BBC

THE ANIMALS WHOSE LIVES RELY ON THE NIGHT SKY

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Sky at Night

THE UK'S BEST-SELLING ASTRONOMY MAGAZINE

ARE WE ALONE?

Alien-hunting experts reveal why we're closer than ever to discovering life among the stars

PLUS
The Red Planet meets the Beehive Cluster

THE EUROPEAN SPACE AGENGY: 50 YEARS OF EXPLORATION

CHINA'S MISSION TO BRING ASTEROID SAMPLES TO EARTH

PORTABLE PLATFORM: NEW SKY-WATCHER MOUNT TESTED

HOW ALIENS WILL DETECT OUR TECH FROM SPACE

THE REAL ZODIAC: THE STARS BEHIND THE STAR SIGNS

Are we ALONE?

We asked the experts

Four specialists in the hunt for extraterrestrial life tell **Ezzy Pearson** how they're hoping to find aliens

For centuries, humanity has asked itself whether it is alone in its ability to comprehend and investigate the cosmos, and whether Earth is the sole bastion of life in the Universe or simply a single outpost among billions of inhabited worlds. In the past, the exploration of extraterrestrial life was firmly left to the realm of science fiction, but in recent years the hunt for aliens has become an increasingly focused area of rigorous scientific research – from looking for echoes of Earth's habitats in our neighbouring worlds to searching for signals from distant star systems. We spoke with four of the leading figures involved in the hunt – an astrobiologist, an icy moon explorer, an exoplanet expert and a SETI searcher – to find out why we're closer than ever to finding an answer. ▶

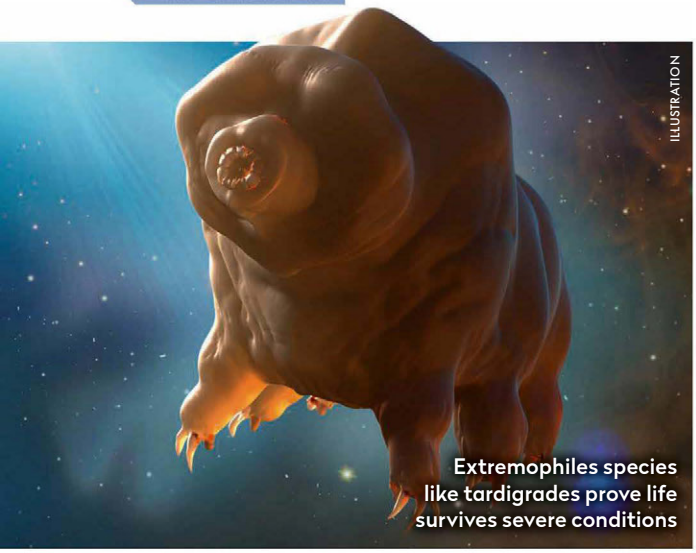
Ezzy Pearson is *BBC Sky at Night Magazine*'s features editor. Her book *Robots in Space* is out now

ILLUSTRATION: FIGURE: LIXU/GETTY; COSMOS: MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY

It's a big Universe out there. Are we really the only life forms in it? We get answers from four people working on the cutting edge of alien-hunting science

Penny Boston

Pioneers the field of astrobiology at the Ames Research Center



ILLUSTRATION

Extremophiles species like tardigrades prove life survives severe conditions

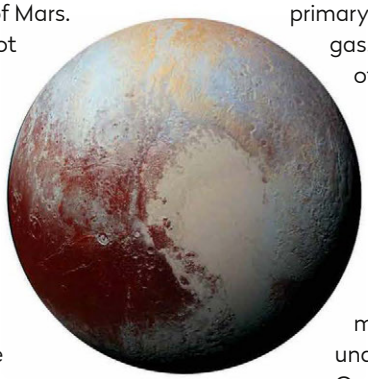
What is astrobiology?
Astrobiology is anything that touches on the quest for understanding whether there are other life forms in the rest of our Universe. It really is an all-encompassing, multidisciplinary area of research, looking at the bodies in our own Solar System for signs of past or present lifeforms, all the way out to the study of exoplanets.

How are you helping in the search for alien life?
I look at extreme life forms here on Earth as a template for other environments. Those that tolerate extreme environmental conditions – high temperatures, being frozen, being trapped in a salt crystal, those that process minerals rather than eating organic carbon made by plants. Other folks have studied some small animals, like tardigrades. Everybody loves a tardigrade – they can tolerate a whole lot.

