New Scientist

WEEKLY June 20–26, 2020

SCIENCE REACTS TO BLACK LIVES MATTER

IS THERE LIFE ON EUROPA?

THE COSMIC WEB IS SPINNING

TURNING SPLEENS INTO LIVERS

SECRET LIFE OF BIRDS

STRANGEST PARTICLE IN THE UNIVERSE

CORONAVIRUS

HOW TO STOP THE NEXT PANDEMIC

What the world needs to do now to stop this ever happening again

SECOND WAVES

Why cases are starting to surge again

REOPENING THE SKIES

Travel bans, bubbles and quarantines

PLUS TWO-LEGGED CROCODILES / **EYE-CONTROLLED PLANES** / **ANGRY GOOSE GAME** / GOATS MAKE DRUGS IN THEIR MILK

Science and technology news
www.newscientist.com
US jobs in science

No3287 US$6.99 CAN$7.99

ROCIO MONTOYA

Life beneath an icy moon

The frigid satellite worlds of our outer solar system may harbour extraterrestrial life. Planetary scientist **Kevin Hand** tells Daniel Cossins his plan to find it

"One thing we've learned is that where you find liquid water, you find life"

OUR best shot at finding life beyond Earth may lie in the icy moons of the outer solar system – particularly Titan and Enceladus, which orbit Saturn, and Jupiter's moon Europa. We think they all have vast liquid water oceans beneath their frozen outer shells thanks to their highly elliptical orbits, which create such intense tidal forces that they are warmed from the inside out. Europa's ocean is thought to be much deeper than those on Earth, but with a similar chemical balance. Enceladus, meanwhile, spews geysers into its atmosphere that contain at least some of the ingredients life requires.

If life exists in these places, Kevin Hand wants to find it. As director of the ocean worlds lab at NASA's Jet Propulsion Laboratory in California, he is a leading expert on the potential habitability of these far-flung moons and a key player in the design of missions to explore them. In his new book *Alien Oceans: The search for life in the depths of space* (Princeton University Press), Hand describes what he has learned from his voyages to the bottom of Earth's oceans and how that informs his plans to send a life-seeking lander to Europa.

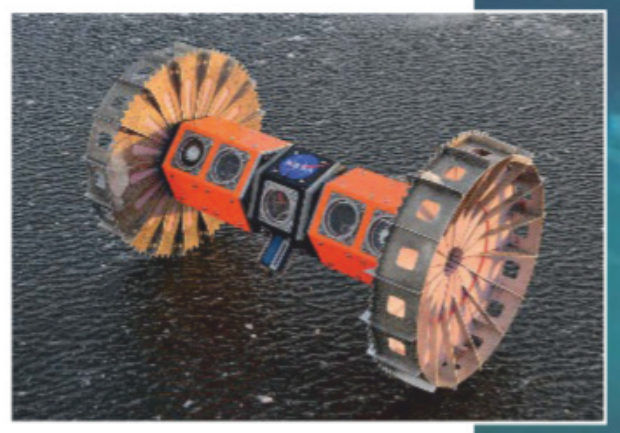
Daniel Cossins: Icy moons such as Europa are as different from Earth as one could imagine. What makes you think they might harbour life?
Kevin Hand: The simplest answer is that they are where the liquid water is. And if we've learned anything about life on Earth, it is that where you find the liquid water, you find life. In the case of Europa, its ocean is perhaps 100 kilometres deep, and we have good reason to predict that it has been around for the history of the solar system.

Combined with that, we also think that on Europa and Enceladus, a moon of Saturn, the seafloors are probably rocky and could have hydrothermal activity.

That's very important because when we think about what it takes for a world to be habitable, we know from our studies of life on Earth that it needs a couple of things as well as liquid water: the elements to build life and some source of energy to power it. On both Europa and Enceladus, we have good evidence that indicates the presence of those two things.

You are currently planning a landmark mission to Europa. What would it look for?
The first thing will be chemical signatures of life. At the most basic level, you want to look for organic compounds. Then you might also look for molecules that have chirality, meaning they are not identical to their mirror images, which is another signature of life on Earth.

You also look for inorganic indicators of life, not least cell-like structures. Life as we know it differentiates itself from its surroundings by making a compartment, the cell, and we predict that life elsewhere would form similar structures. ›



Do you think these places might harbour complex life?
For the most part, when I talk about the search for life elsewhere, I'm talking about the search for even the tiniest of microbes. A single-celled microbe, or the alien analogue, would revolutionise biology. But on Europa at least, I think there is a chance more complex life could have evolved.

The reason is that we've got this very intriguing relationship between Europa's surface and the magnetosphere of Jupiter, which bombards Europa with a rainstorm of charged particles. That, in turn, drives radiolysis, where water molecules are split apart and reform to make other things. We know from our observations with our telescopes and spacecraft that the surface ice on Europa contains hydrogen peroxide, sulphate and molecular oxygen. If these surface oxidants are mixed into the ocean below, you may have a very chemically rich ocean. On Earth, it was the rise of oxygen that enabled the emergence of multicellular life. So it's not completely out of the question that Europa's oceanic oxygen perhaps drove evolution to more complex life there too.

