

# Science Focus

“So long, and thanks for all the fish”

What could  
**ALIEN LIFE LOOK LIKE?**

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# CAN WE STOP IT?

(AND WHAT CAN WE LEARN FROM THE DINOSAURS' DEMISE?)

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# What would alien life actually look like?

As we discover ever more planets orbiting other stars, and plan missions to potentially habitable moons of Saturn and Jupiter, will we find life – and if we do, will we even recognise it?

by MIĆO TATALOVIĆ

**O**ur Universe could turn out to be a pretty wild place. Recent astronomical discoveries suggest that billions of Earth-like planets are dotted throughout our Galaxy, which is just one of billions of galaxies in the Universe. “Our best estimates are that one in four stars have a planet that is the same size and the same temperature as the Earth. That’s very high,” says David Charbonneau, professor of astronomy at Harvard University, US.

And many scientists now think there is life on at least some – if not many – of those planets and their moons. One of them is Dr Chris McKay, a planetary scientist at NASA’s Ames Research Center, who says that we can assume that life is widespread based on “two simple facts”.

First, the chemical elements of life, such as nitrogen, hydrogen and oxygen, are widespread in the Universe, as are the two key compounds of life on Earth: liquid water and organic carbon. Second, we know that life was present

on Earth very early in its history – soon after the planet was formed – which suggests that once the conditions are right, life springs up easily and quickly.

“If the origin of life is widespread, then complex life will be widespread,” says McKay. That means we might expect to find more than just single-celled microbes out there. “The best way to find out is to go look.”

Some scientists and entrepreneurs are already thinking about how to get to distant stars quickly. Yuri Milner, a Russian tech entrepreneur, came up with

**“IF THE ORIGIN OF LIFE IS WIDESPREAD, THEN COMPLEX LIFE WILL BE WIDESPREAD”**

the Breakthrough Starshot project, which proposes that tiny chips could be attached to craft propelled through space by an intense Earth-

based laser. If it works, this would cut the travel time to the closest star system, Alpha Centauri, from 100,000 to just 20 years. The first tests of early designs took place this May.

In the meantime, two NASA missions are set to shine light on the atmospheres of planets that orbit other stars (exoplanets), pinpointing those that could harbour life. The TESS mission started collecting data this year, and the James Webb Space Telescope is expected to launch in 2021. “We know virtually nothing about the actual conditions on those planets,” says Charbonneau. These two missions will change that.

#### VISIONS OF OTHER WORLDS

Some of science’s brightest minds have already brainstormed what we might expect to find, and their conclusions formed the basis of two cult documentaries, *Natural History Of An Alien* and *Alien Planet*, which first aired in 1998 and 2005 respectively. The two films inspired many people ●



to think about how other life may be similar and different on other planets. Indeed, some scientists are now trying to lay down the science of not only how life-as-we-know-it would be different in space, but also of what exotic life that was made of other chemicals might be like.

These shows parted with the common fictional view of sentient green aliens, and they applied rigorous thinking by evolutionary biologists, biomechanics experts and astrobiologists to design plausible living worlds within the restrictions of alien geology and planetary science. Many scientists think the unlikely-sounding creatures dreamed up for these shows two decades ago are still as good a guess as we have for what alien life will look and behave like. Though, with myriad of discoveries since, we also now have new insights that paint an even wilder picture.

“On any planet in the Universe the laws of physics and chemistry will still be the same as here,” says Prof Peter Ward, a palaeontologist at the University of Washington, Seattle. “There’s only a limited number of ways to beat physics.”

Even in outer space, he argues, on an Earth-like planet there would be similar physical constraints leading to the evolution of similar life to what we have on Earth. The premise is that there are only so many ways one can efficiently see, hear,

walk, swim or fly – and that natural selection will largely weed out inefficient body plans, as it has on this planet.

This means we can make educated guesses about what such life would look like, based on our biological understanding of evolution, and our geological and climatic understanding of conditions on other planets. Most of the scientists interviewed for this feature said the educated

**“EVEN ON EARTH, LIFE GIVES  
RISE TO RADICALLY DIFFERENT,  
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AT DIFFERENT TIMES AND IN  
DIFFERENT PLACES”**



**ABOVE** NASA's Transiting Exoplanet Survey Satellite (TESS) launches onboard a Falcon 9 rocket at Cape Canaveral, April 2018

guesswork in the TV programmes mentioned previously might not be too wide of the mark – if anything, those visions might be too tame, given the potential for the vast amount of life that might have evolved on very different planets.

