BBC

THE NEW SEARCH FOR LIFE ON AN ALIEN OCEAN WORLD

Science Focus

The secrets of
BODY FAT STORAGE

Why young
ORCAS BECOME HOOLIGANS

How to
DEAL WITH HEATSTROKE

ADHD IN ADULTHOOD

What we're getting wrong, and why it matters

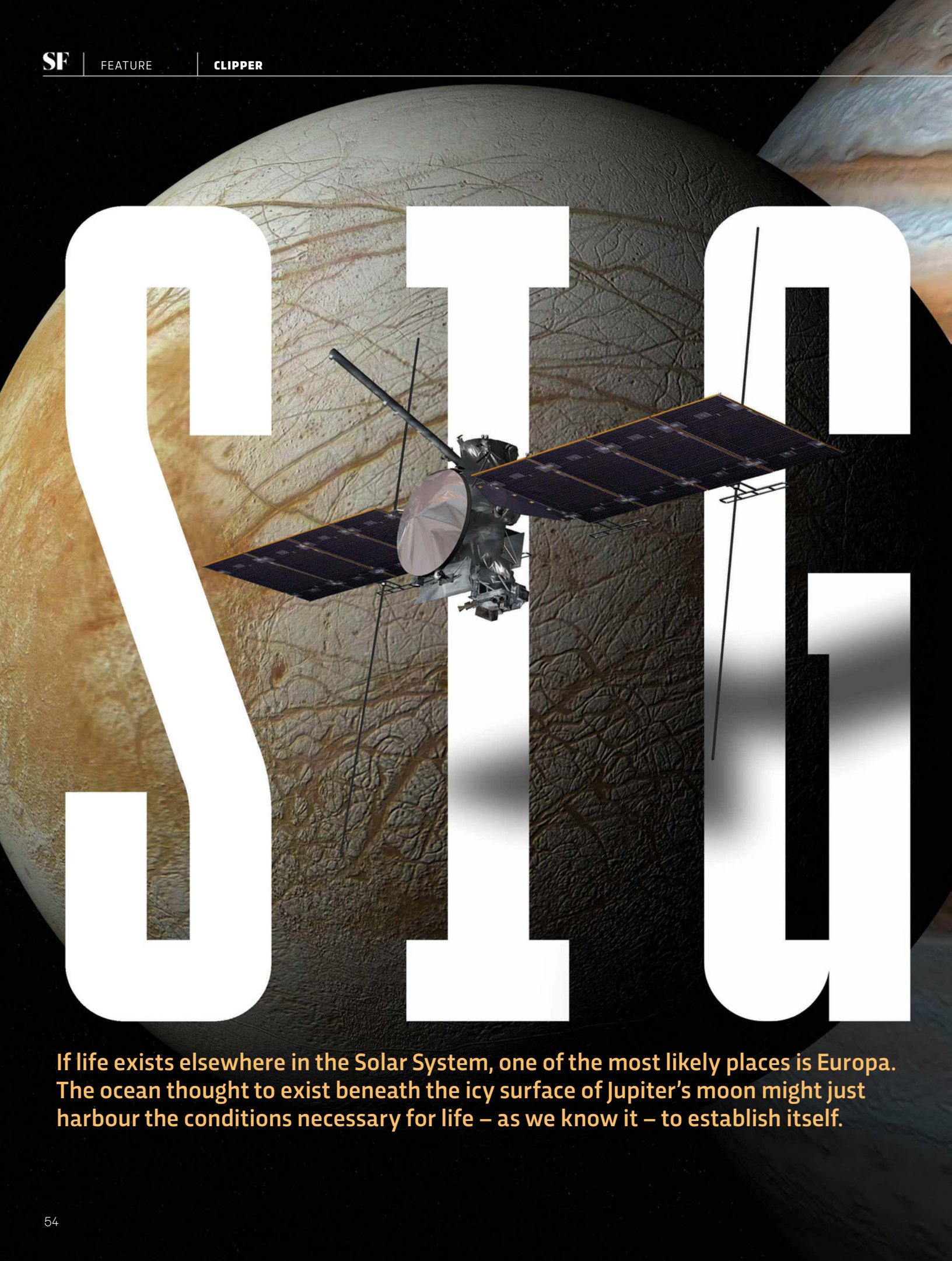
SF
SCIENCEFOCUS.COM
27 >
9 772632 284189
ISSUE #408
SUMMER 2024
UK £5.99

