AMESSAGE FROM HO ARE WE? ARE YOU THERE? WANT TO TALK?

Life beyond Earth?

Life emerging and evolving on Earth

Life first emerged on Earth more than 3.8 billion years ago, less than 700 million years after the formation of the planet itself. It has undergone an evolutionary process since then, seeing new species appearing and others going extinct. All known living organisms share the code that it being used to describe their specificities by means of molecules, and this information is passed on to biological descendants. We therefore think that all life on Earth originated from a common ancestral lifeform. Evolution is frequently illustrated as a "Tree of Life", but it should be noted that genetic information can also be shared across species due to the universality of the code. Notably, humans are a rather recent occurrence, with their ancestral line having finally split from that of the chimpanzees only about 6 million years ago.



Tree of Life on Earth, as seen from a human-centric perspective. More detail is provided on species more closely related to humans, despite the fact that bacteria hold far more genetic diversity and account for far more biomass than plants and animals do. The latter form only a small part of the eukaryotes, which together with bacteria and archaea constitute the three distinct domains of life. Moreover, the tree neglects most of the 99% of species that existed but have gone extinct.

Where are we? - The Solar System

In order of distance from the Sun, Earth is the third out of four small rocky inner planets (Mercury, Venus, Earth, Mars), as opposed to the four large gaseous outer planets (Jupiter, Saturn, Uranus, Neptune), which all revolve around the Sun in the same direction in almost circular orbits and in a common plane. The Solar System also contains dwarf planets like Pluto, satellites such as the Moon that orbit planets, as well as millions of smaller bodies, including asteroids, meteoroids, and comets.

As evidenced by impact craters, smaller bodies have collided with Earth in the past and might do so in the future, posing a threat to life. In fact, it has been suggested that an impact of an asteroid on Earth led to the extinction of the dinosaurs and many other living species about 66 million years ago. Moreover, the Moon may have formed out of the debris left over from a collision between Earth and an astronomical body the size of Mars.

Extra-solar planets

It was not until 1995 that planets were detected that orbit stars other than the Sun. By now we know about 4,000 such "extra-solar planets", and being surrounded by a planetary system appears to be a common feature amongst stars. These extra-solar planets show a large diversity of types (far beyond what we find in the Solar System), and planetary systems show quite different architectures. Whenever you see a pinpoint of light in the night sky, regardless of which one you choose, there is a good chance that there is a planet nearby.

Is Earth any special?

The Sun is one of hundreds of billions of stars within the Milky Way, which itself is just one of hundreds of billions of galaxies in the Universe. So, we would expect myriads of planets within the vast Universe. How does it come that the only place known to us to harbour life is planet Earth?

The large number of potential hosts for life needs to be contrasted with the detailed requirements for life to emerge and evolve. But on this point we are facing big unknowns and severe limitations on predicting outcomes.

Life co-evolved with its environment: Not only did the geological environment determine the evolution of life, but living organisms also changed the planet. Both the mineral record and the atmosphere of the Earth are a result of the evolution of life. This means that subtle differences in the initial conditions could lead to rather different outcomes.



The sky is full of planets (artist's impression). It has been estimated that there should be hundreds of billions of planets in the Milky Way alone, forming planetary systems around their host stars. © ESO/M. Kornmesser

Is biology universal?

All observations are in agreement with assuming that the principles of physics and chemistry are universal, applying in exactly the same way throughout the whole Universe. With biology being based on physical and chemical processes, it would therefore seem surprising if it was specific to planet Earth. However, so far there is no evidence of biological systems beyond our home planet.

While life creates order, the laws of thermodynamics drive a system towards a state of larger disorder. The emergence and evolution of life is not forbidden by thermodynamics, but we don't now why it actually happened and whether it is a straightforward and likely process or rather the result of a fluke. Even if we were able to trace back life on Earth to its origin, we would not be able to answer that question.

Searching for life beyond Earth

If we fail to find answers on Earth on why life emerged and how we came to be here, we should look elsewhere. How similar will another tree of life be to the one that we find on Earth? Will extra-terrestrial life follow the same biochemistry, and where will evolution under slightly different conditions take it?

In order to be able to detect extra-terrestrial life, we need a set of necessary and sufficient characteristics, and this is particularly challenging. Moreover, life can easily escape detection. Microbial life is present in yoghurt, but trying to detect life in a pot of yoghurt without taking a sample is far from being a trivial problem. – Now imagine extra-terrestrial yoghurt...

It would therefore be particularly exciting if probes sent to other bodies of the Solar System (such as Mars or the satellites of Jupiter or Saturn) could establish the existence of life beyond Earth, which could then be studied in detail.

However, while communication between individuals by means of a language is a quite recent feature of evolution, its structure permits to assert some level of "intelligence", and such communication can be detected at interstellar distances if it makes use of technology based on electromagnetic waves.

Will we ever succeed?

If the probability for a civilisation like ours to emerge is so small that we expect this to happen only once amongst hundreds of billions of stars within the Milky Way, we are far from being alone, given that there are hundreds of billions of galaxies. Life unlike humans is far more likely to arise. The Universe could well be teeming with life, while we fail to spot it.

"Searching for Interstellar Communications" was discussed already in 1959 by Giuseppe Cocconi & Philip Morrison, who concluded that "The probability of success is difficult to estimate; but if we never search, the chance of success is zero."



Earthrise as seen by NASA astronaut William Anders on 24 Dec 1968 from Apollo 8 in orbit around the Moon.

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