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HOW THE MAYA PREDICTED THE FUTURE

Science Focus

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Alien Life
The hunt for extraterrestrial fingerprints heats up

Simple Joys
Why we're looking for happiness in the wrong places

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The link between air quality and dementia is getting stronger

SIGNS

The more planets we find outside our Solar System, the better our chances are of

by **GEORGINA TORBET**

The first confirmed detection of an exoplanet, a planet outside our Solar System, came in 1992. We've found a lot more in the years since then. According to NASA, by the end of October 2025, the tally stood at over 6,000. But as astounding as that number may sound, the big question isn't how many exoplanets there are (more than we could ever count); it's how many of them can – or do – support life.

Answering that question is far from simple.

Exoplanets float far away from us, at unfathomably vast distances. Even the closest, the super-Earth Proxima Centauri b, is more than four light-years away (over 37 trillion kilometres or 22 trillion miles). If life is out there, spotting it won't be easy.

But scientists are coming up with new and innovative ways to improve the search. Alongside building bigger, more capable telescopes, they're considering multiple factors in their hunt – from a planet's colour to the combination of gases in its atmosphere, and even evidence of advanced technology.

PURPLE IS THE NEW GREEN

When you imagine a lush planet full of life, one colour springs to mind immediately: green. But recent research suggests that, when we're looking for alien life, we should be searching for other colours too.

Prof Lisa Kaltenegger, an astrophysicist and astrobiologist at Cornell University in the US, has been working to understand what characteristics microbial life might have if it developed on planets with environments unlike Earth's.

"I don't want to miss signs of life just because they're not green, or on a carbon-copy of Earth," she says.

Based on her research, the colour she thinks we should be looking for is purple.

That's because although our Sun is a large yellow star, the majority of other stars in the Universe are smaller and red. If life were to develop on a planet bathed in red sunlight, it wouldn't necessarily use chlorophyll, but it would need to protect itself from the high levels of ultraviolet (UV) radiation given off by flares from these types of stars.

OF LIFE

finding life on one of them. But if there really is life out there, how do we spot it?

ILLUSTRATION: MAGIC TORCH

"When the conditions change, the type of life you get changes," Kaltenegger says. Think about the life we've found around hydrothermal vents deep in the ocean, or the small amounts of microbial life found in Earth's atmosphere. Her team has collected a diverse catalogue of microbial life from around our planet to help suggest a variety of indicators we could use when searching for life on other planets with their own distinct environments.

Life on a planet orbiting a small red star, for example, could make use of biopigments that are protective against radiation or temperature (red stars are typically cooler than our Sun). These pigments can act as a defense mechanism, as they do in some microbes found high in Earth's atmosphere, where the UV light is more intense.

This life, if it were to exist, would need to be able to harness lower-energy red light waves, which isn't unheard of. There are plants on Earth that make use of compounds besides chlorophyll for photosynthesis, such as carotenoids – the same pigments that make carrots orange and tomatoes red.

"Chances are that, wherever you go, life should be colourful," Kaltenegger says.

That's where the idea of purple microbes comes from. According to Kaltenegger, "the redder the light gets, the darker the plants would be. So, in this case, purple and dark purple."

To be able to detect the surface colours of exoplanets, however, we'll need even better technology than we have now. Upcoming telescopes like the Extremely Large Telescope and the planned Habitable Worlds Observatory will be able to see exoplanets in greater detail than ever before, even peering at their surfaces to see the tell-tale colours of microbes.

PEERING INTO THE ATMOSPHERE

Colours might be a great way to search for life eventually, but scientists are always happier when they have supporting, independent evidence. So, another way they're looking for life is by studying the atmospheres of exoplanets.

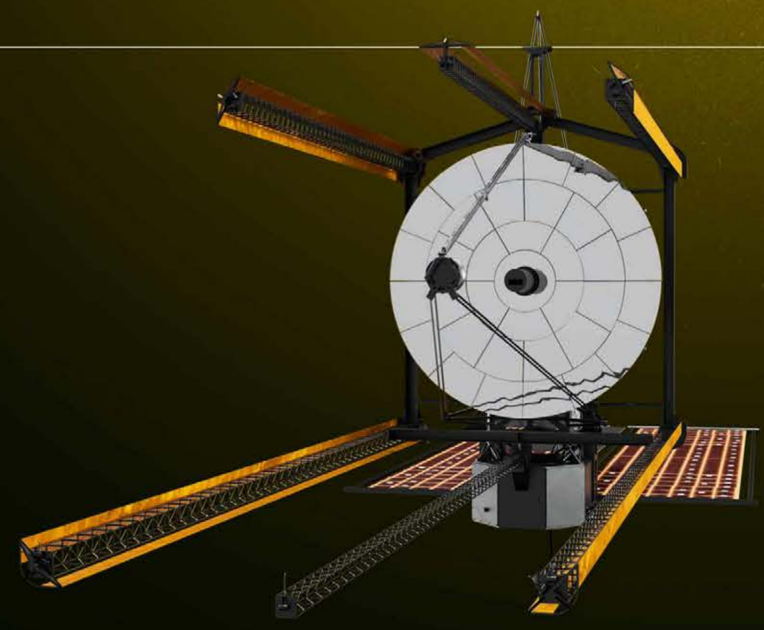
This only became regularly possible very recently, with instruments like the James Webb Space Telescope (JWST). With its near-infrared spectrograph, JWST can look at the way light travels through the atmospheres of exoplanets as they pass in front of their host stars and determine what those atmospheres are made of. It's not a simple process, though, and it's also tough to agree on exactly what we're looking for.