IN THIS ISSUE

Climate
Scientists raise the alarm on deadly, 100% humidity heatwaves

Nutrition
Why you shouldn't feel bad about enjoying sliced, white bread

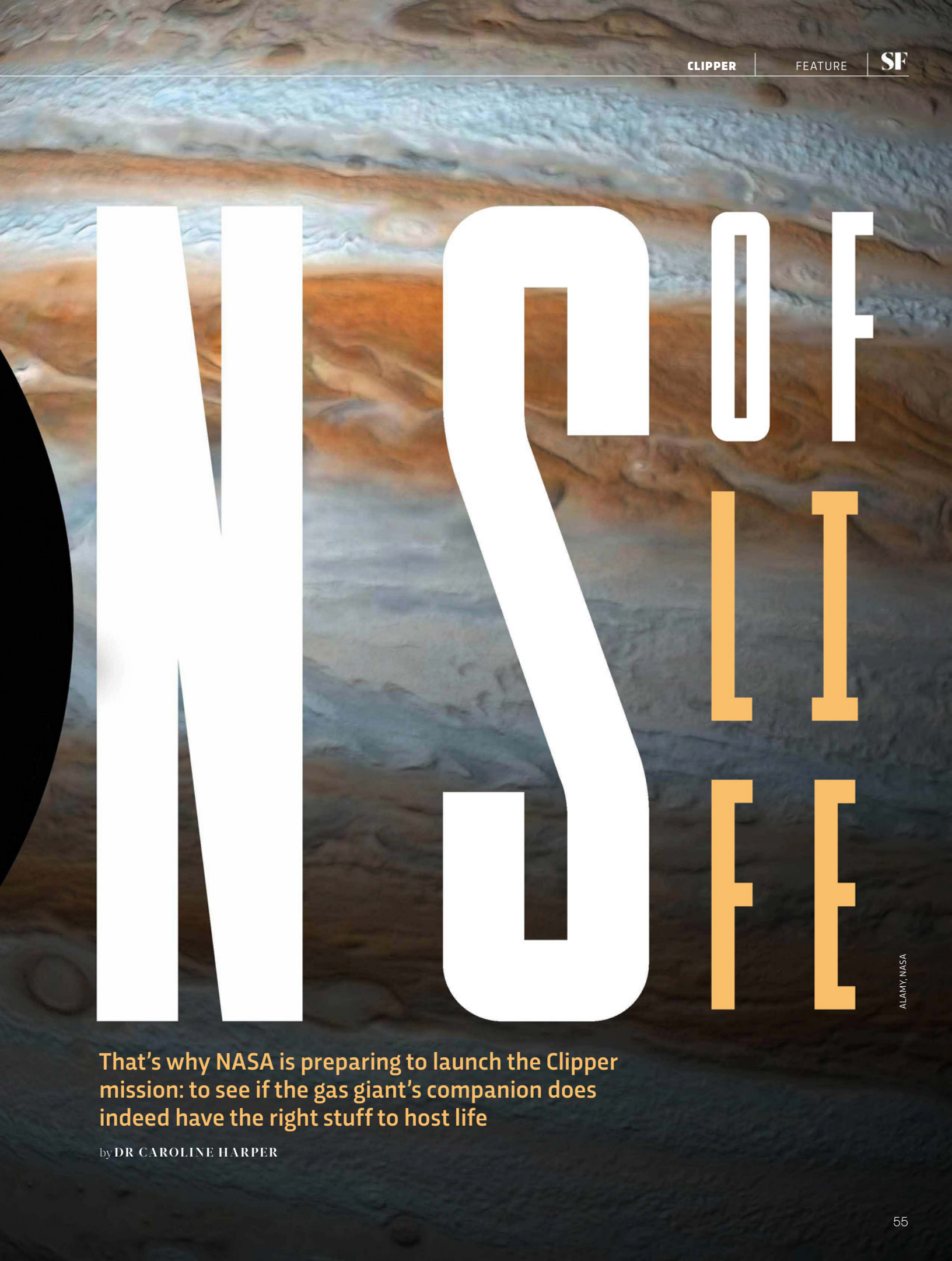
Cosmology
On the trail of the Universe's first stars



SIC

If life exists elsewhere in the Solar System, one of the most likely places is Europa. The ocean thought to exist beneath the icy surface of Jupiter's moon might just harbour the conditions necessary for life – as we know it – to establish itself.

