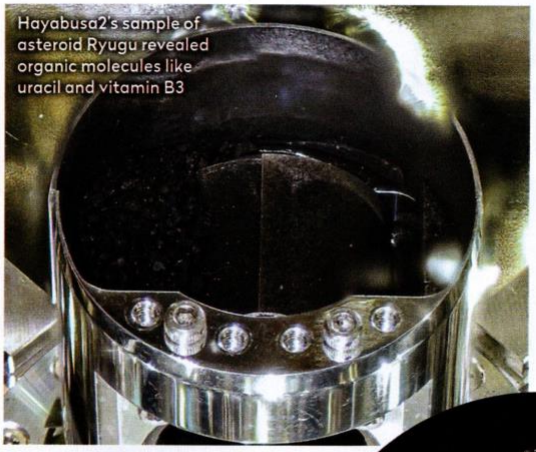
# Did asteroids bring life to Earth?

**Nick Spall** examines the evidence that life on Earth came from outer space – and how close science is to proving it

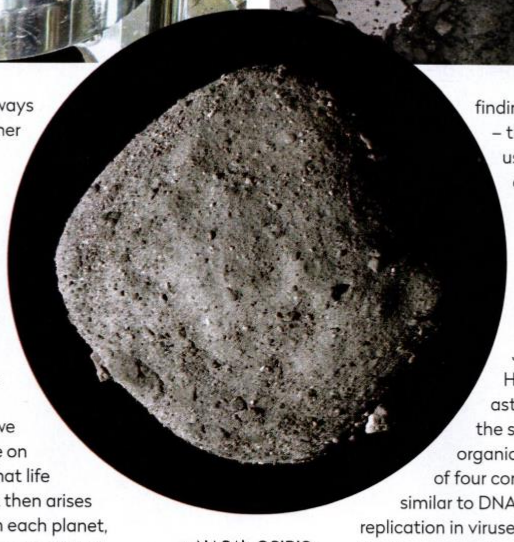
Did asteroid strikes sow the first sparks of life on a world still taking shape? We explore the panspermia hypothesis

PLANET: MARK GARLICK, SCIENCE PHOTO LIBRARY; ALAMY; ASTEROID: ROMOLO TAVANI, GETTY



Hayabusa2's sample of asteroid Ryugu revealed organic molecules like uracil and vitamin B3

Bennu samples contain key ingredients for life, strengthening the case for panspermia



▲ NASA's OSIRIS-REx mission used a Touch-and-Go (TAG) manoeuvre to collect a sample from near-Earth asteroid Bennu

We humans are always wondering whether we're alone in the Universe. But what if we are one of a long line of species that were around long before our planet even existed? This intriguing idea, that life didn't originate on Earth but arrived from elsewhere in the Galaxy, has always been controversial, but it's one that keeps resurfacing. In fact, it's only gaining credence as we uncover more potential signs of life on other planets. If we do find proof that life exists elsewhere, the question that then arises is: did that life evolve separately on each planet, or did it travel there from an earlier source? And if we can entertain the idea that that could have happened elsewhere, why not on Earth?

The 'panspermia' theory asserts that the building blocks of life, or even life itself, were delivered to Earth by piggybacking on a comet or asteroid, kickstarting the evolutionary process that culminates in life existing and, ultimately, you reading this article. It's an idea that's had much derision in the past, so why do so many serious scientists still entertain it as possible fact? What makes it so attractive? Let's have a look at the evidence that supports it...

## Organics everywhere

The panspermia theory isn't new. Over 50 years ago, the work of the late Sir Fred Hoyle and Chandra Wickramasinghe argued that microbial life permeates the Galaxy on a vast cosmic scale. Their hypothesis, extending the thinking of 19th-century scientists, including Lord Kelvin and Svante Arrhenius, was that life may be distributed from world to world by meteors, asteroids, dust and comets.

One of the main reasons that the theory has been gaining traction recently is that we are now finding the building blocks of life – the organic molecules that are used to create living creatures – in all kinds of places: on asteroids, on comets, on Mars, on Saturn's moons and in Earth's upper atmosphere. And these aren't rare findings – in fact, they're increasingly common.

