The hunt for life beyond Earth

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Astrobiology is the name given to a bright new field of science that is engaged in the search for life beyond the Earth. Now this isn’t meant in the sense of ‘aliens’ you may be familiar with from sci-fi films – green bug-eyed monsters – but in hardy single-celled microbes surviving, perhaps, beneath the freeze-dried surface of Mars. By its very nature, this search is deeply interdisciplinary, and sits right in the centre of the Venn diagram overlap between biochemistry, microbiology, geology, planetary science and astronomy.

In some respects, gazing up at the vast expanse of the heavens and querying if we are alone is one of the oldest questions humanity has asked. But it is our age that finally has the technological ability to begin actively searching for life beyond the Earth, and astrobiology has been going from strength to strength in recent years. This growing confidence has been fuelled by huge advances in three main areas – extremophiles, our robotic exploration of the solar system and extrasolar planets.

Extremophiles are organisms that are able to thrive in incredibly hostile, extreme, environments on our own planet; they are like the survival superheroes on Earth. Different extremophiles have been discovered in scalding hot conditions, or punishingly cold, or very acidic or alkaline, or very salty brines or high radiation environments. These extremophiles teach us a great deal about cellular adaptation to particular hazards – such as how halophiles are able to prevent their proteins from denaturing in near-saturated salt solutions, or how thermophiles have modified everything from their proteins to cell membranes and DNA to hold together at a staggering 120°C. Extremophiles also define for us the outer limits of the survival envelope on Earth, and therefore what conditions we would consider to be habitable on other worlds. It is through our discoveries of the astounding diversity of extremophiles that astrobiologists have come to consider more and more seriously the possibility of life on Mars, or the moons Europa or Enceladus.

In recent decades we’ve accomplished phenomenal achievements in our remote exploration of the other planets and moons in the solar system – through our operation of robotic flyby probes, orbiters, landers and even rovers. The more we’ve come to understand about the past environment of Mars, for example, the more plausible it has seemed that the red planet once provided a comfortable, habitable environment and that life may have originated there as well. NASA’s Curiosity rover, for example, has found clay-rich deposits that indicate a past river not unlike a babbling brook on Earth today, as well as organic molecules – the building blocks of life – within that mudstone. The European Space Agency’s ExoMars rover will land in the year 2020 and continue the search for Martian life with a 2 m long drill – the deepest underground we will ever have been able to access. The probes we have sent to the outer solar system – to the gas giant planets Jupiter and Saturn – have also
discovered environments of liquid water beneath the surface of the icy moons Europa and Enceladus, and so microbial marine life may lurk in even the dark depths of these alien oceans.

Astronomers have also been exploring the wider galaxy we live in. Twenty-five years ago we knew of only eight planets – those in our own solar system. Today, the tally has surged to almost 4000. These are the extra-solar planets, or exoplanets – worlds orbiting suns other than our own. Many of these extrasolar planets are nothing like the Earth: barren lumps of rock blasted by radiation from their star, or bloated gas giants orbiting cool, red dwarf stars. But there is every expectation that we are on the brink of discovering a true twin of our home world: an Earth-like planet around a Sun-like star with an orbit of almost exactly one year. This world would lie in the sweet spot between being too close to its star and hot, and too far away and cold, and so offer the perfect climatic conditions for oceans of liquid water and the best possible chances for life to gain a foothold. The next step would be to scrutinize such Earth-like planets with large space telescopes and use spectroscopy to read the composition of their atmospheres: reading what their air is made up of from across the gulf of interstellar space. If we find the telltale signature of oxygen in their air, we’d take this to be very strong evidence that there is photosynthetic life on that planet.

However, this could well represent one of the most frustrating discoveries in the history of science – knowing that there is an Earth-like planet exhibiting clear signs of life, but it being too far away to send a probe to in the foreseeable future. Even the closest stars in our galactic neighbourhood would take decades or centuries to get to. For me, then, the most promising location to find traces of ancient alien microbes would be on Mars. This is a place we can travel to relatively easily – already with our robotic explorers, and hopefully in the not too distant future to visit in person, with human astronauts – and bring pieces of the surface back to the Earth with a ‘sample return mission’. A network of fully equipped laboratories on Earth – far better than the miniaturized instruments fitted into Mars rovers – would have the best chance of securing unambiguous evidence of extraterrestrial life in the rocks or soil. And ultimately, we may find cells that have been well-enough preserved that we could even begin to unpack their molecular biology. Does Martian life also use lipid bilayers for its membranes, proteins for its enzymes and other cellular machinery, and DNA or RNA as its information storage system? Or is it alien in a deep sense – does it work in a fundamentally different way?

Further reading

- Astrobiology Society of Britain: astrobiologysociety.org
- NASA Astrobiology homepage: https://astrobiology.nasa.gov

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