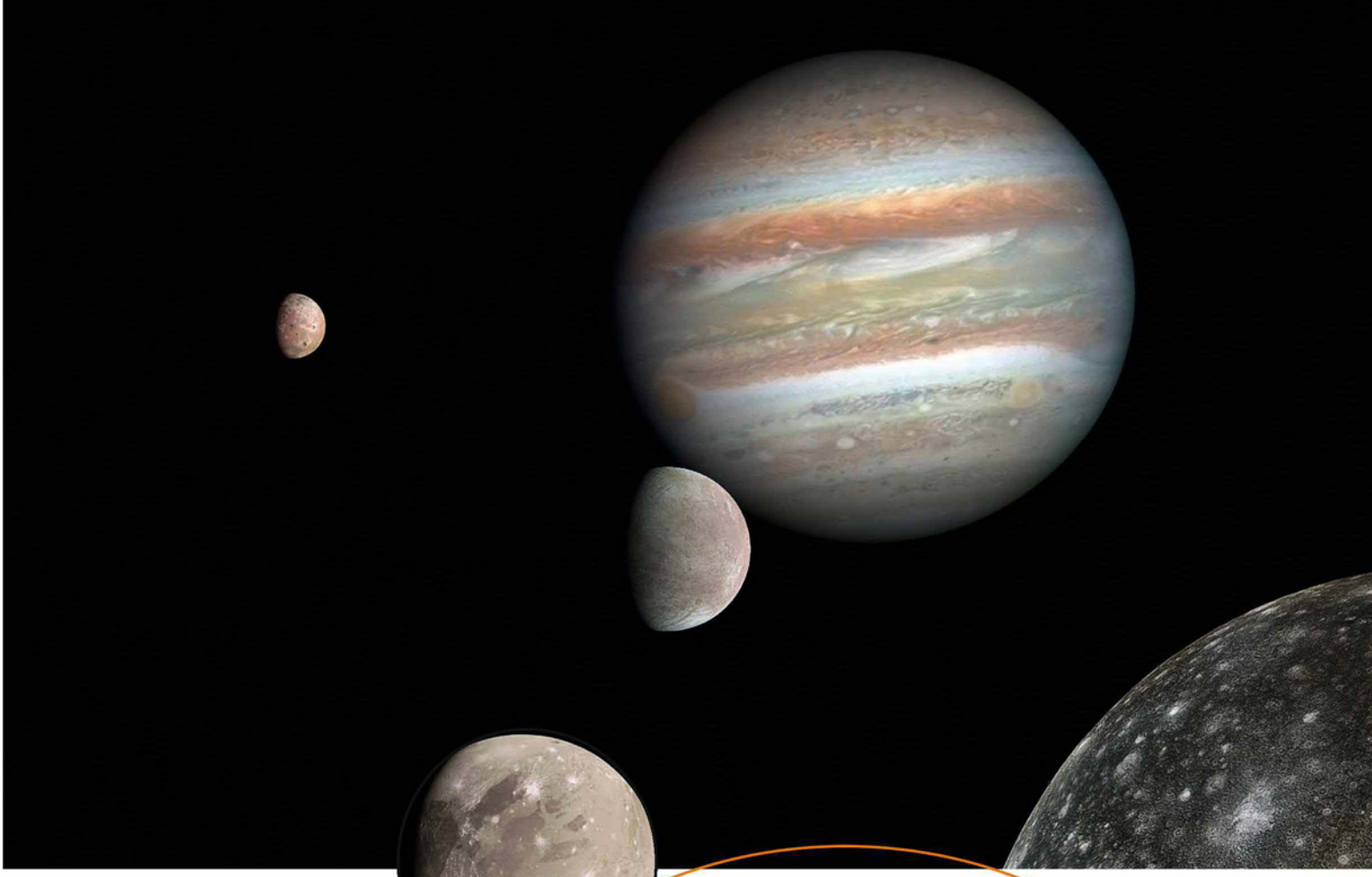
NS OF LIFE



ALAMY, NASA

That's why NASA is preparing to launch the Clipper mission: to see if the gas giant's companion does indeed have the right stuff to host life

by DR CAROLINE HARPER



Are we alone? One of the big questions that people would like to answer is whether life exists elsewhere in the Universe. Given the scale of the Universe, planetary scientists have tended to focus on whether life exists elsewhere in our Solar System. If it does, we think one of the most likely places is under the surface of Europa, an icy moon orbiting Jupiter.

