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THE HUNT FOR LIFE BEYOND EARTH

By Dr Lewis Dartnell

Astrobiology is a bright new field of science, concerned with the possibility of existing life beyond the Earth – of extraterrestrial life. Thus, my research here at University College London is quite literally engaged in the hunt for *aliens*. I am funded on a research fellowship with the UCL Institute of Origins, and split my time between desks at the Centre for Planetary Sciences and the microbiology lab run by Professor John Ward. My own research is focusing on our next-door neighbour planet, Mars, and the likelihood of any bacterial life - Martian microbes - surviving in the dusty surface soils of the red planet.

The current environment on Mars is like that of a frozen desert; the ground is exceedingly dry (any water present is locked away as ice) and the surface is bathed in hazardous radiation from the sun and the rest of the galaxy. But Mars has not always been like this; the fleet of robotic explorers we have sent to the planet over recent decades, from orbiting satellites to surface landers and rovers, have helped us piece together the story of the planet's history. Mars was once a waterworld like the Earth, and the sculpturing of its landscape reveals the prior presence of ancient bodies of liquid water: lakes and seas, river valleys and deltas with fans of deposited sediment. Our more recent lander probes have analysed the mineralogy of Martian rocks and found many examples of sedimentary strata, laid down on ancient sea floors. The Phoenix lander, which touched down close to the Martian north pole in 2008, even grasped Martian water ice – possibly the remnants of a great northern ocean – with its robotic arm. The primordial Mars also sported a much thicker atmospheric blanket than today, and would have received organic molecules, the building-blocks for life as we know it, raining down from the heavens aboard meteorites and comets, just as they did onto the young Earth.

Figure 1: The globe of Mars, Earth's next door neighbour planet, and a possible abode for extraterrestrial life. Image credit NASA.

So it seems as though ancient Mars ticked all the necessary boxes for providing basic life-support as a planet. There is the distinct possibility that it experienced its own independent genesis of life, perhaps even before Earth became alive. The problem today is that Mars has suffered some sort of environmental catastrophe. Most of its early atmosphere has been blown away into space, its surface temperature and air pressure has plummeted, and the frozen dry surface is now consequently extremely hostile to the survival of life. A particular hazard on Mars is the constant stream of high-energy radiation particles from space – cosmic rays. Life on Earth is protected from this space radiation by our thick atmosphere and planetary deflector shield – the global magnetic field – but Mars receives no such protection, and this highly damaging radiation penetrates several metres underground. So the big question is how long might native Martian life or fossil signs of its prior existence survive this constant torrent of radiation, and how deep underground might we have to dig?

To try to answer this question, I am looking into how the hardiest life forms we know about on our own planet, so-called *extremophile* organisms, survive similar harsh environments. In my microbiology lab I am culturing bacteria isolated from the Dry Valleys region of Antarctica. It is one of the coldest, driest deserts on Earth, and so a meaningful analogue to the current Martian environment. I grow up populations of these ultra-hardy cells, and then blast them with gamma rays to get them to die again. From these results I can work out their resistance to radiation, and compare this to my computer simulations of the radiation levels on Mars in order to determine how long organisms could persist the deeper underground we go.

But the survival of Martian life in the face of cosmic radiation is just one tiny jigsaw piece in the extraordinarily broad field of astrobiology. The field is intrinsically multidisciplinary, and draws together the expertise of scientists working in fields as diverse as biochemistry, geochemistry, planetary science and astronomy. UCL is a world leader in many aspects of this research, and the Mullard Space Science Laboratory is even building the robotic eyes that the ExoMars probe will use to survey the surface of Mars when it lands in 2018.

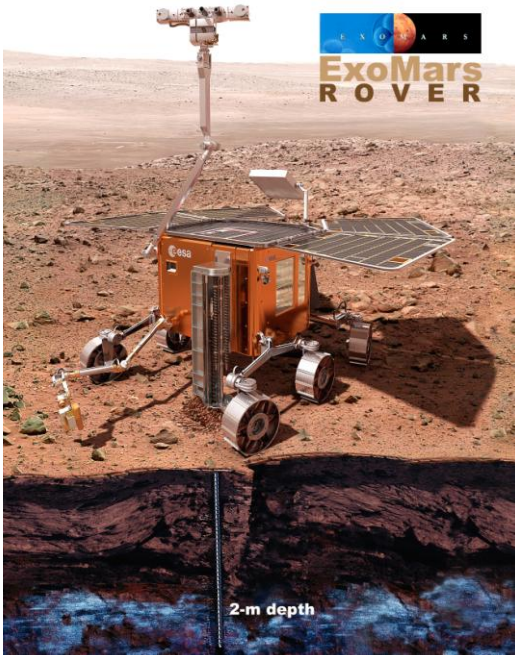

Figure 2: The European Space Agency rover, ExoMars, is due for launch in 2018, and will scour the surface of Mars, as well as underground, for signs of martian microbial life. Image credit ESA.

