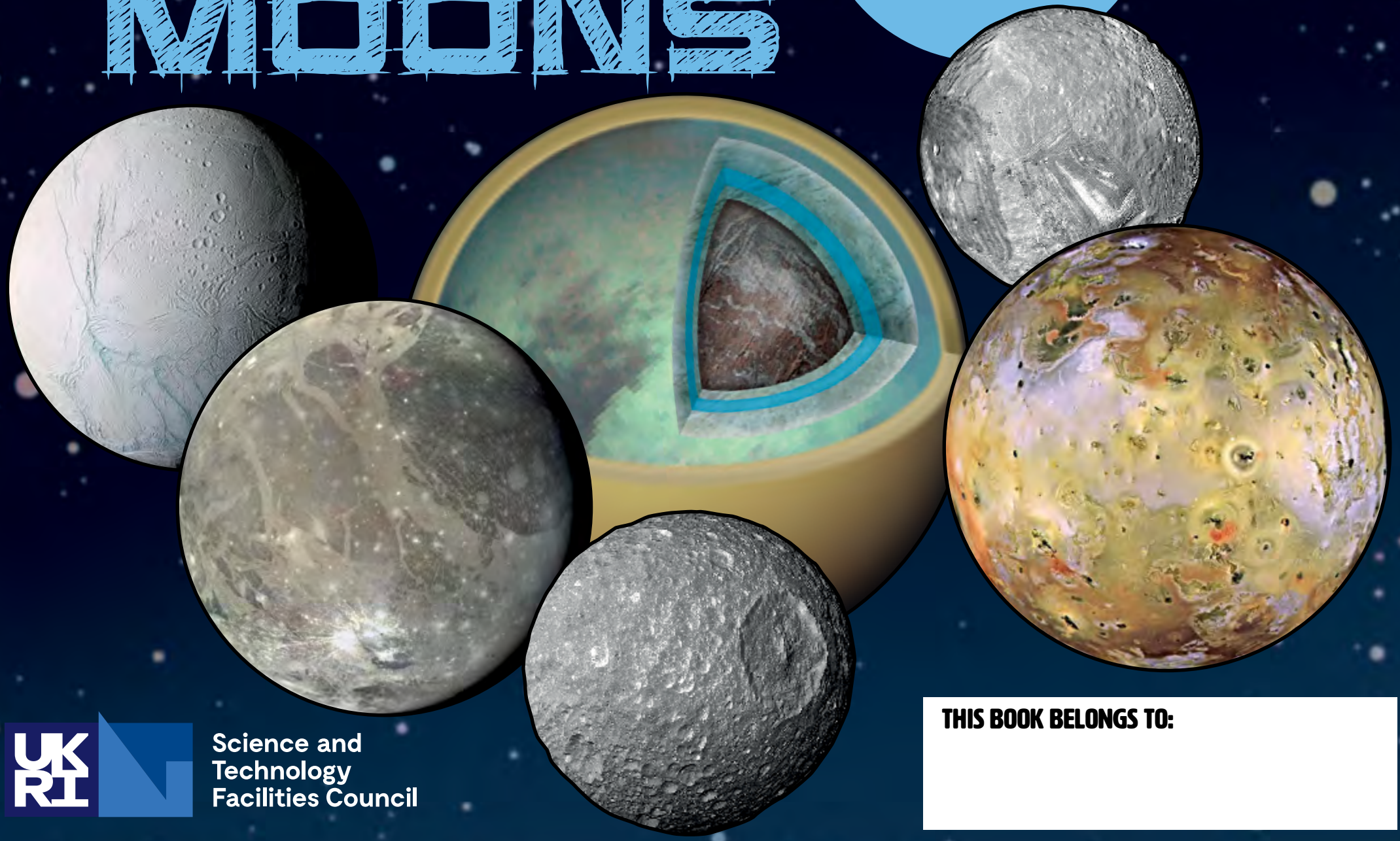
THE LITTLE BOOK OF MOONS

A LITTLE BOOK OF THE PLANETS BOOSTER PACK



UKRI Science and Technology Facilities Council

THIS BOOK BELONGS TO:

Which is the biggest moon in the Solar System? Which is the smallest?

Which has the most moons: Saturn, or Jupiter?

How can moons have volcanoes if they are made of ice?

Which moon looks like the Death Star?

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

THE LITTLE BOOK OF MOONS

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IMAGES: NASA, ESA

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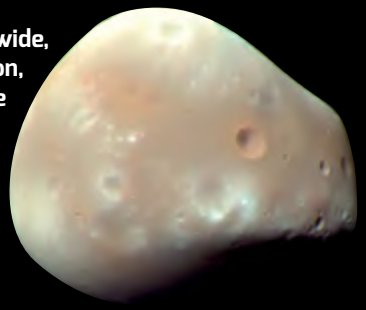
1 WHAT IS A MOON?

Moons orbit planets and asteroids in our Solar System. Earth has only one moon but there are more than 200 moons in our Solar System. Most of the major planets (except Mercury and Venus) have moons. Saturn and Jupiter have the most moons, with dozens orbiting each of the two giant planets. Pluto and some other dwarf planets, as well as many asteroids, also have small moons.

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

Most of the moons that orbit planets probably formed from the discs of gas and dust circulating around planets in the early Solar System. Some moons are objects that formed somewhere else and where captured by a planet's gravity.

At 5,275 km wide, Jupiter's moon, Ganymede, is the biggest moon.

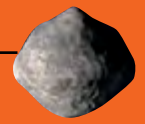


At just 12.4 km wide, Mars' moon, Deimos, is the one of the smallest moons.

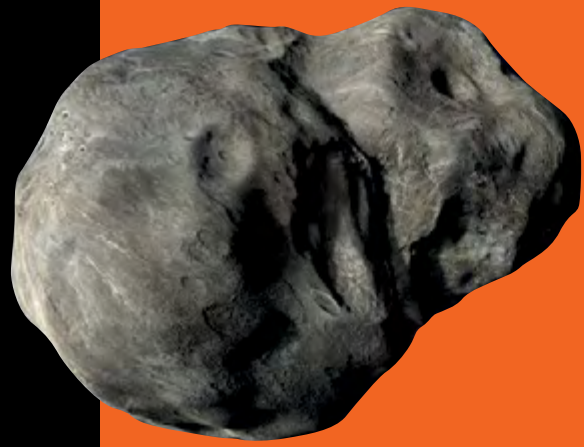
Jupiter's moon, Io, has huge ice volcanos

DID YOU KNOW?

There isn't a really a proper definition of what a moon is. There may be more than 200 moons orbiting the planets, but there are hundreds more orbiting other objects like asteroids.

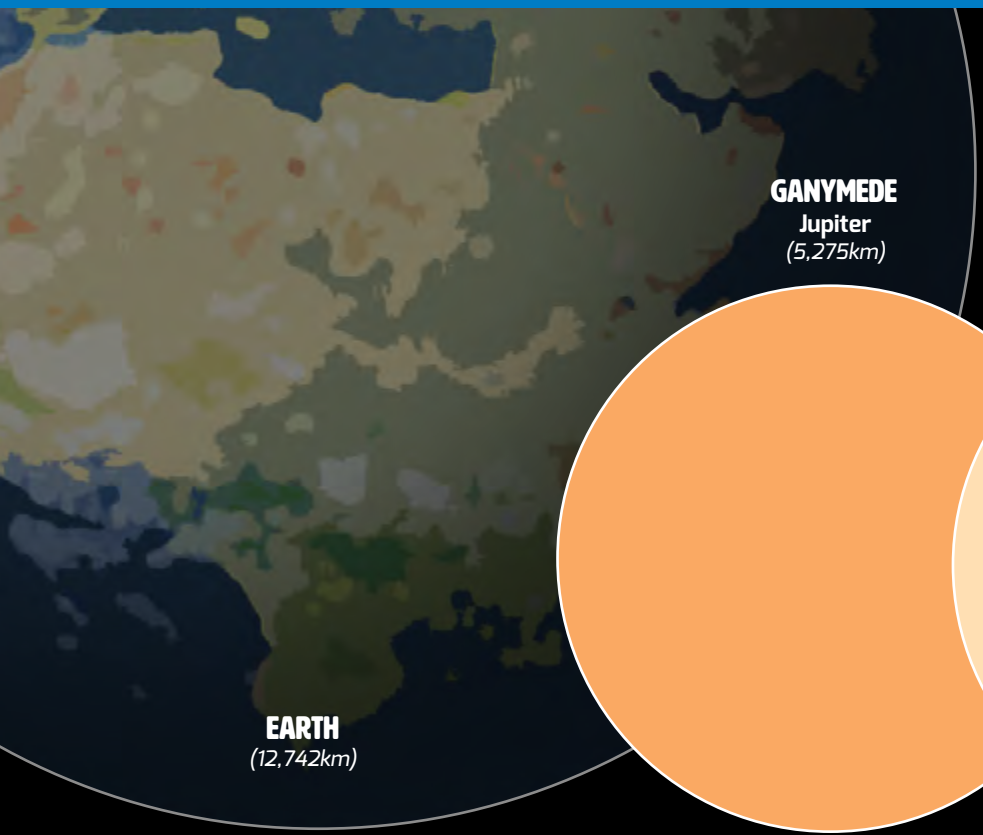


The mini-moon (or moonlet) Dimorphos orbits the astroid Didymos every 12 hours.



Also, do you count any object that orbits a planet as a moon? If that's the case you have to count every piece of ice or rock that orbits as part of a ring system (such as Saturn's rings). If that is the case, there might be hundreds of millions of moons in the Solar System!

1.1 THE TEN BIGGEST MOONS
SIZE & SCALE



These are the ten largest moons in the Solar System. The largest, Ganymede, and Titan are bigger than the planet Mercury (Callisto is about the same size). If they orbited the Sun directly, they'd be classified as planets!

GANYMEDE
Jupiter
(5,275km)

TITAN
Saturn
(5,150km)

CALLISTO
Jupiter
(4,820km)

IO
Jupiter
(3,643km)

EARTH
(12,742km)

DEIMOS
Mars
(12.4km)

MOON

Mars' moon, Deimos, is tiny in comparison. Look how small it is compared to our Moon.

MOON
Earth
(3,475km)

EUROPA
Jupiter
(3,122km)

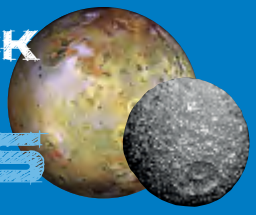
TRITON
Neptune
(2,707km)

TITANIA
Uranus
(1,575km)

RHEA
Saturn
(1,528km)

OBERON
Uranus
(1,523km)

2 THE MOONS OF THE ROCKY PLANETS



Of the rocky planets, only the Earth and Mars have moons. The Earth's moon, also known as Luna, is remarkable because it is the largest moon relative to the planet it orbits. It is also the only moon be visited by human beings.

Mars' moons are tiny compared to the Earth's. They are only a few kilometre's across and they whiz around Mars in less than a day and a half.

THE EARTH SYSTEM – THE MOON

1 MOON

Ave distance from Earth: 354,800 km
Orbital period: 27.3 Earth days
Daytime surface temp: 120°C
Nighttime surface temp: -160°C
Diameter: 3,475 km

The Moon is Earth's only natural satellite and the fifth largest moon in the Solar System.

The moon is rocky and is covered with craters created by asteroid impacts millions of years ago.

You can find out all about Earth's moon in our 'Hands on the Moon' booklet!

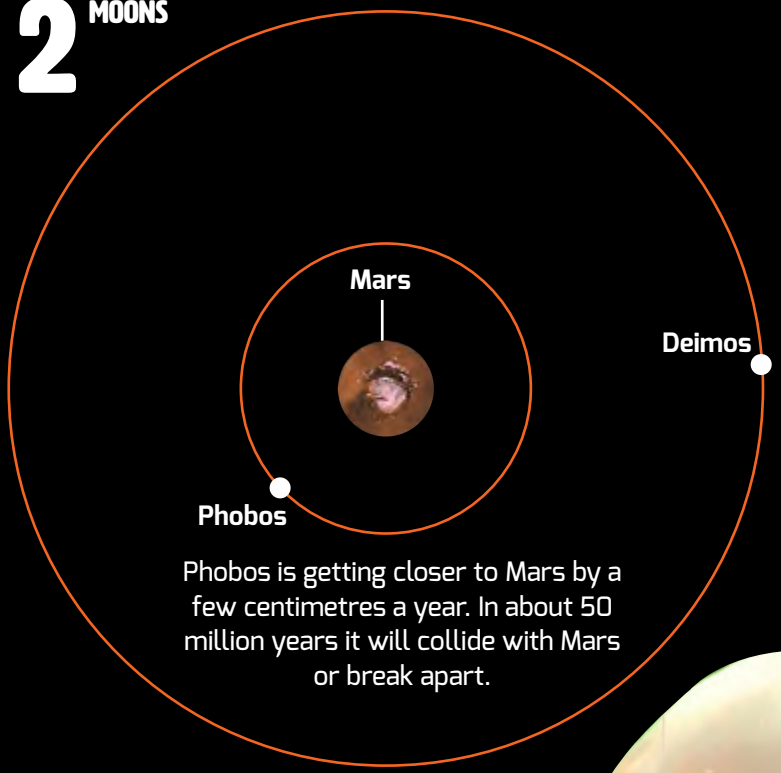
THE HIDDEN SIDE OF THE MOON

The Moon takes 27.3 days to revolve once – the same amount of time it takes it to orbit the Earth. This is why we only ever see one side of the Moon. Spacecraft have seen its hidden side and it looks very different from the part of the Moon we are used to seeing!

