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# COSMOS

THE SCIENCE OF EVERYTHING

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## Future forecast

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# PLANETS UNPACKED

From Mercury to Neptune, you could probably name all eight planets – but how well do you really know your neighbours?

**Evrin Yazgin** asks and answers some of the most fundamental questions about our Solar System.

One of the first astronomical concepts we all come across is the planet. It's easy to get our heads around because we live on one: Earth.

We know planets orbit around a central star like our Sun, come in different sizes and have different compositions – some gassy, others rocky. And we've known about them for many years; the word "planet" is derived from the ancient Greek word *planan*, meaning "wanderer", because of the way Greeks mapped the movement of the six planets visible to the naked eye across the sky. More recently, telescopes enabled us to discover two more Solar System planets: Uranus in 1781 and Neptune in 1846.

Pluto was then discovered in 1930 and named our ninth planet, before being stripped of its title by the International Astronomical Union and re-classified a dwarf planet in 2006. According

to the scientific criteria for planethood, Pluto fails because its gravity is not enough for it to have "cleared the neighbourhood" around its orbit.

But don't worry – there are plenty more planets in the celestial seas. As of writing in early 2024, we have discovered more than 5,500 planets outside our Solar System, known as exosolar planets or exoplanets for short. Many of these are wildly different to our local planets. The more we learn about the universe, the less precise our planetary picture.

And even in our own backyard, the planets are posing puzzles to astronomers, hiding in plain sight and even turning out to be complete imposters (looking at you, Pluto). Let's take a closer look at our neighbours.

## WHY ARE THE GAS GIANTS SO MUCH BIGGER THAN THE ROCKY PLANETS?

A major gap in our understanding of the planets in our Solar System is based on a very real gap: the gap in size between the terrestrial planets (Mercury, Venus, Earth, Mars) and the gas planets (Jupiter, Saturn, Uranus, Neptune).

Gas planets are usually composed of hydrogen and helium (as with Jupiter and Saturn) or heavier, volatile elements (as with Uranus and Neptune). These planets have a solid core with swirling gassy outer layers extending thousands of kilometres. Terrestrial planets, on the other hand, have solid rocky exteriors; some, like Earth, have a core that is more liquid than solid.

Earth is the biggest of the rocky planets, with a diameter of 12,742 km and a mass of roughly  $6 \times 10^{24}$  kg (six billion trillion metric tonnes). Neptune is the smallest gas giant, but still four times wider than Earth. And, despite being five times less dense, it's a whopping 17 times heavier.

What gives?

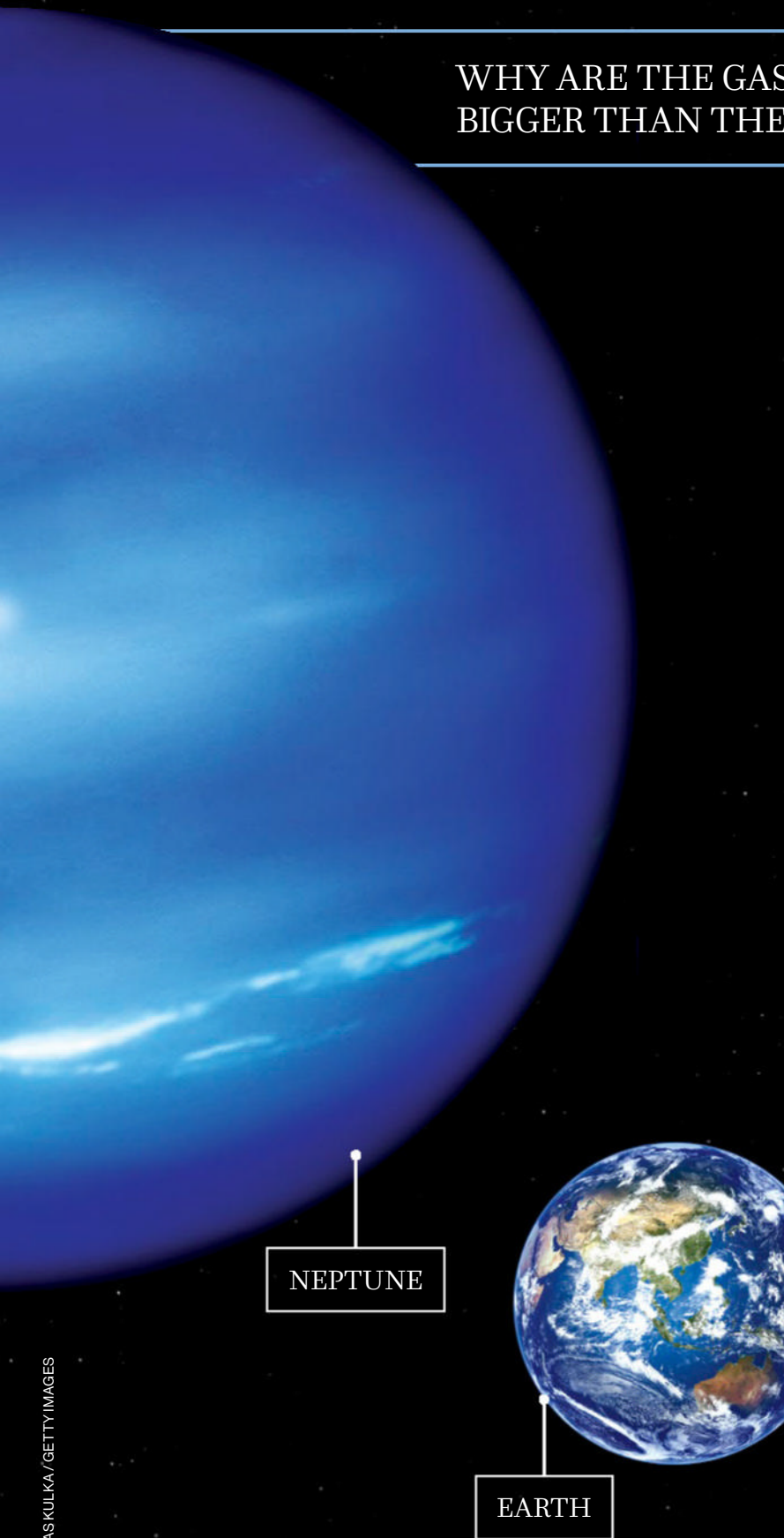
In our Solar System, the trend is to have small terrestrial planets and large gas planets. But other stars are home to large terrestrial planets (called super-Earths) and dwarf gas planets (called mini-Neptunes).

