

See pages 132–133 for the answers

What shape is the Milky Way?

Our solar system is in the Milky Way galaxy. Galaxies, like planets and stars, are constantly spinning through space and hold many solar systems within them. The Milky Way is a spiral galaxy with arms that are made of clumps of stars.

What other galaxy shapes are there?



Elliptical

Elliptical galaxies are egg-shaped and have no arms. The smallest and largest galaxies in the universe are elliptical. This elliptical galaxy, called M87, was discovered in the year 1781.



Irregular

Galaxies with no particular shape are called irregular galaxies. The galaxy shown here, called NGC 1569, is one example. They come in a range of different shapes and sizes.

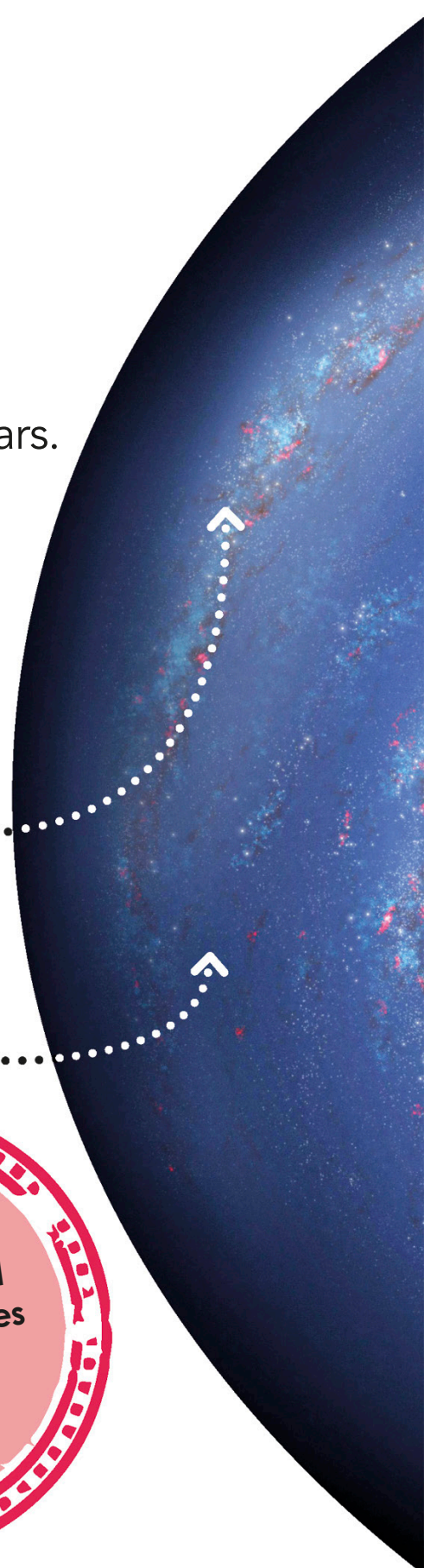
Bright arms

The arms shine brightly because they are full of very bright young stars.

Dust clouds

As well as stars, galaxies are made up of huge quantities of dust and gas.

There are around
200 billion galaxies
in the universe.





Center

All of the stars in a galaxy travel around a central point. In many galaxies this is a supermassive black hole.



Quick quiz

1. What are the arms of some galaxies made of?
 - a) Stars
 - b) Planets
 - c) Black holes
2. What is a galaxy that has no particular shape called?
 - a) Spiral
 - b) Elliptical
 - c) Irregular

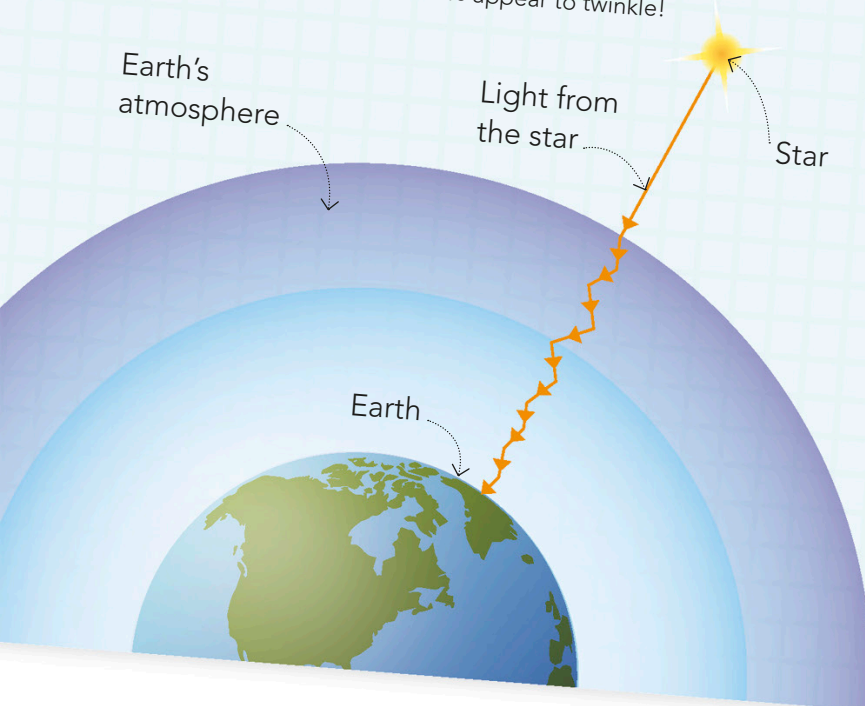
See pages 132–133 for the answers

Why do stars twinkle?

On a clear, dark night, you can see hundreds of stars shining in the sky. But stars don't actually twinkle, they only appear to do so because we are viewing them through the thick layers of the Earth's atmosphere.

Twinkle, twinkle little star

Stars are so far away from the Earth that they appear as tiny points of light in the sky. The light from the stars gets distorted as it travels through the Earth's atmosphere. This means that it doesn't travel in a straight line. The changing direction of the light makes the stars appear to twinkle!



Star patterns

Collections of stars in the night sky make shapes and patterns. These are called constellations. This constellation is called Orion, the hunter. Orion is easy to spot because of the three stars in the middle that make up his belt.

What else can you see in the night sky?



Planet spotting

At different times of the year, you can see planets in the night sky. This image shows Venus and Mars.



The moon

The moon is the brightest object you can see in the night sky. If you look closely, you can see the dark plains on its surface.



Quick quiz

1. Can you see planets in the night sky?
2. What are patterns of stars called?
3. What is the brightest object you can see in the night sky?

See pages 132–133 for the answers

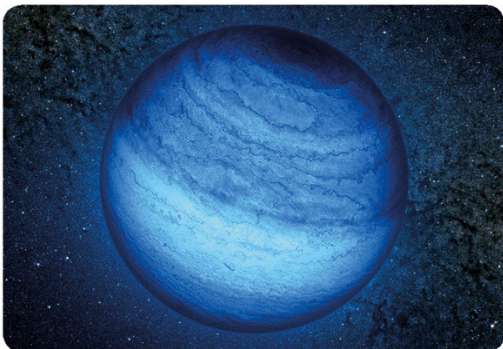
Are there any planets outside our solar system?

When you look up at the night sky, most of the stars you can see probably have at least one planet orbiting around them. There are many planets outside our solar system and more are being discovered all the time.

What are rogue planets?

CFBDSIR 2149-0403

Some planets travel alone through space and do not orbit a parent star. These types of planets, such as CFBDSIR 2149-0403 pictured below, are known as rogue planets.



Planets that orbit around other stars are called exoplanets.

Kepler 62f

This exoplanet is bigger than the Earth and is about 1,200 light-years away. That is too far to take any pictures, so scientists use their research to draw what they think it looks like.

Water world

Kepler 62f takes 267 days to orbit around its parent star, which is called Kepler 62. Its orbit sits in the habitable zone of the star and scientists think that the planet could be covered in water.



Quick quiz

1. Do other stars have planets?
2. What is a rogue planet?
3. What are planets that orbit other stars called?

See pages 132–133 for the answers

What shines the brightest in the universe?

Beaming jets

Quasars give off huge amounts of energy. Jets of material burst outward as matter is ejected.

Quasars are the brightest objects in the universe. They are powered by huge black holes, called supermassive black holes, where stars, gas, and dust are being pulled inward. Some quasars can shine hundreds of times brighter than the whole of the Milky Way.

Far, far away

Quasars exist at the centers of distant galaxies. Even though they are extremely bright, they cannot be seen without powerful telescopes because they are so far away.

What do quasars look like through telescopes?



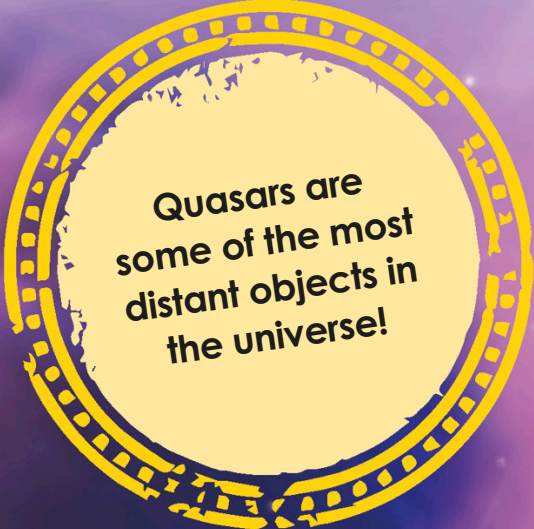
3C 273

Photographed by the Hubble Space Telescope, light from this quasar takes more than 2.5 billion years to reach the Earth. This was the first quasar to ever be discovered.



Colliding quasars

A pair of blue quasars in space were photographed crashing into each other more than 4.6 billion light-years away from the Earth.



Quasars are
some of the most
distant objects in
the universe!



Black hole

A huge black hole is at the center of a quasar. It can be many times bigger than the sun. One quasar has been discovered with two black holes at its center!



Accretion disk

This is a disk of material that is slowly being sucked into the black hole.

? True or false?

1. There is a black hole at the center of a quasar.
2. Quasars aren't very bright.
3. Quasars give off huge amounts of energy.

See pages 132–133 for the answers





Space exploration

People have been fascinated with space for thousands of years. New machines are always being invented to help us travel farther and learn more about the universe.

How do we look into space?

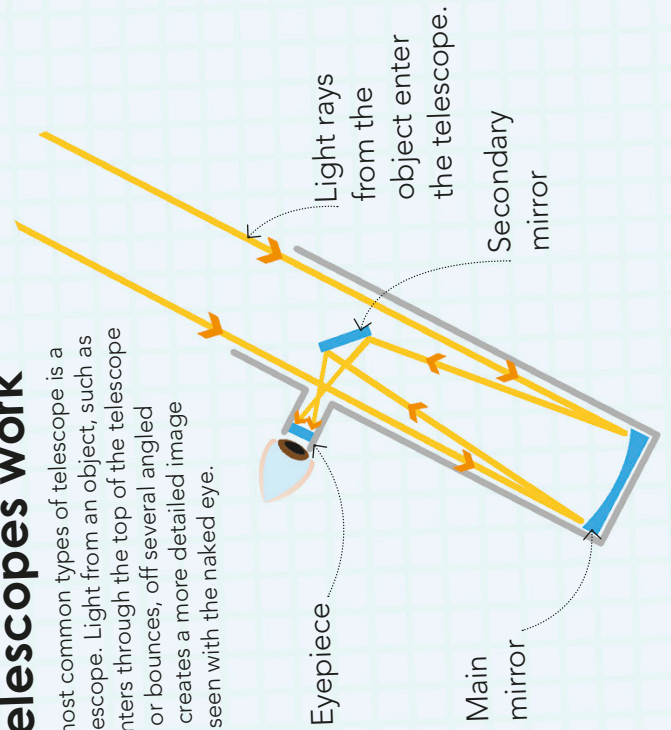
We can use devices called telescopes to look into space. They can be used to look closely at planets and the moon and to find distant stars and galaxies. There are lots of telescopes on the Earth and there are also telescopes that orbit our planet.

Laser beams

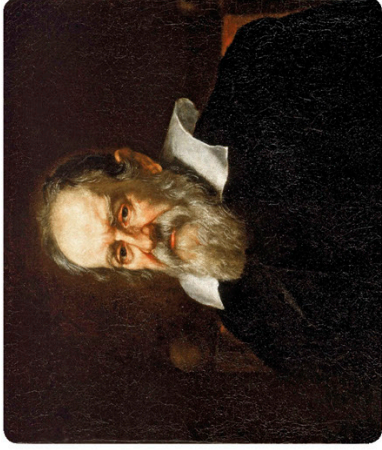
The Earth's atmosphere can make images from space look blurry. This telescope shoots a powerful laser beam into space to help correct the blurriness of the images caused by the atmosphere.

How telescopes work

One of the most common types of telescope is a reflecting telescope. Light from an object, such as the moon, enters through the top of the telescope and reflects, or bounces, off several angled mirrors. This creates a more detailed image than can be seen with the naked eye.



When was the telescope invented?



Galileo Galilei

In 1609, the Italian astronomer Galileo Galilei built his own telescope. It was an improved version of Hans Lippershey's invention. Galileo used it to make lots of discoveries, such as mountains and valleys on the surface of the moon.

Yepun telescope

The Yepun telescope is one of four large telescopes in Chile, South America. Its main mirror is 26 ft (8 m) wide—as wide as a tennis court!

These four telescopes are used to see far into space.



Quick quiz

1. What is a telescope?
2. When did Galileo Galilei make his telescope?
3. How wide is the mirror on the Yepun telescope?

See pages 132–133 for the answers

Who were the first space explorers?

Early space explorers were the first people to ride in rockets, see the Earth from hundreds of miles away, and feel weightless. They were the pioneers of space travel.



Yuri Gagarin

The first person to travel in space was Yuri Gagarin. On April 12, 1961, the Russian orbited the Earth in his spacecraft *Vostok 1* for one hour and 48 minutes.



Valentina Tereshkova

In 1963, Russian Valentina Tereshkova became the first woman in space. She orbited the Earth 48 times on her three-day trip.



First man
in space



Apollo 8 crew

Americans Jim Lovell, Bill Anders, and Frank Borman were the first to leave the Earth's orbit. They circled the moon in their 1968 mission.

First
to leave
the Earth's
orbit



First
people on
the moon

Apollo 11 crew

In 1969, Americans Neil Armstrong and Buzz Aldrin became the first people to walk on the moon. Michael Collins accompanied them on their mission, but stayed in the spacecraft.

