Viruses, ET and the octopus from space: the return of panspermia

A major paper revives the oft-mocked theory that life on Earth began in a rain of cosmic microbes. Stephen Fleischfresser reports.

The search for ET, say researchers, could start and end with the octopus.
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The peer-reviewed journal *Progress in Biophysics and Molecular Biology* recently published **a most remarkable scientific paper** **[1]**. With 33 authors from a wide range of reputable universities and research institutes, the paper makes a seemingly incredible claim.

A claim that if true, would have the most profound consequences for our understanding of the universe. Life, the paper argues, did not originate on the planet Earth.

The response?

Near silence.

The reasons for this are as fascinating as the evidence and claims advanced by the paper itself. Entitled *Cause of the Cambrian Explosion – Terrestrial or Cosmic?*, the publication revives a controversial idea concerning the origin of life, an idea stretching back to Ancient Greece, known as panspermia.

The scientific orthodoxy concerning the origin of life is called **abiogenesis [2]**. This suggests that at some point in the earth's early history, conditions were favourable for the creation of complex organic chemistry that, in turn, led to the self-organisation of the first primitive life forms.

Much is understood about the process, but exactly how information came to be coded in nucleic acids (DNA and RNA) to form the system of genetic inheritance and expression, and how this transformed into life itself, remains unknown. The other slightly uncomfortable aspect of the abiogenic account is that it seems to take place in a surprisingly short amount of time. The theory requires that the "primordial soup" from which self-replicating RNA emerged formed within an 800 million year period following the stabilisation of the Earth's crust, a timeframe **some researchers think is too narrow [3]**.

Despite its drawbacks and lack of detail, abiogenesis is the consensus, the only plausible hypothesis for the origin of life.

The panspermia hypothesis, however, disputes nearly every aspect of this story.

Of the 33 authors, Edward Steele and Chandra Wickramasinghe are the most well-known.

Steele, an Australian immunologist, has a history as **something of a maverick** [4]. He has long championed the idea of inheritance of acquired characteristics, a theory first aired by Jean-Baptiste Lamarck, the French evolutionist prior to Darwin.

Although the latter much admired Lamarck's work, most scientists have since discarded it. In 1979, Steele took a contrary position, advocating a neo-Lamarckian idea known as **"somatic selection hypothesis"** [5], published in 1979. The later advent of epigenetics, and the discovery of horizontal gene transfer (HGT) in numerous microbial organisms have somewhat restored Lamarck's tarnished reputation, with some biologists suggesting HGT represents **"a form of (quasi)Lamarkian inheritance"** [6].

Wickramasinghe is a famed astronomer and astrobiologist with an illustrious career. He has held a string of professorships at Universities in both England and Sri Lanka, and has more than 70 publications in *Nature*.

One of his more notable contributions, along with his long-time collaborator, the late Sir Fred Hoyle, was the hypothesis that interstellar dust was partly made up of organic molecules, which Wickramasinghe went on to confirm experimentally. This finding prompted him to become a lifelong advocate of the panspermia hypothesis, publishing numerous papers on the topic.

Hoyle thus exerts a posthumous influence over the new paper. Originally Wickramasinghe's PhD supervisor, he was an odd mix of genius and far-out ideas: he formulated the notion of *stellar nucleosynthesis*, the now well-established theory that says all elements heavier than helium are created through fusion in the hearts of stars. He also thought that the famous ***Archaeopteryx*** *[7]* **fossil** [8], transitional between dinosaurs and birds, was a manufactured fake.

Astronauts working on the exterior of the International Space Station, which research has found to be covered in bacteria.
CREDIT: NASA/SCIENCE SOURCE

Hoyle and Wickramasinghe developed the model of panspermia at the centre of the recent study. The new paper is a review of "the key experimental and observational data gathered over the past 60 years", write the authors, "consistent with or predicted by the Hoyle-Wickramasinghe (H-W) thesis of Cometary (Cosmic) Biology".

The H-W model holds, the authors state, "that life was seeded here on Earth by life-bearing comets as soon as conditions on Earth allowed it to flourish (at or just before 4.1 billion years ago); and living organisms such as space-resistant and space-hardy bacteria, viruses, more complex eukaryotic cells and organisms, ... perhaps even fertilised ova and plant seeds, may have been continuously delivered ever since to Earth helping to drive further the progress of terrestrial biological evolution."