Researchers have produced a list of gases that we should be looking out for on potentially habitable exoplanets. Gases like these could indicate the presence of life, known as biosignatures, including dimethyl sulfide and phosphine, along with the more obvious ones like oxygen and methane.

"When we say these are biosignature gases, we usually – but not always – mean that we only know a biological process can create them," says Prof Abel Méndez, a planetary astrobiologist at the University of Puerto Rico.

For example, oxygen is one of the key gases related to habitability, but just because you can find it in an atmosphere doesn't necessarily mean there's life there.

Oxygen can be produced by all sorts of processes, some of which are biological and some of which aren't. It's also a highly reactive gas, so it would generally lessen in quantity over time. If you find high levels of oxygen on an exoplanet, then it's a sign that the planet has reached saturation or is being replenished in some way. And that's a good indicator of how suitable a planet is for hosting life.



ABOVE
Concept art of the Habitable Worlds Observatory, a large infrared and ultraviolet space telescope designed to search for signs of life on exoplanets

AN INVITATION TO EXPLORE

But atmospheres aren't fixed things, even without life. Rocks absorb and emit gases, as has recently been seen on Mars, where the levels of methane – another biosignature gas – have fluctuated. So, we need to look deeper.

"With these biosignature gases, it's not only their presence, but also their combinations," Méndez says. The combination of methane and oxygen, for example, would be a particularly exciting find, especially if it were seen on a rocky planet orbiting in a star's habitable zone, as certain ratios of the two gases signpost life.

The concentration of a specific gas is important too, as not only are small trace amounts hard to detect with current instruments, but also larger amounts are less likely to be due to geological factors.

A recent finding of phosphine on Venus caused enormous excitement, as it hinted at the possibility of life being present in the clouds there. Further research found that it was most likely a misinterpretation of the data, however, and that the gas was probably sulphur dioxide. Given the difficulty of correctly interpreting data like this from the planet next door, you can imagine how much harder it is with an exoplanet hundreds of light-years away.

To really understand whether the presence of a particular gas or combination of gases is a true marker of life, we need to model a planet's climate, taking into consideration its geology, the distance it is from its host star, its radiation environment, and more.

The balance of particular gases in an atmosphere is our best current indicator of potential life, but it isn't a simple yes or no answer – it's an invitation to study that planet and learn even more.

LEFT
An artist's impression of the surface of Proxima Centauri b, the exoplanet orbiting the closest star to our Solar System, Proxima Centauri

OVERHEARING ALIEN CHATTER

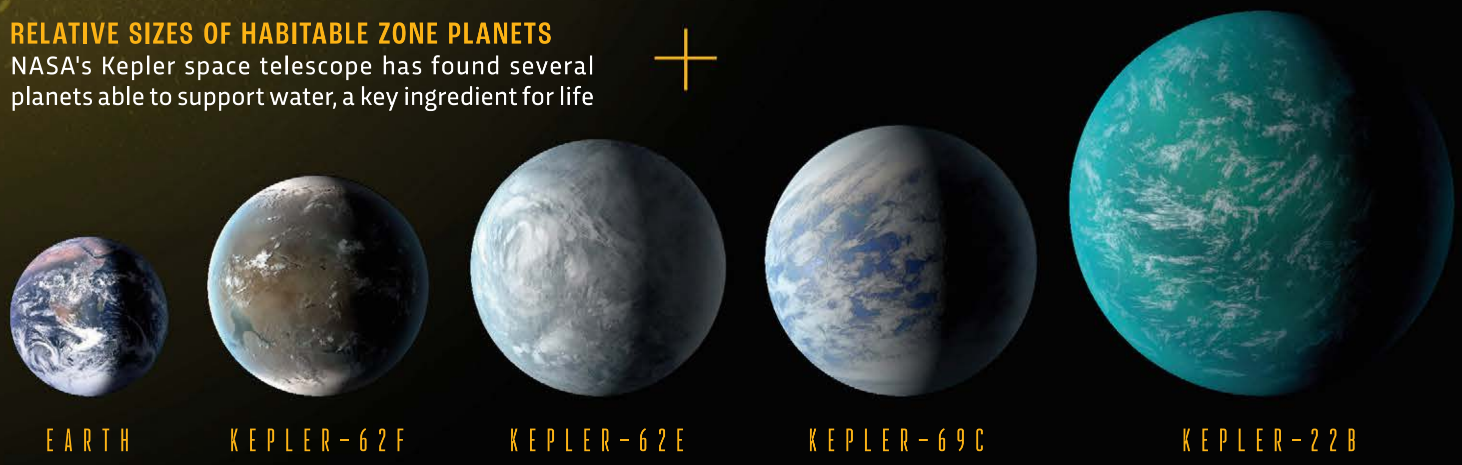
Despite all of the above, the fact remains that searching for a distant planet that might be able to host life, let alone signs of the presence of simple lifeforms on that planet, is hugely challenging. Simple lifeforms are likely to be microscopic and would have to be abundant for their presence to affect the exoplanet's environment or atmosphere in a way that we could detect. There is an alternative way to approach the problem, however.