First walk
in space

Alexey Leonov

In 1965, Russian Alexey Leonov was the first person to leave a spacecraft and take a "space walk." He floated in space for 12 minutes while attached to the spacecraft.



? Picture quiz



John Glenn went into space twice—first in 1962 and again in 1998. Can you guess which record he broke?

See pages 132–133 for the answers

Have animals been to space?

It's not just people who have explored space—animals were sent there first! They helped us understand about the effects of space travel on living things.



Fruit flies

The first animals to travel into space were fruit flies in 1947. Scientists wanted to discover if space would harm the flies.



Mouse

In 1950, American scientists sent a mouse into space. They wanted to understand more about how living creatures cope in space.



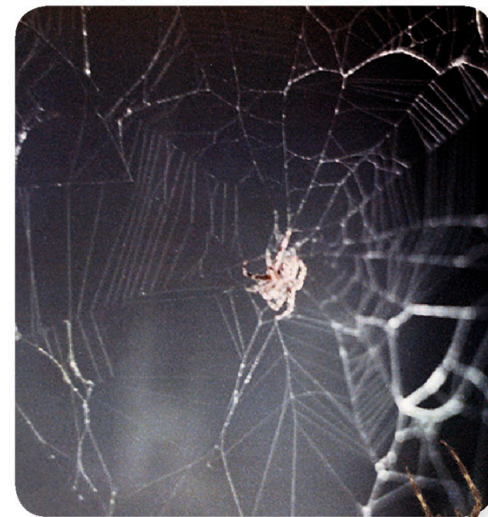
Chimpanzee

A chimpanzee named Ham was four years old when he was blasted into space in 1961. He spent 16 minutes there before his reentry capsule splashed back down in the Atlantic Ocean.



Dogs

In 1966, Russian scientists sent two dogs, called Veterok (left) and Ugolyok, into space together. The dogs orbited the Earth in their spacecraft *Cosmos 110* for 22 days, before returning safely.



Spiders

Two spiders, Anita and Arabella, were taken into space in 1973 to see if they could still make webs. The spiders soon got used to being weightless and spun their webs.



Laika

One of the most famous animal space explorers was a Russian dog called Laika. In 1957, she became the first animal to orbit the Earth. Her journey paved the way for human spaceflight.



Quick quiz

1. What was the name of the first dog in space?
2. What were the first animals in space?
3. How old was Ham the chimpanzee when he went into space?

See pages 132–133 for the answers

**November 3, 1957
Laika the Space Dog**

Russian dog, Laika, was a stray that was found wandering the streets of Moscow. She traveled to space in the *Sputnik 2* spacecraft and became the first living creature to orbit the Earth.



**April 9, 1959
Mercury 7**

In response to the Russians, the United States announced its first group of astronauts. Nicknamed "The Mercury 7," they were the best test pilots in the US.

**October 4, 1957
Sputnik 1 satellite**

Sputnik 1 was the first satellite to be sent into space. Made by the Russians, *Sputnik 1* orbited the Earth for three months.

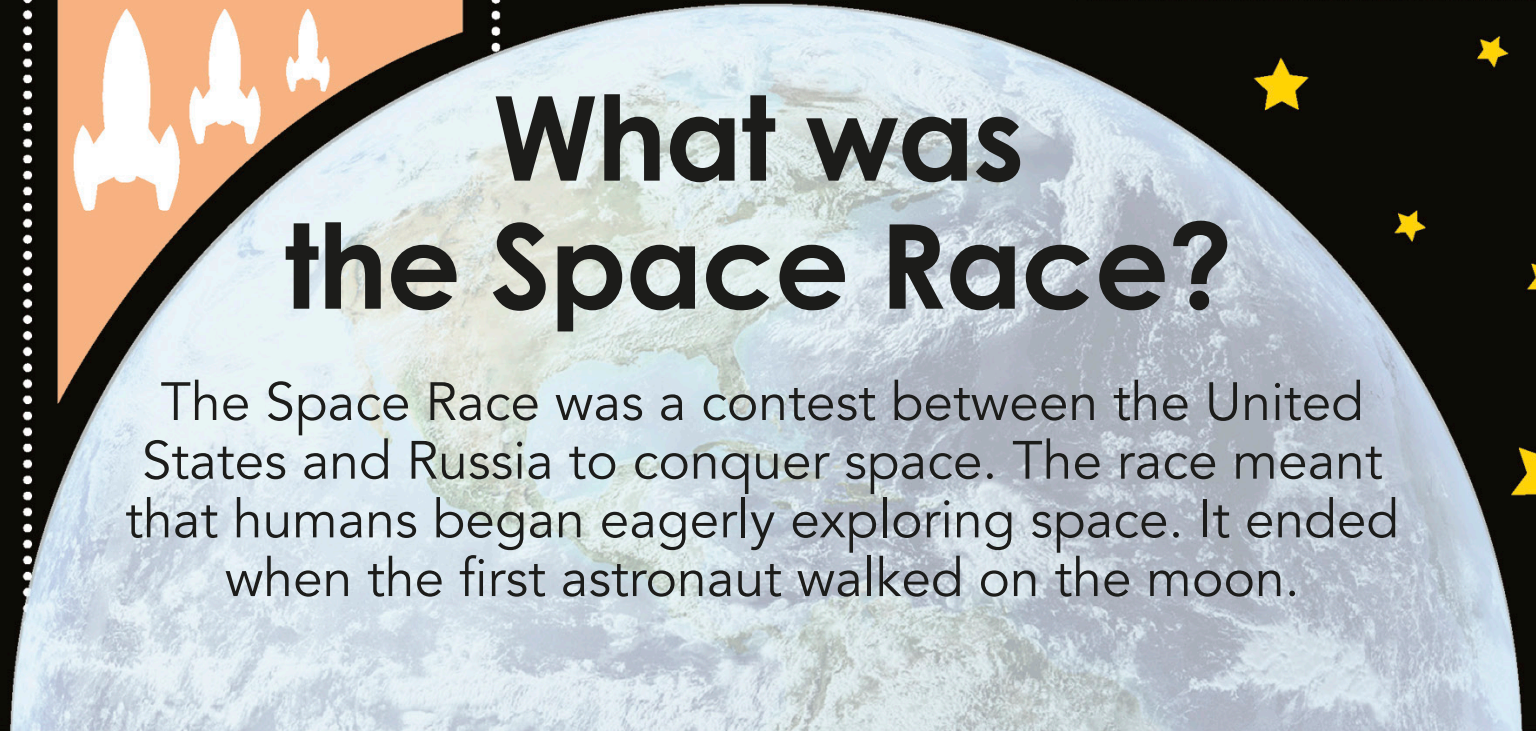
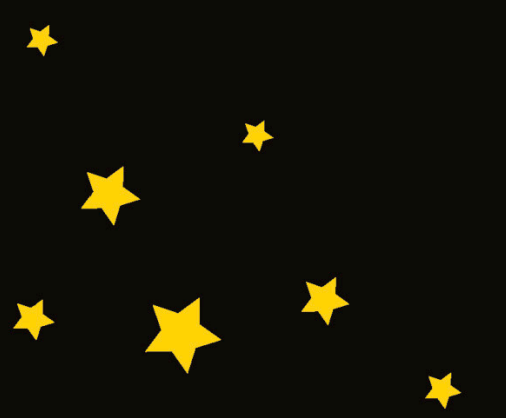
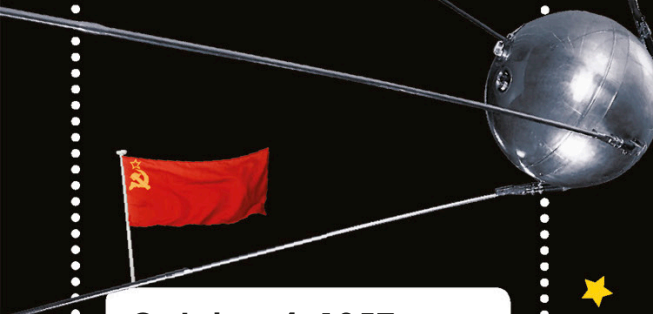


**The race starts here!
3... 2... 1... GO!**



What was the Space Race?

The Space Race was a contest between the United States and Russia to conquer space. The race meant that humans began eagerly exploring space. It ended when the first astronaut walked on the moon.





Picture quiz

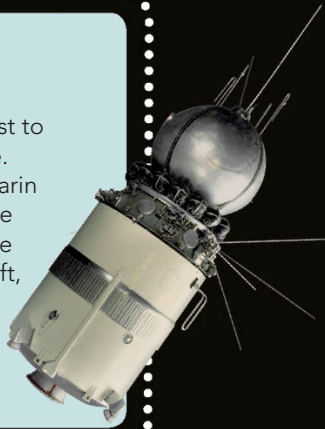


This astronaut was the first person to set foot on the moon. Who was he?

See pages 132–133 for the answers

April 12, 1961 Yuri Gagarin

The Russians were the first to send a person into space. The cosmonaut Yuri Gagarin was the first person to see what the Earth looked like from space. His spacecraft, called *Vostok 1*, made one orbit of the Earth in 108 minutes.



September 12, 1962 President Kennedy

American president John F. Kennedy set the goal of getting an American astronaut to the moon and back by the year 1970.



June 16, 1963 Valentina Tereshkova

Russian Valentina Tereshkova became the first woman in space. She enjoyed skydiving and worked in a factory before training to be a cosmonaut.

March 18, 1965 First space walk

Cosmonaut Alexey Leonov became the first person to take a space walk outside a spacecraft. It was another success for the Russians.



July 20, 1969 First on the moon

The Americans were the first and only nation to send people to the moon. Neil Armstrong and Buzz Aldrin became the first people to walk on the moon.



How many people have been to the moon?

Only 12 people have walked on the moon. They were all American astronauts and made their trips between 1969 and 1972. As there is no air on the moon, the astronauts had to wear special space suits with an air supply for them to breathe.

The moonwalkers

These are the astronauts who have had the amazing experience of walking on the moon. They landed on the moon in six separate Apollo missions.



Neil Armstrong

Apollo 11



Buzz Aldrin

Apollo 11



Pete Conrad

Apollo 12



Alan Bean

Apollo 12



Alan Shepard

Apollo 14



Edgar Mitchell

Apollo 14



David Scott

Apollo 15



James Irwin

Apollo 15



John Young

Apollo 16



Charles Duke

Apollo 16



Eugene Cernan

Apollo 17



Harrison Schmitt

Apollo 17

Buzz Aldrin

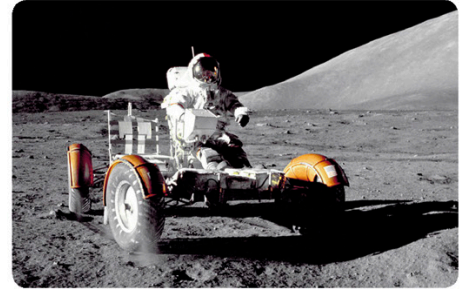
After Neil Armstrong, Buzz Aldrin was the next person to set foot on the moon. He collected rock samples and set up experiments.



... Neil Armstrong

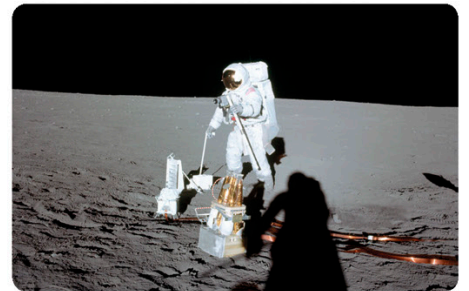
This photo was taken by Neil Armstrong, the first person to set foot on the moon. You can see his reflection in Buzz Aldrin's visor.

What did astronauts do on the moon?



Drove a rover

Some astronauts drove a special car on the moon called a lunar rover. They used the rover to explore the moon.



Science experiments

Astronauts did lots of experiments on the moon to help scientists understand more about how the moon was formed.

? Quick quiz

1. How many people have walked on the moon?
2. Who was the last person to walk on the moon?
3. Is there air on the moon?

See pages 132–133 for the answers

How are rockets launched?

Rockets have engines that burn liquid or solid fuel to make hot gases. The engine pushes the gas out the back of the rocket and the gas makes the rocket move forward. This is a bit like what happens when you let air out of a balloon—the air moves one way, so the balloon moves in the opposite direction.

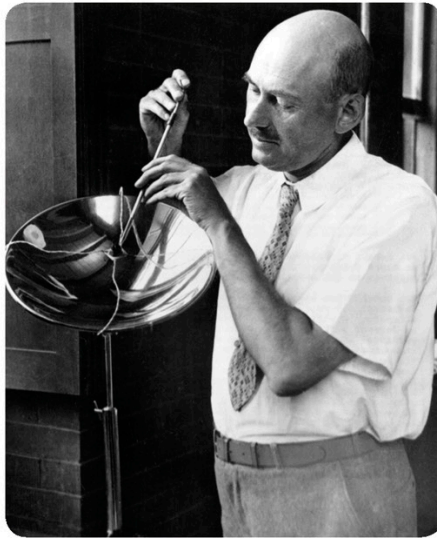
To get into orbit, a rocket must accelerate from zero to more than 17,400 mph (28,000 kph).

Who were the first rocket scientists?



Hermann Oberth

Oberth was a Romanian scientist who is known as one of the "fathers" of modern rocketry. He launched his first rocket in 1931.



Dr. Robert H. Goddard

Goddard was an American who had a talent for inventions. He is known for successfully testing and constructing the first rocket that used liquid fuel.



Fuel and go

Most rockets are made up of two or three stages. When a stage has used up all its fuel, it separates to get rid of the extra weight.

Lightning tower

These towers around the launch pad are designed to stop lightning from hitting and damaging the rocket when it is being prepared for launch.

Hot gas

Lots of hot gas can be seen coming out of the bottom of the rocket as it launches.



Quick quiz

1. What other name is Hermann Oberth often known by?
2. How many stages do most rockets have?
3. What are the towers around the launch pad used for?

See pages 132–133 for the answers

7. Splashdown

After the spacecraft has reentered the Earth's atmosphere, parachutes open to guide the crew safely to "splashdown" in the ocean.



1. Liftoff

The *Saturn V* rocket launches from the Kennedy Space Center, Florida. It is carrying three astronauts and the *Apollo* spacecraft, which comes together in space.

6. Reentry

When they are nearing Earth, the crew capsule separates from the rest of the craft. A heat shield protects the capsule, so that it doesn't burn up during reentry.