It's for this reason that NASA plans to launch its flagship Europa Clipper mission in October 2024. Clipper is intended to study Europa and determine whether there are regions under the ice that are capable of supporting life. The spacecraft will launch on a SpaceX Falcon Heavy rocket from Kennedy Space Center. It'll spend nearly six years travelling to the Jovian system and another four years making close observations of Europa.

Why Europa? Because it seems to have the three things necessary for life as we know it: liquid water, an energy source and the right chemistry.

THE RIGHT INGREDIENTS

We think Europa possesses the 'right' conditions for life because we've been observing it for centuries – it was discovered in 1610 by Galileo Galilei. We know, for instance, that it has a thick crust of water ice, estimated to be 15–25km (10–15 miles) deep. It also appears to have a huge subsurface ocean of salty, liquid water. (Europa is a little smaller than our Moon, but we think this ocean is so deep that there could be more than twice as much water as there is on Earth.)

Furthermore, it's believed to have a relatively warm, rocky core, probably iron-nickel, and there might be volcanic activity or hydrothermal vents like those in the oceans here on Earth, which could generate energy and release nutrients into the water in the same way.

"WHY EUROPA? BECAUSE IT SEEMS TO HAVE THE THREE THINGS NECESSARY FOR LIFE"

The moon is also tidally locked to Jupiter by gravity, so the same side always faces the planet, just as we only ever see one side of our Moon. This means the front and back faces of Europa experience the gas giant's gravitational pull differently. And, because Europa's orbit around Jupiter is elliptical not circular, these gravitational effects also vary with distance from the planet. Consequently, Europa is perpetually being pulled and squeezed, generating thermal energy in a process known as tidal heating. This keeps the subsurface warmer than the icy crust and could produce

LEFT Jupiter and its four largest moons (not to scale) as captured by NASA's Juno spacecraft: Io (farthest left in montage), Europa (closest to Jupiter in montage, Ganymede and Callisto (partially visible in corner)

fissures in the ice, which might connect the surface to what's underneath.

As for the right chemistry, the Hubble space telescope found a thin, but oxygen-rich atmosphere on Europa, and there's data from NASA's Juno mission suggesting that mineral salts and organic compounds exist at the surface. We believe this includes molecules of carbon, hydrogen, oxygen, nitrogen, sulphur and phosphorus, which are necessary for life on Earth, and they might be able to seep down through the fissures into the ocean.

All of this means there's a lot of enthusiasm for the idea of Europa as a place where life could exist. Scientists are eagerly anticipating the data that we'll get from Clipper, even though the spacecraft isn't designed to find life (we would need a lander with a very big drill and a sampling mechanism for that). But by determining whether conditions that could support life are present, and perhaps identifying where the best areas to explore are located, Clipper will tell us whether a lander mission is something to pursue in future.

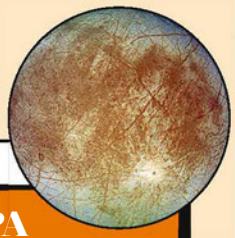
FULLY LOADED

To achieve its mission objectives, Clipper will carry a suite of nine bespoke scientific instruments. The instruments will work together to tell us more about the thickness of the crust and how much it flexes, how deep and how salty the ocean really is, how it interacts with the surface, and whether the chemical ingredients for life are present.

Clipper will have cameras to take high-resolution images and spectrometers to tell us more about the chemistry of the moon's surface. It'll study the gases and particles in Europa's atmosphere and search for plumes of subsurface water jetting up through fissures in the ice. It'll have a radar capable of penetrating the icy crust and a magnetometer and plasma instrument that will measure the moon's induced magnetic field to confirm the presence of a body of liquid water and tell us more about the scale and composition of the subsurface ocean. There will also be a thermal imager to identify areas where the ice is warmest, perhaps indicating recent upsurges of water.