2.1 THE MOONS OF THE ROCKY PLANETS

THE MARS SYSTEM

2 MOONS



Phobos is getting closer to Mars by a few centimetres a year. In about 50 million years it will collide with Mars or break apart.

PHOBOS

Ave distance from Mars: 9,375 km
Orbital period: 8 Earth hours
Daytime surface temp: -4°C
Nighttime surface temp: -170°C
Diameter: 22.2 km

Mars' largest moon might look solid but it's really just a large pile of rubble held together by gravity. Phobos has quite a few impact craters, the largest of which, called Stickney, is 9 kilometres wide. The impact that formed the crater nearly destroyed Phobos.

Stickney crater – the pale lines are made by landslides of rock and dust.

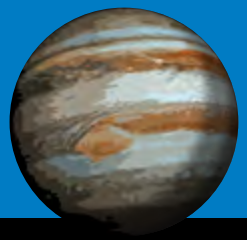
DEIMOS

Ave distance from Mars: 23,460 km
Orbital period: 30 Earth hours
Daytime surface temp: -4°C
Nighttime surface temp: -170°C
Diameter: 12.4 km

Tiny Deimos is about half the size of Phobos. Like it's big brother, the moon is covered in a reddish soil made up of dust and rocks. Phobos looks smoother than Deimos because the soil has settled in all but the newest craters.

The origin of Mars' moons is unknown. Some think they are both captured asteroids; others that Phobos formed from the debris left over when mars formed.

3 THE MOONS OF JUPITER

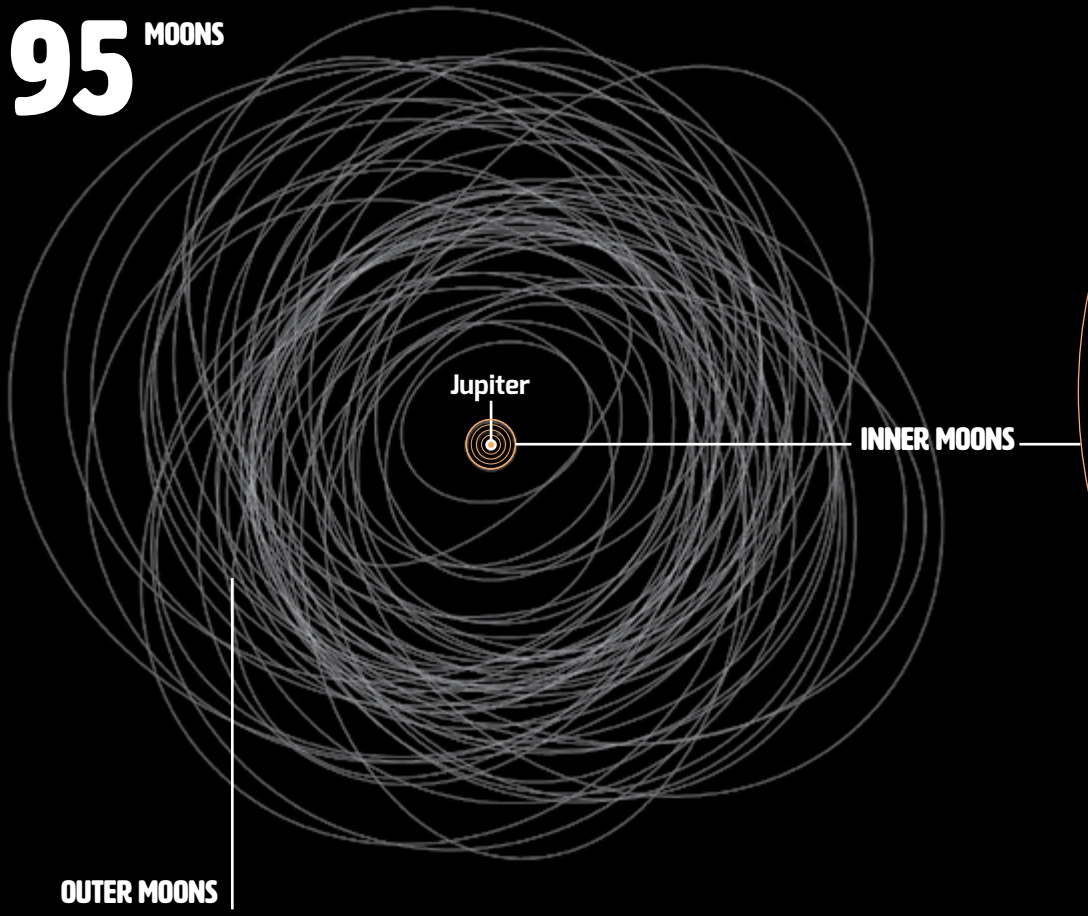


The largest planet in the Solar System also has the biggest family of moons. Scientists have discovered 95 moons so far but, as most are very small, there could be many more yet to be discovered. Jupiter's most impressive moons are its planet-sized inner moons – Ganymede, Callisto, Io and Europa.

Jupiter's four inner moons are also known as the Galilean moons (named after the Italian astronomer, Galileo Galilei, who discovered them in 1610).

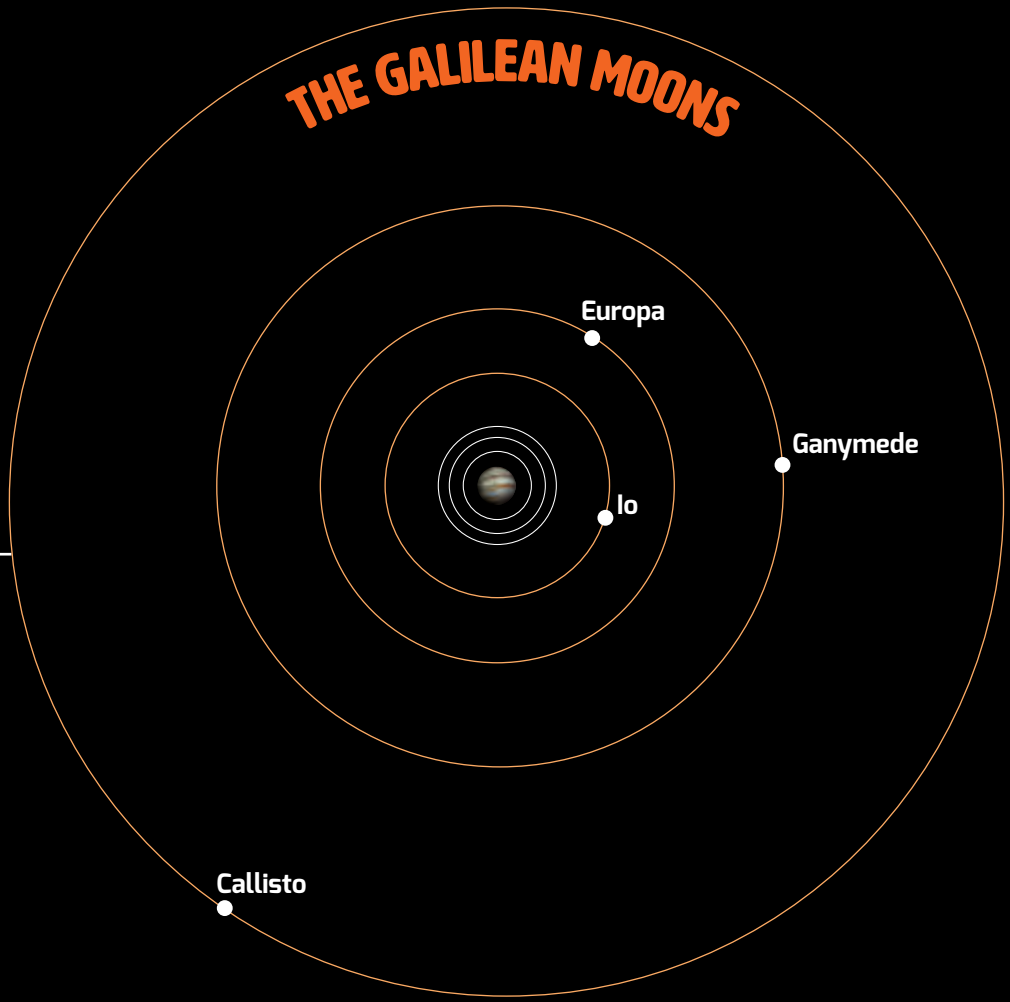
THE JUPITER SYSTEM

95 MOONS



This spaghetti-like mess of lines shows the orbits of some of Jupiter's many outer moons. These small lumps of rock and ice include captured asteroids and comets. Most are only a few metres across but a few measure tens of kilometres.

THE GALILEAN MOONS



Many of Jupiter's outer moons orbit in the opposite direction to the spin of the planet in what is called a 'retrograde orbit'.

3.1 JUPITER'S GALILEAN MOONS

Io

Ave distance from Jupiter: 421,700 km
Orbital period: 1.77 Earth days
Ave surface temp: -130°C
Diameter: 3,643km

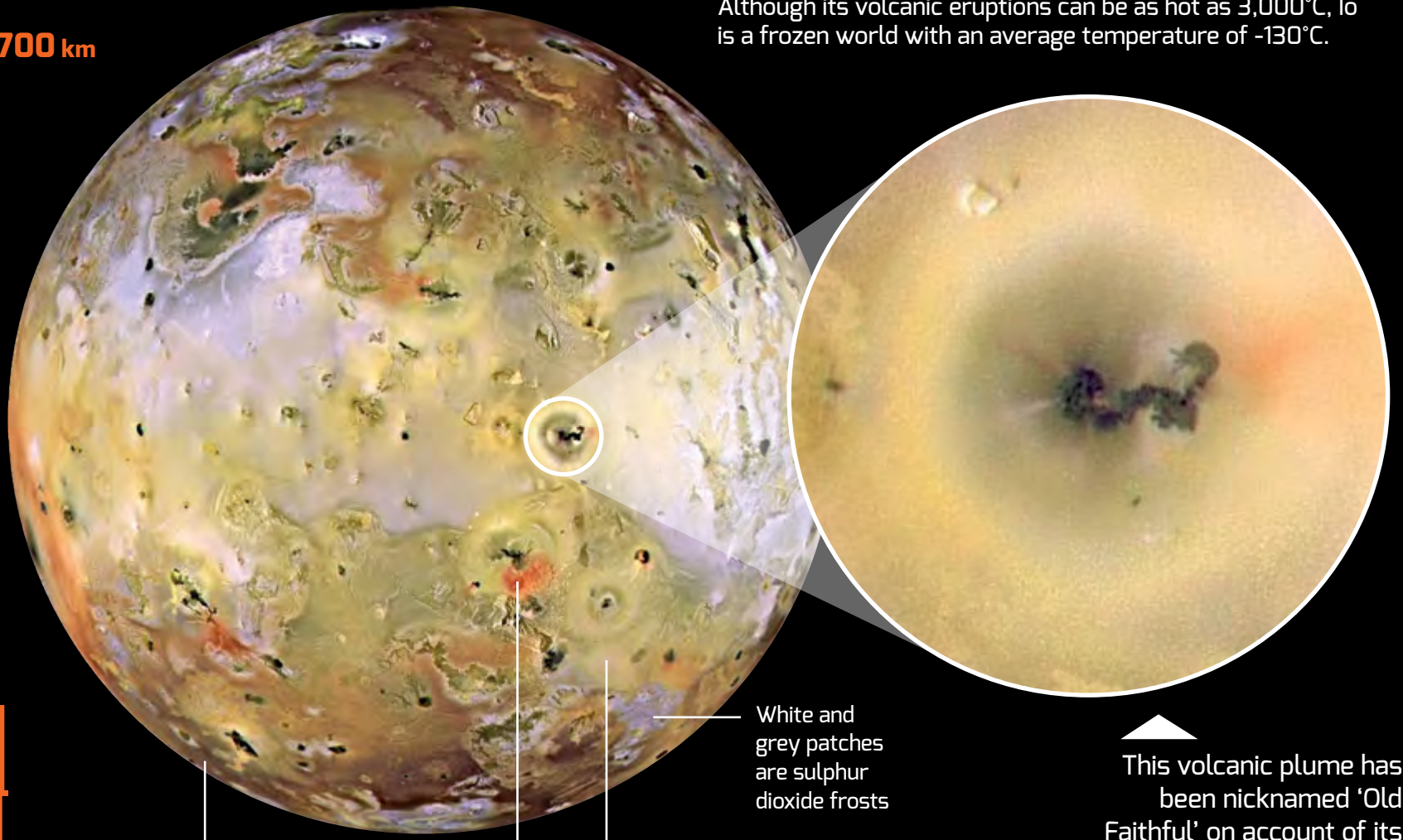
Io is the most volcanically active world in the Solar System, with hundreds of volcanoes, some erupting as lava fountains dozens of kilometres high.