In November 2019, the Japanese robotic spacecraft Hayabusa2 took samples from asteroid 162173 Ryugu. Analysis of the samples revealed the presence of organic compounds such as uracil – one of four components in RNA (a molecule similar to DNA that plays a similar role in replication in viruses and animal cells) – and vitamin B3. These samples were carefully protected in sealed capsules, so there was little chance of contamination from Earth.

Similarly, in October 2020, NASA's OSIRIS-REx probe took samples from asteroid 101955 Bennu. Analysis revealed the presence of carbon- and nitrogen-rich compounds, including 14 of the 20 amino acids that make up proteins found in Earth organisms, together with all five of the building blocks that make up DNA and RNA – that's pretty much everything needed for life to reproduce.

Of course, simply detecting such molecules on asteroids isn't enough. They must be organised in a way that they can interact with each other. And we need to be able to rule out the possibility that they formed through purely chemical, non-biological processes (a concept known as abiogenesis).

Whether from a life source or not, these molecules could still have kickstarted life on our planet. But for that to be possible, we'd need to show they could remain viable after their journey through the harsh conditions of space, with its high ultraviolet radiation, vacuum and hostile temperatures – not to mention being smashed into Earth at immense speeds.

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# Scooping up spacedust for clues of life

## Could a robotic mission capture biological 'seeds' arriving from space?

Convincing tests of the panspermia theory face the need for hard evidence – actual incoming material, perhaps in the form of dormant spores, bacteria or viruses. One way to investigate this would be a dedicated exobiology spacecraft equipped with a collector system.

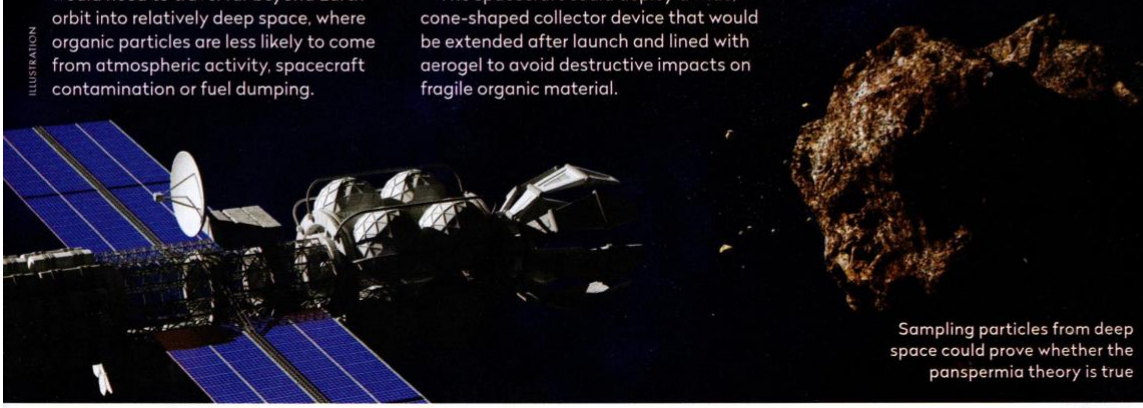
These organics-seeking missions would need to travel far beyond Earth orbit into relatively deep space, where organic particles are less likely to come from atmospheric activity, spacecraft contamination or fuel dumping.

To avoid the same criticisms that the Indian Space Research Organisation's (ISRO) 2001 balloon experiment faced – when some claimed that the high-altitude particles collected were merely molecules that originated on Earth – a long-distance orbit might extend out to 1.6 million km (1 million miles) from Earth.

The spacecraft could deploy a wide, cone-shaped collector device that would be extended after launch and lined with aerogel to avoid destructive impacts on fragile organic material.

The samples could then be sealed in tubes of a similar design to those used in ISRO's balloon sampler mission and returned to Earth using OSIRIS-REx-type re-entry capsules. And perfect sterilisation of the spacecraft would, of course, be vital to ensure results remained uncontaminated.