“The Universe has a way of surprising us,” says Theresa Fisher, an astrobiologist at Arizona State University, US. “My suspicion is that, with a range of environments that we could be looking at, it could feel very alien.”

She says that any life would be expected to follow the broad principles of ecology: it would need to have a way of getting energy, and there would be competition leading to the emergence of predators and prey, for example. But beyond that, it's anyone's guess what life might look like. “There's no reason that it would have to be particularly similar to what we see on Earth.”

### **STRANGER THINGS**

So we can't really say that alien life would look like Earth life. Even on Earth, life gives rise to radically different, sometimes unique life forms at different times and in different places.

When dinosaurs went extinct, what came after them wasn't more of the same. And the flora and fauna of New Zealand, with kiwi birds and practically no land mammals, are very different

from those of the Serengeti, with its elephants and giraffes, or Madagascar with its lemurs.

For unique life forms on Earth, look no further than seahorses, says Dr Lauren Sallan, a palaeontologist at the University of Pennsylvania. The animal shares basic components of other fish but has a unique shape, and reaching that form required a very unlikely evolutionary pathway. “You do get weird things that happen once – both now and in the distant past,” says Sallan.

On an Earth-like alien planet, things could get even weirder. It's possible that we wouldn't even recognise them as life, given that our current efforts focus on finding “life as we know it”, says Casey Brinkman, an astronomer at the University of Hawaii: “There's all sort of possibilities out there for weird stuff.”

Sallan agrees. Any life forms will have to get energy, but the way they would go about it is hard to predict, she says. “They would be filling similar ecological roles, but whether we would recognise them without a lot of study – I doubt it.”

So to start with, astronomers are focusing their search on signatures of life that we know from Earth, such as oxygen. They're also focused on finding Earth-like rocky planets where liquid water could exist. “We have to begin with a search for life as we know it,” says Charbonneau. ▶

“There could be life that’s very different than life on the Earth, but we wouldn’t recognise that in our data, because we don’t know and understand that chemistry very well,” he adds.

#### WHEN GRAVITY MEETS BIOLOGY

There are many different conditions on other planets and moons, beyond chemistry, that could affect how life would evolve there. Take gravity, for example. On a bigger or denser planet, the gravity would be higher, meaning that life would evolve to be shorter, sturdier and perhaps with multiple limbs for structural support. Conversely, on a lighter planet with weaker gravity, life could hop, soar and glide more easily, and would be more likely to evolve a lighter, taller build.

The density and chemical makeup of the atmosphere would affect how easy it is for life to take to the skies: denser air would allow for more life forms treating the sky like an ocean they can ‘swim’ in, while oxygen-rich air would fuel more energetic creatures.

The seasons could be vastly different, too. Many planets have much shorter orbital periods than the Earth’s 365.25 days, speeding up seasonal changes to weeks or days rather than months. Some planets have more elliptical orbits that would make seasons much more



**ABOVE** Launching in 2021, the James Webb Space Telescope will tell us more about exoplanets, their atmospheres and their potential for hosting life

extreme, with scorching, short summers followed by long, deep-freeze winters.

The type and number of stars a planet orbits, as well as how closely it orbits them, would also affect how much solar energy and radiation it receives, and whether photosynthesis is possible or whether life would have to instead rely on chemosynthesis – using energy derived from reactions involving inorganic chemicals rather than sunlight.

The majority of stars are red dwarfs, says Charbonneau, which are less energetic and more durable than our Sun, so could offer longer time periods for life to evolve. But, early on in their evolution, such stars emit a lot of radiation that could be harmful to life and planets’ atmospheres, or even eliminate them. *Alien Planet* envisaged life around such a star as plant-like creatures that could fold up to protect themselves when there are solar flares, and dinosaur-like animals with a third eye on top of their heads to give them early warning that a burst of radiation is on its way.

Closer to Earth, many scientists hope we’ll find life in space within our lifetime, possibly on the icy moons of Saturn and Jupiter, such as Enceladus and Europa. “I’m willing to bet you a flat white that in the next 20 years we’ll find some life,” says Dr Seth Shostak, senior astronomer at the SETI Institute, US. “It will probably be microbial life squirting out of Enceladus or maybe Europa, or maybe under the sands of Mars: there are all these places in our own Solar System where we could find this stuff.”

