

The detection of extra-terrestrial life and the consequences for science and society

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A thin layer near the surface of Earth is teeming with life of huge diversity: from micro-organisms to plants and animals, and even intelligent species. Up to now, this forms the only known sample of life in the Universe. We now readily accept that the laws and concepts of physics and chemistry apply throughout the cosmos. Is there a general biology as well: is there life beyond Earth?

Pinpoints of light in the night sky have probably always made humankind speculate about the existence of other worlds, but the presence of planets orbiting stars other than the Sun has become a proven reality only within the last 15 years. While the vast majority of the more than 450 extra-solar planets that are known to date are gas giants like Jupiter and Saturn, some spectacular discoveries of about 20 planets of less than 10 Earth masses have already indicated that rocky planets with conditions suitable to harbour life are probably rather common.

One of the big unknowns is how likely it is for life to emerge once all conditions are right. There is no lack of its building blocks; the number of molecules fundamental to Earth's biochemistry that have already been found in the interstellar medium, planetary atmospheres and on the surfaces of comets, asteroids, meteorites and interplanetary dust

particles is surprisingly large. Giant "factories", where complex molecules are being synthesised, appear to make carbonaceous compounds ubiquitous in the Universe. If the genesis of life arises from chemistry with a high probability, one might speculate whether this process occurred more than once on Earth itself, leading to the existence of a terrestrial "shadow biosphere" with a distinct Tree of Life. Moreover, there are several other promising targets within the Solar System, namely Mars, Europa, Enceladus, and, for biochemistry based on a liquid other than water, Titan. Evidence for life is not easy to gather; any chemical footprint needs to be unambiguously characteristic, and to exclude an abiogenic origin. The most powerful probe would result from returning a sample to a laboratory on Earth.

The year 2010 marks the 50th anniversary of the first search for radio signals originating from other civilisations and up to now all "Search for Extra-Terrestrial Intelligence" (SETI) experiments have provided a negative result. However these have probed only up to about 200 light-years distant, whereas the centre of the Milky Way is 25,000 light-years away from us. And, even if there is no other intelligent life in the Milky Way, it could still be hosted in another of the remaining hundreds of billions of other galaxies. Advanced efforts are now on the drawing board or already underway for the further exploration of the Solar System and the detection of biomarkers in the atmospheres of extra-solar planets, while searches for signals of extra-terrestrial intelligence are entering a new era with the deployment of the next generation of radio telescopes.

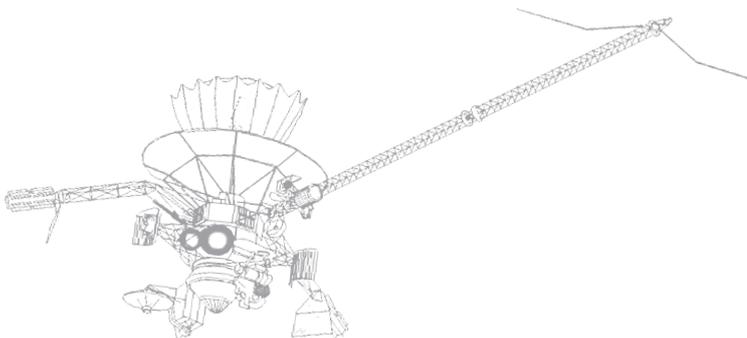
With the detection of extra-terrestrial life being technically feasible, one needs to address whether perceived societal benefits create an imperative to search for it, or whether such an endeavour may rather turn out to be a threat to our own existence.

44%

of people believe in extra-terrestrial life

Main image - A line drawing of the Galileo spacecraft.
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Archive image - A map of Mars from *A popular guide to the heavens* by Sir Robert Stawell Ball, 1913. From the Royal Society archive.



Evolutionary convergence, as seen in the biological history on Earth, suggests that the limited number of solutions to sensory and social organisational problems will make alien civilisations at a comparable stage of evolution not look too different from our own. As historical examples indicate, meeting a civilisation similar to ours might actually turn into a disaster. However, with the Sun just about half-way through its life-time, humankind as we know it is likely to constitute a rather short transient episode, and advanced extra-terrestrial life might be inconceivable to us in its complexity, just as human life is to amoebae.

Rather than aliens invading Earth, realistically expected detection scenarios will involve microbial organisms and/or extra-terrestrial life at a safe distance that prevents physical contact. As far as exploring other lifeforms is concerned, any applied strategy must exclude biological contamination - not only to protect ourselves, but also to support cosmic biodiversity. No legally enforceable procedures are in place yet, and a broad dialogue on the development of a societal agenda on extra-terrestrial life is required.

The search for life elsewhere is nothing but a search for ourselves, where we came from, why we are here, and where we will be going. It encompasses many, if not all, of the fundamental questions in biology, physics, and chemistry, but also in philosophy, psychology, religion and the way in which humans interact with their environment and each other. The question of whether we are alone in the Universe still remains unanswered, with no scientific evidence yet supporting one possible outcome or the other. If, however, extra-terrestrial life does exist, an emerging new age of exploration may well allow living generations to witness its detection.



From the archive

The search for extraterrestrial life has had intriguing implications for our view of life on Earth. In 1965, Dr James Lovelock published a paper in *Nature*¹ where he highlighted the conundrum at the heart of the search for E.T. – how can we look for life on other planets when we don't know what alien life looks like?

One of Lovelock's proposed solutions to this question is that the atmosphere of a planet where life exists should contain compounds which are "incompatible on a long-term basis". The Earth's atmosphere contains both oxygen and hydrocarbons sustained by life – if there were no living beings to replenish these compounds, they would quickly react and disappear. While alien life might not necessarily produce oxygen and hydrocarbons like Earthly life, we may see similar disparities of known unstable mixtures of compounds in the atmosphere of an inhabited extraterrestrial planet.

Lovelock's analysis of the Martian atmosphere did not reveal any of the life signatures found in the atmosphere of Earth (without necessarily ruling out that Mars was once home to life). He found the idea of life leaving a 'signature' in a planet's atmosphere intriguing and began to think about the idea's wider implications. When he became a Fellow of the Royal Society (FRS) in 1974, he was already working on the theory that would make him famous.

In 1979, Lovelock published his radical contention that life is not merely a collection of individual organisms, but that the whole planet should be considered as one huge, fantastically complex ancient organism. Since publication, Gaia Theory has been tremendously influential and continues to develop and inspire today. Lovelock may have begun by looking up to the skies, but for many people, he changed the view of our home planet forever.