Caught between Jupiter's massive gravitational pull and that of its neighboring moons, Io's interior is heated and melted by colossal tidal forces.

DID YOU KNOW?

Tidal forces cause Io's surface to rise and fall by as much as 100 metres (that's about the same height as Big Ben).

Although its volcanic eruptions can be as hot as 3,000°C, Io is a frozen world with an average temperature of -130°C.



White and grey patches are sulphur dioxide frosts

This volcanic plume has been nicknamed 'Old Faithful' on account of its reliable outbursts. The plume sends bursts of molten sulphur into atmosphere.

Dark areas on the surface are layers of sulphur that has been baked by Jupiter's radiation

Red patches around active volcanoes are sulphur ejected in recent eruptions

Yellowy-green areas are thought to be pure sulphur.

3.2 JUPITER'S GALILEAN MOONS

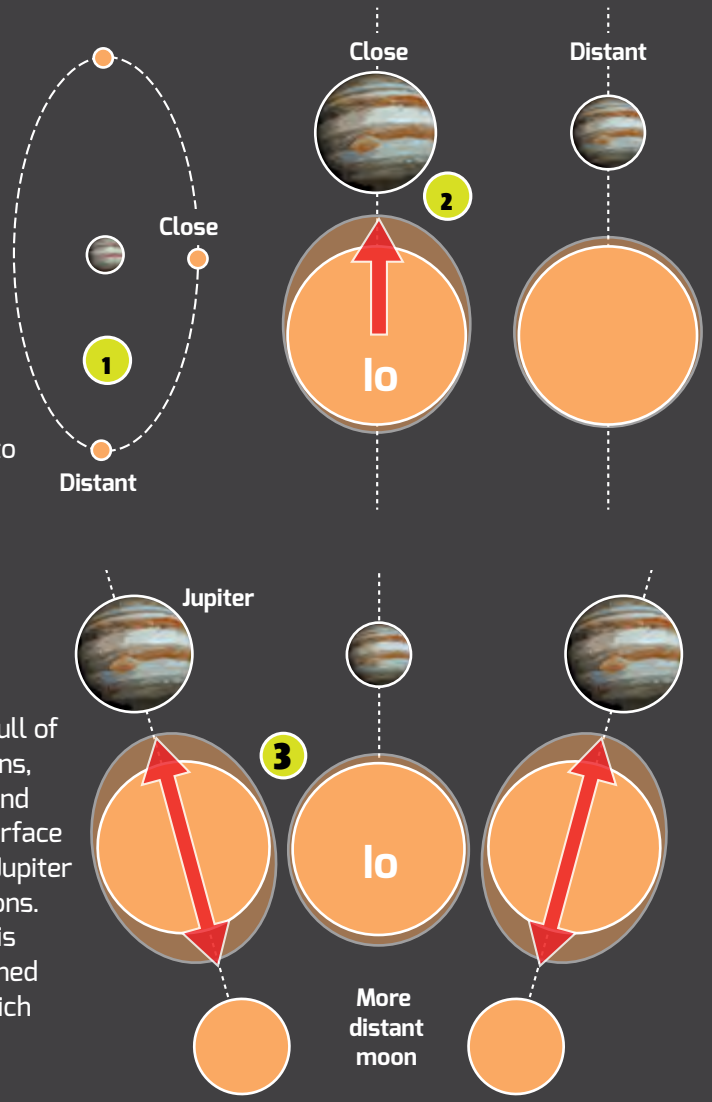
WHAT IS TIDAL HEATING?

Tidal heating is the heating of the interior of one planetary body caused by tidal forces created by the gravitational pull of another.

1 Jupiter's huge mass means that it exerts a tremendous gravitational force. Compared to Jupiter, Io, is a tiny moon that is strongly affected by the pull of Jupiter's gravity.

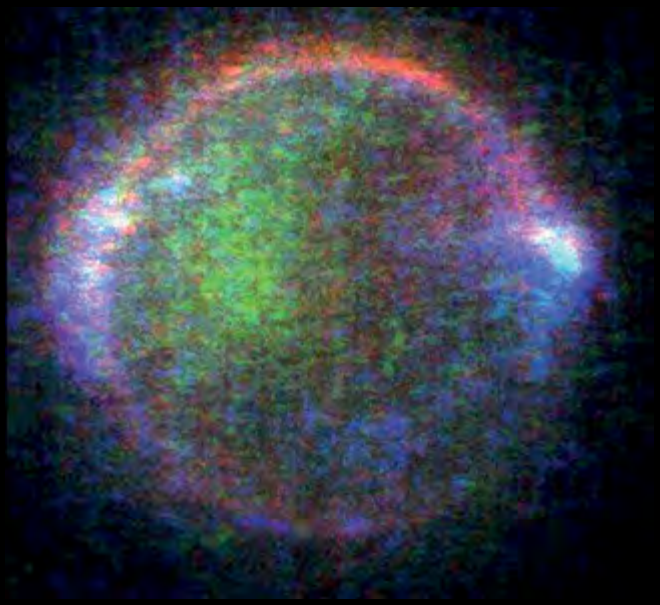
2 When Io is close to Jupiter during its orbit, one side of the planet feels more of a gravitational pull that the other.

3 Io also feels the pull of more distant moons, Europa, Callisto, and Ganymede. Io's surface is tugged toward Jupiter and the other moons. So, as it orbits, Io is continually stretched and squeezed, which heats the planet's interior.

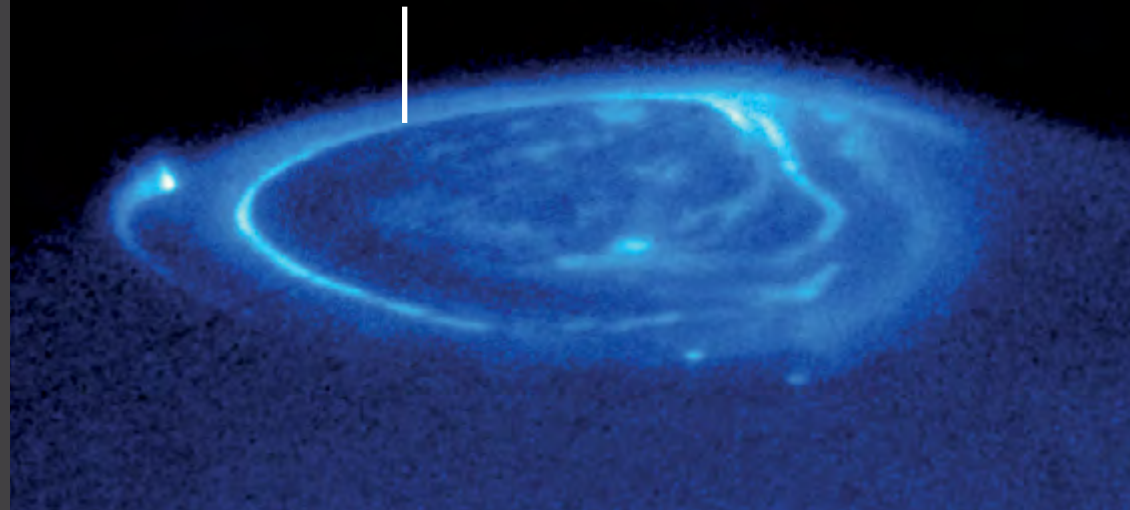


AURORA ON IO

Io sits within Jupiter's powerful magnetic field. It is constantly bombarded by high-energy particles trapped in the planet's radiation belts. When these particles collidee with Io's thin atmosphere, they produce glowing aurorae with bright green and red colours.



Io also fuels the aurorae that appear at Jupiter's poles. Io's volcanic eruptions throw tonnes of charged particles into space. They are captures by Jupiter's magnetic field and smash into the atmosphere at the planet's poles.

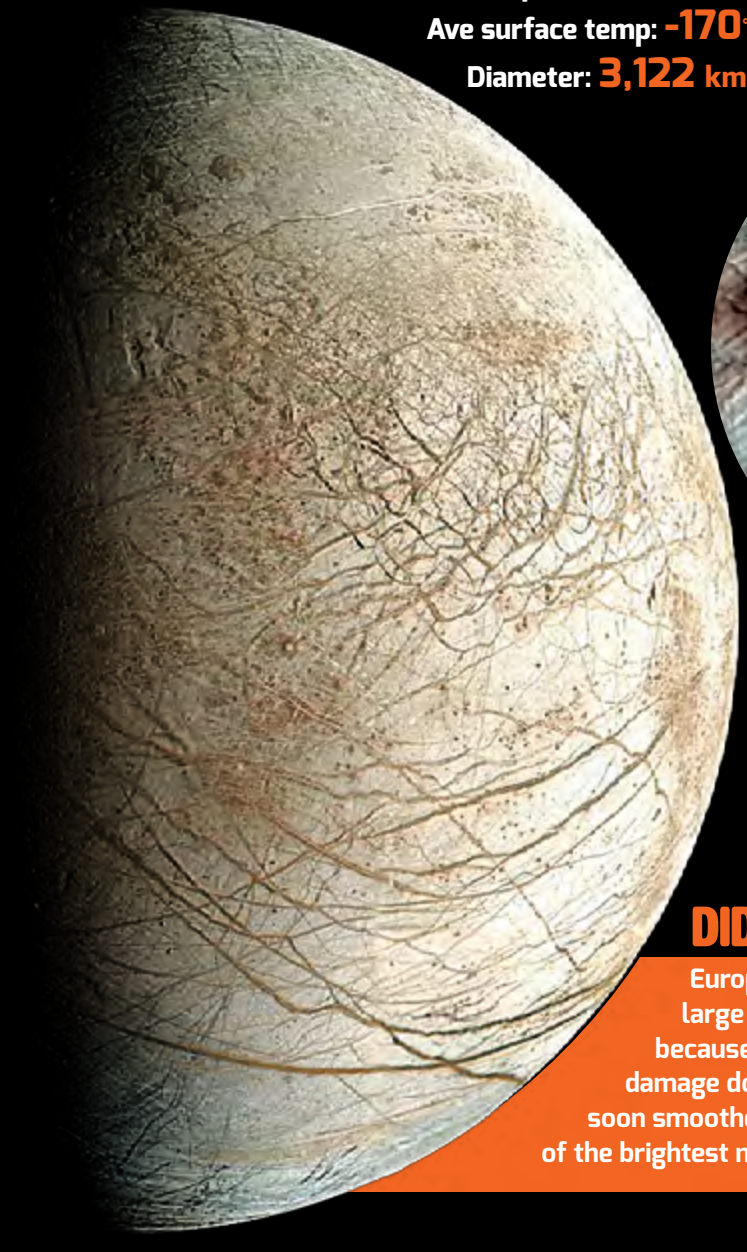


3.2 JUPITER'S GALILEAN MOONS

EUROPA

Ave distance from Jupiter: 670,900 km
Orbital period: 3.5 Earth days
Ave surface temp: -170°C
Diameter: 3,122 km

Beneath Europa's icy surface, scientists believe there is a vast hidden ocean. Like Io, Europa is squeezed and stretched by tidal forces – from Io and Jupiter on one side and from the planet-sized Ganymede on the other. These tidal forces heat the planet and melt the ice – creating a salt-water ocean maybe 100 km deep.



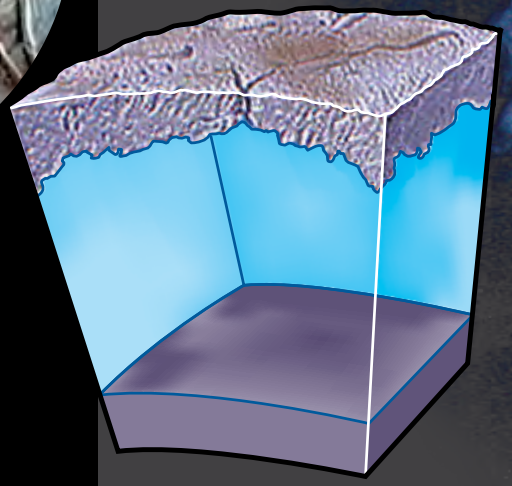
The cracks that crisscross the surface are called lineae. These cracks are formed by tidal forces. Warmer ice, stained red by sulphur and salts, wells up fill the cracks.

DID YOU KNOW?