> *"Mars has been in our sights for decades as a potential place to look for life"*

How does learning about Earth help us find aliens?
There is no extreme environment on Earth that is an absolute match for another planet, so we extract nuggets of information about how an organism would make its living in an environment that has some similarities to an extraterrestrial one.

For example, we're very interested in the deep subsurface of Mars. We know a lot about deep subsurface microbiota here on Earth, down to many kilometres. It gets very hot, but there are exotic organisms living off hydrogen. It's a template for stimulating our thinking about how microorganisms may have arisen and adapted on another planet.



▲ Icy on the surface but warm inside, Pluto may have a subsurface ocean

Do we currently have the technology to find life?
The answer is probably yes and no. Opinion about this varies widely throughout the scientific community.

We have a good grasp of detecting biopolymers: big molecules that store information like DNA... if we can get to the environment. There's a lot of attention right now on trying to advance pinpoint landing and engineering robotics that can get us into rougher terrain.

Where is the best place to look for life beyond Earth?
Anywhere with the potential for liquid water. We take water for granted, but it's quite extraordinary. Within the temperature range of our planet, it has the ability to exist in all three major primary phases: solid, liquid and gas. It enables the chemistry of life to actually occur.

Mars has long been in our sights for many decades as a potential place to look for life. Several of the icy moons around Jupiter and Saturn have liquid material in their interior under kilometres of ice. One of my favourites is Pluto; it turned out to be a geologically incredibly active body. We really do have quite a list that we want to investigate in the coming decades.

***Penny Boston** is an astrobiologist and researcher at NASA's Ames Research Center*

Astronaut 'cavewalk' training for subterranean alien environments

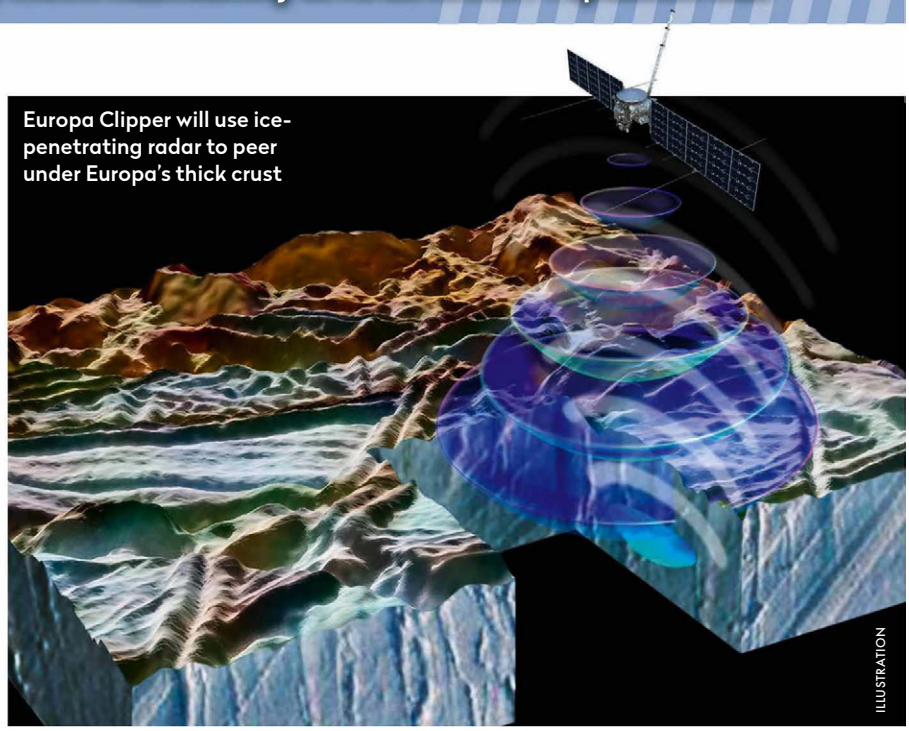
DENIS-ART/GETTY, NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/SOUTHWEST RESEARCH INSTITUTE, ESA–V. CROBU, NASA/JPL-CALTECH, NASA/JPL-CALTECH/SETI INSTITUTE

Bonnie Buratti

Explores icy moon habitability at NASA's Jet Propulsion Lab

How are you helping in the search for alien life?
I serve as the deputy project scientist of Europa Clipper, a NASA flagship mission to explore one of Jupiter's moons, Europa. We're almost certain it has a subsurface ocean and we're trying to determine whether life could be sustained in that ocean. We're not a life-detection mission; that's a little too sophisticated. We're just looking for a habitable environment.

What will you be looking for?
There are three necessities for life as we know it: liquid water, energy and food. The building blocks of life as we know it are carbon, hydrogen, oxygen and nitrogen. We're going to be looking for minerals that have those types of chemicals in them and mapping them on the surface.