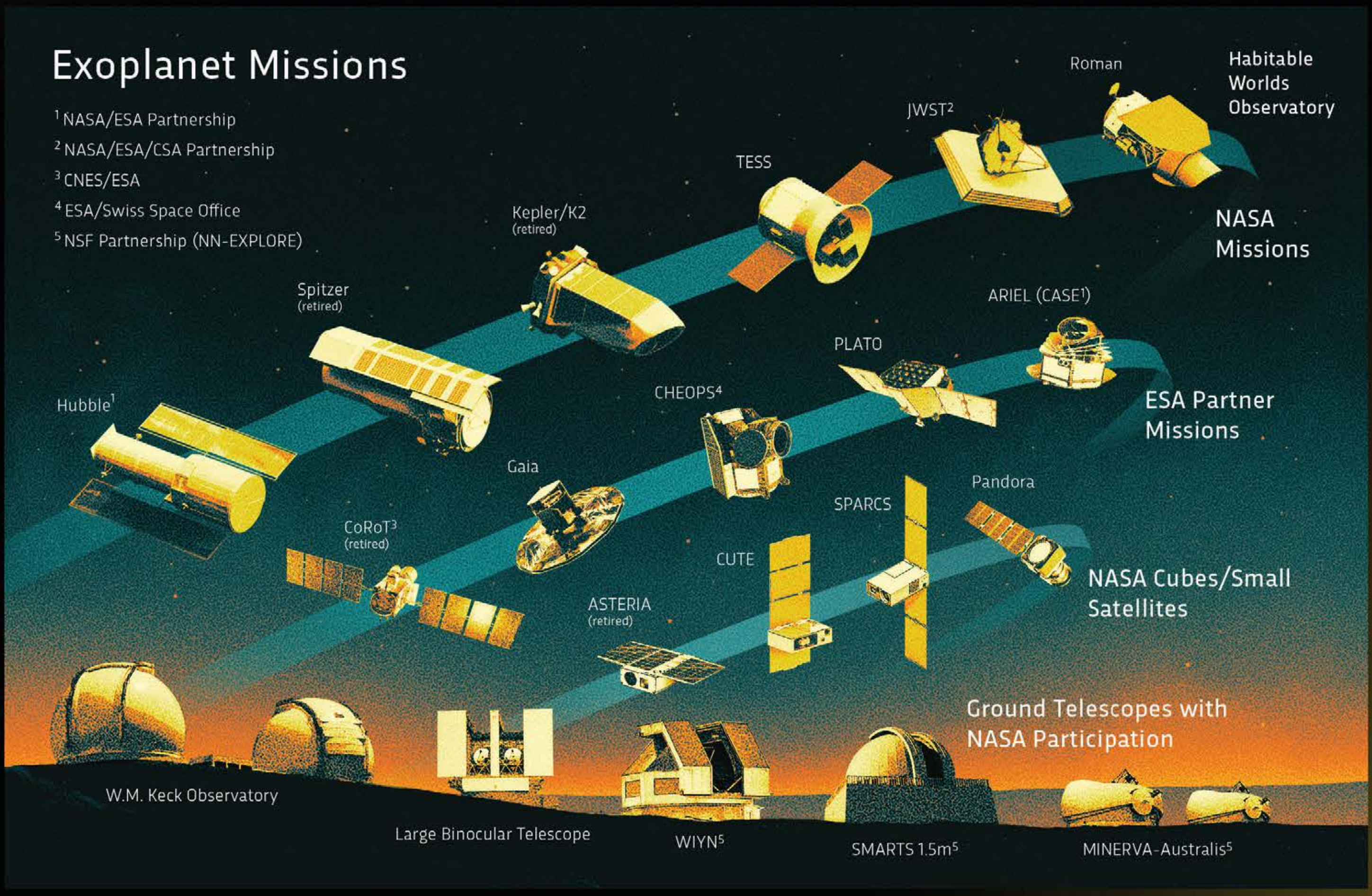
Instead of looking for exoplanets that could host simple forms of life, we look for signs of complex life. In other words, we look for advanced civilisations that have developed and use technology, particularly the sort of technology that emits detectable signals that can travel vast distances across space, such as radio waves.