2. To the moon

In space, the main part of the spacecraft separates from the rocket. Panels open to reveal the Lunar Module, the part that lands on the moon. The spacecraft turns around and docks with the Lunar Module.

How long does it take to get to the moon?

During the Apollo moon landings of 1969–1972, it took astronauts three days to travel to the moon from the Earth. Each mission followed the same path around the moon and back again.

? True or false?

1. During the Apollo missions, the whole spacecraft landed on the moon.
2. It took astronauts on the Apollo missions 10 days to reach the moon.
3. Parachutes helped the crew of the Apollo missions return safely to Earth.

See pages 132–133 for the answers

Can you see the Earth from the moon?



Earth rising

This photo of the Earth rising over the moon was taken by the crew of *Apollo 8*. Some astronauts who visited the moon described the Earth as looking like a "blue marble" in the sky.

4. Landing on the moon

Once it enters lunar orbit, the Lunar Module, with two of the astronauts onboard, undocks from the main craft and heads for the moon. Once they have safely touched down, they prepare to walk on the surface.

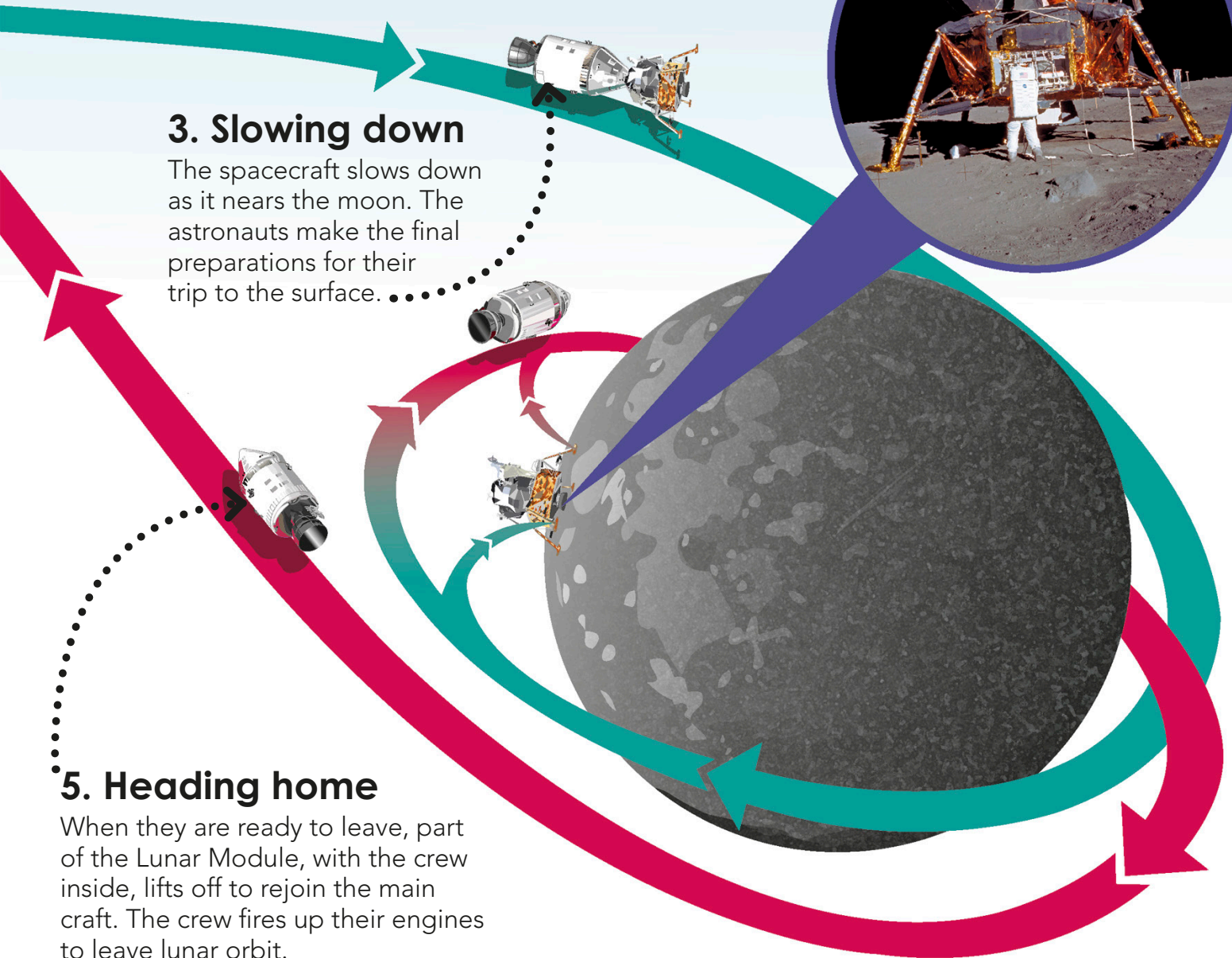


3. Slowing down

The spacecraft slows down as it nears the moon. The astronauts make the final preparations for their trip to the surface.

5. Heading home

When they are ready to leave, part of the Lunar Module, with the crew inside, lifts off to rejoin the main craft. The crew fires up their engines to leave lunar orbit.



How do astronauts train for space?

Going into space is not an easy job. It takes years of training. Spacewalking is the most exciting work for astronauts. They train for it by practicing working underwater, which is similar to how it feels to be in space.

Where else do astronauts train?



Vomit Comet

Astronauts can practice floating, just like in space, during flights in a special plane called a reduced-gravity aircraft. It is nicknamed the "Vomit Comet" as it makes some astronauts sick!



Virtual reality

Virtual reality is a digital world that is created by computers. Trainee astronauts wear virtual reality goggles and practice tasks before they go to space.

Astronaut trainer

This person is an astronaut trainer. They help to guide the astronaut through their underwater tasks.

Space suit

Astronauts train in bulky, protective space suits. This helps the astronauts get used to wearing the suits before they go on real space walks.

Astronauts spend up to seven hours underwater during each training session.



A photograph of an astronaut in a white space suit floating in space. The astronaut is smiling and pointing towards the camera. The background is a complex structure of blue and white equipment, likely part of a space station or shuttle. A dotted line with an arrow points from the 'Astronaut' section header to the astronaut's helmet.

Astronaut

Astronauts need to be fit and healthy, with good eyesight, to go into space. Many are also scientists or engineers.

? True or false?

1. Astronauts only have to train for one week before they go to space.
2. Astronauts can't wear glasses in space.
3. Astronauts practice floating in the "Sick Comet."

See pages 132–133 for the answers

Why do astronauts need space suits?

There is no air to breathe in space and temperatures can quickly change from being very hot to very cold. To stay safe, astronauts must wear a special space suit when they are outside their spacecraft.

? True or false?

1. The first space walk was by Alexey Leonov.
2. Astronauts have visors on their space suits.
3. A life jacket can help stranded astronauts.

See pages 132–133 for the answers

Helmet and visor

The main part of the helmet is the clear plastic bubble that protects the astronaut's head. There is also a special visor to protect the astronaut's eyes from the sun's harmful rays.

Drink bag and straw

Sometimes space walks can last for hours, so astronauts get thirsty! They can drink through a straw in their helmet.

Microphone

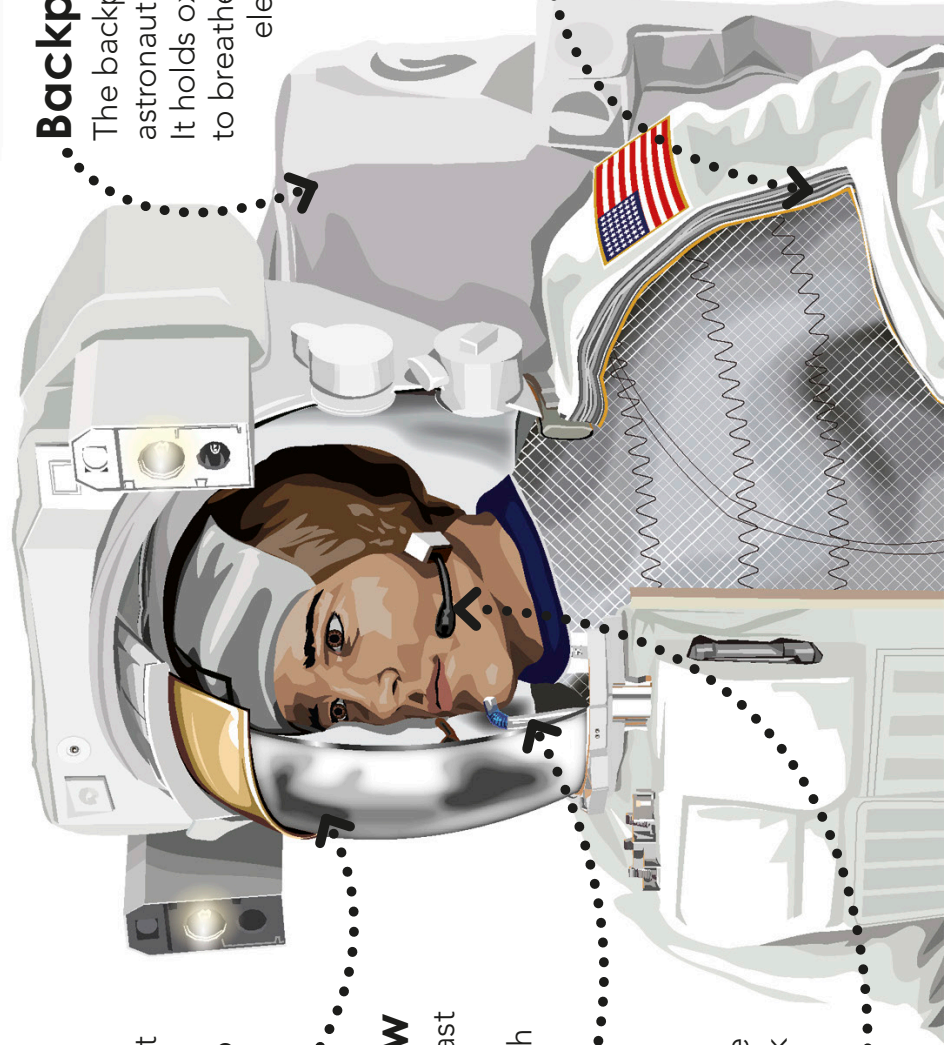
Spacewalking astronauts have a microphone so they can talk with other astronauts and the support team on Earth.

Backpack

The backpack contains the astronaut's life-support system. It holds oxygen for the astronaut to breathe and a battery for electrical power.

Inner layers

There are lots of layers to a space suit. Some help to keep the astronaut warm and others help to cool them down.





Underwear

Once they are out in space, astronauts can't take their space suits off to go to the bathroom. Instead, they wear absorbant underwear that can soak up fluids.

Rescue unit

The rescue unit is controlled by a joystick on the arm of the space suit. It has jet thrusters that propel a stranded astronaut back to the safety of the spacecraft.

A space walk is also known as an EVA, which means "extravehicular activity."

How have space suits changed?

Mercury space suit

These silver space suits were worn by America's first astronauts. Their group was called "The Mercury 7." They only wore these space suits inside the spacecraft.



Future space suit

There are plans to send people to Mars and new space suits are being created for the mission. These will use newer technology than the current space suits.



What was the space shuttle?

The space shuttle was the first ever reusable spacecraft. It was used by NASA for 30 years to send astronauts into space. Astronauts who flew on it helped to build the International Space Station, repaired the Hubble Space Telescope, and completed lots of important science experiments.

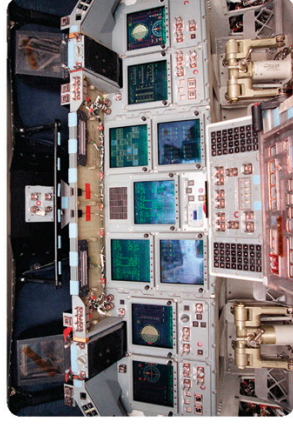
Fuel tank

This contained liquid fuel for the shuttle's main engines.

Living space

This is where the crew would live and work. For launches and landings, the pilot and commander would sit at the front of the space shuttle.

What was it like in the space shuttle?



The cockpit

There were five computers with lots of screens (monitors) and control buttons inside the cockpit. These helped the astronauts to fly the shuttle.



Open doors

Astronauts could go outside the main cabin to work in the cargo bay. In the cargo bay, they would have to wear space suits to protect them from the harsh environment of space.

Rocket power

The two Solid Rocket Boosters, nicknamed "SRBs," would create most of the force needed to get into space.

Cargo bay

The cargo bay could be used to carry things, such as satellites, into orbit. There was also a robotic arm inside that could be used to retrieve things from space.

Main engines

There were three main space shuttle engines. These would fire along with the solid rocket boosters to lift the space shuttle off the launch pad.

The space shuttle could get from the Earth to space in 8.5 minutes!

? Picture quiz



To travel long distances on Earth, the space shuttle Orbiter had to be carried on the back of what?

See pages 132–133 for the answers



Ready to depart

The departing astronauts say goodbye and close the hatch to the *Soyuz* spacecraft. They then make sure the *Soyuz* is ready to return them home safely before undocking from the space station.

How do astronauts return to Earth?

Astronauts travel between Earth and the International Space Station in the *Soyuz* spacecraft. The craft fits three astronauts and takes around three and a half hours to return from the space station back to Earth.



Journey home

The *Soyuz*'s descent module separates from the spacecraft and it leaves orbit. A special heat-shield protects the module as it reenters the Earth's atmosphere. Then, parachutes open 15 minutes before landing.