Europa has the smoothest surface of any large object in the Solar System. This is because it is covered with a icy crust. Any damage done to the surface by meterorites soon smoothes itself out. This also makes it one of the brightest moons in the Solar System.

A HOME FOR ALIEN LIFE?

Europa's sub-surface ocean makes it one of the best places in the Solar System to look for alien life.



If Europa is hiding a 100 km-deep ocean, it would contain twice as much water as all the Earth's rivers and oceans combined.

On Earth, in the deepest oceans where the Sun's rays can't reach, life has been found around geothermal vents called 'black smokers'. It is possible that Europa has similar vents.

3.3 JUPITER'S GALILEAN MOONS

GANYMEDE

Ave distance from Jupiter: 1,070,400 km
Orbital period: 7.2 Earth days
Ave temp: -165°C **Diameter:** 5,275 km

The largest moon in the Solar System, Ganymede is 8% wider than the planet Mercury but is much less dense, which suggests that it is made up of a mix of rock and ice. It is the only moon in the Solar System to have a significant magnetic field so may have a liquid iron core.

About 90% of Ganymede's surface is made up of water ice.

Light patches form where the older dark plates of ice have drifted apart.

It has a very thin mostly oxygen atmosphere.

CALLISTO

Ave distance from Jupiter: 1,883,000 km
Orbital period: 17 Earth days
Ave temp: -139°C **Diameter:** 4,820 km

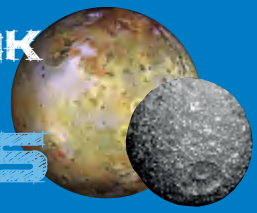
Unlike Ganymede, Europa and Io, Callisto's dark, heavily cratered surface seems to changed little since it was formed. Solar radiation has slowly darkened the moon's surface, which makes the youngest craters seem bright against the dull, seemingly dead, landscape.

Callisto is thought to be the most heavily cratered object in the Solar System.

It is the third-largest moon in the Solar System.

Callisto hasn't been affected by tidal heating so it is thought to be made up of an even mix of ice and rock.

4 THE MOONS OF SATURN

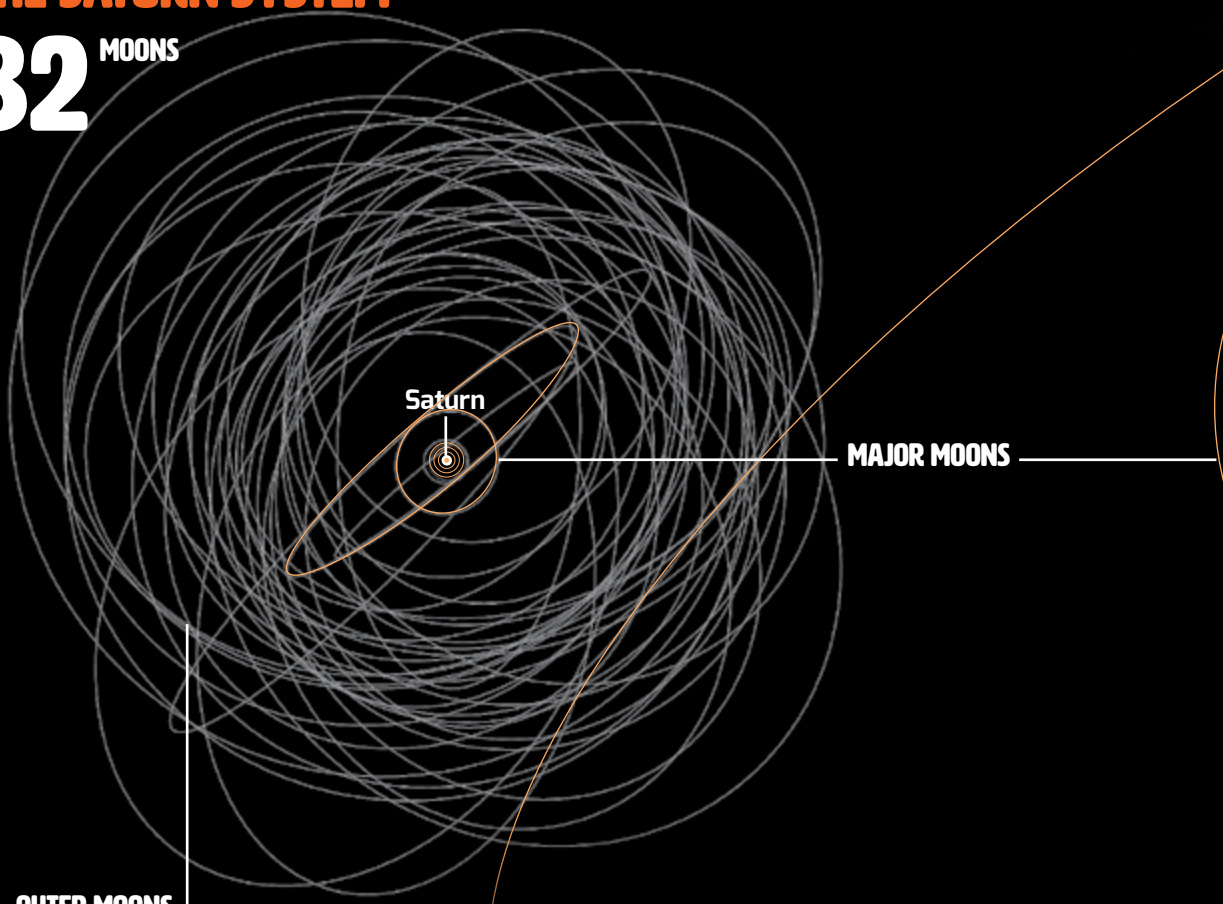


Saturn has 83 moons – 53 are confirmed and named and another 30 moons waiting to be confirmed and named. They range from planet-sized worlds with atmospheres to small lumps of rock and ice. The moons closest to Saturn actually orbit within the planet's famous rings – these are known as 'shepherd moons.

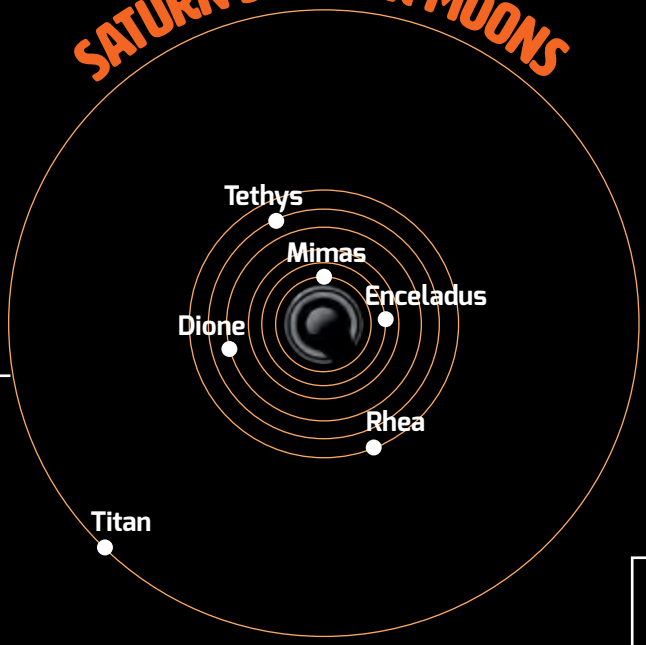
There also more than 150 smaller objects, known as 'moonlets' orbiting within the rings. Saturn's biggest moons, known as 'major moons' orbit outside of the rings.

THE SATURN SYSTEM

82 MOONS



SATURN'S MAJOR MOONS



OUTER MOONS

There are currently 59 outer moons that orbit Saturn. They range from 2 km to 213 km in size. These moons are probably captured asteroids, or the bits and pieces of debris from objects that broke up after they were captured.

Some of the outer moons orbit in the same direction as Saturn's rotation (called prograde orbits) and some in the opposite direction (retrograde).

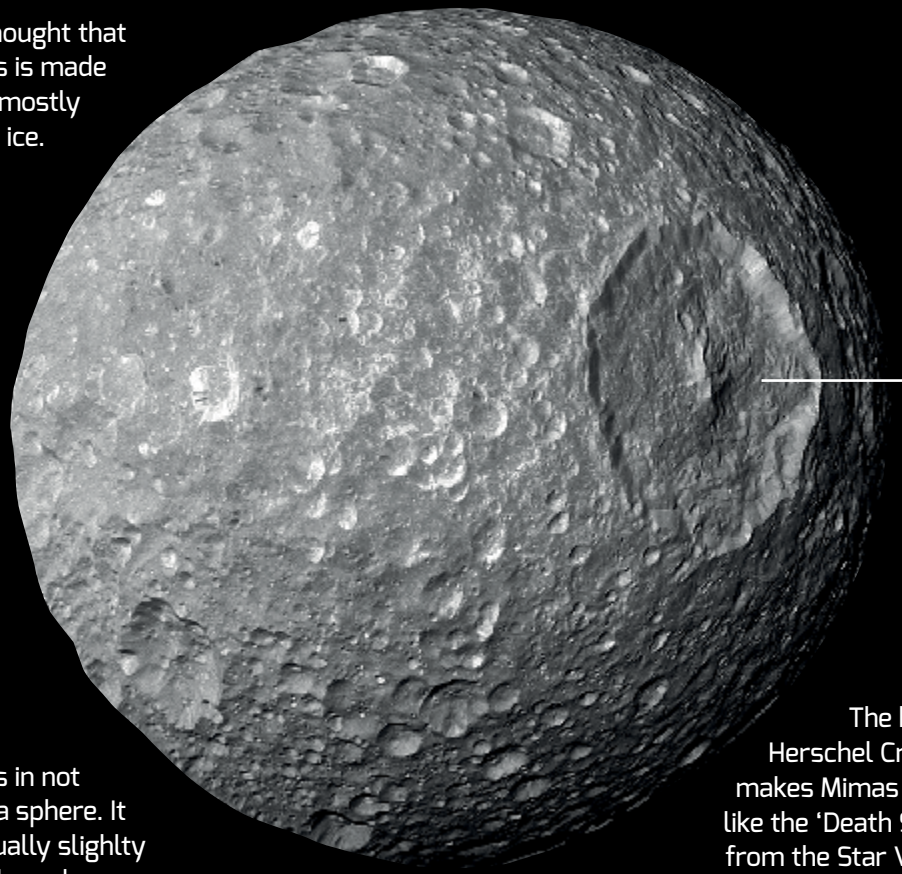
4.1 SATURN'S MAJOR MOONS

MIMAS

Ave distance from Saturn: 186,000 km
Orbital period: 22.5 Earth hours
Ave temp: -200°C **Diameter:** 396 km

Mimas is one of the smallest objects in the Solar System to have become (almost) spherical though its own gravity. It is covered in small craters and one giant crater that is 130 km wide and was created by an impact that nearly destroyed the moon.

It is thought that Mimas is made up of mostly water ice.



The huge Herschel Crater makes Mimas look like the 'Death Star' from the Star Wars movies.

Mimas in not quite a sphere. It is actually slighlty egg-shaped.

ENCELADUS

Ave distance from Saturn: 238,000 km
Orbital period: 32.9 Earth hours
Ave temp: -201°C **Diameter:** 504 km

Stuck between the gravitational pull of Saturn and Dione, this small moon is subjected to powerful tidal forces that melts the moon's icy interior. Melted water erupts from the surface in huge geysers that are source of Saturn's faint outermost ring.

Enceladus' shiny white surface makes it Saturn's brightest moon.

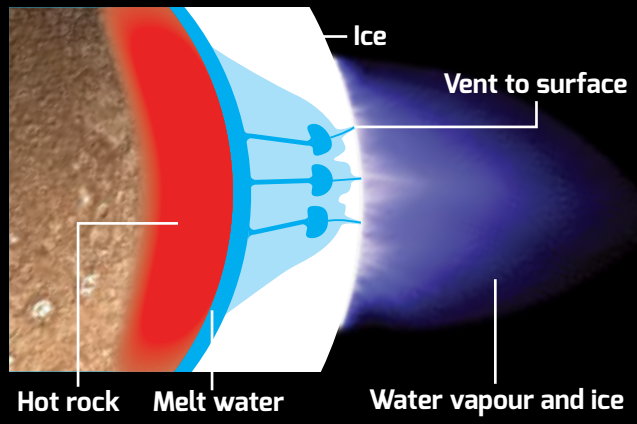
Ice particles thrown into space by geysers have been detected travelling at 1,200 kph.

The big blue cracks near the moon's pole are nicknamed 'Tiger stripes'.

ENCELADUS' ICE VOLCANOS

Hiding beneath its surface are pockets of liquid water that create Enceladus' famous ice volcanoes and may even be home to simple alien life.

Tidal forces warm the interior enough to melt the ice and create subsurface pool of liquid water.
This water travels up through the ice where it collects in caverns beneath the tiger stripes. It erupts from the surface and violently boils in the vacuum of space.