ILLUSTRATION





Sampling particles from deep space could prove whether the panspermia theory is true

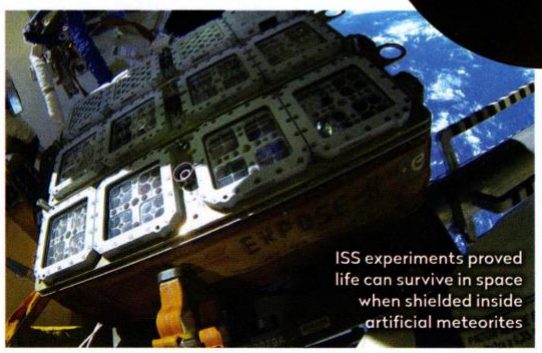
However, experiments on the International Space Station (ISS) as part of the EXPOSE project have now shown that, if protected with suitable meteorite-like material, biological samples could withstand and survive the rigours of entry into Earth's atmosphere. It also found that bacterial spores and even seeds could survive in the harsh vacuum of space.

## Did life come from Mars?

Some scientists have suggested that life on our planet might have been seeded from our nearby neighbour, Mars. In the BBC TV series *Seven Days on Mars*, Professor Brian Cox noted: "We know that material moves from Mars to Earth and from Earth to Mars. It is entirely possible that life began on Mars and was transferred to Earth." This idea is known as lithopanspermia, the hypothesis that extremophile-type microscopic life could survive in debris blasted into space from planetary collisions with asteroids and comets.

In 2024, NASA's Perseverance rover discovered 'leopard spots' on a reddish rock in Jezero Crater, hinting at possible microbial life from Mars's wetter, warmer past. These sediments date to about 4 billion years ago – around the same time that life is thought to have begun on Earth. Rock core samples are waiting in tubes for a sample-return mission to bring them back to Earth for analysis. Only then will we know whether these molecules formed biologically or through inorganic processes alone – and perhaps whether Earth's life story began on Mars.

There's been speculation about other locations in our Solar System that could be our source of life, including Saturn's moons. ▶



ISS experiments proved life can survive in space when shielded inside artificial meteorites

Samples taken near 'leopard spot' rocks on Mars recently revealed signs of past microbial life

Phosphine gas in Venus's toxic clouds remains a mystery – is it chemistry or a sign of life?

ILLUSTRATION

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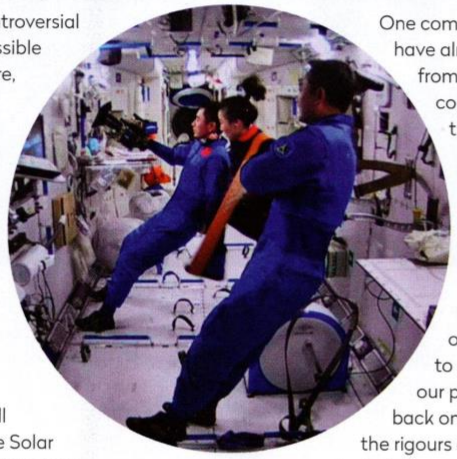
▶ In the high atmosphere of Venus, controversial studies have questioned if there is a possible organic origin to the phosphine gas there, which on Earth has a biological source.

## Is all life the same?

If evidence of past or present life is ever found anywhere else in the Universe, whether through exploratory sampling missions or remote spectral analysis, the key test will be whether it has the same constituents as Earth's biochemistry.

As Professor Ian Crawford of Birkbeck University of London explains: "If panspermia has been operating, it will predict that all life found throughout the Solar System will have a common origin and thus share key biochemical characteristics – such as the same genetic code. On the other hand, if life did not travel between planets, we would expect that any life we find would be quite different from our own."



▲ Chinese astronauts found a new bacterial strain aboard the Tiangong Station

One complication is the possibility that we have already contaminated space with life from Earth. In 2017, Russian cosmonauts collected samples from the exterior of the ISS – 400km (250 miles) above the planet – that were claimed to contain 'space bacteria'. These findings are still being debated, but it seems likely they originated on Earth.