The smallest known gas planet, for example, is Kepler-138 d. It is 60% larger in volume than Earth, but less dense, with only two thirds of the Earth's mass. On the other hand, the largest known terrestrial planet, TOI-849 b, is estimated to have a diameter more than three times that of Earth and be 40 times more massive.

No one knows why our Solar System has this size gap. Some astronomers believe it's because Jupiter's immense gravity suppressed the formation of a super-Earth by flinging material into the Sun.

No matter what the exact reason, we should probably be thankful. In a 2023 paper published in the *Planetary Science Journal*, US astrophysicist Stephen Kane ran simulations to see what a super-Earth in our Solar System would do. He placed the super-Earth in another gap in the Solar System – the one between Mars and Jupiter, where the asteroid belt lies. It ended poorly for everyone.

Mercury, Venus and Earth were flung from their orbits. In some simulations, even Uranus and Neptune were sent into outer space.



SATURN

## WHY DO SOME PLANETS HAVE RINGS?

One of the most recognisable features of our Solar System is Saturn's ring system.

Saturn isn't the only ringed planet, though. In the 1970s, astronomers discovered that all the gas giants have rings, albeit smaller, darker, fainter and sometimes weirder. Uranus's rings are nearly perpendicular to the plane of its orbit, thanks to its highly eccentric rotational axis.

Exoplanets have shown us how strange rings can get. The planet J1407b, 420 light-years away, has rings that stretch 600 times further than Saturn's. And closer to home, the dwarf planet Quaoar – only 1,200 km in diameter, and orbiting the Sun in the Kuiper belt, a region of icy debris beyond Neptune's orbit – is ringed too.

Its ring was discovered in 2023, to much fanfare. That's because Quaoar's ring shouldn't exist: it's too far from the planet. The ring orbits at a distance seven times the dwarf planet's radius. For comparison, Saturn's rings all lie within three of Saturn's radii.

The discovery calls into question what astronomers thought they knew about ring formation.

Matter orbiting a young planet will either form a moon or a ring system, depending on its distance from the planet: a ring if the material is close, a moon if the material is further out. And they can morph into each other. Some astrophysicists think Saturn's rings will coalesce over the next 100 million years to form new moons, while rings can also form when moons break up or crash into one another because they have gotten too close to their host planet.