The instruments are custom-made and state of the art, and so is the spacecraft. Clipper is the biggest spacecraft NASA has ever built for a planetary mission, and it'll take a launch vehicle as powerful as the Falcon Heavy to lift →

NASA/JPL X4



LIFE ON EUROPA

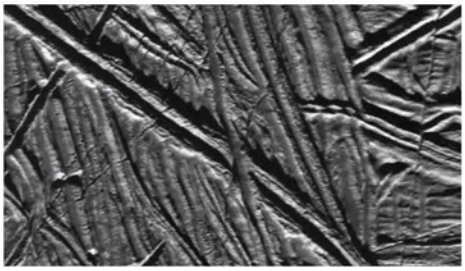
WHAT COULD BE LURKING UNDER THE ICE?

If life is present on Europa, we think it'll most likely be microbial. It'll definitely be in the ocean under the ice, because nothing could survive the radiation at the surface. If there are hydrothermal vents, it's possible that more advanced forms may have evolved, perhaps resembling some of the species we find around deep-sea vents on Earth, such as worms and coral. But we can't know for sure.

Either way, if we do find that life has emerged more than once in the Solar System, it might be reasonable to suppose that it exists throughout the Milky Way (our galaxy) and the Universe as a whole.

Scientists hope that Europa Clipper will help us to understand more about this intriguing moon's potential for habitability, adding to our fundamental knowledge of humanity's place in the Universe and how we came to be. But while we're searching for life, as we know it, in the far reaches of the Solar System, we need to remember that conditions on these icy worlds are very different to those on Earth, so there's also the intriguing possibility that life as we don't know it has developed and exists on a moon like Europa.

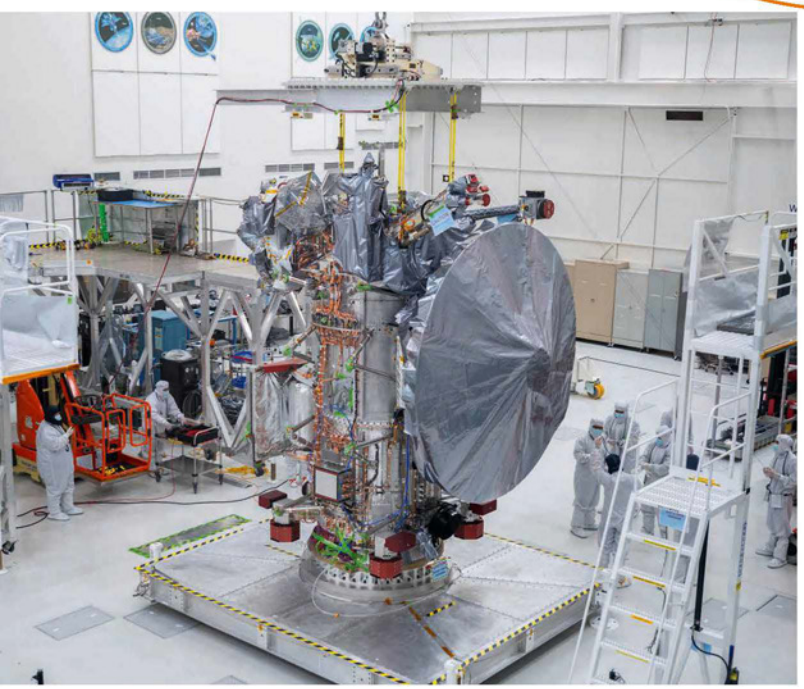
BELOW A photo showing how the surface of Europa is crisscrossed with deep ridges. These are scars in the ice produced by the geological and gravitational stress working on Jupiter's moon. It's thought that, in certain places, the ridges may be deep enough to allow fissures to form in the ice. Water from the ocean below Europa's frozen crust could erupt and burst out through these fissures, possibly reaching heights of around 200km (125 miles), as depicted in the artist's impression below.