In other words, the researchers suggest that abiogenesis did not happen on Earth and the main source of genetic novelty is not caused by the selection of naturally occurring advantageous mutations, but rather comes from a rain of extra-terrestrial living matter that integrates itself, via neo-Lamarckian mechanisms such as horizontal gene transfer, into the genomes of terrestrial life.

Beyond this, the model also postulates that various epidemics are caused by the arrival of viruses from space and that extra-terrestrial retroviruses drove the Cambrian explosion.

Not to mention that the octopus might well be an alien.

One might be tempted to laugh, if it weren't for the volume of titillating evidence they present, and the nagging worry that the naysayers have been wrong before. For decades everyone knew, for example, that continents didn't just go drifting about the place. Until they did. But just because theories seen as crackpot by the scientific establishment have later been vindicated does not necessarily mean that is the case here.

The proof advanced "*would* support an extra-terrestrial origin of life," writes commentator and evolutionary scientist Keith Baverstock from the University of Eastern Finland, **puts it in the same issue of the journal [9]**, but is "not evidence that could not be explained in any other terms." In other words, the argument advanced by Steel and colleagues in plausible, but not not convincing.

Nonetheless, the paper has withstood a year of intense peer review. As Steele points out to *Cosmos*, "It has thus passed some severe and tortuous tests already." The tension between the evidence and the claims based on it make for uneasy reading.

Just as the field of Alzheimer's research **ponders [10]** if its main theory of many decades is wrong, perhaps it is worth entertaining a quaint notion: what if panspermia is right?

The paper is remarkable in tone. Far from the cautious claims of normal scientific literature, it is almost triumphant. "The consistency with panspermia of a vast swathe of new data," Wickramasinghe tells *Cosmos*, "often entailing new and unexpected developments of technology, over the past four decades have given us the confidence to adopt this tone."

The evidence is enough to back their confidence, fascinating and detailed. Central to their paper, and indeed their model of panspermia, is the action of viruses, retroviruses, in particular, and much of the evidence presented revolves around them.

Retroviruses are fiendishly clever. They are the foremost practitioners of horizontal gene transfer, integrating their own genetic material into the genome of the infected host to produce more viruses.

Intriguingly, if they infect germline cells, sperm or ova, for example, then the organism will transmit the integrated retrovirus, known as a provirus, to their descendants. In other words, the acquired genetic material becomes part of the offspring's inheritance. It's a solidly Lamarckian mechanism and Steele's own somatic selection hypothesis is based on such viral capacities.

This ability to affect the genetic makeup of their hosts makes viruses a force to be reckoned with. As a group of researchers, led by microbiologist Matthew B Sullivan, **wrote in 2016** **[11]**, "viruses modulate the function and evolution of all living things, but to what extent remains a mystery."

And the truth is there are a lot of viruses around.

Virologist Curtis Suttle from the University of British Columbia in Canada and his colleagues last year **published the first research** **[12]** into the number of viruses being deposited from the atmosphere. The amount is staggering, possibly billions a day for every square metre of the earth. Viruses are puissant and ubiquitous.

Steele and colleagues seem to have been finally spurred to action by new virological data connecting viruses and evolution.

In 2017 Pakorn Aiewsakun and Aris Katzourakis from the University of Oxford in the UK **published a paper in** **[13]*****Nature Communications*** ***[14]*** that concluded that "retroviruses emerged together with their vertebrate hosts in the ocean" at least 460 million years ago. They also established that the two entities demonstrate patterns of co-speciation: as the host organisms transform into new species, their viral counterparts similarly transform. This, claim Steele and colleagues, is a key prediction of the H-W panspermia hypothesis.

Steele and colleagues derive two points from Aiewsakun and Katzourakis' findings.

The first is that viruses are successful only because they have evolved to make use of the host's cellular machinery and genetic regulatory make-up – that is, they are "in touch with the whole of the cell's very ability to grow and divide to produce progeny cells and to evolve". Given this, evidence that retroviruses emerged at the same time as, and co-speciated with, their hosts, simply doesn't add up. Retroviruses are carefully adapted to the stable make-up of their target hosts and such co-variance just shouldn't happen.

The second point is that the emergence of these retroviruses barely predates the Cambrian Explosion, a period in which sudden and unparalleled biological diversity and complexity appeared on Earth. They also emerge not long after a mass extinction event at the end of the Ediacaran period, 542 million years ago.