Then, in 2023, Chinese astronauts aboard the Tiangong Space Station discovered a previously unknown strain of bacteria living on its hardware. Similar to a bacterium found in soil and food on our planet, it was likely to have originated back on Earth but had adapted to deal with the rigours of living in space. These adaptations included genes for oxidative stress response and radiation damage repair, as well as the ability to form biofilms by breaking down gelatine to extract carbon and nitrogen – strategies that help it survive in a resource-limited environment.

# "The case for panspermia is building"

Professor Chandra Wickramasinghe on the latest evidence that life originated in space

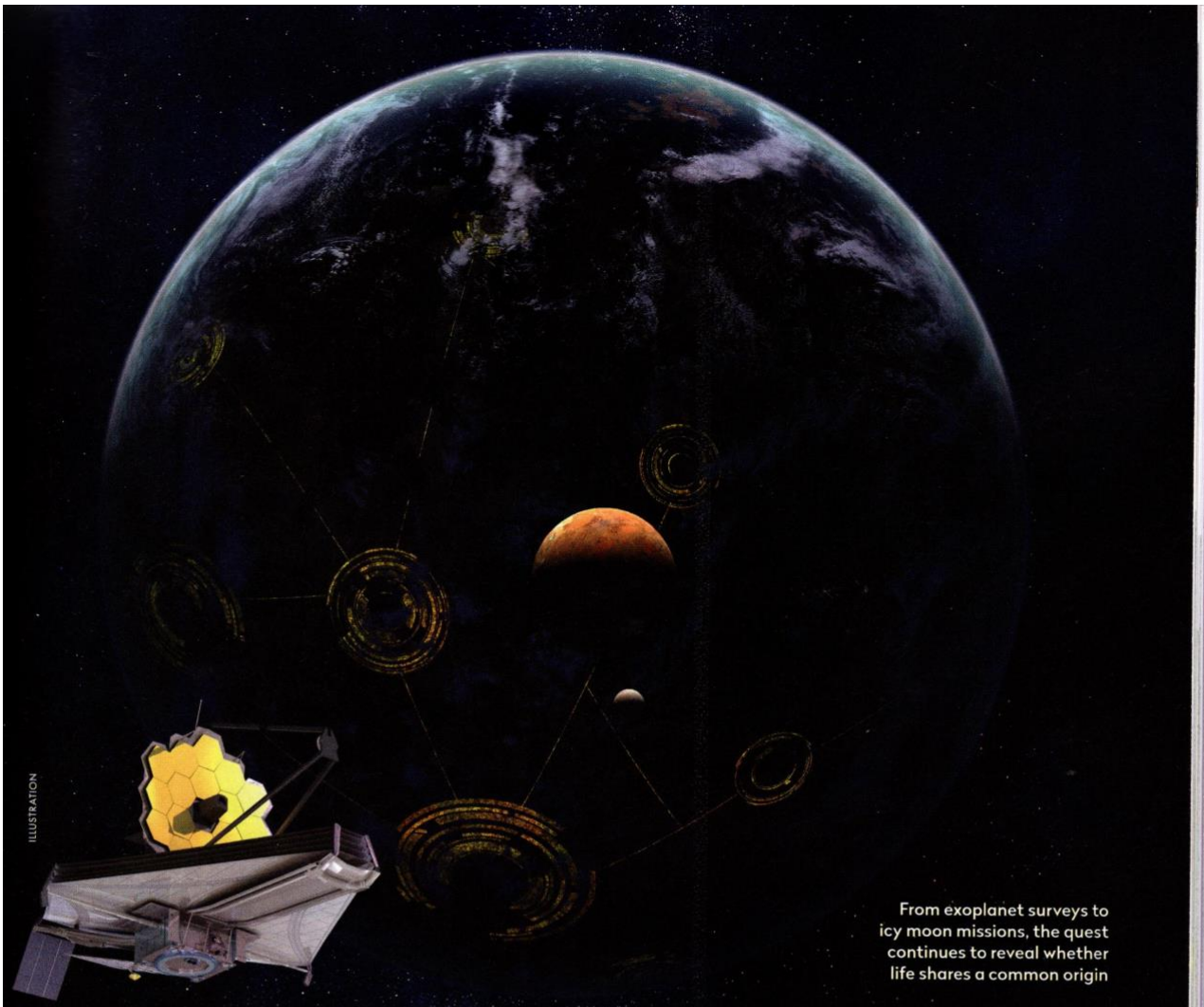
"In my view, and those of researchers like Fred Hoyle, life permeates the Universe and had its origins early on at the centre of the Galaxy. Fred and I made the case for the existence of complex organic building blocks in comets and interstellar clouds back in the 1970s and '80s. We were proved correct.