Peter Grindrod is building detailed representations of the Martian landscape and studying the geochemistry of rocks formed in aqueous conditions to identify signs of ancient liquid water on Mars. Also working in my microbiology lab are two geologists, Claire Cousins and Lottie Hobday; Claire is looking at earthly bacteria that thrive at the interface between fire and ice, where subglacial volcanoes erupt inside thick glaciers. She has been organizing expeditions to volcanic field sites in Iceland that are similar to many locations throughout Mars's history. Lottie is studying hardy cells that live in very alkaline and salty waters, such as the soda lakes in East Africa. These habitats are thought to resemble certain ancient Martian lakes, and possibly the subsurface ocean of Jupiter's icy moon Europa. This alien ocean lies deep beneath the frozen ice surface, and may provide the most promising habitat for extraterrestrial life in our solar system. Meanwhile, Dom Fortes and Lucy Norman are looking into the possibility of the complex chemistry of life being based not on liquid water, but on liquid methane as a solvent. Methane flows down rivers and fills up lakes on Saturn's frigid moon Titan, but it is still very much an open question as to whether life could be based on an exotic solvent like this.

Looking beyond our solar system, astronomers have now discovered over four hundred planets orbiting other stars in our galaxy. In general, the *exoplanets* detected so far are supermassive and hugging tight orbits around their sun; this is simply because the effects of big planets orbiting close to a star are easiest to spot. Their hot, bloated atmospheres are not the sort of place for life to begin, but over time we have been finding more and more Earth-like worlds. The expectation is that within the next few years we will discover a true Earth twin. The next step will be trying to work out what this new world is like.

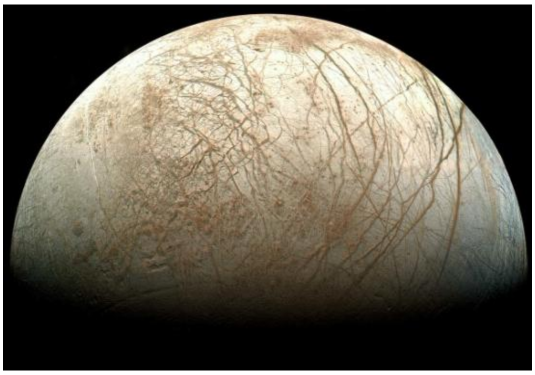

Figure 3: Europa is one of the large icy moons of the gas giant Jupiter, and hides a deep alien ocean beneath its smooth frozen face. Image credit NASA.

Giovanna Tinetti is supported by a Royal Society fellowship for her work in characterising the chemistry of an exoplanet's atmosphere. The basic science is that if you can isolate the light coming from the planet (which is incredibly dim compared to the glare of the star) you can perform spectroscopy and identify the absorption fingerprints of different gases in the atmosphere. Carbon dioxide, water vapour and methane have already been found in the atmospheres of gas giant planets, and would be a very exciting discovery in the air of an Earth-sized world. Astrobiologists would be extremely keen to find the signature of oxygen, in particular, in a terrestrial atmosphere, as this would provide a convincing case for photosynthetic life.

David Kipping, another astronomer at UCL, is making ground-breaking progress on the detection of new worlds far beyond the Earth. We have already discovered many other planets in distant solar systems, but not any moons; David is working on a technique for detecting large moons around gas giant planets, based on the wobble the planet would exhibit due to a massive orbiting body. The expectation is that such moons may even approach the size of the Earth, and could provide an environment for life, not unlike the habitable moon Pandora in the recent sci-fi film *Avatar*.

There has been a growing buzz of excitement surrounding astrobiology in recent years. This is being fuelled by a string of revolutionary discoveries made in the study of microbiology and the hardiest life forms on Earth, in robotic explorations of the solar system and the discovery of potentially habitable environments on other worlds, and in astronomers detecting more and more alien solar systems. Now is a wonderful time to be working in this dynamic and diverse field, and I am certainly looking forward to the discoveries that await us just over the horizon.

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