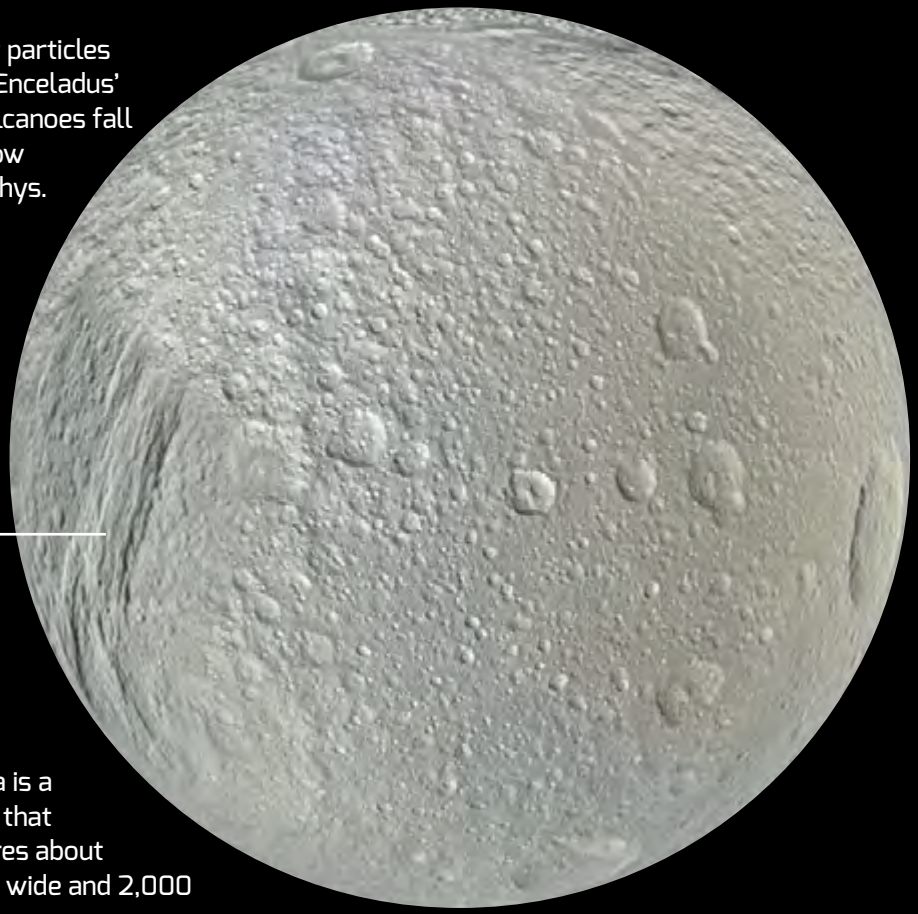


TETHYS

Ave distance from Saturn: 295,000 km
Orbital period: 45 Earth hours
Ave temp: -187°C **Diameter:** 1,062 km

Tethys is very similar to its sister moons, Dione and Rhea, except it's not as heavily cratered. This may be because it is close enough to Saturn to experience tidal warming. This warming may have kept Tethys partially melted for longer, erasing some of its early scars.

Water particles from Enceladus' ice volcanoes fall as snow on Tethys.



Ithaca Chasma is a canyon that measures about 100 km wide and 2,000 km long.

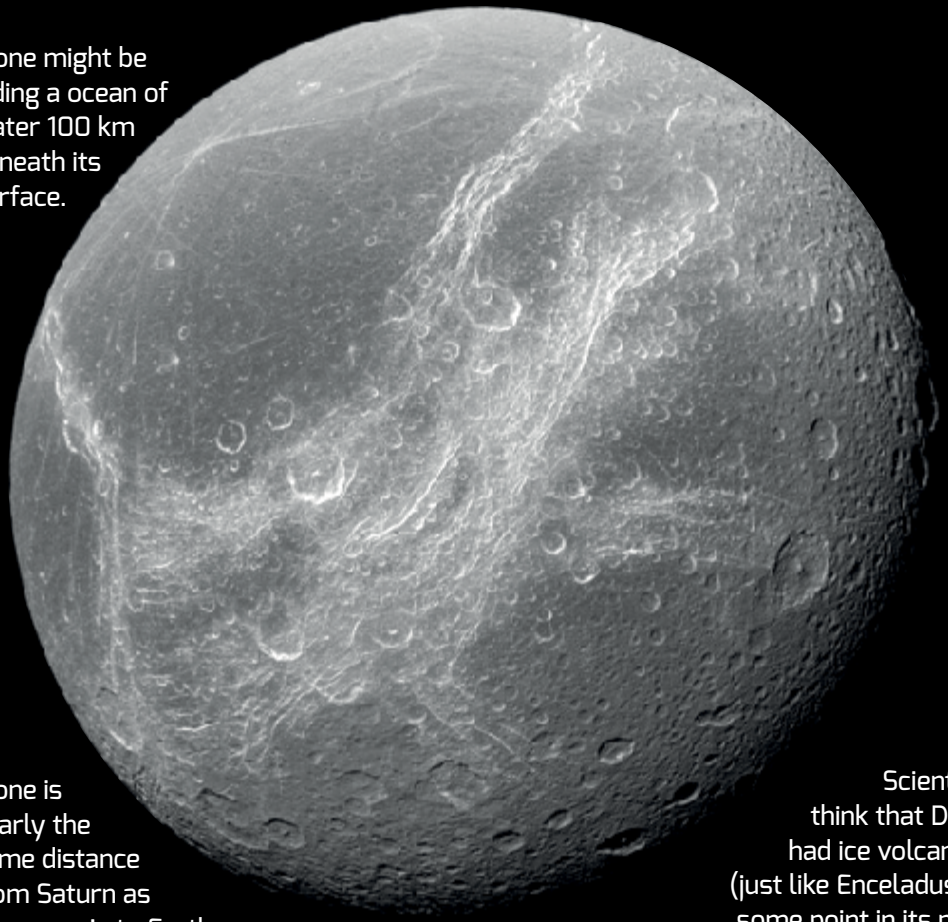
4.3 SATURN'S MAJOR MOONS

DIONE

Ave distance from Saturn: 377,400 km
Orbital period: 2.7 Earth days
Ave temp: -186°C **Diameter:** 1,123 km

Dione is about 1.5 times denser than water, which suggests it has a quite large rocky core. Much of the moon's icy surface is heavy scarred with impact craters - some of the largest are more the 100 km wide. The moon is so cold that its ice behaves like rock.

Dione might be hiding a ocean of water 100 km beneath its surface.



Dione is nearly the same distance from Saturn as the moon is to Earth.

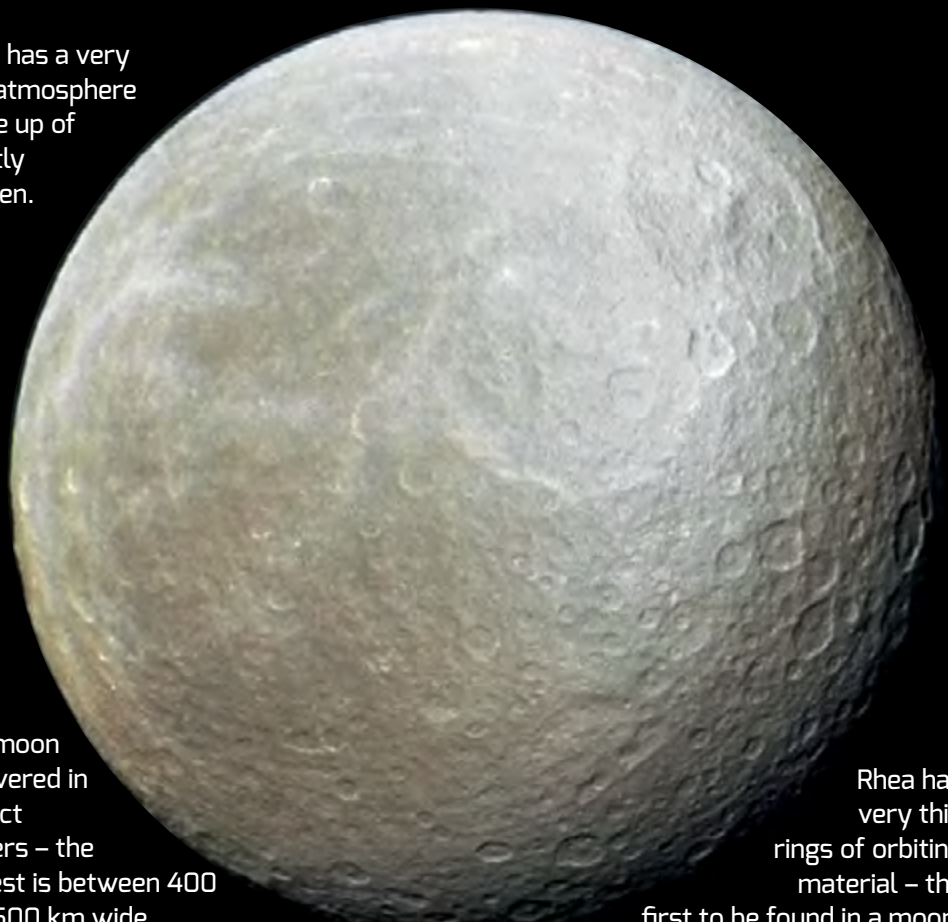
Scientists think that Dione had ice volcanoes (just like Enceladus) at some point in its past.

RHEA

Ave distance from Saturn: 527,000 km
Orbital period: 4.5 Earth days
Ave temp: -197°C **Diameter:** 1,528 km

Rhea is Saturn's second largest moon (although it a lot smaller than its big brother, Titan). It is made up of about 75% water and, rather than having a rocky core, it is an even mixture of ice and rock — like a huge frozen dirty snowball

Rhea has a very thin atmosphere made up of mostly oxygen.



The moon is covered in impact craters – the largest is between 400 and 500 km wide.

Rhea has very thin rings of orbiting material – the first to be found in a moon.