ILLUSTRATION

Europa Clipper will use ice-penetrating radar to peer under Europa's thick crust

Why are you looking on Europa?
We're fairly certain that Europa has a subsurface ocean, and ground-based observations have also found evaporate deposits on its surface – things like magnesium salts and carbon dioxide. It's very complex chemically.

The current idea is that life developed on Earth in the deep oceans where thermal vents, so-called smokers or oceanic vents, seem to have developed primitive bacteria. We think there might be a similar environment on Europa.

Ocean worlds may be fairly common in our Solar System. This is the first one we're exploring in detail. Now that we've discovered so many planets around other stars, it opens up a whole new area to look for habitable environments.

What might a mission to search for life on Europa look like?
We know so little about this. We don't even really understand how life arose on Earth. On Europa, you have to get through a crust that's about 15 to 20 kilometres thick. We're not sure how deep it is; that's one of the things we have to find out. We have an ice-penetrating radar to see if there are any ponds under the surface.

To understand the problem, look at Antarctica where there are subglacial oceans like Lake Vostok. We barely have the technology to get down there here on Earth, when we don't have to deal with the strong magnetic field of Jupiter and trying to get miniature instruments on spacecraft. Right now, we really don't have the technology to look into subsurface oceans in the outer Solar System.

"Right now, we really don't have the technology to look into sub-surface oceans"

Europa's strange streaked surface could hide massive underground oceans

Do you think there is life out there in the Solar System?
You only have scientific opinions based on the evidence and right now, we don't have any evidence. We're just looking for an environment in which life could thrive or even exist.

***Bonnie Buratti** is a JPL fellow and a senior research scientist and deputy project scientist of Europa Clipper* ▶

Lisa Kaltenegger

Investigates exoplanet atmospheres at the Carl Sagan Institute

How are you helping in the search for alien life?
I'm trying to figure out, remotely through a telescope, how we can find life on planets orbiting other stars. I look at the starlight filtering through the air of planets to tell me what's in the atmosphere of these other worlds. Earth's life has significantly changed our atmosphere, so I'm looking for where life has altered either the atmosphere or the surface of the planet so much that I can tell the difference.

What is it that you're looking for in exoplanet atmospheres?
The combination of chemicals that we cannot explain without invoking life. The best combination that we have right now is oxygen with a gas like methane. Those two gases react with each other, so if they're in the air right now it tells you that both are being produced in huge amounts. For that combination, we have no other explanation than there being life. What that doesn't do is tell us what kind of life – it could mean slime mould or dinosaurs, or us.

Do we currently have the technology we need to find life?
What I find so fascinating is that we went from "it's impossible" to "it's possible". That's the James Webb Space Telescope. But we're not anywhere close to "it's easy"! The more light we can get, the more time we get to look at these planets and the more we can tell you. There is hope that we will get a space telescope just for the search for life.


We know one in five stars have planets about the size of Earth in their habitable zone

ILLUSTRATION

MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY, HONGLOUWAWA/GETTY, GETTY X 2

Do you think there is alien life out there waiting to be found?
What we know right now is that one out of five stars has a planet in the habitable zone that's small enough to be rocky. We have 200 billion stars in our Galaxy alone, and there are billions of galaxies. The biggest surprise would be if we find nothing. However, the key point is 'find', because it's so hard to actually find it.

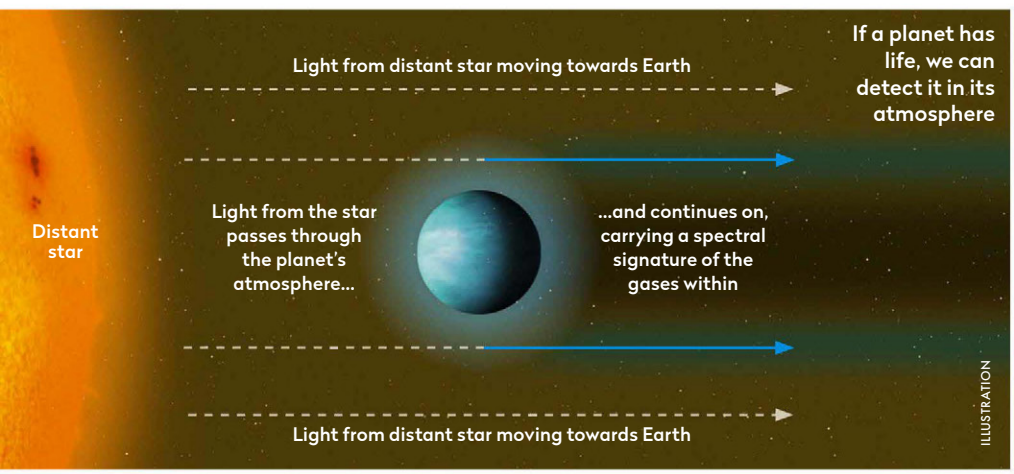
I think that's a numbers game. Right now, we know of 48 worlds that could be like ours. If we're really lucky and a planet close to us shows signs of life that we can spot, then we can do it with JWST.