Landing

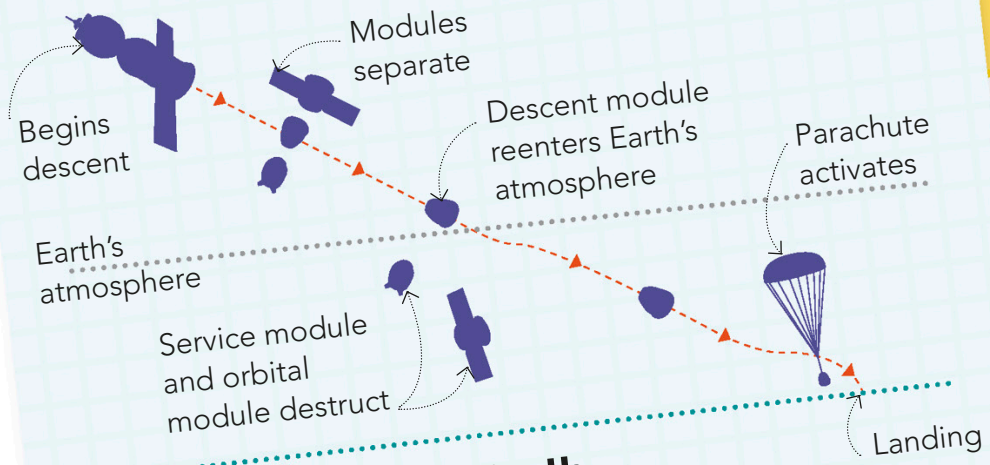
One second before landing, engines fire to soften the impact. The crew also sit in specially molded seats, to help make the landing as comfortable as possible.



Quick quiz

1. How long does it take astronauts to get back to the Earth in the *Soyuz*?
2. What do astronauts have to get used to when returning from space?
3. When do the parachutes open on the *Soyuz*?

See pages 132–133 for the answers



Getting back to Earth

During the return journey to the Earth, the Soyuz has to slow down from traveling at 16,750 mph (27,000 kph) to zero!



Exit team

A team tracks where the descent module lands and rush to find the astronauts to help them out of the spacecraft.

Back on Earth

The astronauts are now out of the spacecraft and back on Earth. After being in space for so long, it takes them a little while to adjust to the gravity on the Earth.

How did the space shuttle land?



Runway finish

When the space shuttle flew, it would return to the Earth like a glider and land on a runway. A special drag chute would help slow it down as it landed.



Where do astronauts live in space?

The International Space Station (ISS) is where astronauts live, sleep, exercise, and work in space. It is the biggest object ever flown in space and is the first step toward exploring deeper into our solar system.

Kibo module

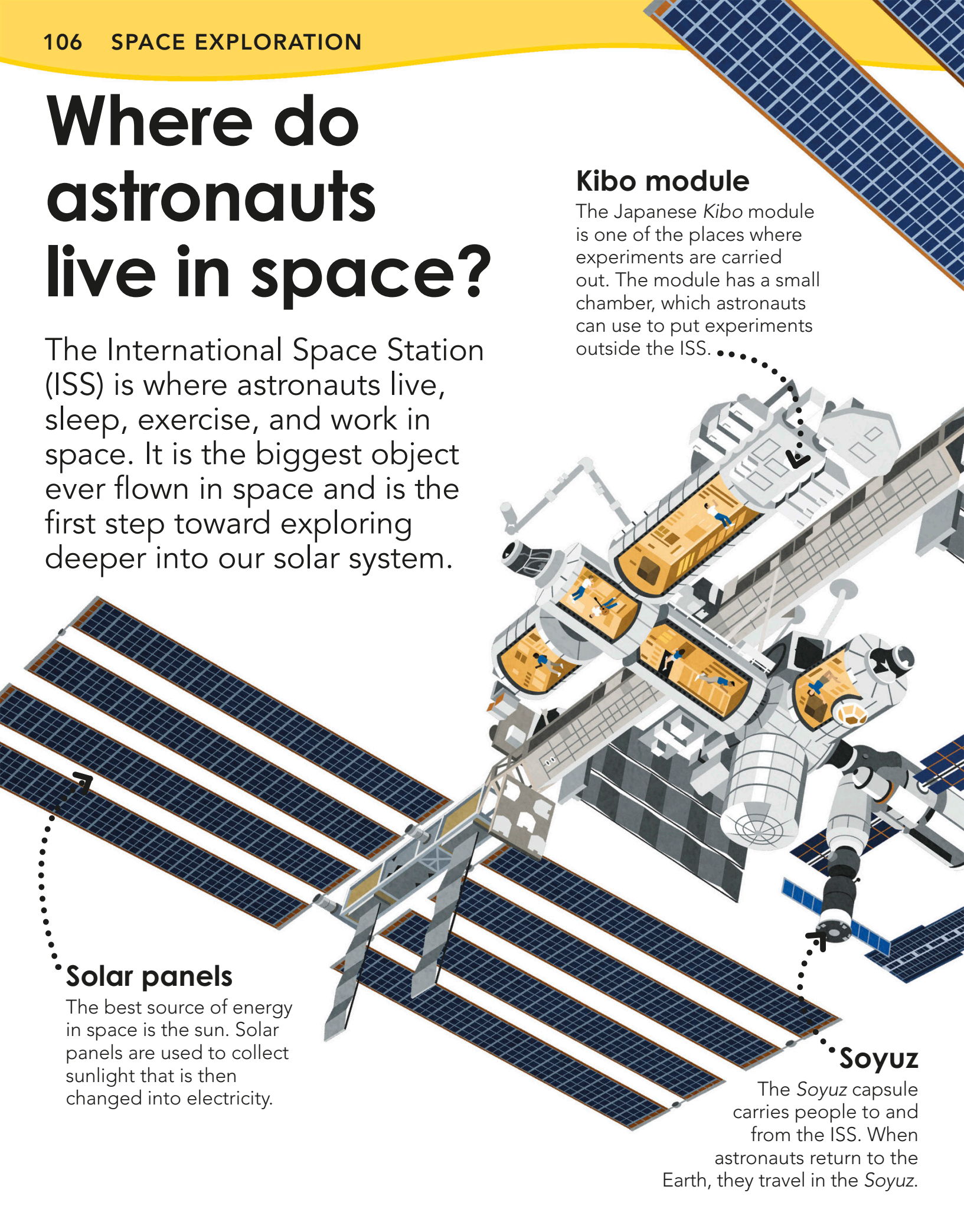
The Japanese *Kibo* module is one of the places where experiments are carried out. The module has a small chamber, which astronauts can use to put experiments outside the ISS. . . .

Solar panels

The best source of energy in space is the sun. Solar panels are used to collect sunlight that is then changed into electricity.

Soyuz

The *Soyuz* capsule carries people to and from the ISS. When astronauts return to the Earth, they travel in the *Soyuz*.



What do astronauts do in space?



Space walks

Sometimes astronauts go for space walks to repair and maintain the outside of the International Space Station.



Science experiments

Astronauts study how materials and living things behave in space. What they learn can help how we live on the Earth.

Temperature control

The ISS is equipped with a temperature control system to keep the station's temperature comfortable for the astronauts inside. Without it, the station's sun-facing side could reach temperatures of 248°F (120°C), and its dark side could be as cold as -238°F (-150°C).

Zvezda module

The Zvezda module is a Russian module on the ISS. It provides life-support systems, as well as living quarters for two astronauts.

? Quick quiz

1. How hot would the ISS get without controlling its temperature?
2. What do the solar panels on the space station do?
3. What is the *Kibo* module used for?

See pages 132–133 for the answers

Why do astronauts float in space?

In space, astronauts don't walk around on the floor like people do on the Earth. Instead, they float! This is because they do not feel the effect of gravity, which is the force that pulls you toward the ground on the Earth. This state is called microgravity, and it makes things seem to be weightless.

Floating food

Anything that is not tied down in a spacecraft will float around. This includes the astronauts' food!



? Quick quiz

1. What is microgravity?
2. Can humans float on the Earth?
3. Would you float on the moon?

See pages 132–133 for the answers

• Super strength

Weightlessness in space lets astronauts look as though they are super strong. They can lift objects, such as big pieces of equipment, that would be far too heavy for them to move on the Earth.

How do astronauts stay fit and healthy in space?



Exercise

With very little gravity to push against, a person's bones and muscles soon become weak. Astronauts exercise every day to stay healthy and help avoid any problems when they return to the Earth and its gravity.



Sleeping quarters

In space, there is no up and down. Astronauts can attach their sleeping bags wherever they want—even on the ceiling! They have to strap themselves in too or they will float away.

What do astronauts eat in space?

Astronauts living in space need to eat three meals a day. The food they eat is similar to ours, but it needs to be “cooked” and eaten differently. Astronauts aren’t allowed crumbly food such as bread because the crumbs can float around and clog up the spacecraft’s air vents!

Making dinner

Many space meals are dried. To prepare them, astronauts inject hot water into the packages and wait several minutes before eating them.



Astronauts use liquid salt and pepper so the grains don't float around and get in their eyes.

What other things are difficult to do in space?



Brushing teeth

There's no running water in space, so astronauts soak their toothbrushes before cleaning their teeth. After brushing, they swallow their toothpaste because there's nowhere to spit it out.



Using the bathroom

Going to the bathroom is very different in space. Astronauts need to strap their legs down, so they don't float away. A space toilet works a bit like a vacuum cleaner, sucking human waste away!

Eating food

Astronauts don't use plates, knives, and forks. Instead, they can use spoons, "sip" their food through plastic tubes, or eat it as it floats in front of them.

Creamed spinach
Add hot water and wait 5–10 minutes.

Crackers

Vacuum-sealed

Many space meals are vacuum-sealed. This means that all the air is sucked out of the packet, so the food stays fresh for a long time.

Knead before opening.

Candy-coated peanuts

Orangeade

? Quick quiz

1. How many meals do astronauts need a day?
2. How do astronauts eat their food?
3. How is most food packaged for astronauts to eat in space?

See pages 132–133 for the answers

What is mission control?

The work that astronauts do would be impossible without mission control. It is a place where many people work to help space missions and astronauts in space. People work in mission control every hour of the day, every day of the year.

What jobs do people have in mission control?



Spacecraft communicator

The person at mission control who communicates with astronauts in space is called a CAPCOM, or capsule communicator.



Flight surgeon

A flight surgeon is a doctor who gives astronauts advice on how to stay healthy. If an astronaut gets hurt in space, the surgeon will tell them what they need to do to recover.

Keeping watch

There are lots of big screens, or monitors, in mission control. They let the people working there keep a close watch on the spacecraft and the astronauts.

Support teams

Teams of people on the ground provide support for astronauts working in space. They help astronauts with many jobs, including space walks and experiments.

Instant information

The ground team at mission control gather data from the spacecraft. They study it to help make decisions about what to do next on the mission.



ВАРЯ" / "ЗВЕЗДА" / "ПИРС" / "ПОИСК" / "РАССВЕТ" / "СОЮЗ ТМА-05М" / "ПРОГРЕСС М-16М" / ...
 начало зоны КВП 18:35:58 начало зоны КВП 20:12:31
 конец зоны 44 18:54:02 конец зоны ЩЛК 20:23:50
 до начала зоны 00:14:23 до конца зоны 00:18:25
 TDRSS 17:55:57 - 18:40:00
 = 92.8 км
 = 427.9 км
 = 404.6 км
 = 51.7°



МКС 33

С. Уильямс (НАСА)
 Ю. Маленченко (Роскосмос)
 А. Хошда (JAXA)

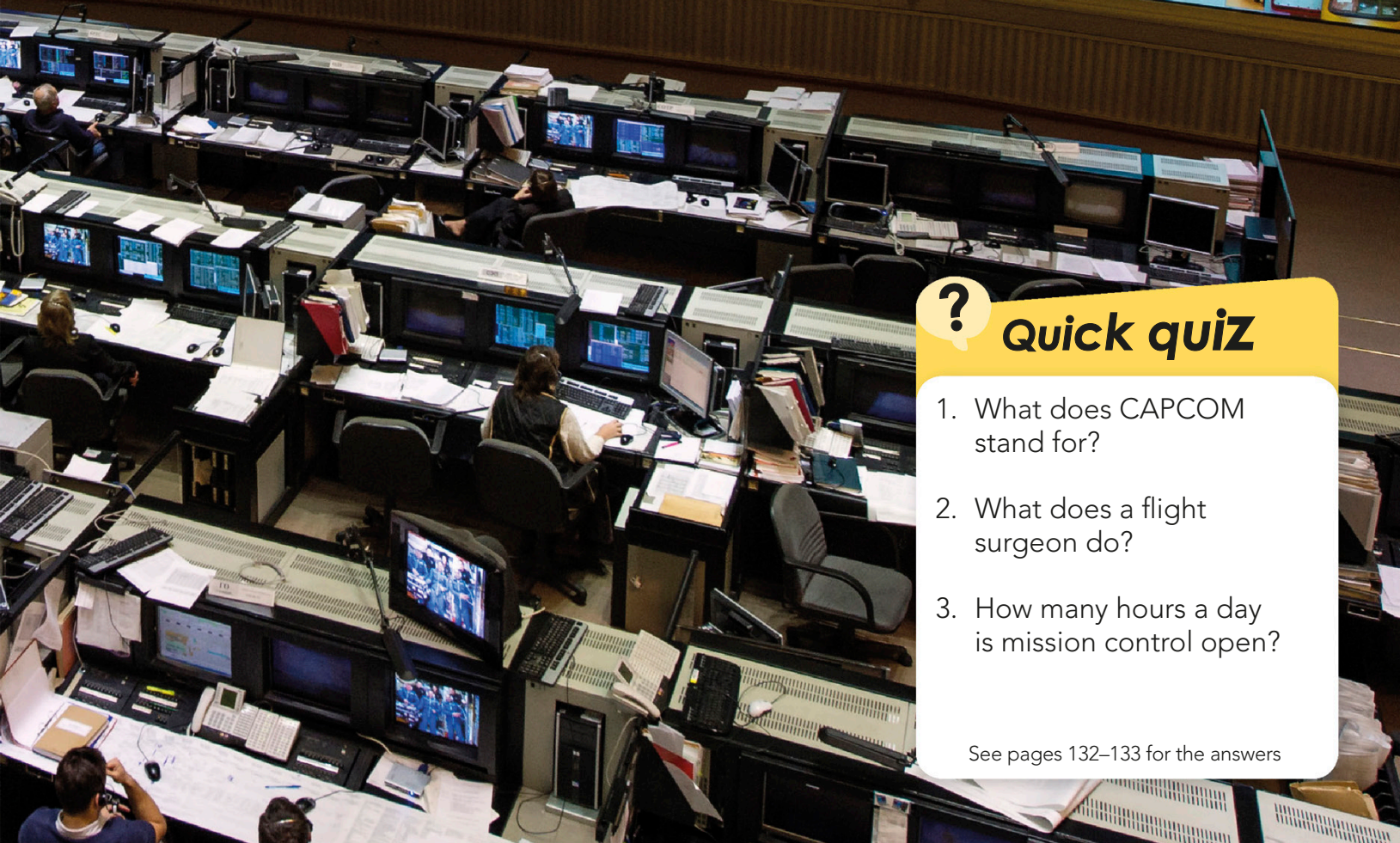
Е. Тарелкин (Роскосмос)
 О. Новичий (Роскосмос)
 К. Форд (НАСА)