**“MANY SCIENTISTS HOPE  
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OF SATURN AND JUPITER”**

# WEIRD WORLDS

Life could possibly exist on any number of different types of planets and moons that have very different properties, which would shape the evolution of life there. Here are just a few of them, together with the challenges and opportunities they would pose for life

## YO-YO PLANETS

Unlike Earth's circular orbit, these planets have elongated, elliptic orbits that bring them very close to their sun for brief periods of scorching hot summers, and then take them far away from it for long, freezing winters. There would be two brief growing periods when the planet is approaching and departing the sun, when Earth-like life could blossom, but it would have to be adapted to endure the evaporation of its oceans in the summer and snowball planet periods in wintertime.

## TIDALLY-LOCKED PLANETS

Many planets orbiting close to their star get locked by their sun's gravity so they always face the sun with the same side. This means one side of the planet is plunged in constant darkness, while the other always basks in sunshine. This could create a massive, ongoing storm in the centre of the Sun-facing side and freeze over the other side of the planet, leaving a strip in-between with possibly Earth-like conditions. Air and ocean circulation could allow the exchange of heat between the two sides, perhaps fuelling some life on the dark side.

## LAYERED OCEANS OF GANYMEDE

Some scientists think Jupiter's moon, Ganymede, has several layers of oceans underneath its frozen surface, each separated by a different type of ice that forms at certain pressures and temperatures. If there is life there, it would most likely have originated in the bottom ocean layer where it meets a rocky base. Eventually, some life might have made its way into the next layer, finding an unexploited new habitat and possibly adapting to different conditions there, and later moving on again to yet another layer. This would essentially create vertical continents, each with its own life forms and ecosystems – but all with a common origin.

## ROGUE PLANETS

Some planets get ejected from their orbit around their host stars and become lonely wanderers through the Universe. Cloaked in cold and darkness, they could remain habitable for any life, fuelled by the internal engine of their hot cores, for billions of years – but that life would have to adapt to no sunlight and rely on chemosynthesis, like life deep inside Earth's rocks and oceans. "There is plenty of heat in the