"The biggest surprise would be if we find nothing. However, the key point is 'find'"

What impact would it have if we found alien life?
People of my generation think it will have this huge effect. But 1995 was when the announcement was made of the first planet around another star; my students have never lived in a world where they didn't know whether there were planets around other stars. It's not going to be shocking if we find something. For them the question is, when are you going to figure out if there's life out there?

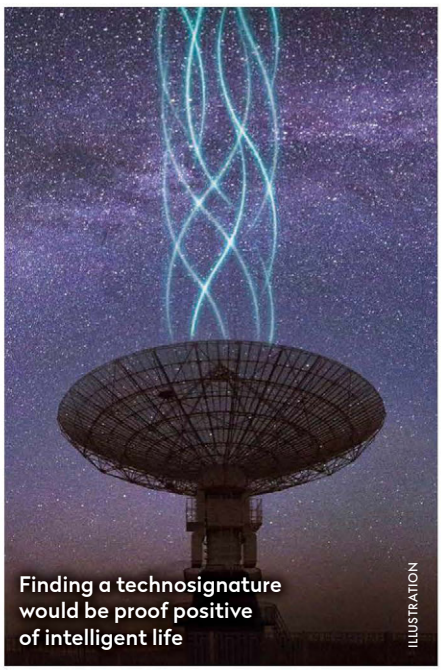
However, if there were a UFO landing on the White House lawn saying, "Take me to your leader", I don't know what effect that would have!

***Lisa Kaltenegger** is the director of the Carl Sagan Institute at Cornell University and a professor of astrophysics*



Frank Marchis

Hunts for signals from alien civilisations at the SETI Institute



Finding a technosignature would be proof positive of intelligent life

How are you helping in the search for alien life?
I work for the SETI Institute. SETI is the search for extraterrestrial intelligence. One thing we look for is technosignatures – signals that can't be explained by natural phenomena because they're too complex. They could be the light from cities on a planet, telecommunication signals or even the presence of artificial chlorofluorocarbon molecules (CFCs) in an exoplanet atmosphere.

What advantages does SETI have over other ways of searching for life?
A technological signature is an obvious signature. If one day we find the signature of life in the atmosphere of an exoplanet, there will be a huge debate about whether or not this is life. If we detect a radio signal which is not natural, we'll know something made it right away.

But SETI is a very binary thing. In other searches, there is an incremental discovery that happens. For the SETI researcher, it's yes or no. It's yes, you discovered something, or no, you did not. Agencies hate that; they want to see results being made steadily.

What is the public involvement with SETI?
One of my roles at the Institute is to develop citizen science for SETI. I am also the CSO of a telescope company called Unistellar which makes small telescopes, and I develop citizen science around those telescopes and their users. We have 3,000 registered users of these telescopes all around the world, so we can observe the sky all the time. We are training this team of people to learn how to do research using the telescopes, to study comet activity, asteroids that fly by Earth, satellites and other things. So if one day SETI detects a signal, we can ask this network to continuously monitor it.

Do we currently have the level of technology needed to detect these signals?
Frank Drake used to say SETI is a way to anticipate the future. For example, we expect advanced civilisations to have built gigantic 10-gigawatt lasers to communicate with other planets. We're building instruments to detect those, assuming one day – maybe 100 years from now – humans will build these powerful lasers to propagate through space. But those aliens, maybe they already did it. It's science fiction meets science; what is the next big step in humanity's evolution and technology?

> ***"Finding an alien will tell us 'You're not an anomaly'. We'll know we have a future"***

What would be the impact of finding life beyond Earth?
For me, it will have a huge impact because that's something I really want to witness in my life. Right now, we are the only biological, technological, intelligent civilisation. Is that something that evolution makes happen, or is that an anomaly? Maybe our civilisation is not something that can last for long. Finding an alien like us will tell us "You're not an anomaly". We will know we have a future as a civilisation.

***Franck Marchis** is director of citizen science at the SETI Institute and CSO of Unistellar*

Global networks of telescopes are on alert to detect laser signals from space