Научная программа МКС-33

45 экспериментов

- Медицина и биология: 23
- Технические исследования: 9
- Физика: 3
- Геофизика, зондирование Земли: 6
- Образование: 4

Спутники: Спирит-2, Скайлаб, Биориск, Платинарид, Биотрак, Взаимодействие, Телюграм, Бактериобог, Кальция, Иммерс, Асептак, Дакотин, Каскад, Жемчужь-2, Хроматомаспектр М, Структура, Аидрикс, Адип, ОЧВ, Космическая Биоматрица, Матрица-5, Визир - Альфида, СРС, Высокочастотный Бар, Вектор-Т, Изгиб, Радикал-Р, БТН-Нейтрон, Микроступень, Этон, Силвер, Микроступень, Матрица-Р, БТН-Нейтрон, Плазменный кристалл, Кулоновский кристалл, Тем-Маш, МАИ-75, МАТИ-75



? Quick quiz

1. What does CAPCOM stand for?
2. What does a flight surgeon do?
3. How many hours a day is mission control open?

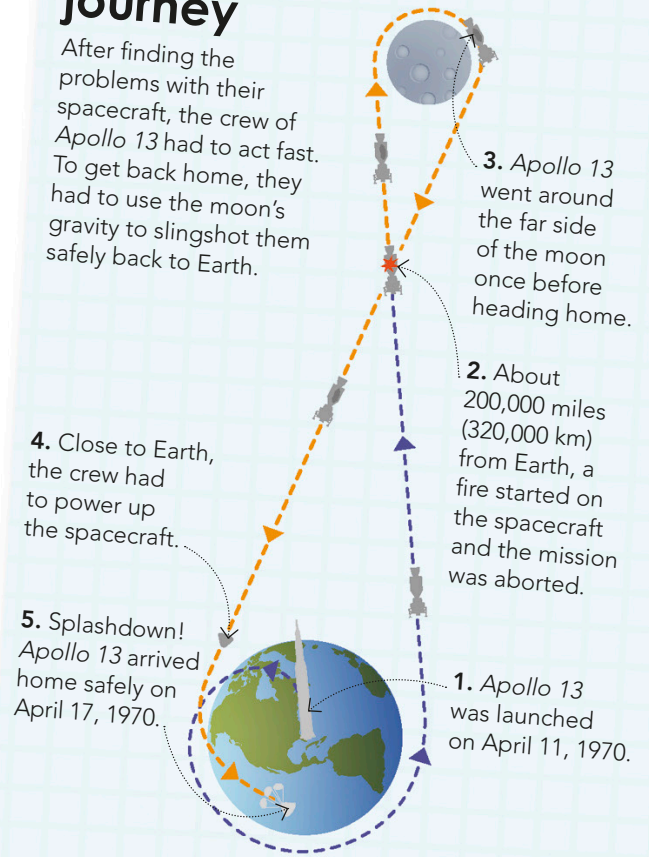
See pages 132-133 for the answers

What happens when things go wrong in space?

Sometimes things don't go as planned when astronauts are in space. However, lots of people back on Earth work with astronauts to help them get through any emergencies, as happened with the Apollo 13 mission...

Apollo 13's journey

After finding the problems with their spacecraft, the crew of *Apollo 13* had to act fast. To get back home, they had to use the moon's gravity to slingshot them safely back to Earth.



Crew

Apollo 13 was meant to be the third manned mission to land on the moon. The American astronauts on this trip were Jim Lovell, Jack Swigert, and Fred Haise.



What happened?

On the way to the moon, a spark in an oxygen tank caused an explosion on the spacecraft. It wouldn't be safe to land on the moon, so the astronauts had to return home quickly.



Solving problems

There were lots of problems to solve to get the astronauts home safely. Mission control worked hard until they figured out the best ways to keep the crew safe.

How do astronauts stay safe in space?



Soyuz spacecraft

The Soyuz spaceship is a Russian craft that takes astronauts to and from the International Space Station (ISS). If they need to leave the ISS in an emergency, astronauts can use it to return to Earth. This spacecraft is known as a Crew Return Vehicle (CRV).

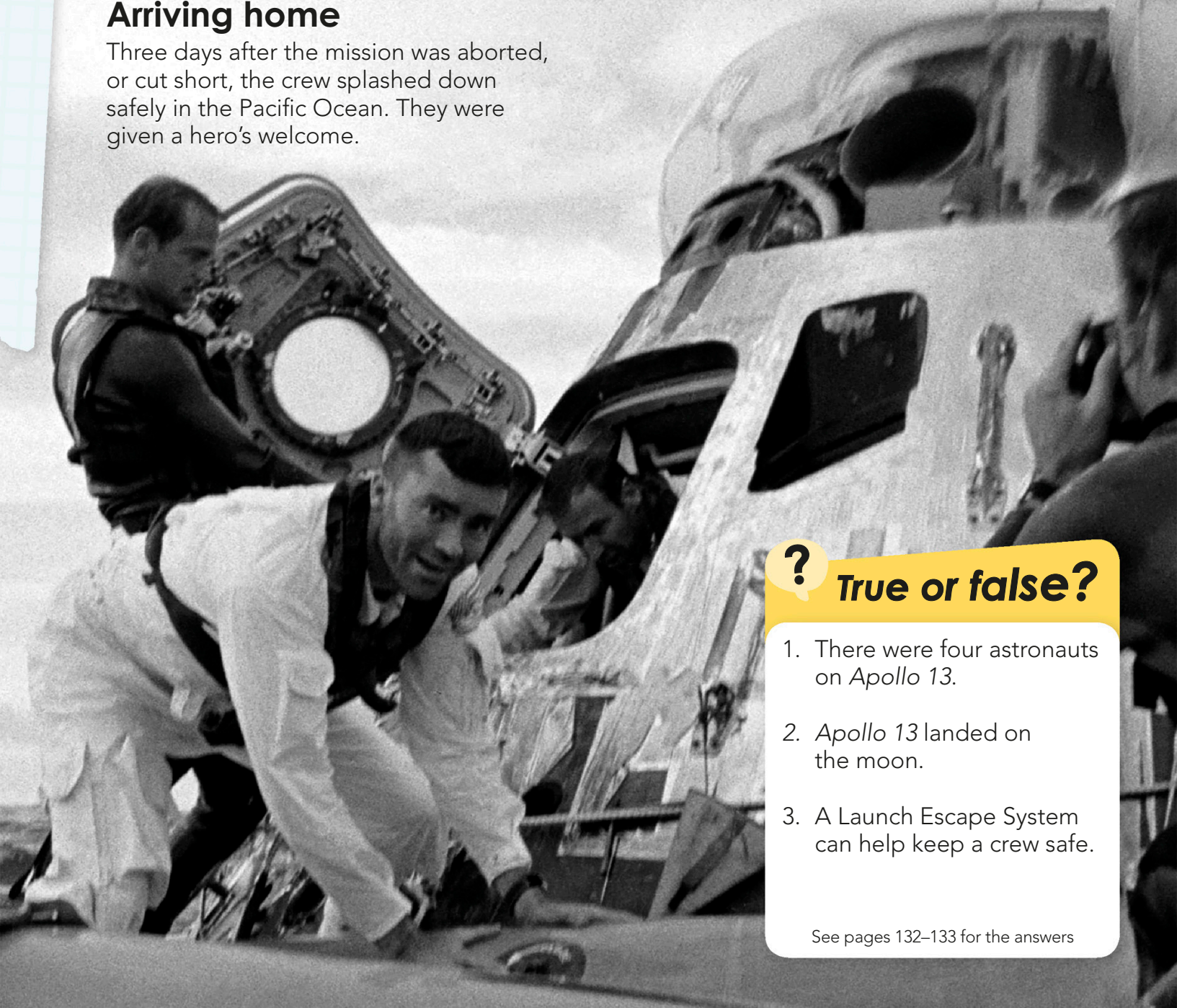


Launch Escape System

Rockets have a Launch Escape System (LES). If anything goes wrong soon after the rocket's launch from Earth, the LES engines fire and carry the crew capsule a safe distance away from the rocket.

Arriving home

Three days after the mission was aborted, or cut short, the crew splashed down safely in the Pacific Ocean. They were given a hero's welcome.



? True or false?

1. There were four astronauts on *Apollo 13*.
2. *Apollo 13* landed on the moon.
3. A Launch Escape System can help keep a crew safe.

See pages 132–133 for the answers

Have we been to Mars?

Humans haven't yet been to Mars because we don't have the technology to do so. However, we have sent robots to investigate the Red Planet. *Curiosity* is a NASA rover that has been exploring Mars since August 2012. It is helping us understand if life could have existed there.

Cameras

Curiosity has 17 cameras. They take pictures of Mars and some of them act as the rover's "eyes."

What's next for Mars?



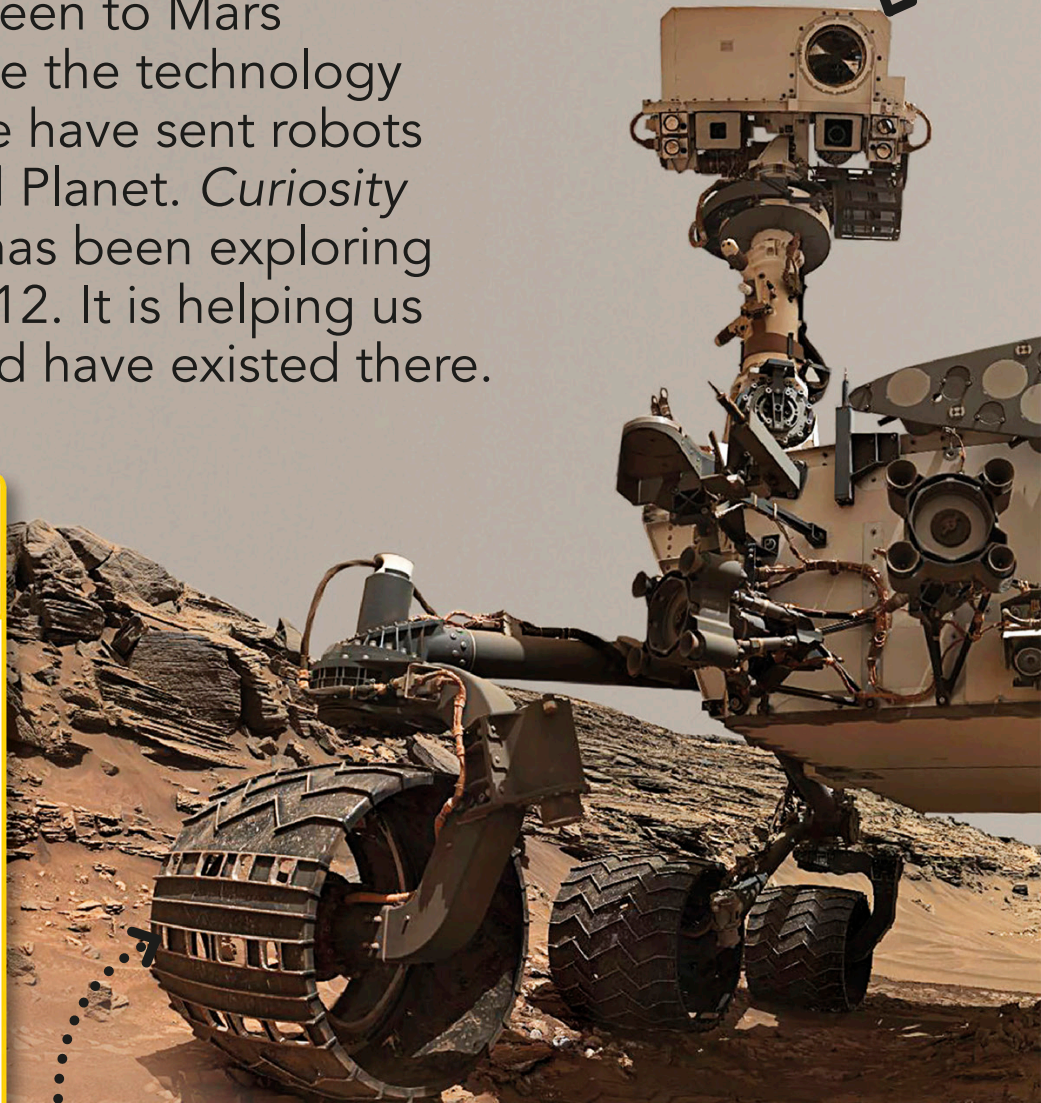
More robots

The ExoMars rover is a European rover that will travel to Mars in 2020. It will drill into the surface of Mars to see if life could exist underground.



Human missions

There are plans to send people to Mars this century. Human explorers will be able to discover more about the planet than current robotic missions can.

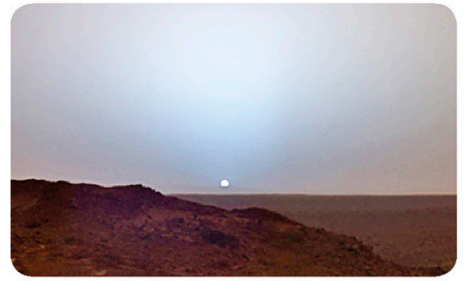


Wheels

Wide wheels help the rover grip to the bumpy martian surface. They do not have tires because they could get punctured too easily.

Curiosity only
travels 1.5 inches
(3.8 cm)
each second.

? Picture quiz



This image was taken at sunset on Mars. Can you guess what the white circle is?

See pages 132–133 for the answers

..... Robotic arm

This arm holds tools to collect and examine rocks for scientists back on Earth. It has joints just like a human arm.



Why do we put satellites in space?

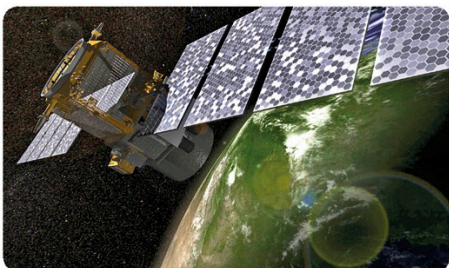
Traveling around the Earth high above you are hundreds of satellites. These are machines that have been launched into space to orbit the Earth. Satellites do many useful jobs such as helping us forecast the weather, letting us use cell phones, and taking pictures from space.

What else do satellites do?