"Most of the searching we've done in the past was very anthropocentric. We were searching for radio signals, because in the 1960s we thought that was the top of technology; now we're looking for laser signals," says Dr Franck Marchis, astronomer and Director of Citizen

RELATIVE SIZES OF HABITABLE ZONE PLANETS

NASA's Kepler space telescope has found several planets able to support water, a key ingredient for life





"IT'S AN INVITATION TO STUDY THAT PLANET AND LEARN EVEN MORE"

NASA/SVG, SCIENCE PHOTO LIBRARY X2 ILLUSTRATION: MAGIC TORCH

Science at the SETI (Search for Extraterrestrial Intelligence) Institute. These common communication technologies seem like an obvious place to start searching for life, because they can have distinctive patterns unlike those that arise from natural processes.

But, as Marchis explains, there's an even newer approach: "Why don't we search for the consequences of the technology instead of searching for the technology itself?"

That means looking for pollutant gases like chlorofluorocarbons (CFCs), which, as far as we know, are only produced by technological processes. Or we could search for evidence of large structures in space used for power harvesting, or even for fluctuating light levels that suggest the use of artificial lighting.

The disadvantage of this approach is that intelligent life takes much longer to develop than microbial life, so we assume intelligent life is much rarer. The advantage, however, is that some of these technosignatures – large structures, for example – could persist far beyond the lifetime of the civilisation that created them. Finding evidence that there once was intelligent life could be as profound as finding that life exists right now.

The challenge is that we're searching for an intelligent needle in a cosmic haystack. Researchers trawl through huge datasets from any available telescopes and get help from machine learning to look for technosignatures like radio signals, hoping to find a clue – even if it comes from somewhere we wouldn't expect, such as from a planet outside of a star's habitable zone.

"We're trying to be the least anthropocentric as possible," Marchis says. "We don't know what technological life is, we have no idea how civilisation will evolve over time... We're not searching for life, we're searching for the signal of the way this life communicates."

Of course, even that is hard to predict. Perhaps hypothetical alien life could communicate through some sort of quantum entanglement technology that we can barely imagine – we can't search for that. But the laws of physics have some limitations: for communication within the electromagnetic spectrum, you'd want to use a wavelength that isn't too energy-intensive, which is why, here on Earth, we tend to use radio waves and lasers.

New projects like LaserSETI are being built to search for evidence of lasers, which would give an indication of technological life. But even if a laser signal were detected, it wouldn't be sufficient proof of life on its own. "The detection will give us a motivation and a direction to look in," Marchis says. But then we'd need more research, more investment and more telescopes to look for the source of that intelligence in the vastness of the cosmos. It would be the beginning of a journey rather than the end of one.

ABOVE The LaserSETI observatory was set up in Robert Ferguson, California, to look for visible light signals that could be attributed to extraterrestrial intelligence

LASERSETI TEAM

"THE RACE TO DISCOVER LIFE BEYOND EARTH IS WELL AND TRULY ON"

A LIFELONG SEARCH

The biggest questions in science don't have easy answers, and a detection of potential life on an exoplanet – as enormously exciting as that would be – would require years or even decades of further research to confirm.

The race to discover life beyond Earth is well and truly on, though, and enormous leaps have been made in the short time since it began. The first exoplanet wasn't discovered until 1992. Less than 20 years later, came the discovery of the first exoplanet in a habitable zone. And the ability to investigate the atmospheres of rocky exoplanets came 10 years after that, with the launch of the JWST.

"In 2030, maybe if we have big telescopes like the Habitable Worlds Observatory, we'll be able to see planets around Sun-like stars in more abundance," Méndez says. Not only will we be able to look at a wider range of exoplanets, but we could also, potentially, see whether there's land and ocean present on an exoplanet.

Beyond that, in the decades to come, we might be able to see the colours of an exoplanet's surface, and determine if plant life might be present there. And then we can search for changes in a planet's brightness or heat levels that could indicate the presence of cities, and intelligent life – life we might one day be able to communicate with.

As we begin to dip our toes into the study of distant exoplanets, we'll need to keep our minds open to the varieties of life that could exist and how we could locate it. "At the forefront of science, you have to be creative," Kaltenegger says. "Because you have to imagine things that are possible, and then figure out how to determine if they're possible or not." **SF**

by **GEORGINA TORBET**

Georgina is a freelance space journalist, writing about planetary science, and robotic and human space exploration.