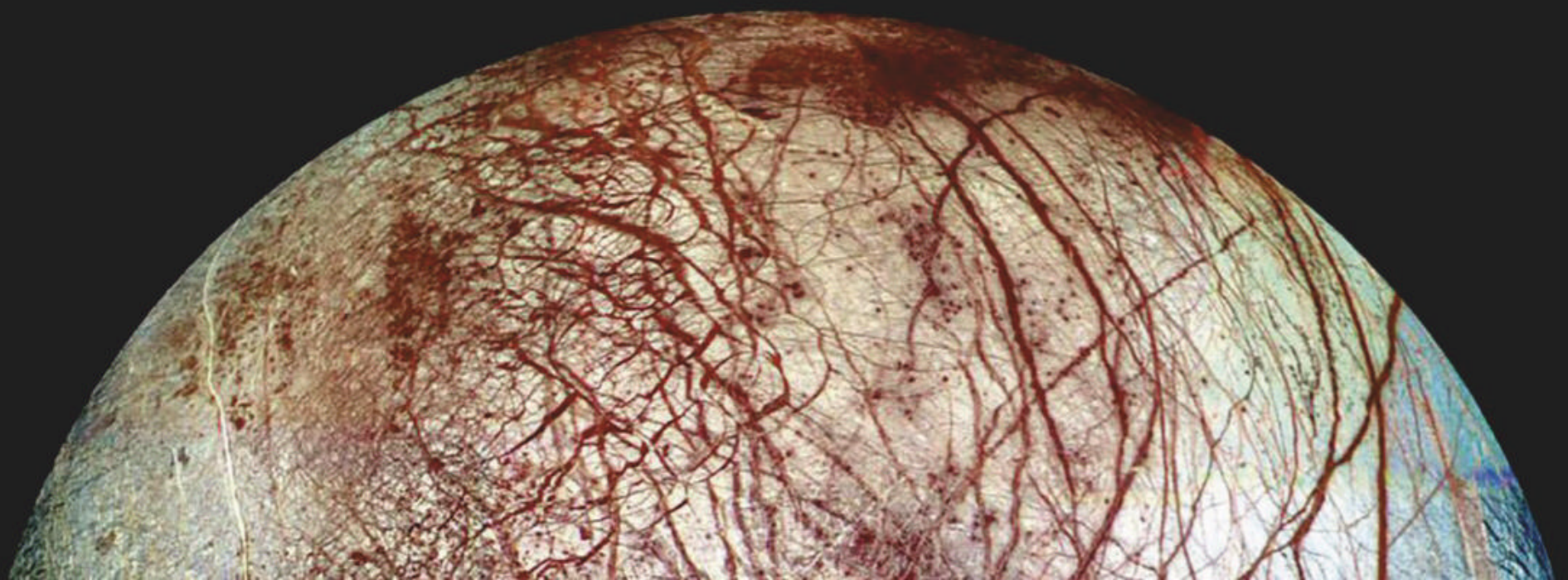
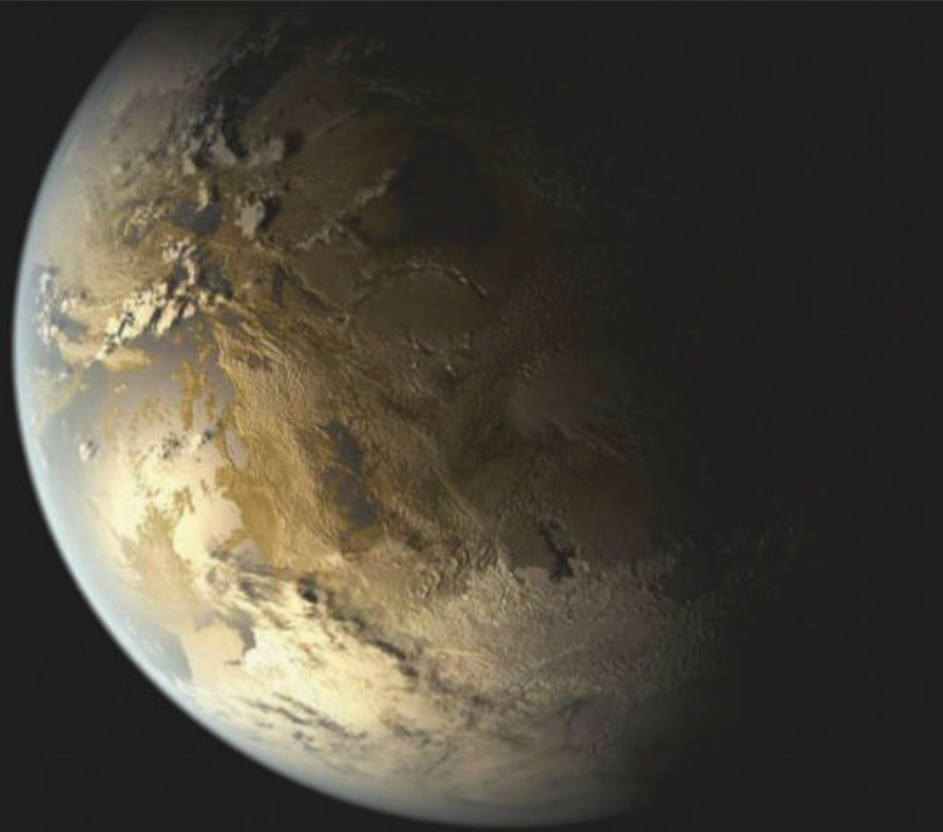
interior of a planet for billions of years; it is longer than the lifetime of host stars," says Dimitar Sasselov, astronomy professor and director of the Harvard Origins of Life Initiative.

## DISCO-BAR PLANETS

Around pulsar stars created after the explosion of a star, planets would be devoid of much sunlight and any life would have to rely on chemosynthesis, though its chemistry may be very different as such planets are unlikely to have many organic molecules common on Earth. Such planets would be dry, metallic and bathed in the pulsating light of their star.

## LIQUID METHANE WORLDS

Titan, the moon of Saturn, appears very Earth-like with its hills, rivers and lakes filled by rains from its clouds. But it couldn't be more different: temperatures are freezing, turning water rock-hard, and the only liquid present is in fact methane, the major component of natural gas here on Earth. If life exists there, it will most likely be based on different chemistry to Earth life, and probably evolve very slowly because colder temperatures slow down chemical reactions.



## WHAT ALIENS MIGHT LOOK LIKE

Scientists have long speculated about what living creatures on other planets and moons might look like, based on what we know about those planets and the principles of evolution and biomechanics. Here are some of the strange organisms they have imagined...

### WALKING PLANTS

On other planets the boundaries between plants and animals could be blurred, and you might have trees with beating hearts, or with feet to move to better positions as they compete for light and water. You could also have an animal that spends most of its time staying still, photosynthesising, only running away if threatened. Or a massive dinosaur-like creature that splays itself out on the ground to get nutrients directly from the soil, and obtains extra energy with the help of photosynthesising plants on its back.