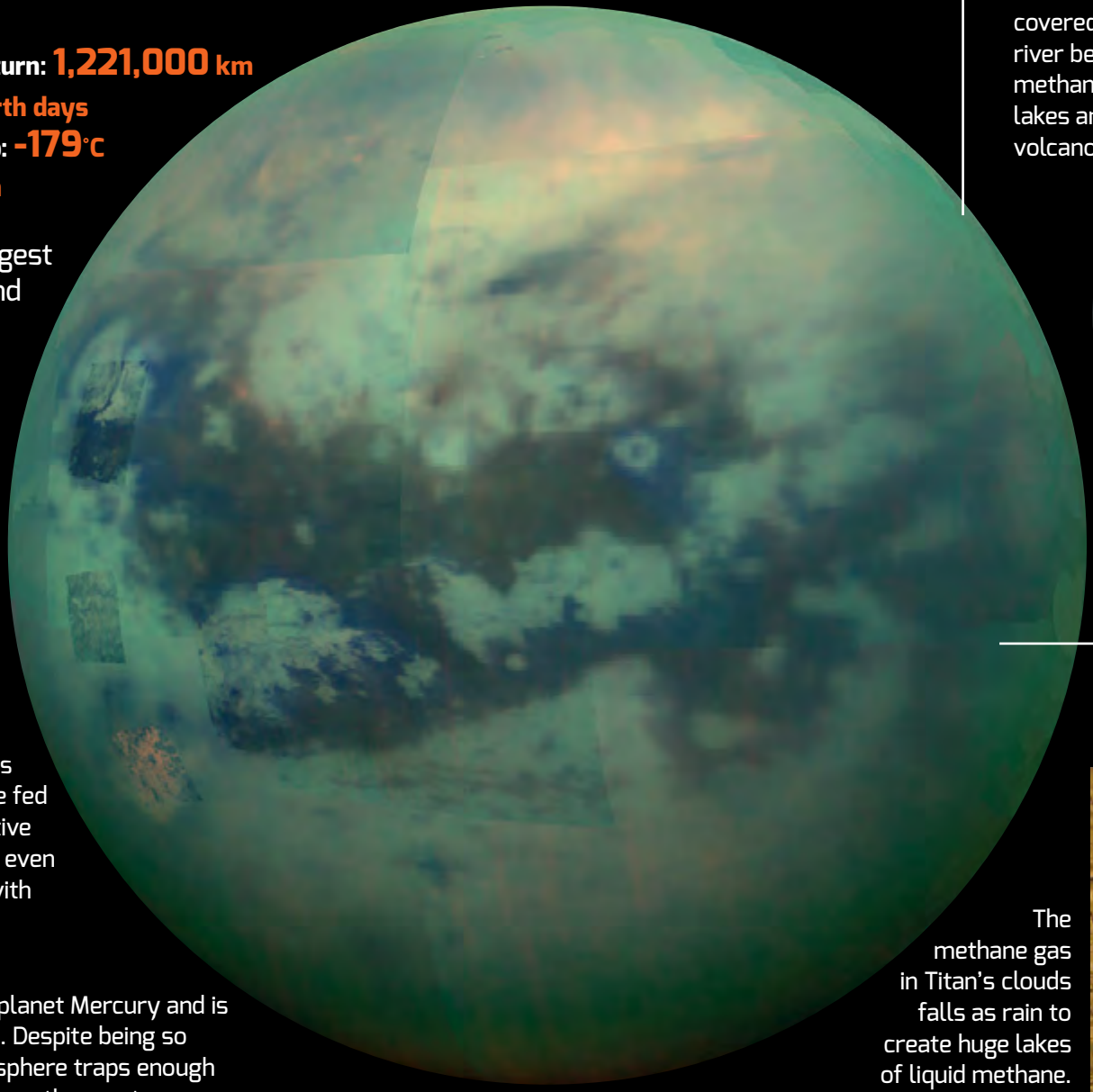
TITAN

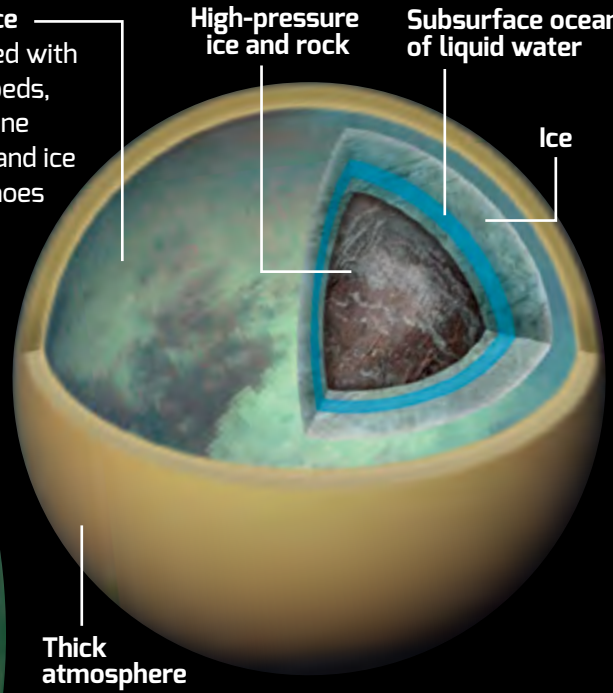
Ave distance from Saturn: 1,221,000 km
Orbital period: 16 Earth days
Average surface temp: -179°C
Diameter: 5,150 km

Titan is Saturn's largest moon and the second largest moon in the solar system. It is the only moon known to have a dense atmosphere and is the only body, other than Earth, to have a mostly nitrogen atmosphere.

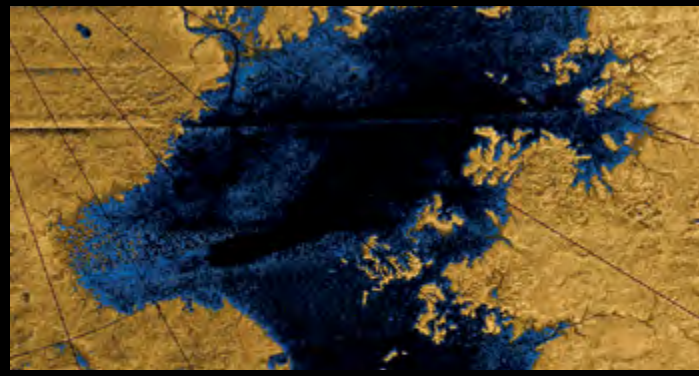
Also like Earth, Titan has lakes and rivers that are fed by rain deposited by active weather systems. Titan even has deserts complete with shifting dunes.

Titan is bigger than the planet Mercury and is made up of rock and ice. Despite being so cold, Titan's thick atmosphere traps enough heat to power complex weather systems.



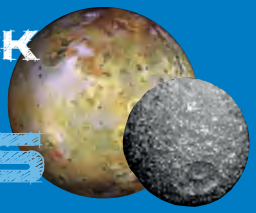


Titan's atmosphere is too thick to see the moon's surface. This image was taken using special infrared cameras that can see through the thick methane clouds.



The methane gas in Titan's clouds falls as rain to create huge lakes of liquid methane.

4.5 SATURN'S MAJOR MOONS



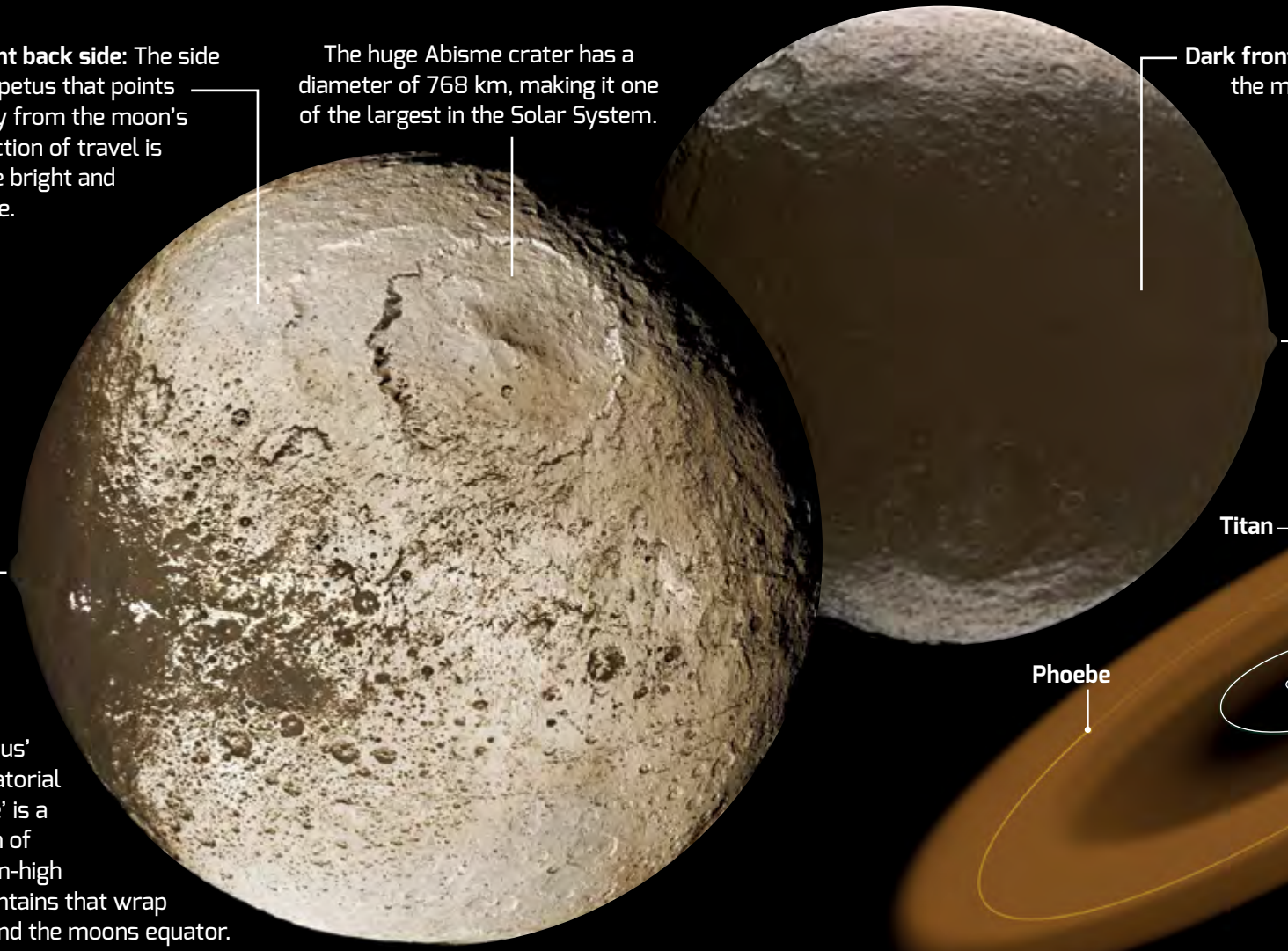
IAPETUS

Ave distance from Saturn: 3.5 million km
Orbital period: 79 Earth days
Ave temp: -160°C
Diameter: 1,469 km

Saturn's most distant major moon is also its third largest. Thought to be made up of 75% water and 25% rock, Iapetus has one very bright side and one very dark side. It's surface is heavily cratered and it has a 13 km-high ridge that runs like a 1,300 km long belt along the moon's equator.

Bright back side: The side of Iapetus that points away from the moon's direction of travel is quite bright and white.

The huge Abisme crater has a diameter of 768 km, making it one of the largest in the Solar System.

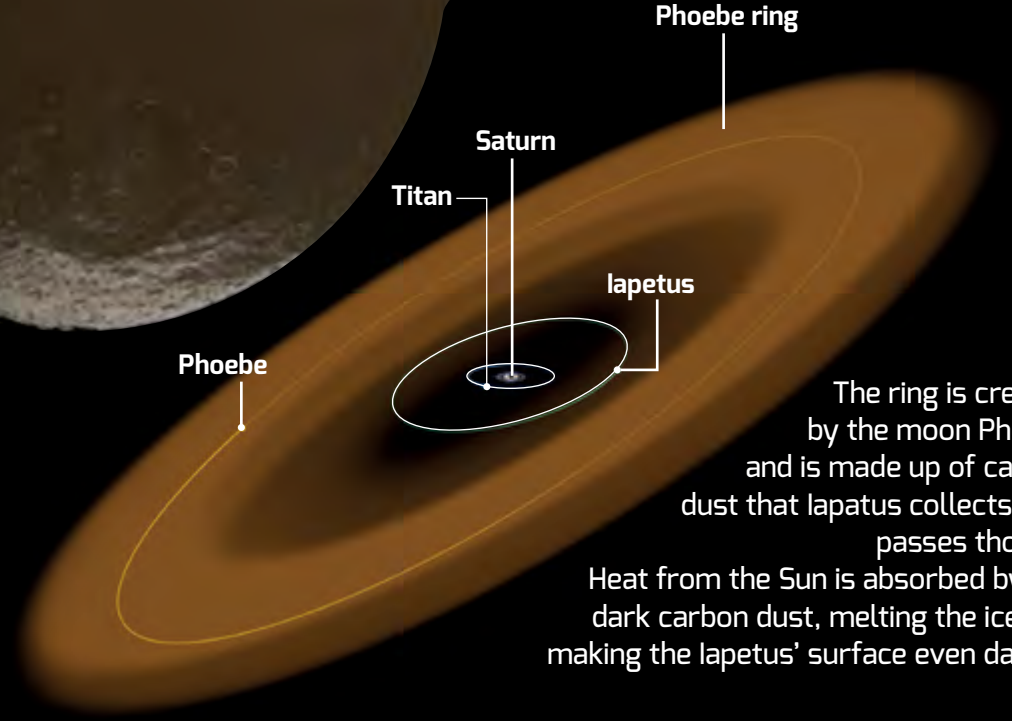


Dark front side: The side of Iapetus that points towards from the moon's direction of travel is much darker – in fact its about as reflective as a lump of coal.

It is thought that Iapetus' strange dark side might be caused by Saturn's Phoebe ring.

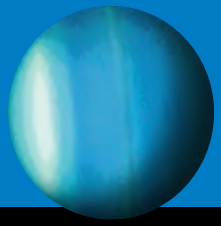
Equatorial ridge

Iapetus' 'equatorial ridge' is a chain of 13 km-high mountains that wrap around the moons equator.



The ring is created by the moon Phoebe and is made up of carbon dust that Iapatus collects as it passes though.
Heat from the Sun is absorbed by the dark carbon dust, melting the ice and making the Iapetus' surface even darker.

