OUTBACK OUTLOOK NEW AUSSIE MEGASCOPE SEEKS ALIENS & BIRTH OF UNIVERSE

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FINDING ALIEN LIFE IN OUR SOLAR SYSTEM

Forget the Martian thing: alien life is possible in our solar system, and future space probes might confirm it, writes **Sara Webb**.

Are we alone in the universe? It's one of the most intriguing questions in science, because there are only two possibilities, Yes or No, and either is equally exciting and terrifying.

The bounds of our astronomical knowledge have expanded exponentially in the past 100 years; our observable universe is suddenly bigger than we can comprehend. With trillions of galaxies and quadrillions of stars, it seems impossible that we'd be the only living things within this vast universe, and the only way to know for sure is for us to look.

The easiest place for us to really investigate first-hand the possibility of alien life, is in our very own cosmic backyard, the solar system. Our solar system is home to some pretty remarkable places, many with the potential for life as we know it.

Before we dive into where we should be looking and why, let's first define what life needs to survive.

All life on Earth is something called "carbon based". Our DNA, tissues, proteins, fats and almost everything else in living cells are built around carbon. Carbon allows up to four different and simultaneous bonds between it and other atoms, making it incredibly good at forming long chains of molecules, like the ones that form our DNA.

One of the most important things carbon-based life needs to survive is water. Water is used by our cells to facilitate chemical reactions. So when we're searching our solar system we're looking for hints of organic carbon-based matter, and for water.

Only in very recent times have we discovered or confirmed the existence of water in our solar system beyond Earth. Places like the Moon and Mars appear to have pockets of frozen water at their poles, but these are not the places we're excited about.

It was the 2005 discovery of liquid water spewing out of Saturn's icy moon Enceladus that changed everything. The images sent back from the Cassini space probe were mesmerising. They showed an alien moon with huge geysers of liquid water flowing out of the surface. It only got better when plumes of water were finally confirmed in 2018 on Europa, the icy moon of Jupiter.

We believe that both of these moons harbour massive amounts of liquid water, in under-surface oceans that could have friendly conditions for life to form. The frozen ice crust of each moon is thick enough to provide protection from harmful radiation. The building blocks of DNA are amino acids, organic compounds that can be destroyed if exposed to radiation over long periods of time. The water on each moon likely contains important ingredients for life – such as salt, carbon, hydrogen and sulphur – and on Enceladus we've even found organic compounds in the escaped water.

> "THEY SHOWED AN ALIEN MOON WITH HUGE AMOUNTS OF LIQUID WATER FLOWING OUT OF THE SURFACE.

The Juno spacecraft's September 2022 images of Europa (above) were taken from just 400km above the Jovian moon's surface. They're the highest-resolution close-ups of Europa captured to date. In 2005, the Cassini probe's flyby of Saturn's moon Enceladus (opposite) provided evidence of liquid water: a game-changer in the search for possible alien life in our solar system.

So with two excellent locations to look for life, where do we focus our attention?

NASA's answer is Europa. (Don't worry, I'm sure we'll be back examining Enceladus one day.) One of the main reasons Europa is a great first candidate is because we are currently already there.

The Juno spacecraft has been orbiting the Jovian giant since 2016, investigating both Jupiter and its orbiting moons. The images and science we've received from this mission are astounding; we now have a better understanding of Jupiter's storms, changing magnetic field and auras, and the highest resolution images of Europa we've ever seen.

Just in September 2022, Juno dipped down to only 400 kilometres above the surface and took breathtaking images that provide us with the information we need to plan a detailed probing mission.

NASA is currently developing the Europa Clipper mission, designed to perform several close flybys,

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using speciality scientific equipment to scope out the surface like never before. The main science objectives of this program are first, to determine the thickness of Europa's outer icy shell and how this changes over the surface; second, to scope the composition of Europa's under-surface ocean and learn if it has all the key ingredients to support life; and third to characterise Europa's geology, to identify the most likely places for life to exist – information to inform future investigations and missions.

We've been exploring our solar system via rovers and probes for more than 50 years, and in the next 10–20 we're expecting to get closer than ever to answering "is there life out there?". Missions like Europa Clipper will provide us with the most detailed data about just one of the places we might find life, but we'll have to be patient. Currently under development, the mission's expected to launch in 2024, and arrive at the big friendly giant Jupiter in 2030.

> "THE SAME AS ENCELADUS AND EUROPA, WE SUSPECT TITAN IS HOME TO A SUB-SURFACE OCEAN.