Panspermia accounts for all this, the authors explain, thus: the Ediacaran extinction was most likely brought about by comets that brought with them complex retroviruses. The retroviruses were the main driver of the Cambrian explosion. They integrated themselves into the genomes of countless terrestrial species, introducing novel genetic material which resulted in an explosion of diversification of living forms.

They integrated so quickly and easily, without the need or time to evolve to the target host's genetic make-up, because they arrived already primed to do so. This is because the H-W panspermia hypothesis posits a cosmic biology, in which, write the researchers, "the entire galaxy (and perhaps a local group of galaxies) constitutes a single connected biosphere". All life, both terrestrial and extra-terrestrial, is related, according to this view, as all life comes from the greater biosphere in which genetic material in the "cosmic gene pool" is readily shared. There is an underlying biochemical unity of all life, differing only in which isotopes of essential elements life from different parts of the universe might use.

As Wickramasinghe puts it, “Our point of view is that in the context of an interconnected cosmic biosphere involving at least 100 billion habitable exoplanets in our galaxy alone, and with continuing exchanges of biomaterial, large scale HGT including exchanges of complex genetic packages in the form of viruses, seeds, bacteria is unavoidable.”

One of the loudest champions of panspermia theory, the late astronomer, Fred Hoyle.
CREDIT: DAVID LEVENSON/GETTY IMAGES

One of the reasons for adopting panspermia, he explains, is the “*superastronomically* improbable transition from non-life to life”.

The idea that abiogenesis occurred on the cosmically insignificant earth in an awkwardly short amount of time strikes him as improbable, at best.

“The choice between life originating on Earth against manifestly insuperable odds,” he says, “and an origin in the connected volume of a large part of the almost infinite universe is a simple binary choice. We chose the most probable.”

Steele and colleagues argue that abiogenesis is deeply unlikely here on earth and that “it is many orders of magnitude more likely that it emerged in one of the trillions of comet-like incubators or water-bearing planets (cosmic-wide versions of **Darwin's 'warm little ponds' [15]**) at a very early time in the growth of this universe”.

Despite this, Wickramasinghe, Hoyle and Steele have all entertained the notion that there is no need for such a creation story. When asked if there must be abiogenesis at some point, somewhere in the universe, Steele replies, “Actually no. If the universe is steady state infinite there is no formal abiogenesis! I am not saying I agree with that. But Big Bang or steady state are so mind-boggling I find both incredible!”

The reason for this, and a common factor amongst the three scientists, is a commitment to, or interest in, the steady state theory of cosmology.

The idea, first put forward by Hoyle and two colleagues in 1948, holds that the universe has no beginning or end and remains the same size. As matter at the outer reaches of the universe loses energy and goes dark, new matter is created.

In this view, biology is as timeless and without origin as the universe itself. Hoyle famously lost the fight over cosmological models to George Gamow and the advocates for the Big Bang. Despite the discovery of cosmic microwave background radiation in 1964, something predicted by Big Bang theory, Hoyle never recanted his beliefs, and the steady state universe seems an underlying presence in the H-W model of panspermia.

The background theories and characters may be unsettling, but they don’t detract from the evidence upon which the paper rests, which must be taken on its own terms. Much of it is peer reviewed, but it is not always as persuasive as billed. Nonetheless, there is a good deal that gives one pause for thought.

For example, when asked why we haven’t found obvious signs of microbial life elsewhere in the solar system, both Steele and Wickramasinghe seem adamant that such evidence has, in fact, been found. Both point to **the work of Gilbert Levin** **[16]**, the principal investigator of the 1976 Viking mission to Mars and his colleague Patricia Straat. Viking’s results pointed to something with a metabolism in the Martian soils, but then couldn’t detect any organic material. The result is interesting, but inconclusive.

The authors also insist fossil microbes have already been found in various meteorites, including the famous **Murchison meteorite** **[17]** that fell in Victoria, Australia, in 1969. While they point to refereed journal articles for support, it seems the jury is still out. Once again, the evidence is tantalising but not conclusive.

More recently, traces of seemingly biological carbon deposits have been found in rocks predating the emergence of life, during a period of heavy comet and asteroid bombardment. The authors see this as evidence of life carried to earth, but, as Baverstock suggests, there are other reasons such carbon might be there.

More intriguing is the discovery of bacteria and microbes in unlikely places, such as the stratosphere, 30 to 40 kilometres above the surface of the planet, and more excitingly **on the outside of the International Space Station [18]**. In the case of the ISS, contamination has been ruled out and the physics suggests that it is not possible for the microbes to have been lofted up from the earth's surface.