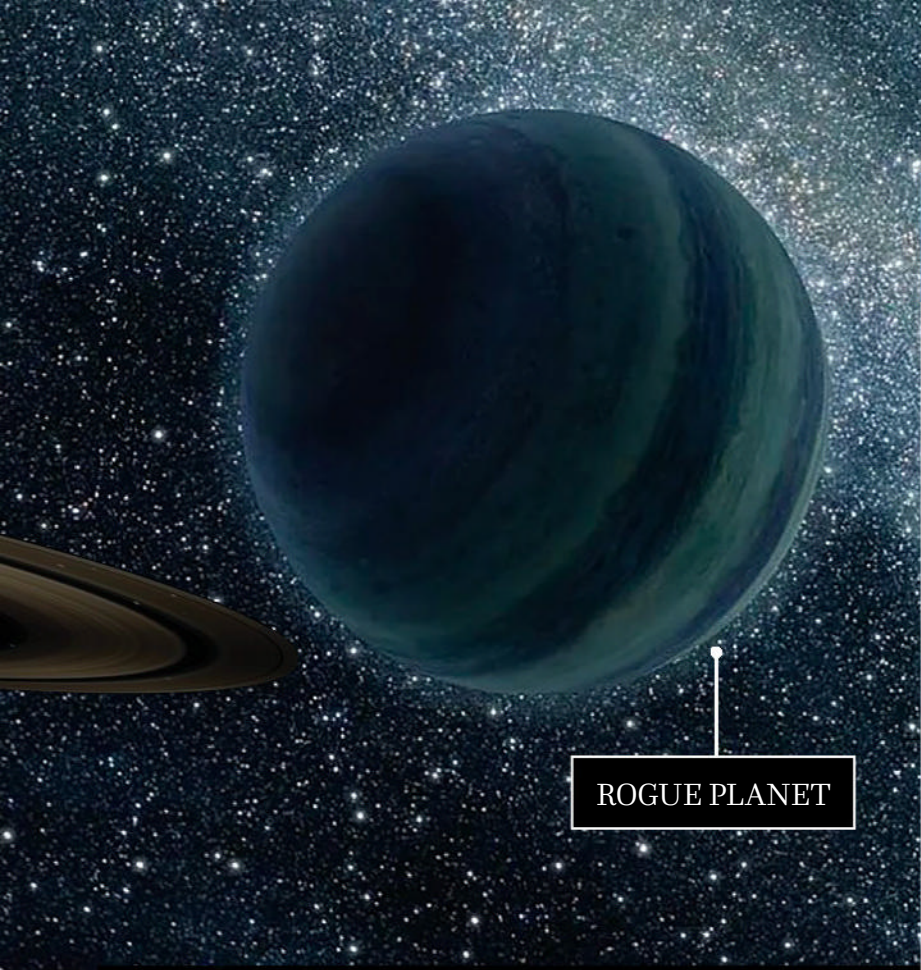
Being so far away, the material in Quaoar's ring should have formed a moon, like the small 170km-diameter moon Weywot which already orbits the dwarf planet.

Guess it's back to the drawing board on ring formation.

URANUS

QUAOAR





ROGUE PLANET

## CAN A PLANET EXIST WITHOUT A STAR?

When you think of a planet, you probably picture it orbiting a star – usually our Sun. But what if I told you that not all planets orbit stars?

These planets which refuse to be gravitationally bound to a star are known as “rogue planets”. The first rogue planets were imaged in 2000 using the UK InfraRed Telescope and they were huge – even bigger than Jupiter.

Their size caused some astronomers to question whether they were planets at all, or just brown dwarf stars – objects that are too massive to be a planet, but too small to spark into a fully-fledged star. (The technical cut off between planet and star is 13 times the mass of Jupiter.)

But smaller rogue planets have since been found. Recent studies by researchers at Japan’s Osaka University in collaboration with NASA suggest that there could be trillions of them in our galaxy alone.

It’s not known exactly where these wanderers come from, but it’s believed they are from formed planetary systems, possibly ejected by interaction with another large planet. [➦](#)

## COULD THERE BE ANOTHER PLANET IN OUR SOLAR SYSTEM?

We’ve been finding planets around other stars since 1992, and in 2021, astronomers even found evidence of what might be the first planet discovered outside the Milky Way, in Messier 51 (the Whirlpool galaxy). Now, with the James Webb Space Telescope sending back images and data about the very edge of the universe, you’d be forgiven for thinking we’ve already learned everything about our own backyard.

Think again.

Some astronomers suspect we might have entirely missed a Neptune-sized planet in our own Solar System.

In 2015, researchers at the California Institute of Technology suggested the existence of a ninth planet – Planet X – orbiting, on average, 20 times further from the Sun than Neptune. Such a planet could take between 10,000 and 20,000 years to complete a single orbit around the Sun. According to the researchers, its orbit would be highly elongated, thus helping to explain mathematical anomalies in the orbits of smaller objects in the Kuiper belt.

Astronomers hope they might be able to catch a glimpse of Planet X with existing telescopes, though it is likely very faint and hard to detect.

Pretty cool that a massive planet could remain hidden in plain sight.



JUPITER

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