Study space

Some satellites work as telescopes. The Kepler space telescope scans space to look for Earthlike planets.

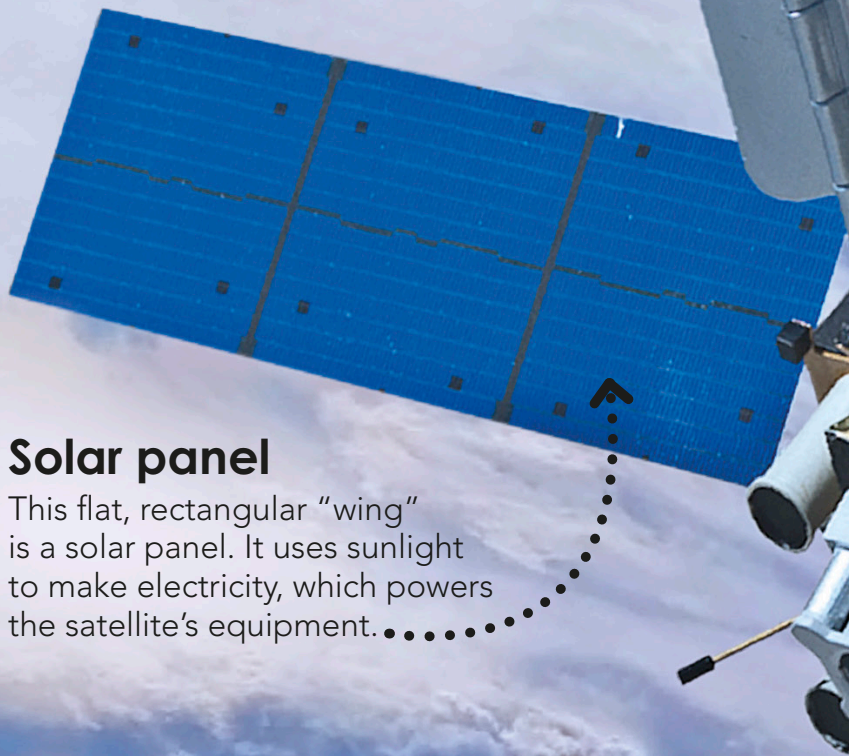


Look at the Earth

A lot of satellites look back at the Earth. This satellite is called CALIPSO and it monitors the clouds and weather on Earth.

Antenna

The antenna sends out signals to the Earth. It can also receive signals from the Earth.



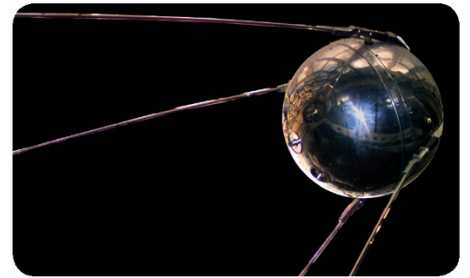
Solar panel

This flat, rectangular "wing" is a solar panel. It uses sunlight to make electricity, which powers the satellite's equipment.

Satellites travel very fast. Some can orbit the Earth 14 times in one day!



Picture quiz

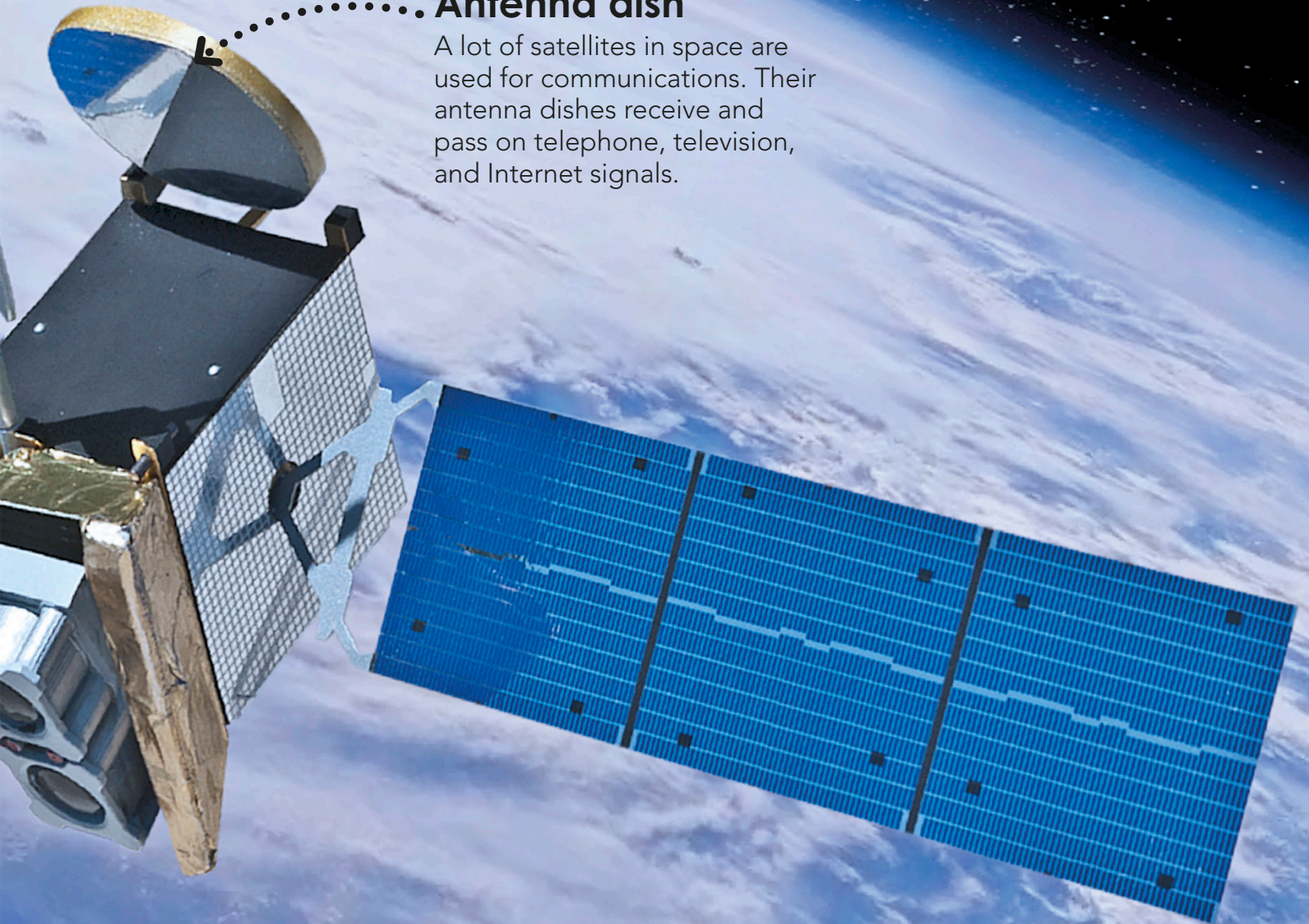


In October 1957, the first satellite was put into orbit. What was its name?

See pages 132–133 for the answers

Antenna dish

A lot of satellites in space are used for communications. Their antenna dishes receive and pass on telephone, television, and Internet signals.



How far have we traveled in space?

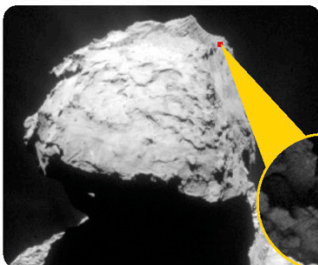
Humans have sent spacecraft to visit every planet in the solar system, as well as the dwarf planet, Pluto. We have also visited the asteroid belt, landed on a comet, and seen the moons of other planets up close.

Jupiter

Several spacecraft have visited the gas giant Jupiter. They have studied its Great Red Spot, or storm, photographed its many moons, and helped us understand more about this huge planet.



Can spacecraft get lost?



Yes, and sometimes found again!

Contact with the lander *Philae* was lost after it landed on a comet. However, scientists later found it hidden in the shadow of a cliff on the comet.

Beyond the solar system

The *Voyager 1* spacecraft has traveled so far through space that it has now left our solar system. It is still sending information back to scientists.



Mars

This planet is populated by robots! These roving robots, sent there by us, are looking for signs that there was once life on Mars.



Pluto

New Horizons is the only spacecraft to have visited Pluto. It discovered a world of ice volcanoes.

There may also be a liquid ocean hidden below its surface.



The moon

Humans have walked on the moon and driven rovers across its surface. We have also sent many spacecraft there to find out more about it.



? True or false?

1. Humans live on Mars.
2. The storm on Jupiter is called the Great Blue Puddle.
3. The spacecraft that visited Pluto is called *New Horizons*.

See pages 132–133 for the answers

What is space junk?

Everywhere humans go, they leave garbage—and that includes space! Space junk is the garbage left over from things we have sent into space. These things are either broken or no longer needed. There are millions of pieces of space junk orbiting our planet.

...Parts of rockets

Space junk includes parts of rockets that were used to launch satellites into space. These parts are left orbiting Earth.



Picture quiz



How often do you think a piece of space junk falls to Earth?

See pages 132–133 for the answers

How can we clean up space?



Locate the junk

Big telescopes on the ground are able to locate space junk orbiting Earth. They are powerful enough to detect pieces of junk as small as 0.4 in (1 cm) across.



Collect the junk

These grids are junk collectors that are being tested outside the ISS. The grids are made up of trays of a spongelike gel, which traps tiny pieces of space junk orbiting Earth.

Astronauts' equipment

Sometimes when astronauts go on space walks, they "drop" things, such as cameras. These things float away as space junk.

Old satellites

There are lots of old satellites in space. Sometimes they crash into each other, creating even more junk!.....



Is there anyone else out there?

So far we have only found life on Earth, but the universe could be full of life we haven't yet discovered. An organization called SETI (Search for Extra-Terrestrial Intelligence) is trying to find out if there is anyone else out there.

Allen Telescope Array

This collection of radio telescopes is called an "array." It is used by SETI to hunt for signals, which may come from life elsewhere in the universe.

Astrobiology is the study of life in the universe.

Scanning the sky

Scientists use a group of radio telescopes to scan the sky for radio signals that might be coming from space.

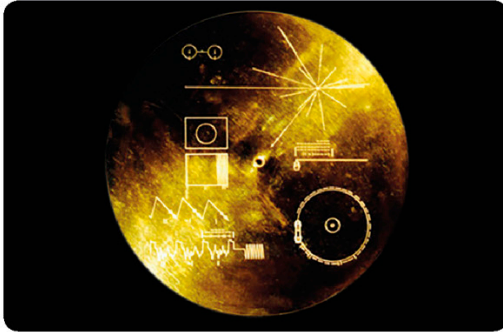


What messages have we sent out to space?



Arecibo message

Beamed to a group of thousands of stars, this message was the most powerful broadcast ever deliberately sent into space. It contains details of life on Earth and a stick figure drawing of a human being.

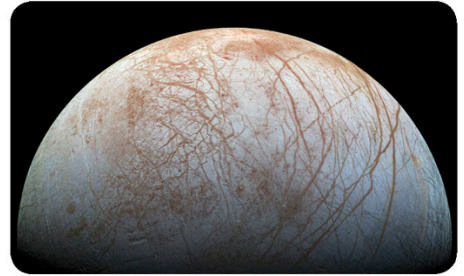


Golden record

The *Voyager 1* and *2* spacecraft have onboard records that explain where they came from. These include images and sounds from life on Earth.



Picture quiz



The frozen moon, Europa, could support life. Which planet does it orbit?

See pages 132–133 for the answers

Radio receiver

The radio receivers are the telescopes' "ears." They are used to receive radio waves that are coming from space.



What is space mining?

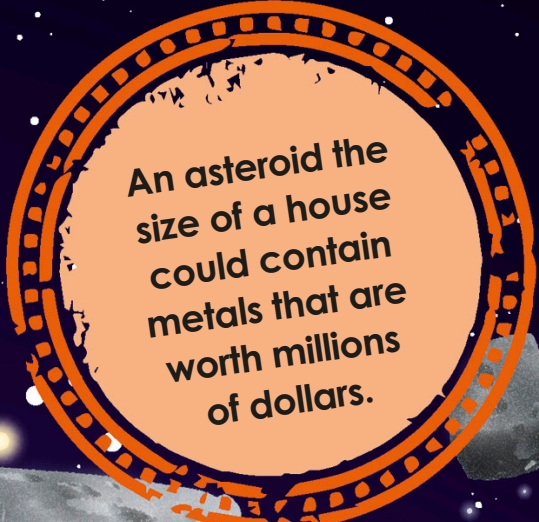
Space is full of things that could be useful to humans. Asteroids, for example, have the ingredients that we could use to make rocket fuel. In the future, humans may mine, or dig, on asteroids to find these ingredients and help us explore farther into space.