5 THE MOONS OF URANUS



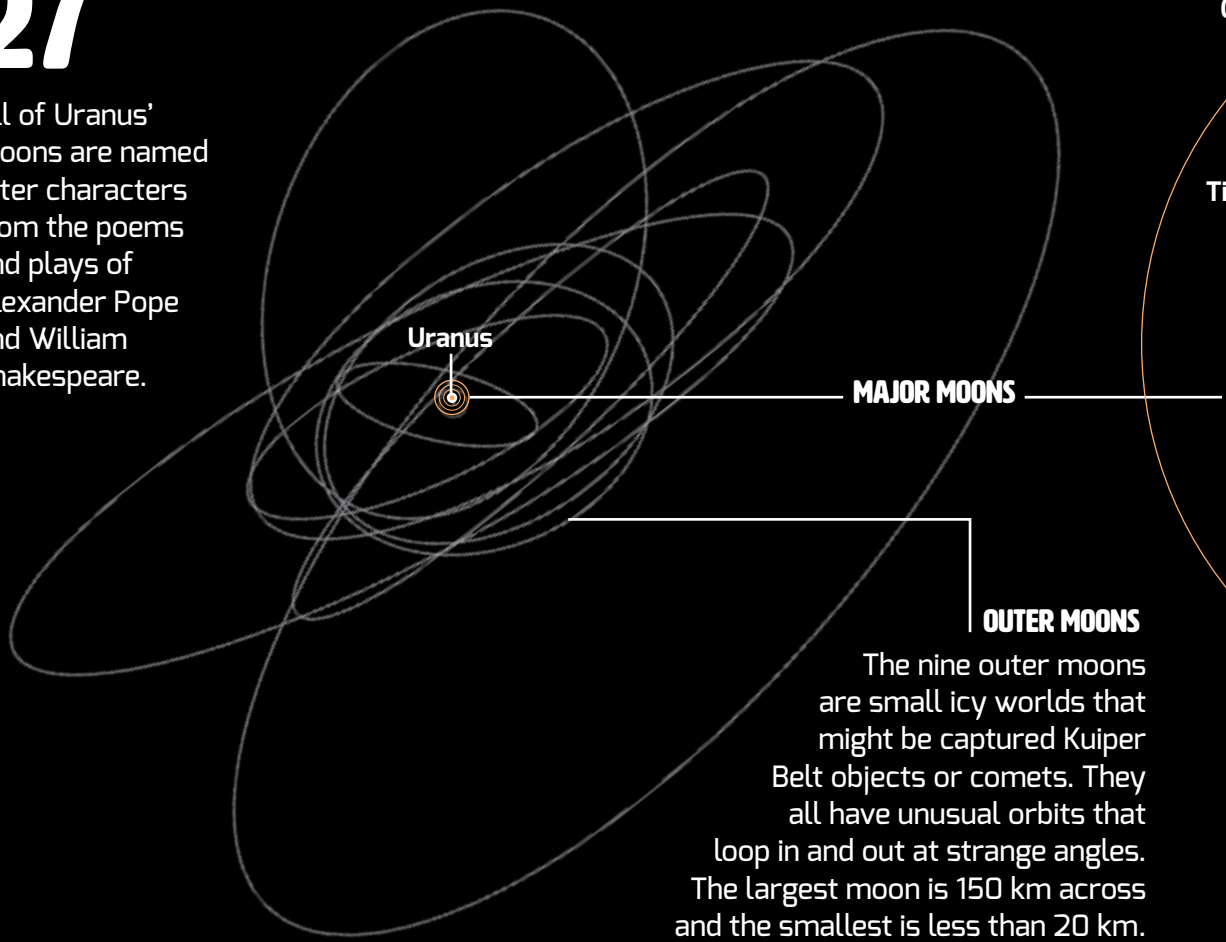
Uranus has 27 moons - 13 inner moons, five major moons, and nine outer moons. Titania and Oberon are among the Solar System's top ten biggest moons, but even if you were to add together all Uranus' 27 moons, they wouldn't match the size of a single one of the major moons of Jupiter or Saturn.

All of the inner moons and the major moons appear to be made up of roughly half water ice and half rock – expect Miranda, which is mainly ice.

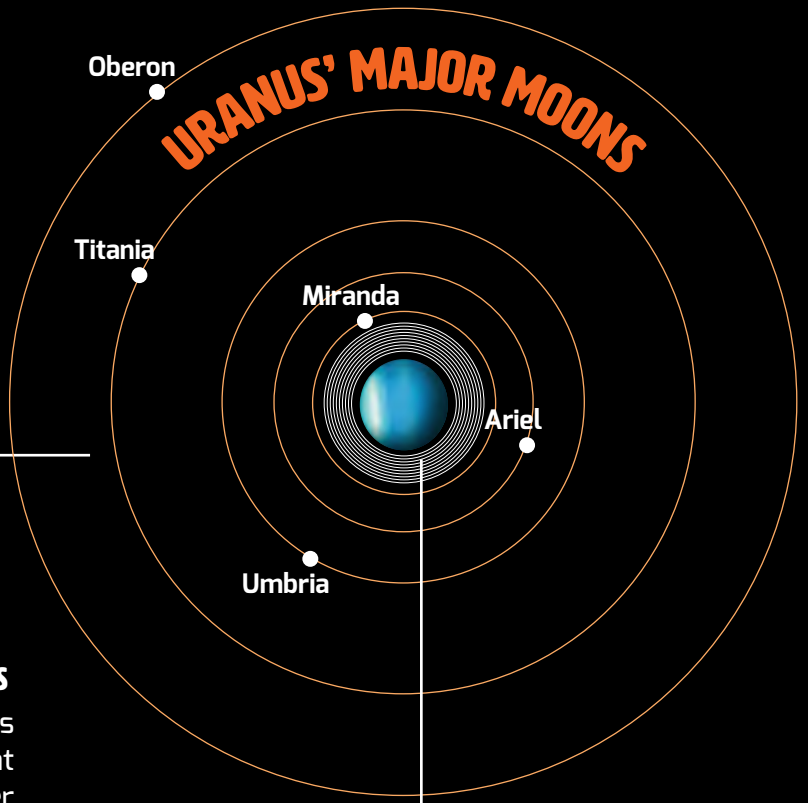
THE URANUS SYSTEM

27 MOONS

All of Uranus' moons are named after characters from the poems and plays of Alexander Pope and William Shakespeare.



The nine outer moons are small icy worlds that might be captured Kuiper Belt objects or comets. They all have unusual orbits that loop in and out at strange angles. The largest moon is 150 km across and the smallest is less than 20 km.



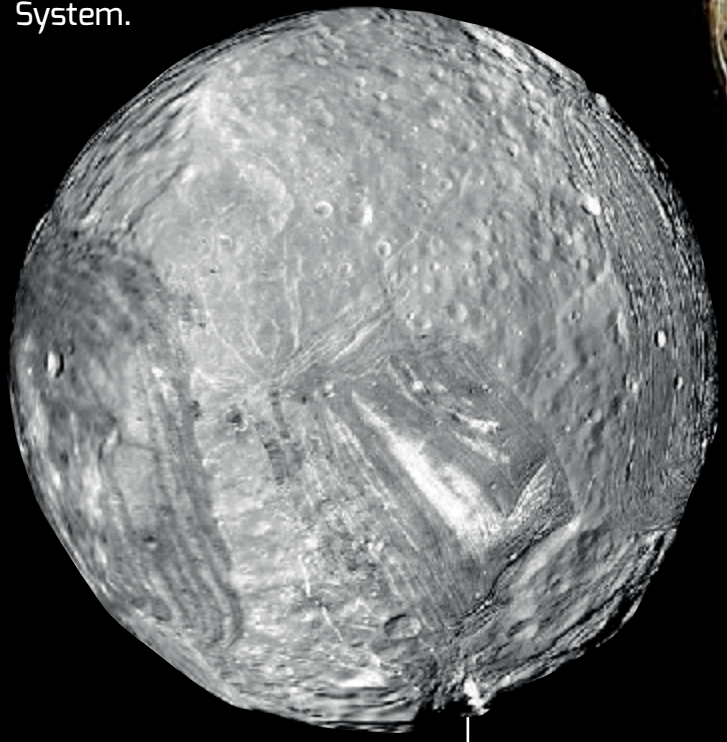
Uranus has 13 inner moons that lie within Ariel's orbit. These small moons are thought to be the remains of one or two moons that broke apart.

5.1 URANUS' MAJOR MOONS

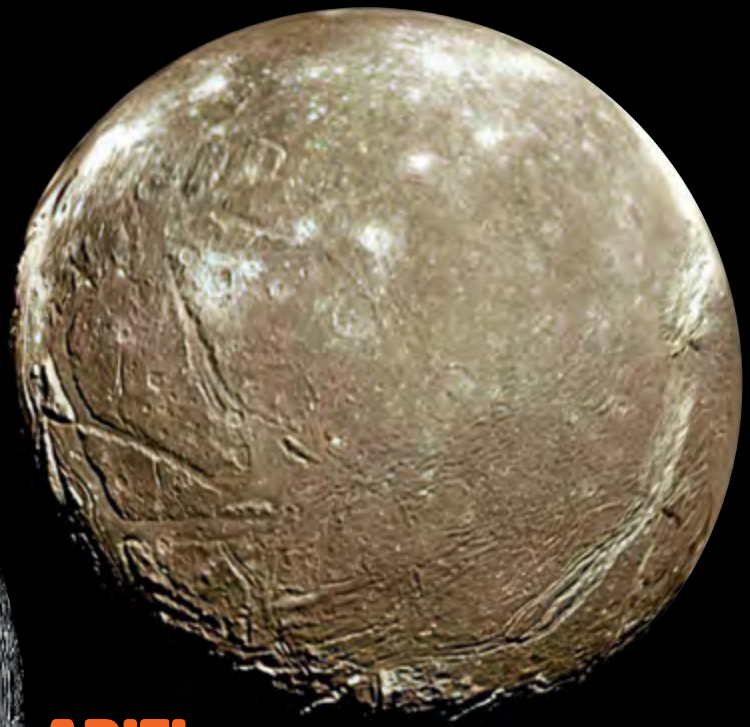
MIRANDA

Ave distance from Uranus: 129,400 km
Orbital period: 34 Earth hours
Ave temp: -210°C **Diameter:** 470 km

Miranda might be Jupiter's smallest major moon but it is definitely the strangest. A weird patchwork of ridges, scars and craters, the moon boasts the highest cliff in the Solar System.



A rock dropped off the edge of this 10 km-high cliff would take nearly ten minutes to hit the bottom.



ARIEL

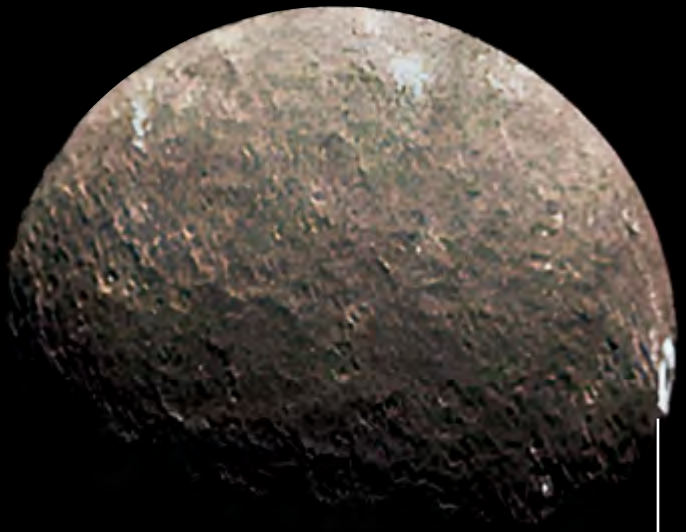
Ave distance from Uranus: 190,900 km
Orbital period: 2.5 Earth days
Ave temp: -213°C **Diameter:** 1,158 km

Ariel is Uranus' fourth largest moon. It is tidally locked with Uranus, so one side of it always faces towards the planet, the other side facing away. The moon has lots of canyons on its surface – the longest of which is 620 kilometers long.

UMBRIEL

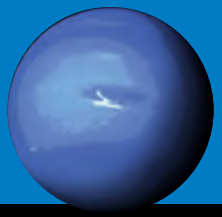
Ave distance from Uranus: 266,000 km
Orbital period: 4.1 Earth days
Ave temp: -200°C **Diameter:** 1,169 km

Umbriel is the darkest of Uranus' largest moons. It reflects only 16 percent of the light that hits it. No one knows why it is so dark. Umbriel has more craters than any of Uranus' moons, apart from Oberon.



Umbriel's most unusual feature is a mysterious ring of bright material around an impact crater.