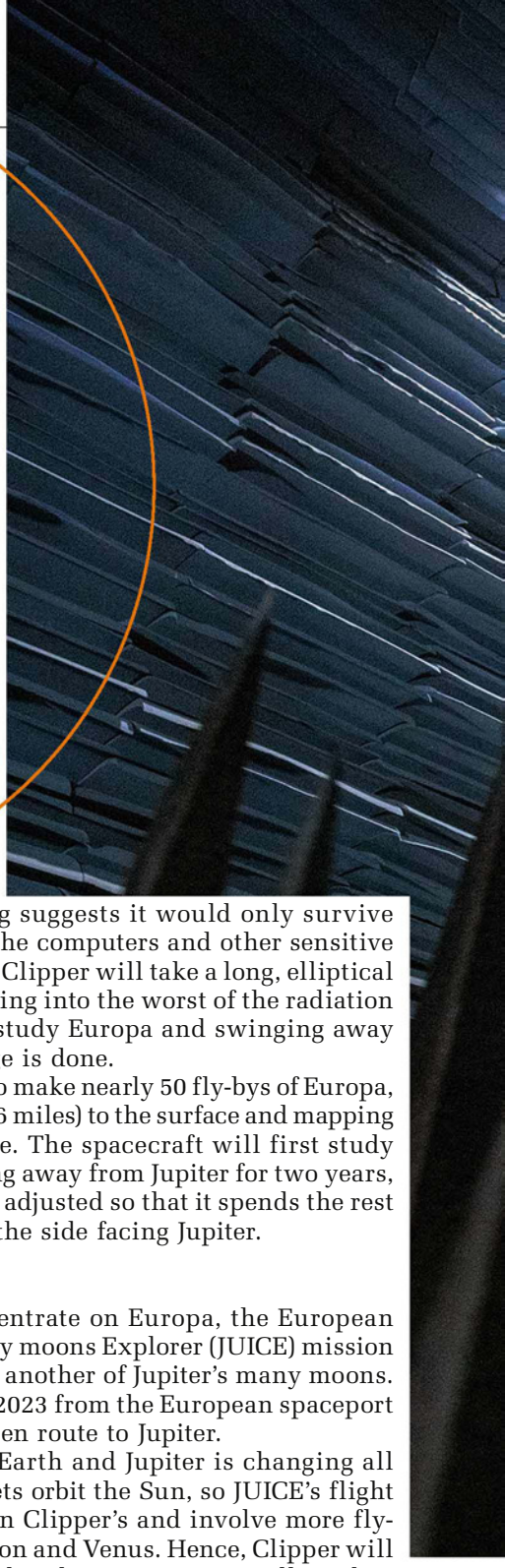


→ it into space. Jupiter is about 780 million kilometres (500 million miles) from Earth, so Clipper will need 24 engines to get it there, and a lot of fuel for its almost-six-year cruise – 2,750kg (6,000lbs) of it, nearly half the mass of the whole spacecraft. Even then, it'll need to take a convoluted route to Jupiter, involving fly-bys of Mars (in 2025) and Earth (in 2026) to use the gravity of the planets to increase its momentum and slingshot itself further into space.

Just getting Clipper to Jupiter is a complicated affair, but the challenges don't end there. Because Jupiter and its moons are five times further from the Sun than Earth, the sunlight reaching the spacecraft will be 25 times weaker than on Earth. Clipper will have gigantic solar panels measuring 30m (almost 100ft) across – about the same length as a basketball court – to collect enough sunlight to generate the power the spacecraft needs.

"WHEN CLIPPER DOES MAKE IT TO JUPITER, IT'LL THEN HAVE TO CONTEND WITH A HARSH RADIATION ENVIRONMENT"





When Clipper does make it to Jupiter, it'll then have to contend with a harsh radiation environment, produced by the fast-spinning planet's incredibly strong magnetic field (Jupiter spins on its axis once every 10 hours). The sensitive electronics on board will be shielded in a vault made of aluminium-zinc alloy almost 1cm (0.3in) thick. Even then, it won't be able to orbit Europa because the moon sits within Jupiter's radiation belt and testing suggests it would only survive for a few months before the computers and other sensitive components fail. Instead, Clipper will take a long, elliptical orbit around Jupiter, dipping into the worst of the radiation belt for short periods to study Europa and swinging away before any lasting damage is done.