The case for panspermia is building. The ISRO's 2001 balloon experiments collected samples 30–41km (19–25 miles) above the Earth. These showed new strains of bacteria never seen before.

The survivability of bacteria and viruses in space, as well as plant seeds and even complex life like tardigrades, has been proven via the recent EXPOSE tests on the ISS. Viruses such as the worldwide 1918–19 flu pandemic may have arrived from space – illnesses from that outbreak occurred across the world on virtually the same day, well before intercontinental jet travel.

Current scientific views on the abiogenesis origin of life on Earth is strongly influenced by Western-based cultural and theological views. Eastern-based cultures have less of a problem in this regard. Despite over 50 years of experiments to prove spontaneous generation, using the best-equipped biochemical laboratories in the world, no evidence for such a process has been discovered.

As for proof of panspermia, whilst Carl Sagan said 'Extraordinary claims require extraordinary evidence', I would ask: where is the evidence that extraterrestrial life and panspermia do not occur?"

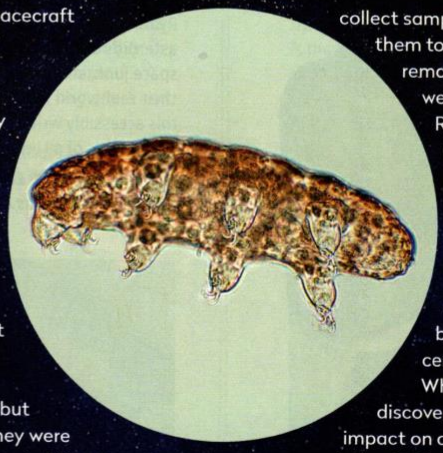


ILLUSTRATION

From exoplanet surveys to icy moon missions, the quest continues to reveal whether life shares a common origin

Despite our best efforts to sterilise spacecraft by ending their missions in a fiery and destructive plunge into a planet's atmosphere, it's possible that some life has slipped through the net accidentally – even complex life forms. Take tardigrades, otherwise known as water bears. These are some of the most resilient creatures on planet Earth. They can survive high levels of radiation, extreme cold, complete vacuum and even a complete lack of water. And thousands of them were part of the cargo on an Israeli space mission that crash-landed on the Moon.

It's likely they were killed in the crash, but some argue that should the container they were stored in have survived the descent, they could be waiting in their dormant state for their chance to colonise the Moon.



▲ Tiny but tough tardigrades survive conditions that mimic deep space

## What if we found proof?

New findings about possible alien life regularly make the headlines, thanks to data from missions currently exploring our Solar System and the research on distant exoplanets by space telescopes such as the JWST. However, until we can physically collect samples of active or historic life and return them to Earth, solid proof of its existence remains elusive. And if life were to be found, we would then have to test its DNA or RNA composition to see if it arose independently or shares a common panspermia origin with Earth life.

Even if active microscopic life of a different nature to Earth's is ever discovered, panspermia exponents would inevitably argue that other life elsewhere in the Galaxy could well be the same as Earth's. It may take centuries to reach any real conclusion.

Whatever the outcome of the debate, the discovery of life elsewhere will have a profound impact on our science, culture and philosophy. As Arthur C Clarke famously said: "Two possibilities exist: either we are alone in the Universe, or we are not. Both are equally terrifying."

**Nick Spall** is a science writer who specialises in aviation, spaceflight and astronomy