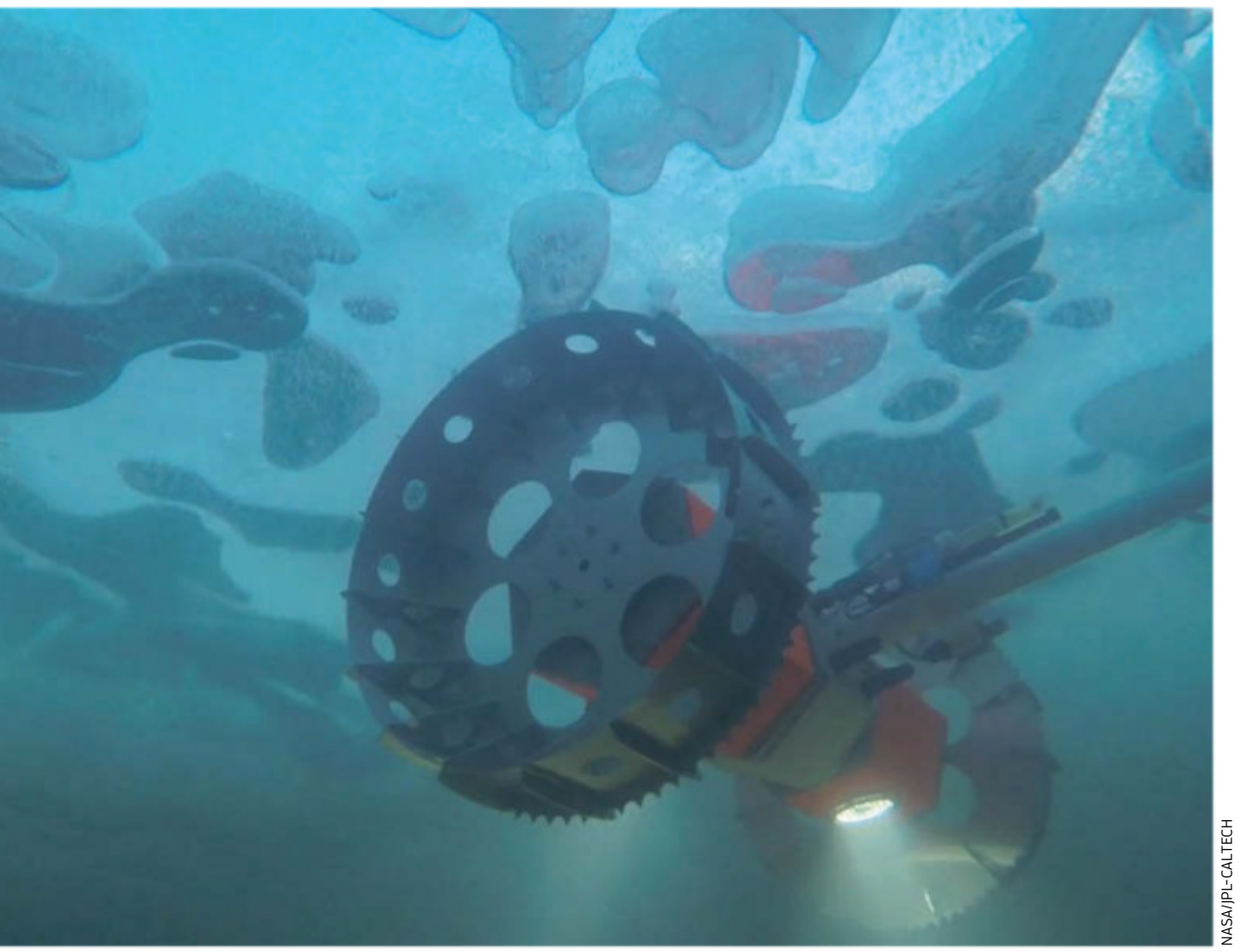
You've followed those ideas about the origin of life to the very depths of Earth's oceans, including a visit to Lost City, a system of hydrothermal vents at the bottom of the Atlantic. What was that like?
It was a transformative experience. It was like a combination of being in a time machine, transporting me back to the origin of life on Earth, and a spacecraft taking me to the deep ocean of Europa. I'm in this tiny, pressurised glass sphere, just me and the pilot, and we're looking at these cathedrals of carbonate, these chimneys that could have been the site of the origin of life on Earth. Now, there's much debate about that, and it is possible life arose in a warm pond on an ancient seashore, or in some other locale that we have yet to understand. But hydrothermal vents like those at Lost City are a strong candidate. And at that moment, I did allow myself to imagine that this could be what we would find at the bottom of Europa's ocean.