6 THE MOONS OF NEPTUNE

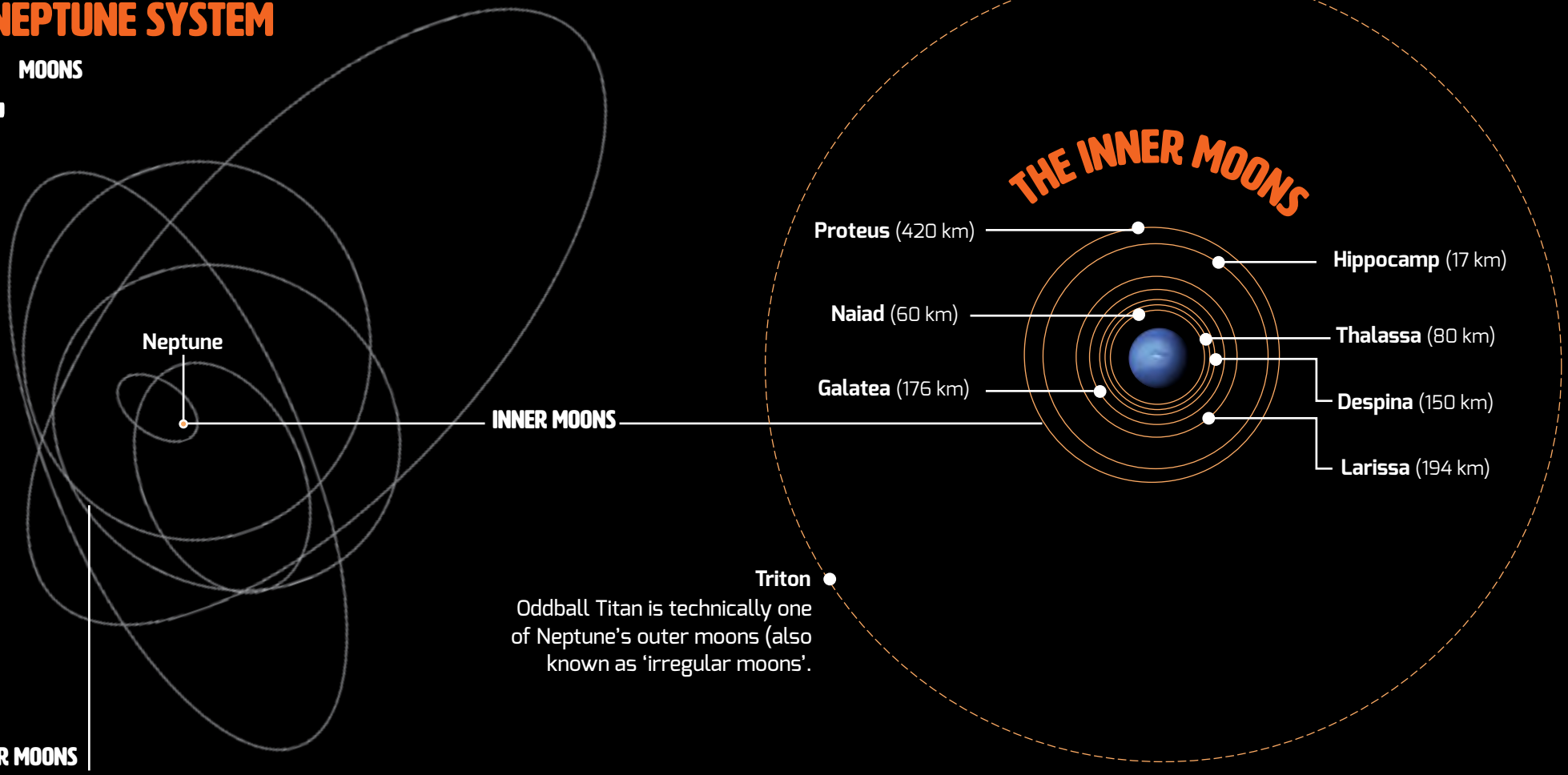


Neptune has 14 moons that we know of at this time. Before the Voyager visited the system in 1989, Triton was the only moon we knew of. This isn't surprising because Triton is much more massive than all of Neptune's other moons added together.

Unlike the outer moons. Neptune's inner moons have nearly circular orbits. These moons formed along with Neptune rather than being captured by Neptune's gravity.

THE NEPTUNE SYSTEM

14 MOONS



None of Neptune's outer moons have a circular orbit - they loop around the planet in wide ellipses. Most of the outer moons are tiny icy objects that are most likely captured from the Kuiper belt (a doughnut-shaped ring of icy material that orbits the Sun near Neptune.

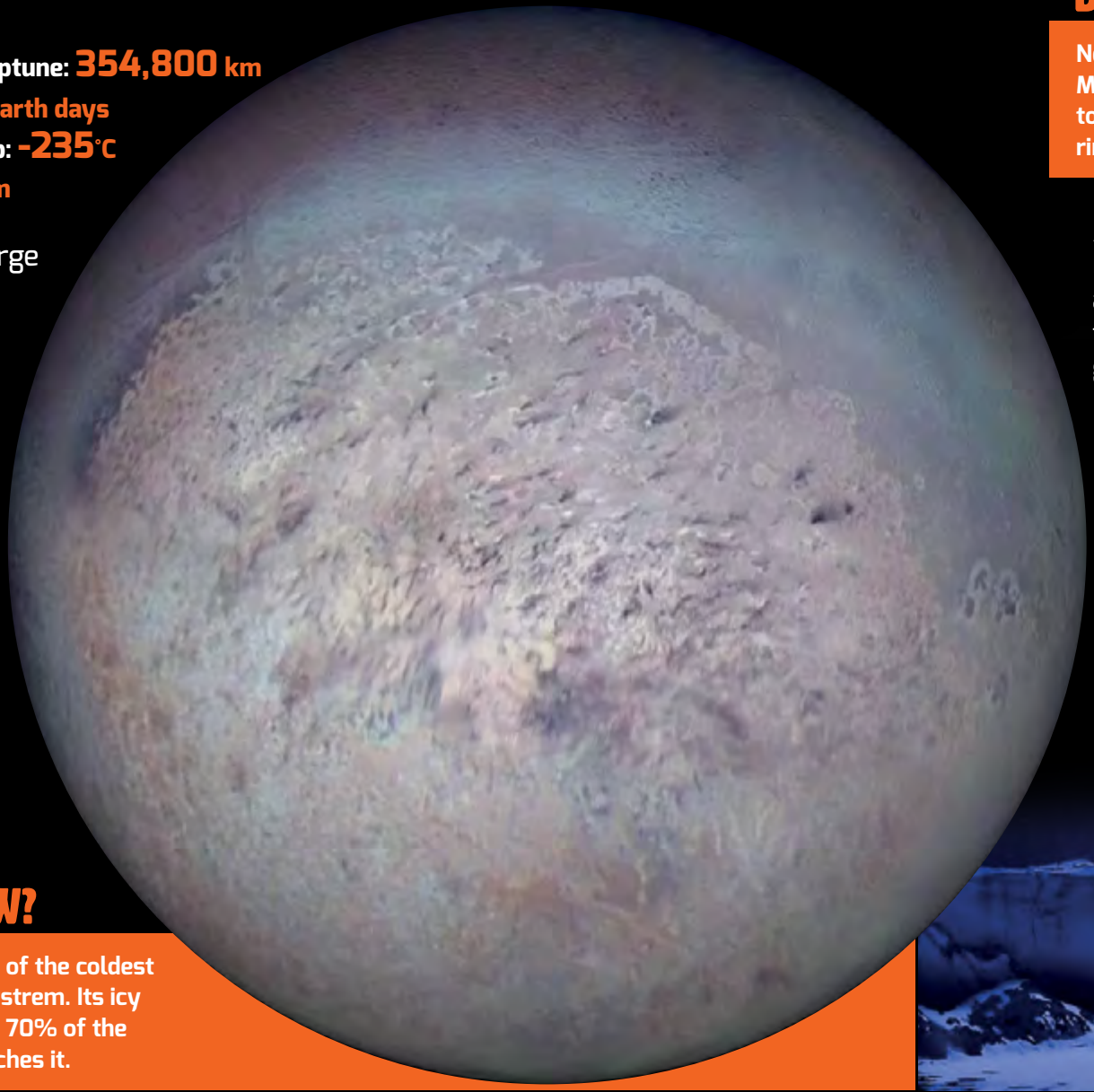
Neptune outermost moon, Neso, has the most distant orbit of any planet in the Solar System – taking it millions of kilometres away from Neptune.

5.1 NEPTUNE'S BIGGEST MOON

TRITON

Ave distance from Neptune: 354,800 km
Orbital period: 5.9 Earth days
Average surface temp: -235°C
Diameter: 2,707 km

Triton is the only large moon in the Solar System that orbits its planet in the opposite direction from the planet's rotation.
Triton has a thin nitrogen atmosphere. Its surface is coated in methane and nitrogen ice.



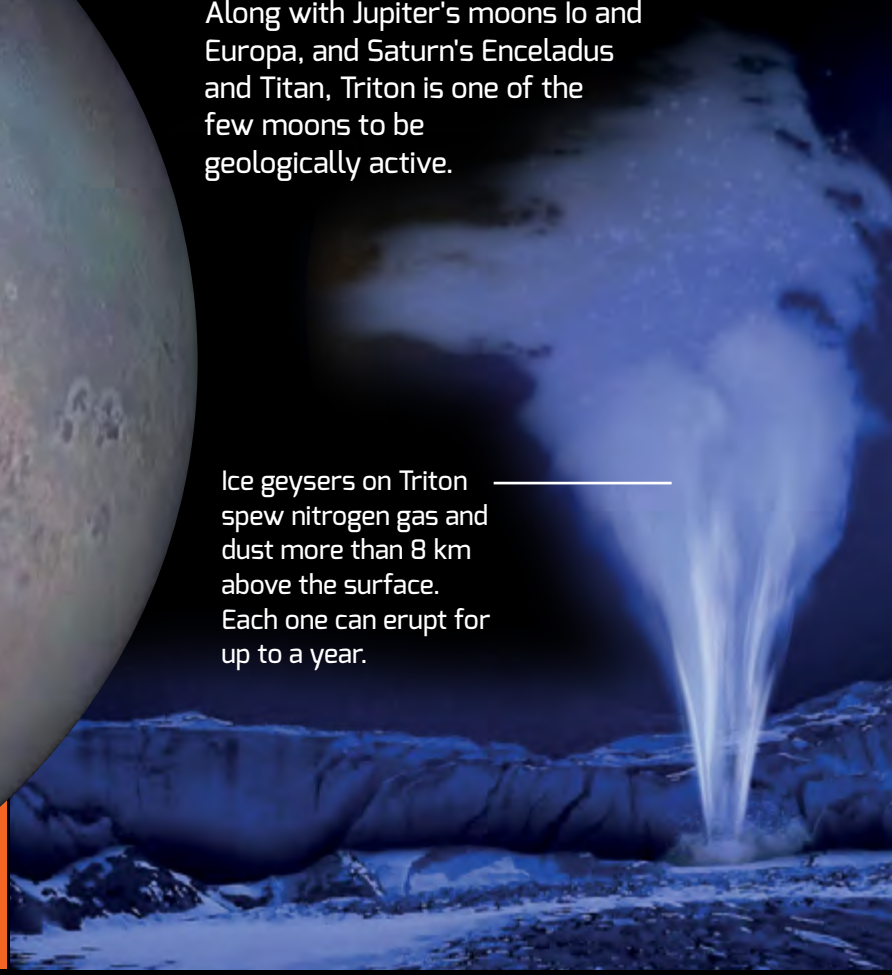
DID YOU KNOW?

At -235°C Triton is one of the coldest objects in the Solar Systrem. Its icy surface reflects about 70% of the little sunlight that reaches it.

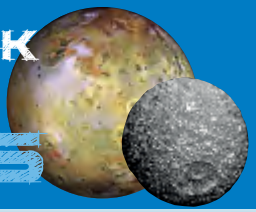
DID YOU KNOW?

Neptune's gravity is slowing down Triton's orbit. Millions of years from now, Triton will get too close to Neptune and break apart – maybe creating a new ring around the planet.

Along with Jupiter's moons Io and Europa, and Saturn's Enceladus and Titan, Triton is one of the few moons to be geologically active.

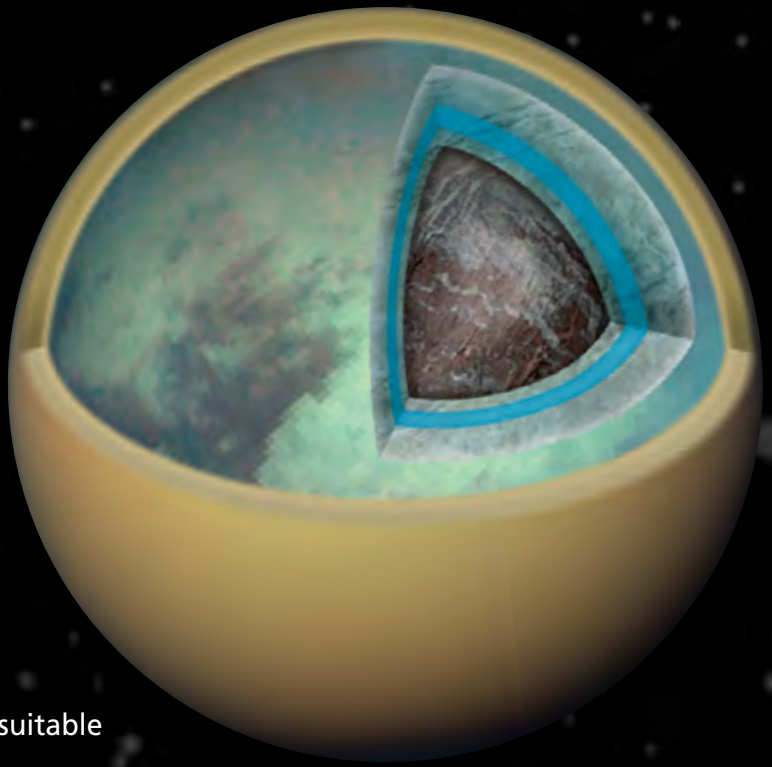


Ice geysers on Triton spew nitrogen gas and dust more than 8 km above the surface. Each one can erupt for up to a year.



NOTES

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



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