Good things always come to those who wait, and the 2030s will see more missions to get excited about.

In 2034, the Dragonfly mission is expected to reach Saturn's moon Titan. Titan is unlike any other moon in our solar system, because it's home to a dense atmosphere and surface lakes. The same as Enceladus and Europa, we suspect Titan is home to a sub-surface ocean. Titan's nitrogen-rich atmosphere is thicker than Earth's, and we've previously

WHAT MIGHT IT LOOK LIKE?

The Dragonfly mission will be heading into the depths of the very alien world of Titan, one us earthlings can barely imagine. So, what would life look like living in lakes of methane, or breathing in nitrogen?

We have two theories. One is that life might be like extremophile organisms here on Earth; and two is that it may be completely unlike anything we've even seen before. Both possibilities are incredibly exciting.

We've found extremophiles here on Earth in some unlikely places, including 6.7km inside Earth's crust, 10km deep inside oceans and incredibly, inside hydrothermal vents. We've even found certain organisms in this group that can metabolise methane, called Methanotrophs, which can be found living in terrestrial mud volcanoes. Organisms like these teach us that life on Earth is persistent, and found in places we once thought would be uninhabitable.

In my opinion extremophiles give us the greatest hope when it comes to finding alien life in our Solar System – which is both cool and a little underwhelming. It may be that alien life is visible only under a microscope – huh, and wow! Extremophiles on Earth are some of the most interesting creatures I've ever seen.

One of the best examples is the beloved tardigrade or water bear. These tiny creatures – just 1mm in length – can survive very harsh environments. Their signature bear appearance comes from their six leg-like appendages, each with claws attached. As remarkable as these creatures are – and we suspect they could, in theory, survive on other celestial bodies – we don't think they would survive on Titan's surface. So, what other organisms could, and how would they have evolved in this environment?

One of the most common theories is that Titan life might be completely different to anything we've found on Earth and could have evolved in the hydrocarbon lakes: which brings us to a second theory.

Life on Titan could be unlike anything we've even seen before, and possibly not even carbon based. Researchers have speculated that silicon-based life might be suitable for a Titan-like environment, where a completely different type of biochemistry would be needed to survive in the methane lakes. Titan's surface has very low temperatures and severely lacks the oxygen and liquid water that carbon-based life needs to survive. In theory, silicon-based life would look very different to us – how different is hard to say. We haven't found or created silicon-based life here on Earth and it's unlikely we'll find it on Titan either. Early estimates suggest there might be too little silicon on Titan's surface, with most likely locked up deep in the interior. But until we explore this mysterious moon, we won't know what might be living on the surface.