What sort of technology would we need to explore these alien oceans?
One of the wonderful things about developing a programme to search for life in these alien oceans is that we potentially get this win-win situation: we develop the tools and technologies to explore them, while simultaneously advancing our capabilities to study our own oceans. And that's where robotic vehicles like BRUIE [Buoyant Rover for Under-Ice Exploration] come into it. We've taken it down to Antarctica and demonstrated that it can help us study life at the ice-water interface here on Earth. But ultimately, we hope that BRUIE is kind of like an early ancestor – the *Australopithecus* to a robotic vehicle that eventually makes it to Europa.

What are the prospects for a mission that drills into the ice, or even gets samples from the oceans?
I would love nothing more than to do the dream of all dream missions, which is getting a submersible directly into these oceans. But scientifically and technologically, we need to follow a bit of a progression. We've got a commitment to a fly-by mission called Europa Clipper, scheduled to launch in the mid-2020s, and that mission will assess habitability. But it won't be able to search for biosignatures. I would hope that the follow-on mission would get to the surface with capabilities to directly search for signs of life, while also doing a lot of the measurements that we'd need to inform a mission that would drill or melt through the ice.

Keep in mind, though, that other than on the moon and Earth, we haven't drilled deeper than about 10 centimetres anywhere in the solar system. So going directly to a world like Europa and drilling through many kilometres of ice is an incredibly tall order, technologically speaking – and very expensive. Funding for such a mission, and

"I'm in this tiny pressurised glass sphere, just me and the pilot, looking at these chimneys that could have been the site of the origin of life on Earth"



NASA/JPL-CALTECH

The BRUIE rover, tested under the Antarctic ice, could inspire probes that will one day explore alien oceans

the scientific motivation, would require initial surface reconnaissance.

If we were able to spot complex life in these oceans, what would it look like?
My experience at Lost City inspires my thinking on this. As I was collecting samples, I saw this undulating, shimmering, glass-like sheet of a creature just a couple of metres away. It looked kind of like a very large, translucent umbrella, nearly 2 metres across, and it was presumably filter-feeding on the microbes and other organisms surviving from the chemistry of the hydrothermal vents. So when I think about the prospect for larger life within an alien ocean, it is these sorts of creatures that come to mind.

Apart from your plans to send a lander to Europa, what is the most exciting thing happening in astrobiology at the moment?
In the next two decades, we will send the Dragonfly spacecraft to study Titan, another moon of Saturn, and it will be equipped to look for any biosignatures. We think Titan has a subsurface liquid water ocean sheltered beneath its icy crust, though we don't know much about the extent of the water-rock interaction there, which is important because it's really the rocks that give you those other elements that life needs.

What makes Titan a great place to search for weird life, life completely unlike any life form that we know of here on Earth, is that it has liquid methane lakes and seas on its surface. Liquid methane has very different chemical properties to liquid water, allowing all sorts of unusual compounds to dissolve and react within it. So there's a chance that Mother Nature could have a surprise in store for us with weird life, unlike anything that we have ever seen or been able to predict, crawling along the shores of Titan's liquid methane lakes and seas.

What would the discovery of life elsewhere tell us about the origins of life?
It would help answer a fundamental question, which is whether life arises wherever the conditions are right. That's something we address not by looking for life beyond Earth, but for a second origin of life. If we find it within these alien oceans in our own solar system, I think we can predict that we live in a biological universe.

Contrast that with finding life on Mars. I love Mars. But even if we're being incredibly optimistic and we say we found extant life beneath the surface of Mars, and that life is based on DNA, I would argue that you have to hedge towards conservativism and say that it would be indicative of life on Earth seeding Mars or vice versa. These alien oceans far out in the outer solar system, however, are much harder to cross-pollinate.

How confident are you that any form of life exists elsewhere?
I prefer not to approach this from the standpoint of how confident I am or what I believe. Rather, I like to frame it as a prediction, because that's ultimately what we do in science: we formulate hypotheses and we test them. And when you consider the combination of the evidence we've amassed that these alien oceans beyond Earth are habitable, combined with everything that we've learned about life on Earth, especially the presence of microbial life in an extraordinary range of extreme environments, we can now put forth a solid hypothesis: if life emerges easily wherever the conditions are right, then these alien oceans beyond Earth should be inhabited.

What difference will it make if we find life beyond Earth?
It's potentially a revolution akin to the one Galileo ignited with his first glance up at the night sky with his telescope, observing and discovering the moons of Jupiter. With those observations, he opened the door to the Copernican revolution and our place in the universe was never the same. Here, we're talking about a revolution in the science of us: biology. And I don't know what's going to unfold out of that. But I think it's incredibly exciting to think about what we might learn from, say, discovering that we live in a biological universe where life on Earth is just one point in a vast periodic table of life. ▮

Daniel Cossins is a features editor at *New Scientist*