Asteroid riches

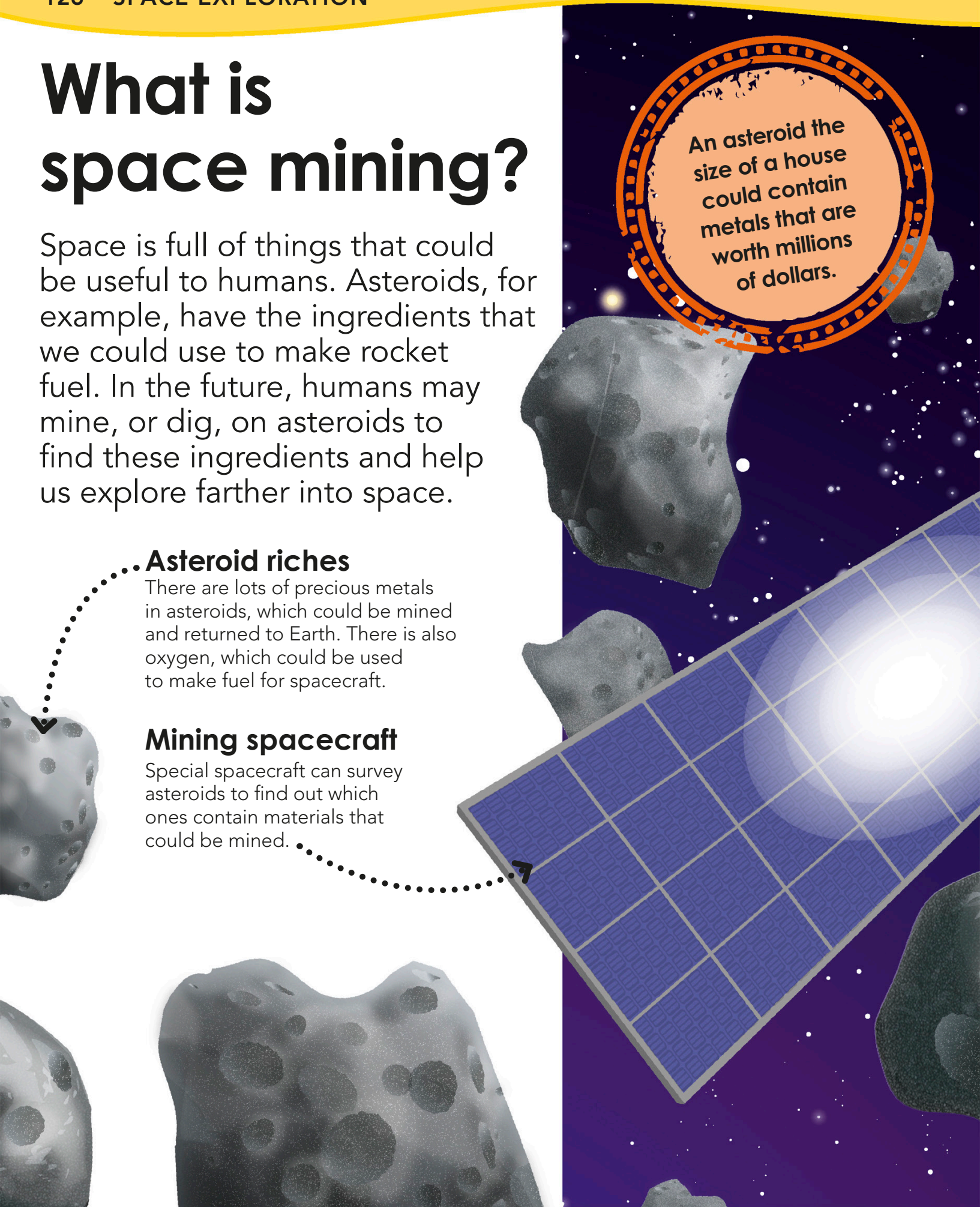
There are lots of precious metals in asteroids, which could be mined and returned to Earth. There is also oxygen, which could be used to make fuel for spacecraft.

Mining spacecraft

Special spacecraft can survey asteroids to find out which ones contain materials that could be mined.



An asteroid the size of a house could contain metals that are worth millions of dollars.

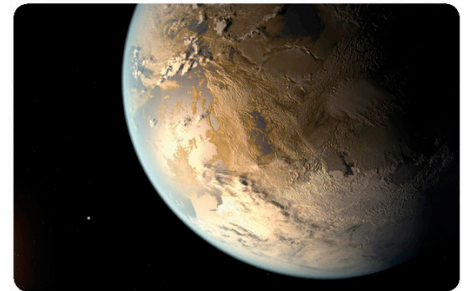


Where else can we mine in space?



The moon

The moon has the potential to be mined. Future spacecraft could even refuel at the moon on the way to other planets.



Distant worlds

As we explore deeper into the solar system, spacecraft will be able to mine faraway worlds for useful materials.

? True or false?

1. One day, we could mine asteroids.
2. Mined oxygen could be useful to future astronauts.
3. Some metals can be found on asteroids.

See pages 132–133 for the answers

Can you go on vacation to space?

So far, fewer than 600 people have traveled into space. Of those, only a few have not been scientists. At the moment, lots of companies are developing new ways to send us on space vacations.

Wish you were there...

One day you could be able to see the Earth from space, and in the future, people could even explore faraway worlds in the solar system.



How else will we get to space?



Vacationers

Virgin Galactic is one of a few companies developing spaceships to send tourists into space. The trips would last a few hours and passengers would get to feel weightless.

Space cruise

Using pressurized capsules, high-altitude balloon rides may take tourists to the edge of space. This is *Voyager*, made by World View Enterprises.



Quick quiz

1. Who was the first space tourist?
2. How much did the first space tourist pay to go to space?
3. In the future, how might tourists travel to the edge of space?

See pages 132–133 for the answers

Moon base

A future moon base could use some of the moon's rocks for the buildings where astronauts would live and work.

Will we go back to the moon?

People haven't visited the moon since 1972. However, since then we have sent spacecraft there and learned a lot more about the moon. There are plans for astronauts to return to the moon in the future and build a base, where they could live and work.

The moon is moving away from the Earth at a rate of about 1½ in (4 cm) a year.



Quick quiz

1. When did people last visit the moon?
2. How will people breathe on the moon?
3. Where in space are inflatable bases being tested?

See pages 132–133 for the answers

Space suit

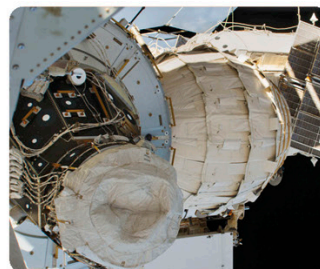
People living in the moon base will still need a space suit with an air supply to go outside. This is because there is no air to breathe on the moon.

What's in the future for space exploration?



New rockets

New rockets will allow humans to explore farther into space than ever before. The SpaceX *Falcon Heavy* is a new rocket that will be one of the most powerful in the world when it launches.



Inflatable bases

Future bases in space could be made from special materials that can be inflated, or blown up like a balloon in space. A base like this is being tested on the International Space Station.

Answers

Page 9 1) An area where baby stars form. 2) People have been going into space for more than 50 years. Many more space missions have been planned for the future. 3) Yes, the Earth and everything else in the universe is in space.

Page 10 1) a. The Karman Line is 62 miles (100 km) above the Earth's surface. 2) c.

Page 13 1) False. The universe is around 13.8 billion years old. 2) True. 3) False. The universe is still growing.

Page 15 1) The Milky Way. 2) Roughly, more than one million Earths can fit inside the sun. 3) The moon is Earth's closest neighbor in space.

Page 17 1) Triton. Temperatures on this moon can drop to -391°F (-235°C) 2) The Boomerang Nebula.

Page 19 1) True. 2) True. 3) False. It takes the moon 27 days 7 hours and 43 minutes to orbit the Earth.

Page 21 1) Spacewalking astronauts wear microphones so that they can talk to each other. 2) A vacuum is an area with nothing in it. 3) No, there is no air in space.

Page 25 1) a. 2) b.

Page 26 1) False. There are four rocky planets. 2) True. 3) True.

Page 28 The blue whale.

Page 30 The Earth.

Page 33 1) True. 2) False. Mars has a north and a south pole. 3) True.

Page 35 1) False. Jupiter, Uranus, and Neptune also

have rings. 2) True. Saturn has many rings. 3) True.

Page 37 1) Pluto is a dwarf planet. 2) Five dwarf planets have been discovered. They are Ceres, Eris, Haumea, Makemake, and Pluto. 3) Pluto has five moons. They are Charon, Hydra, Kerberos, Nix, and Styx.

Page 39 1) The hottest part of the sun is its center, or core. 2) Solar flares are gigantic eruptions of energy from the surface of the sun. 3) The Earth is about 93 million miles (150 million km) away from the sun.

Page 41 1) False. The moon orbits the Earth. 2) True. 3) True.

Page 43 1) Usually just a few minutes, but sometimes as long as seven minutes. 2) Because the sun is so bright that it can blind anyone who looks at it without glasses. 3) A partial eclipse.

Page 45 Mars.

Page 47 1) Meteoroids are found in space. 2) Arizona. 3) A meteorite is a piece of space rock that has fallen to Earth.

Page 49 1) True. 2) False. It is the comet Tempel-Tuttle. 3) False. It is not a star, but a piece of space dust or rock that is falling to Earth.

Page 51 1) False. Comets only develop tails when they pass near the sun. 2) True. It is usually called the nucleus, but it is sometimes described as a "dirty snowball." 3) False. The lander was called *Philae*. The spacecraft, *Rosetta*, ended its mission in 2016 by crashing into a

comet after sending its last pictures and data back to Earth.

Page 53 Yes, the asteroid Ida (shown in the picture) has a tiny moon called Dactyl orbiting it (the dot in the picture).

Page 55 1) True. 2) False. 3) True

Page 57 1) True. The best time of year to see them is during winter. 2) True. They can be green, purple, pink, red, or yellow. 3) True.

Page 59 1) False. Mercury is the closest planet to the sun. 2) True. 3) False. Venus is covered in gray rocks.

Page 63 It's a spiral galaxy.

Page 65 1) True. These clouds are called nebulae. 2) False. The sun is about 4.6 billion years old.

Page 67 1) True. There are red and blue giants. 2) True. There are red, white, black, and brown dwarfs. 3) False. Our sun is an average star.

Page 69 1) The speed of light is 186,500 miles (300,000 km) per second. 2) Light from the sun takes more than eight minutes to reach the Earth. 3) It takes the International Space Station around 90 minutes to orbit the Earth.

Page 71 1) A black hole doesn't look like anything—it's invisible. 2) Gravity is the force that pulls things into a black hole. 3) Time goes slower near a black hole.

Page 73 1) c. 2) c.

Page 75 1) a. The arms of some galaxies are made of stars. 2) c. A galaxy that

has no particular shape is called an irregular galaxy.

Page 77 1) Yes, you can see planets in the night sky. Mercury, Venus, Mars, Jupiter, and Saturn are the brightest planets that can be seen from Earth without a telescope. The planets can be seen at different times of the year. 2) Patterns of stars are called constellations. 3) The brightest object that you can see in the night sky is the moon.

Page 79 1) Yes, other stars often have planets. 2) Rogue planets are planets that don't orbit a star. 3) Planets that orbit other stars are called exoplanets.

Page 81 1) True. 2) False. Quasars are the brightest things in the universe. 3) True.

Page 85 1) A telescope is something that we can use to see farther into space. 2) Galileo made his telescope in 1609. 3) The Yepun telescope is more than 26 ft (8 m) wide.

Page 87 When John Glenn went into space for the second time, he was 77 years old, which made him the oldest person to have been in space.

Page 89 1) The first dog in space was called Laika. 2) The first animals in space were fruit flies. 3) Ham the chimpanzee was four years old when he went into space.

Page 91 The first person to set foot on the moon was Neil Armstrong.

Page 93 1) Twelve people have walked on the moon. 2) Eugene Cernan—he was actually the 11th person to

step on the moon, but the last person to leave it. 3) No, scientists have found a thin layer of gas on the moon, but no air.

Page 95 1) Hermann Oberth is often called one of the fathers of modern rocketry. 2) Most rockets are made up of two or three stages. 3) The towers around the launch pad are to protect the rocket from lightning strikes.

Page 96 1) False. Only the Lunar Module landed on the moon. 2) False. It took astronauts on the Apollo missions three days to reach the moon. 3) True. A parachute helped to guide the *Apollo* crew to safety.

Page 99 1) False. Training for space takes years. 2) False. Lots of astronauts wear glasses. As long as their vision is perfect when they wear them, they are still able to go to space. 3) False. They practice in the "Vomit Comet."

Page 100 1) True. In 1965 Alexey Leonov was the first person to go on a space walk. 2) True. The visors protect their eyes from the sun's harmful rays. 3) False. A rescue unit will help stranded astronauts.

Page 103 To travel on Earth the space shuttle Orbiter had to be carried on the back of an airplane.

Page 104 1) It takes astronauts three and a half hours to return to Earth in the *Soyuz*. 2) Astronauts have to get used to gravity when they return from space. 3) The parachutes on *Soyuz* open 15 minutes before landing.

Page 107 1) If the temperature was not controlled, the ISS could get as hot as 248°F (120°C). 2) The solar panels create electricity. 3) The Kibo module is used to conduct experiments on the ISS.

Page 109 1) Microgravity is the state in space where people and things seem to be weightless and can float. 2) Humans cannot float in the air on Earth because gravity pulls us to the ground. We can, however, float in water! 3) No, the moon has its own gravity, but it's much weaker than the Earth's gravity. You would weigh less on the moon, and if you jumped, you would be able to jump higher than on the Earth. You wouldn't float away, however, but land back on the ground more slowly than on the Earth.

Page 111 1) Astronauts need to eat three meals a day. 2) Astronauts can use a spoon, "sip" their food through a tube, or eat it as it floats in front of them. 3) Most food that astronauts eat in space is vacuum-sealed.

Page 113 1) CAPCOM stands for capsule communicator. 2) A flight surgeon is a doctor who gives astronauts advice on how to stay healthy. 3) Mission control is open 24 hours a day, 7 days of the week, every day of the year.

Page 115 1) False. There were three astronauts on *Apollo 13*. 2) False. There was a problem and *Apollo 13* had to return to Earth before landing on the moon. 3) True. A Launch Escape System can help carry the crew away from a rocket.

Page 117 The white circle is the sun.

Page 119 The first satellite was called *Sputnik 1*.

Page 121 1) False. Only robots, that were sent by humans, can be found on Mars. 2) False. The storm on Jupiter is called the Great Red Spot. 3) True. The spacecraft, *New Horizons*, visited Pluto in 2015.

Page 122 At least one tiny piece of space junk falls to Earth every day.

Page 125 Europa orbits Jupiter.

Page 127 1) True. 2) True. Oxygen mined from asteroids could be used to make rocket fuel and many other things. 3) True. Many different metals can be found on asteroids.

Page 129 1) Dennis Tito was the first space tourist. 2) Dennis Tito paid \$20 million to visit the International Space Station. 3) In the future, tourists might be able to travel to the edge of space in a balloon, such as *Voyager*, or in a spaceship.

Page 131 1) People last visited the moon in 1972. 2) People will have a supply of air so that they can breathe on the moon. 3) Inflatable bases are being tested on the International Space Station. One such base is called the Bigelow Expandable Activity Module (BEAM) and can expand by five times its compressed size in just 45 minutes.



Quiz your friends!

Who knows the most about space? Test your friends and family with these tricky questions. See pages 136–137 for the answers.