Just as fascinating are suggestive astronomical findings, such as the Rosetta mission's **discovery [19]** of organic compounds on and around the comet 67P/Churyumov-Gerasimenko. This finding coincides nicely with Hoyle and Wickramasinghe's demonstration that interstellar dust is partly made of organic molecules.

Perhaps the most intriguing astronomical evidence of all is that which converted Steele to the panspermia hypothesis.

A development from the research into organic interstellar dust, the spectrum of light produced as infra-red radiation passes through cosmic dust **turns out [20]** to have the exact same spectral signature as freeze-dried *E. coli* bacteria. Steele's frustration with the scientific community's indifference to this staggering result is palpable.

"All our knowledge of the universe," he says, "has been built this way – get the spectrum (emission, absorption) in the laboratory on Earth, then focus the telescope on a cosmic source/object and ask, What is the spectrum or signature? Does it match that found in the Earth-based laboratory?"

The answer? "It is an exact match – you cannot get better than that in science."

So why has the result largely been passed over as a curiosity? Steele muses, "The situation is reminiscent to the problem Galileo had with the Catholic priests of his time – most refused to look through his telescope to observe the moons of Jupiter."

Perhaps the most controversial aspect of the new paper concerns the origins of the octopus. The discussion begins, as it so often does in the paper, with some intriguing evidence.

Cephalopods (the group comprising squid, cuttlefish, nautilus and octopus) have a somewhat confusing evolutionary tree, first appearing in the late Cambrian period and seemingly descending from an ancestral primitive **nautiloid [21]**.

Of these, the octopus is the most striking, with features, such as a complex nervous system, sophisticated eyes and a capacity for camouflage, that appear quite suddenly in its evolution. The genes necessary for this transformation, the authors suggest, are not present in its ancestry. Thus, they hold that "it is plausible then to suggest they seem to be borrowed from a far distant 'future' in terms of terrestrial evolution, or more realistically from the cosmos at large."

Interestingly, the octopus has some real and pervasive biochemical differences from the nautilus, presumably the closest living relative of the former's ancestor. In particular, there is evidence of extensive changes in the RNA, and thus proteins, found in the neural structures of cephalopods.

These changes have been evolutionarily preserved and are not found to this extent elsewhere in nature, not even in the nautilus. This indicates that a qualitative evolutionary transformation occurred relatively recently and abruptly in behaviourally complex cephalopods. The sheer scale of these changes leads the authors to conclude that it cannot be explained by normal neo-Darwinian processes. Or even Lamarckian processes. And they may have a point.

But here things get weird. "One plausible explanation, in our view, is that the new genes are likely new extraterrestrial imports to Earth – most plausibly as an already coherent group of functioning genes within (say) cryopreserved and matrix protected fertilised octopus eggs," write the authors. This would "be a parsimonious cosmic explanation for the octopus' sudden emergence on Earth [about] 270 million years ago."

It's moments like this that point to the source of the paper's unease. It lies not with the evidence it presents, but rather the larger conclusions drawn.

The evidence is nonetheless provocative. Taken together it indicates, if nothing else, that there is much we don't know and that our prevailing scientific orthodoxies will undergo transformations, as all scientific theories do.

The orthodox scientific response is encapsulated in the **commentary from the decorated virologist Karin Moelling [22]** of the Max Planck Institute Molecular Genetics, in Berlin, and Institute of Medical Microbiology, Zürich, published in the same journal issue.

"So this article is useful, calling for attention, and it is worth thinking about," she says, "yet the main statement about viruses, microbes and even animals coming to us from space, cannot be taken seriously."

These kinds of pronouncements have led to the near-radio silence from the media, except for the occasional piece **riffing on the theme of space octopuses [23]**. Scientific commentary is muted, confused by the tension between the outlandish claims and the peer-reviewed status of the paper.

Maybe we should side with sage advice of the journal's editor, the renowned British biologist Denis Noble. "The usual mantra 'further research is needed' applies even more than usual," **he writes [24]**. "In the future, the ideas will surely become testable."

The authors, too, think this the best course of action. "The whole issue is on the verge of being decided by decisive evidence of extra-terrestrial life being found elsewhere in our solar system," they conclude.

Instead of dismissing panspermia out of hand, perhaps then, we should just wait for the discoveries that future space probes might bring. Evidence, as always, will be the ultimate decider.

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