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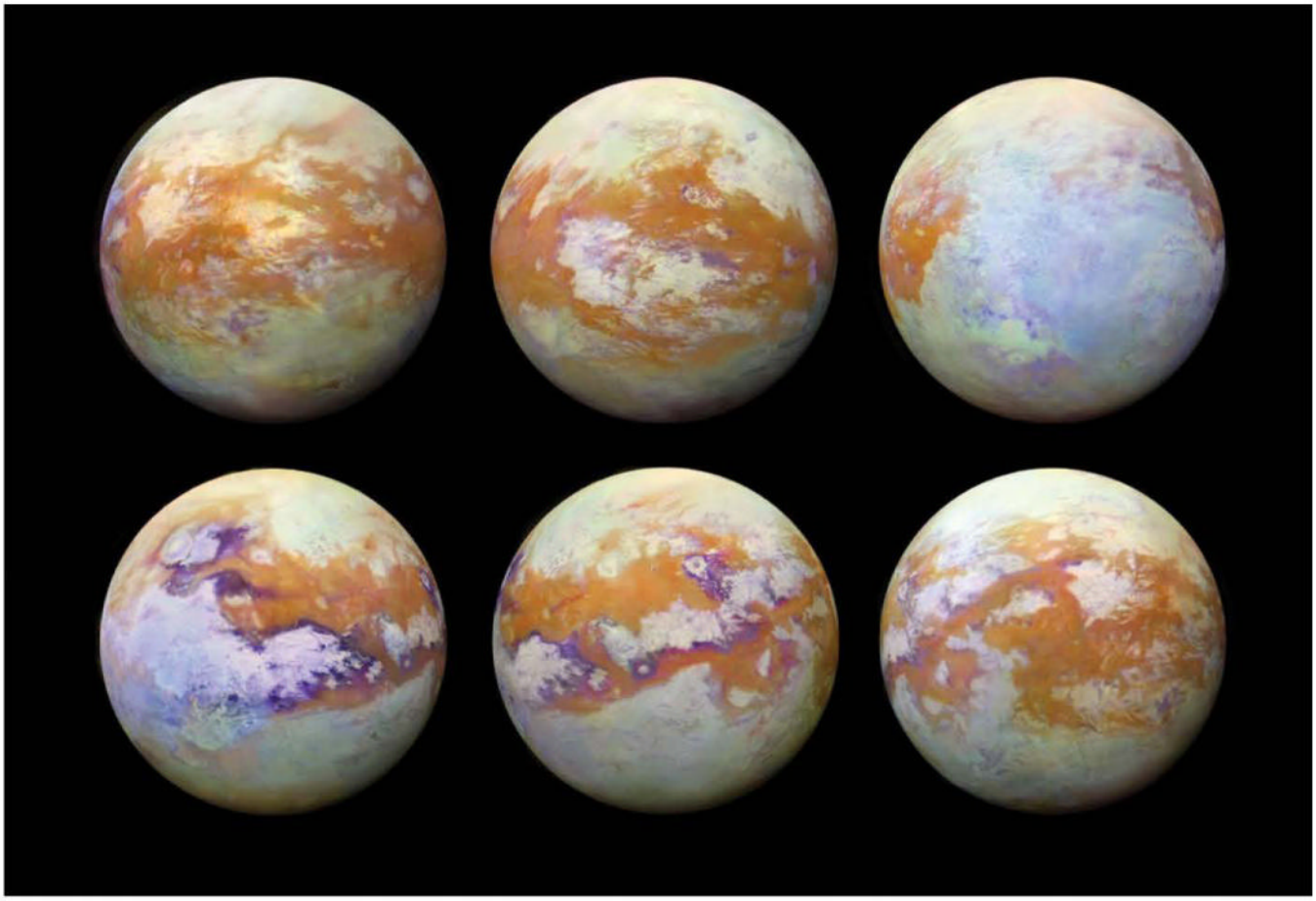

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These infrared images (above) of Saturn's moon Titan represent some of the clearest global views of the icy moon's surface produced so far. The images were assembled from 13 years of data acquired by NASA's Cassini spacecraft.

identified complex organic chemicals and hydrocarbons within it. This unique atmosphere has intrigued astronomers ever since its discovery and we're still trying to understand it with our best telescopes.

In December 2022 the James Webb Space Telescope teamed up with the Keck Observatory on Earth to image and track the movements of clouds around Titan. This new data made me stop in my tracks because for the first time, I saw a pale blue dot in space that wasn't the Earth. Titan suddenly didn't seem so alien, with its hues of blue and green, and visible clouds. These observations have confirmed long-held modelling theories that clouds should be able to form in its northern hemisphere. We're still investigating what this new data means, but we're closer to understanding this amazing little world.

Titan is also an intriguing place thanks to its surface lakes of liquid methane. Some scientists hypothesise that life could possibly exist in these lakes, inhaling hydrogen-2 instead of oxygen, and exhaling methane instead of carbon dioxide. We've never found life like this on Earth, but on this alien moon, the mechanisms for the formation and evolution of life might just be entirely different.

The only way for us to really know for sure is to investigate it with probes. The Dragonfly mission will drop a large drone down into Titan's atmosphere and study in-situ how far prebiotic chemistry might have progressed there. Another exciting mission that hopes to push humanity closer to understanding how likely life is elsewhere in the solar system.

Each of these missions will no doubt provide us with greater understanding of these extreme and unique environments like never before, and possibly close the case of "are we alone?" in the universe.

WHAT ABOUT LIFE IN THE GREAT BEYOND?

Our Solar System might not be hiding little green men for us to find, but that doesn't mean they aren't out there, somewhere.

Our universe is unimaginably big. With over two trillion galaxies in our observable universe, it's unlikely that we're the only beings. In our galaxy alone we have over 400 billion stars and likely, many more planets. If life could form like it has here on Earth, statistically across the universe, it should be able to form again and again. The problem we face is confirming if this is true, and this is where us astronomers start to talk a lot about the Fermi paradox. The big question famously asked by Fermi was "where is everybody?". The answer is we don't know, but we can't rule out that, somewhere, there are other beings like us, asking the exact same question.

SARA WEBB is an astrophysicist at Swinburne University of Technology. Her last story – on JWST – was in Issue 96.