Questions

1. Which planet has the most moons?

4. How long does it take for the **Earth** to complete one full **orbit** around the **sun**?

7. How old is our sun?

10. What crashes into the **moon** and creates **huge craters** on its surface?



2. Do **Mercury** and **Venus** have any moons?

6. What is the **largest telescope** ever launched?

5. Which was the first **rover** to land on Mars?

8. Which **planet** has the **biggest ocean**?

9. Which metals can be found in **meteorites**?

12. What is the **largest object** in the asteroid belt?

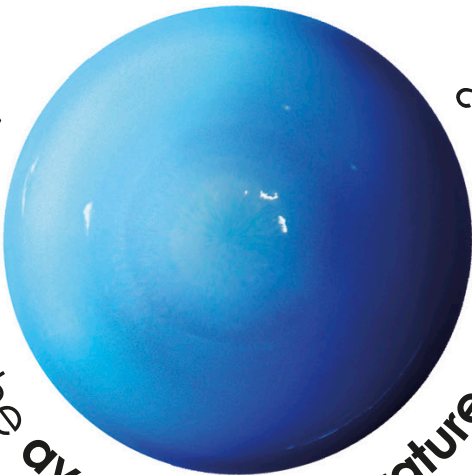
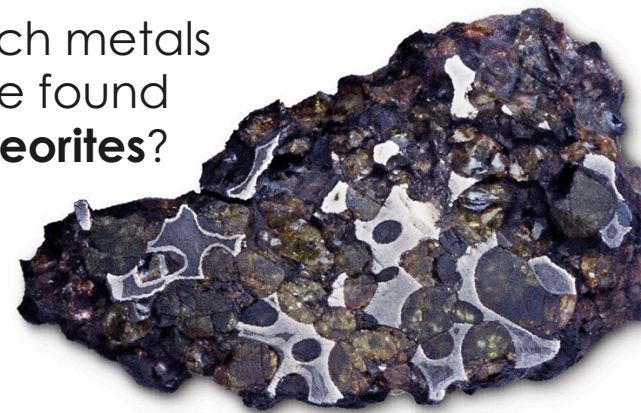
13. How many people live on the **International Space Station (ISS)** at a time?

11. What is the **average temperature** on Neptune?

14. Can you see twinkling stars from **the surface of the moon**?

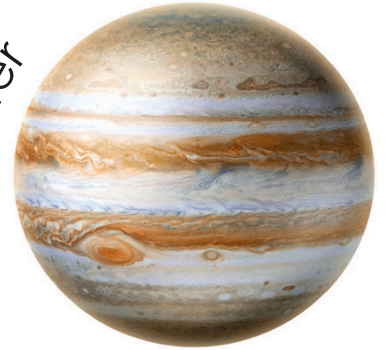
15. Which **spacecraft** was the first to land on a **comet**?

3. How fast does the **Earth** rotate?

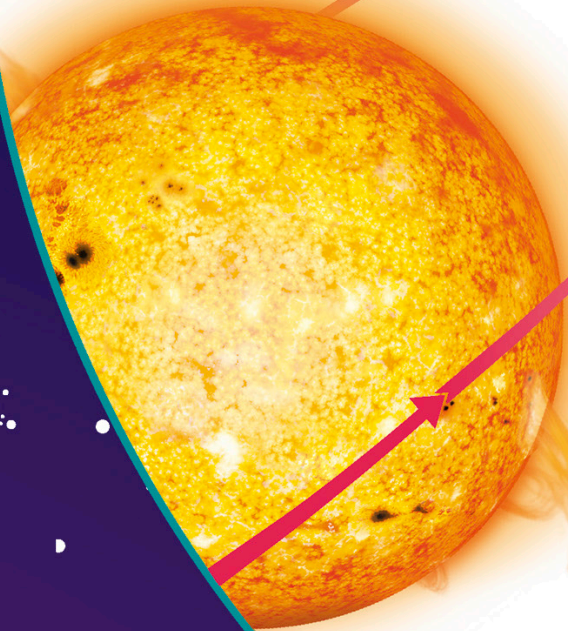


Answers

1. Jupiter



4. The Earth takes **365 days** to complete one full orbit around the sun.



2. **Mercury** and **Venus** do not have any moons!



3. The Earth rotates on its axis at a speed of up to **1,037 mph** (**1,670 kph**).

5. In 1997, the **Sojourner** rover became the first rover to **land** on the surface of Mars.

6. The Hubble Space Telescope

7. The sun is **4.6 billion years** old.

9. **Nickel** and **iron** are metals that can be found in meteorites.

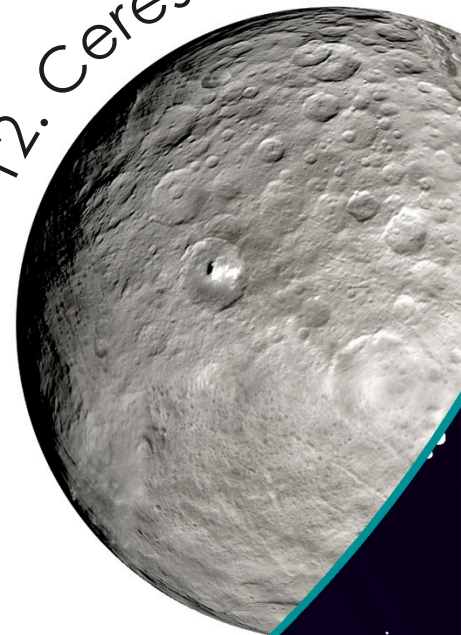
8. Earth



10. Meteorites

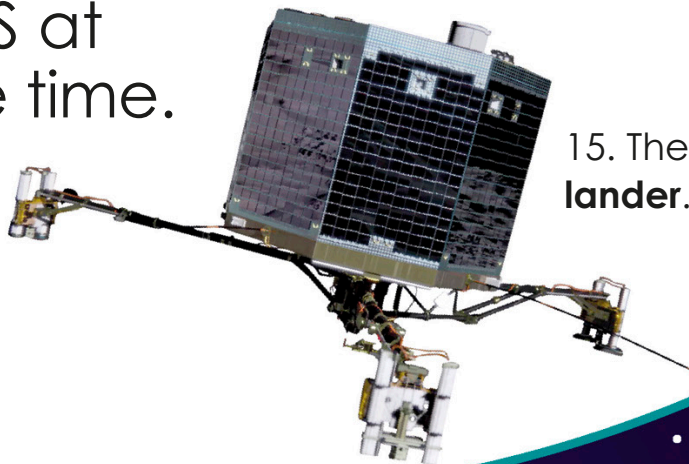
11. **Neptune** averages a temperature of around **-346°F (-210°C)**, making it the **coldest planet in the solar system**.

12. Ceres



13. **Six astronauts** can live and work on the ISS at the same time.

14. No, because the moon has **no atmosphere**.



15. The **Philae** lander.

Glossary

accelerate

When something, often a vehicle, quickly picks up speed

altitude

How high above sea level or the ground something is

array

Display or range of a certain thing

asteroid

Small, rocky object that orbits the sun

atmosphere

Layers of gas that surround a planet

atoms

Smallest things that exist—everything is made of atoms

aurora

Naturally occurring light displays that happen at the north and south poles of some planets

big bang

Huge explosion that created the universe

black hole

Object in space with a strong force of gravity that nothing can escape from, not even light

comet

Object made of dust and ice that orbits around the sun, developing a tail as it gets closer to the sun

constellation

Group of stars that forms a particular pattern

corona

Outer atmosphere of the sun

cosmonaut

Term for a human space traveler, mainly used to refer to Russian astronauts

crater

Bowl-shaped dent on the surface of a planet or other object in space, caused by the collision with a space rock

crew

Group of people who work on a spacecraft

dense

When something is thick and tightly packed, such as a dense fog

dwarf planet

Object in space that is similar to a planet but is smaller.

eclipse

When an object is in the shadow of another object

exoplanet

Planet that orbits a star other than the sun

galaxy

Huge group of stars, gas, and dust held together by gravity

glacier

Large mass of ice found on land

gravity

Force that pulls things toward each other

habitable zone

Area around a star that has conditions that are suitable for life

ice cap

Area of ice that usually covers the north and south poles of a planet

Karman Line

Imaginary line that is 62 miles (100 km) above the surface of the Earth and marks where space begins

Kuiper Belt

Region of ice and rock that lies beyond Neptune

light-year

Distance that light can travel in one Earth year

lunar

Word used to relate to the moon

matter

Stuff that all things are made of

meteor

When a meteoroid burns up as it enters the Earth's atmosphere, appearing as a streak of light in the sky

meteorite

Meteoroid that lands on a planet or moon's surface

meteoroid

Particle of rock, metal, or ice traveling through space

meteor shower

What happens when there are lots of meteors in the sky

microgravity

When things become weightless in space

molecular cloud

Dense cloud in space where stars can form

- moon**
Object made of rock or rock and ice that orbits a planet or asteroid
- nebula**
Cloud of gas and dust in space where stars are born
- north pole**
Area at the most northern point of a planet
- nucleus**
Central and most important part of something such as a comet or black hole
- orbit**
Path an object takes around another when pulled by its gravity
- ozone layer**
Area in the Earth's atmosphere that protects the surface from the sun's harmful rays
- parent star**
Star that provides heat and light for the planets that orbit around it
- particles**
Extremely small parts of a solid, liquid, or gas
- pioneer**
Person who is one of the first to explore a new place
- planet**
Large, spherical object that orbits a star
- pressurized**
Something that is sealed with air that humans are able to breathe
- rogue planet**
Planet that does not orbit a star
- rover**
Vehicle that is driven on the surface of a planet or moon
- satellite**
Object that orbits another larger object. It can be natural, such as rock, or made by people
- solar flare**
Gigantic eruptions of energy from the surface of the sun
- space probe**
Unmanned spacecraft designed to study objects in space and send information back to Earth
- space suit**
Sealed, protective clothing worn by an astronaut to protect them in space
- space station**
A large spacecraft that is usually occupied by humans, where experiments can be conducted
- space walk**
When an astronaut in space is outside a spacecraft, usually to repair or test equipment
- star**
Huge, glowing sphere of gas that creates energy in its core
- sunspots**
Dark spots that appear on the surface of the sun
- supernova**
Explosion that happens in space when a star dies
- telescope**
Instrument used to look at distant objects
- test pilot**
Pilot who flies aircraft to test how they work
- tourist**
Person who visits a place for a vacation
- toxic**
Poisonous
- universe**
All space and everything in it
- vacuum**
Area with nothing in it, not even air
- virtual reality**
Environment that has been created by computers. It appears to be real and can be seen, but nothing in it is solid, or physical
- visor**
Part of a helmet that can be moved up and down over a person's face
- wormhole**
Possible passage in space that can connect two places that are far apart. Scientists have not yet found a wormhole, but do think they could exist

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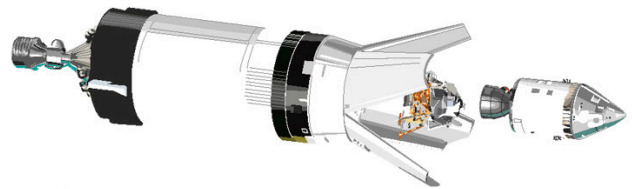
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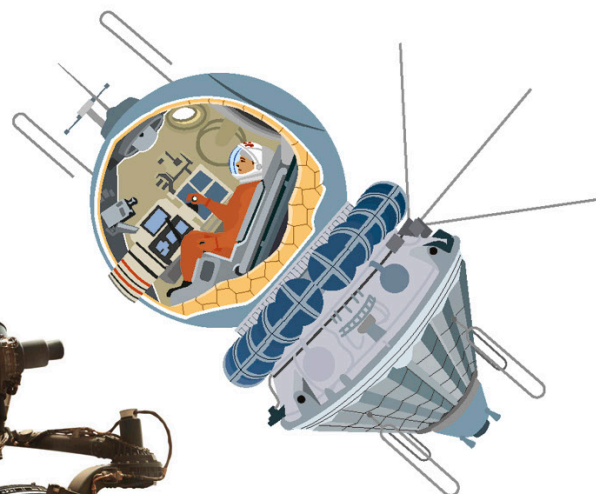
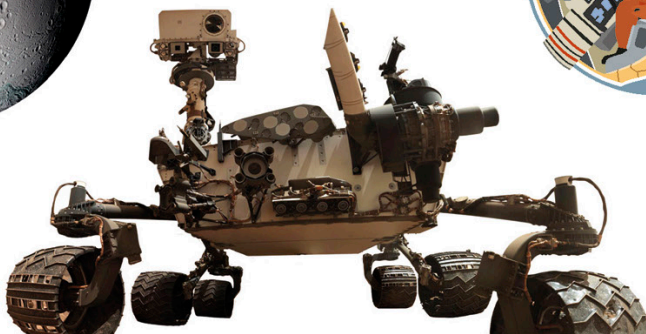
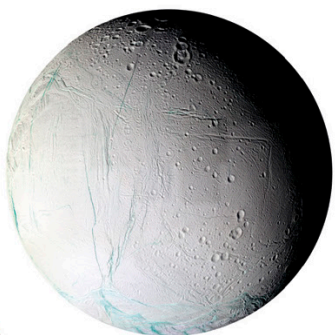
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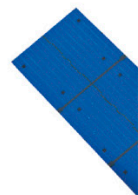
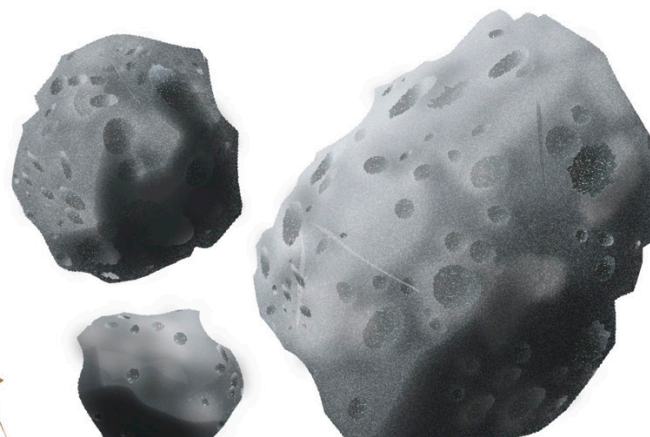
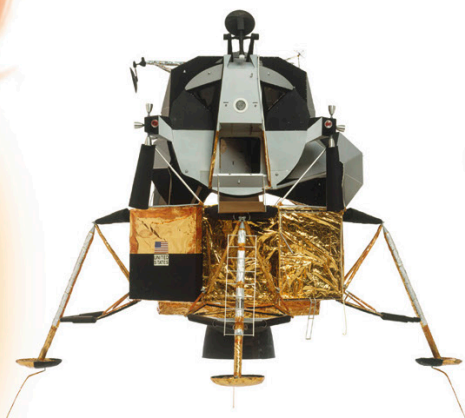
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