### MEGA CREATURES

Cooperation could lead to some fascinating creatures, such as a sea of amoebae acting as single jelly-like mega-creature, thousands of voracious shrimp-like carnivores forming a single organism that devours anything in its way, or a web of intertwined trees that collect water in wide pitchers at the top of their canopies. Similar entities do exist on Earth: for example, the world's largest organism is a 43-hectare forest of aspen trees in Utah, comprised of about 47,000 genetically identical stems, and one massive root system.



▶ NASA is preparing a mission to Europa for a 2023-24 launch, and is backing a private endeavour to reach Enceladus and study signs of life there. Meanwhile, the European Space Agency is hoping to launch a mission to Jupiter and its moons Ganymede, Callisto and Europa in 2022.

There is early evidence that those moons have oceans of liquid water deep under their icy crusts. This has raised hopes that there might be life there, especially given that we see oases of unusual life in the extreme environments around hydrothermal vents at the bottom of our own oceans.

Indeed, *Natural History Of An Alien* suggested that entire ecosystems may be based around deep-sea thermal vents on Europa, with tall towers of bacteria powered by the warmth and nutrients from the vents rising high above the sea bed, and territorial fish-like grazers sucking the nutrients from those towers, and in turn being preyed upon by streamlined shark-like animals.

In principle, this vision might be possible, says Dimitar Sasselov, astronomy professor and director of the Harvard Origins of Life Initiative, US, a centre that supports multi-disciplinary research aimed at revealing if life is abundant in the Universe. But he adds that because there is less energy available in the dark ocean, so any complex life there would be expected to be



## EXTREME ENDURANCE

Getting oxygen to muscles is a key determinant of an animal's endurance. Here on Earth, cephalopods like octopus use a copper-based molecule in their blood to shuttle oxygen, making them more sluggish than mammals and birds that use iron-based hemoglobin. Scientists have speculated about other types of oxygen transport that could make animals fitter: in atmospheres with more oxygen, we might see creatures that can fly without ever having to stop for a rest.



## TINY, BLIND WORLDS

On cold planets and moons without much sunlight, such as the moons of Saturn and Jupiter, life might have to get by with chemosynthesis, giving them a more limited energy supply. This could still lead to similarly complex life, but on a much smaller scale: a miniature version of Earth's life. Also, in worlds without light, such as the depths of Enceladus's oceans, there might be little need to evolve eyes: whole worlds of creatures may exist that sense their environments using other means.



## FLOATING WORLDS

On planets with denser atmospheres, animals and plants could reach dizzying heights more easily and essentially 'swim' in the air as a result of their higher buoyancy. Scientists have envisioned flying whales feasting on green clouds of algae, octopus-like creatures and balloon-like plants floating high, using sacs filled with hydrogen or methane, and trees and forests reaching 10 times the height of those on our planet.



much smaller. "You have to take anything from today's Earth and recent Earth history of complex life and just shrink it," he says. "Can you have exactly the same behaviour and the same level of complexity but 100 times smaller? Absolutely. What's wrong with a shark that's just 5cm long? Nothing."

Not everyone thinks life on those moons will be complex, though. "If there is life in the Solar System, it's probably microbial," says Dr Yael Kisel, support scientist at NASA's Ames Research Center. And scientists agree that most life in the Universe as a whole is likely to be microbial, especially given that for the majority of the history of life on Earth it has been microbial. "What does a typical alien look like? It's going to be a little blobby thing under a microscope," says Shostak.

That's not to say there won't also be complex, perhaps even sentient life. Any intelligent life might not look like us, though: even here on Earth, if you take a trip to the zoo, most animals there are highly related to you but don't look much like you. But as Shostak jokes, "If you ask trilobites: 'Hey, what do you think the aliens will look like?', they would probably figure they're going to look like trilobites."

In fact, highly advanced and intelligent life, if it exists, might be machine-based. "The majority of the intelligence in the Universe is probably

## "HIGHLY ADVANCED AND INTELLIGENT LIFE, IF IT EXISTS, MIGHT BE MACHINE-BASED"

not soft and squishy biology," Shostak says. "The majority of the really smart staff in the Universe is going to be machinery." This vision of artificially intelligent, highly autonomous machine life featured in *Natural History Of An Alien*, imagining it travelling the Universe, analysing planets, and adapting to local conditions much quicker than any biological life ever could.

Whatever the case, life is most probably out there, many scientists believe. "Statistically, it's almost a certainty," says Fisher. And this means the search must go on, says Brinkman.

"We should continue to try – because if it were to get discovered, it would be the most important

by **MİĆO TATALOVIĆ**  
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