ABOVE Clipper's 3m-diameter (10ft) antenna, needed to transmit data back to Earth, is attached during its construction

ABOVE RIGHT Prior to being attached to the spacecraft, the antenna was tested in 2022, at NASA's Langley Research Center in Virginia

This orbit will allow it to make nearly 50 fly-bys of Europa, getting as close as 25km (16 miles) to the surface and mapping a different area each time. The spacecraft will first study the side of the moon facing away from Jupiter for two years, then its trajectory will be adjusted so that it spends the rest of the mission flying by the side facing Jupiter.

TRAVELLING COMPANION

While Clipper will concentrate on Europa, the European Space Agency's JUpiter ICy moons Explorer (JUICE) mission will focus on Ganymede, another of Jupiter's many moons. JUICE launched in April 2023 from the European spaceport in French Guiana and is en route to Jupiter.

The distance between Earth and Jupiter is changing all the time as the two planets orbit the Sun, so JUICE's flight path will take longer than Clipper's and involve more fly-bys around Earth, our Moon and Venus. Hence, Clipper will arrive a year before JUICE, but the two missions will overlap.

JUICE will orbit Jupiter, making detailed observations of the planet and performing fly-bys of three of its largest moons: Ganymede, Callisto and Europa. Then, it'll adjust its trajectory to enter orbit around Ganymede to make close-up observations, becoming the first spacecraft ever to orbit a moon other than our own.

Ganymede is of great interest because it's the biggest moon in our Solar System (bigger than the planet Mercury) and it's the only moon we know of that generates its own magnetic field. Even more compelling is the fact that data from Hubble suggests that, like Europa, Ganymede also has an enormous ocean beneath its icy crust. JUICE will be able to orbit Ganymede because it's further away from Jupiter

NASA/DAVID C BOWMAN, NASA/JPL

and its damaging radiation, so the spacecraft will be able to remain close enough to make very detailed measurements, telling us much more about these icy ocean worlds in general.

The data from the two missions will be complementary and undoubtedly yield more insights when combined, so scientists working on JUICE and Clipper are already working together, preparing to share what they learn.

When Clipper eventually reaches the end of its life, JUICE might still be operational. Clipper may be intentionally deorbited and crashed into Ganymede to safely end the mission, so JUICE would be able to watch the impact and learn more about the surface. It's worth noting that there's no plan to crash Clipper into Europa – Ganymede's ice shell is thought to be much thicker than Europa's and far more stable, with no possibility of contact between the ocean and the surface. NASA's Planetary Protection Office calculates that there is too much risk of contamination from the spacecraft reaching Europa's subsurface ocean if Clipper were to deorbit there.

ALTERNATIVE CANDIDATES

Europa isn't the only icy moon in our Solar System to meet the basic requirements for life – there are a few more candidates worthy of investigation, including two of Saturn's moons, Enceladus and Titan.

Enceladus also has a fissured, icy surface and we know that it produces enormous plumes of vapour that burst through cracks in the ice at its South Pole, shooting hundreds of miles into space. The Cassini spacecraft famously flew through some of these plumes and revealed that they contain water, ice grains and salts.

Titan, meanwhile, is the only moon in the Solar System known to have a thick atmosphere of organic compounds, as well as rivers, lakes and seas on its surface – although they're bodies of liquid methane and ethane rather than water. Nevertheless, it's thought Titan is a moon where another ocean of salty liquid water exists beneath the surface. We can expect missions to explore these more distant destinations in the future, but the technological challenges will be even greater.

Until then, we can look forward to the launch of Europa Clipper – an historic mission from one ocean world to seek to understand another. When it launches, it'll carry a plate made of tantalum with the word for 'water' inscribed on it in over 100 languages. It'll also be engraved with a poem written by the US Poet Laureate Ada Limón, entitled 'In Praise of Mystery: A Poem for Europa', and the Drake Equation, which estimates the probability of finding civilisation beyond Earth. All this is to celebrate humanity's spirit of exploration and connection, typified by this inspiring mission to assess the potential for life on another world. **SF**

by **DR CAROLINE HARPER**

Caroline is a fellow of the Royal Astronomical Society and head of space science at the UK Space Agency.