

In July 2004 the Cassini probe will enter into orbit around Saturn. This artist's impression by Craig Attebery shows the probe descending to the surface of Titan - Saturn's largest moon. The Cassini spacecraft flies overhead with its high-gain antenna pointed at the probe as it nears the surface

Space



Jonathan Caddick explains why scientists searching for extraterrestrial life need not necessarily leave the planet, the most likely places where planetary scientists believe life might be found in the Solar System and the four missions currently on their way to Mars

LIFE IN PLANET EARTH is abundant but whether life exists elsewhere in the Solar System remains uncertain. The debate concerning the infamous Martian meteorite ALH4001, found in 1996, is still raging as to whether we already have conclusive evidence of life from another planet'. As part of an effort to discover more concerning the possibility of extraterrestrial life, there are at present no fewer than four spacecraft en route to Mars. These include Europe's Mars Express, Japan's Nozomi and two NASA missions, Spirit and Opportunity.

The principal reason for a revival of interest in Mars has been due to a celestial alignment that occurred on Wednesday 27 August 2003 at 09.51 GMT, which meant Mars passed within 56 million km

(35 million miles) of Earth; the closest the two planets have been together since 12 September 57,617 BC! Not only has this heavenly configuration presented an opportunity to minimise the fuel required for the journey to Mars but it has also offered an appropriate occasion for the presentation of an article regarding the topic of life existing on other planets within our Solar System which most planetary scientists will agree are most likely to be microscopic organisms.

The search for extraterrestrial life is aided by the fact that Earth is teeming with life. Researchers are currently able to recognise microorganisms which may pose a hazard relating to interplanetary contamination and identify possible habitats on other planets that were once thought to be too

extreme for life to survive. The word extremophile is a broad term used to describe microorganisms which live in environments that from a human vantage, are considered extreme. Microorganisms that are characterised in this way are of particular use to planetary scientists because the extreme habitats which are home to them are representative of conditions encountered on other planets in the Solar System. A group of extremophiles known as thermophiles (heat lovers) are used by researchers to understand how life survives in temperatures that can exceed 100°C. Probably the most well known of this group of microorganisms is *Thermus aquaticus*; the microorganism famous for giving us *Taq* polymerase (the first enzyme used for PCR).

Invaders!



In June 2003 the first of two US missions to Mars was launched from Cape Canaveral. The Mars Exploration Rover, dubbed 'Spirit' is expected to arrive at the red planet in January 2004. The robotic Spirit is expected to cover as much as 40 meters a day and will search for evidence of ancient water, from which implications might be drawn about the possibility of ancient Martian life. A second rover named 'Opportunity' was successfully launched on July 7th 2003 and will arrive at Mars a few weeks later. A few days prior to the US missions, Europe's Mars Express commenced its journey to Mars from Baikonur Cosmodrome, Kazakhstan. This is the first European mission to Mars and will deliver a rover to the surface while a probe simultaneously orbits the planet

Recently a thermophile that can thrive at temperatures of 121°C was discovered near super-hot springs found at the bottom of the Pacific Ocean³. The deep-sea hydrothermal vent system where this microorganism was found is one of the most inhospitable places on Earth. There is no sunlight, temperatures exceed the boiling point of water and the pressures are hundreds of times more intense than on the Earth's surface. In fact researchers have already observed that this microorganism, named simply *Strain 121*, can survive autoclaving, which is one of the main techniques used for sterilising equipment that will travel through outer space. A microorganism such as *Strain 121* demonstrates that life can adapt to environments considered, until recently, sterile; environments yet

undiscovered on other planets!

It is not only the hottest wettest places on Earth that are inhabited by microbes but also the coldest driest places. The Dry Valley's of Antarctica are another place of interest to planetary scientists as the conditions there mimic climates found on both Mars and Europa. The microorganisms which can survive the extreme cold of the Dry Valley's are known as psychrophiles (cold lovers). Soil microbes that are found in this hostile environment are for the first time being DNA fingerprinted⁴. From the data that is generated it is possible to gain a greater understanding of the diversity of these microbes and also identify how these microorganisms survive in such an extreme habitat. Researchers are currently trying to identify what

substrates the microbes are metabolising and how they are adapted to survive extended periods of desiccation. Cold environments are of particular interest to planetary scientist as there are more potential subzero habitats in the Solar System than warm ones.

Similar studies are being undertaken on other types of extremophiles including halophiles (salt lovers), acidophiles (acid lovers) and alkaliphiles (alkaline lovers). In the outer limits of Earth's atmosphere researchers from Sheffield University have been able to culture two species of bacteria (*Bacillus simplex* and *Staphylococcus pasteurii*) and one fungus (*Engyodontium album*) from samples collected by a weather balloon cruising at 41,000 metres (135,000 feet)⁵. It is uncertain how the microorganisms reached this

altitude as particles of their size are not thought to be able to pass through an area of the atmosphere called the tropopause found at about 17,000 metres above sea level. Contamination from back on Earth is considered unlikely as the samples were freeze dried due to the extreme cold, dry conditions experienced at an altitude of 41km. One theory is that the microorganisms did originate from Earth and were carried past the tropopause by global air currents, however, this is considered highly unlikely.

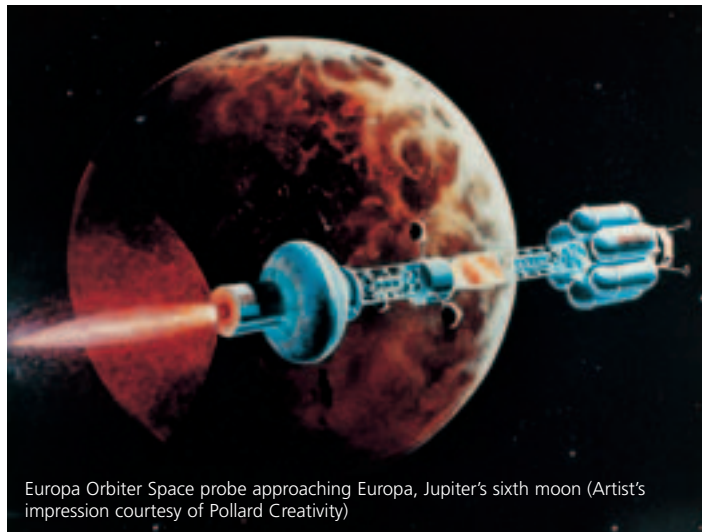
Another explanation is that the microbes are in fact alien in origin and were slowly descending to the Earth's surface due to gravitational pull. The latter possibility is based on a theory developed by Chandra Wickramasinghe and the late Fred Hoyle in the 1970s which suggests life

originated elsewhere in the universe and arrived on Earth via a passing comet.

Whether life began on Earth or arrived from somewhere else planetary scientists agree that there are to three highly probable contenders in the search for extraterrestrial life in the Solar System. These locations are Mars (the fourth planet from the Sun), Titan (Saturn's largest moon) and Europa (the sixth moon of Jupiter).

Europa is an icy moon, named after a Phoenician beauty seduced by Zeus in Greek mythology, which is roughly the size of our Moon. The surface temperature is on average -170°C , which would obviously mean any water on the surface of this planet is frozen. It is believed, however, that beneath the thick crust, which resembles sheets of ice, there is an ocean of water that remains in a liquid state due to heat generated by tidal forces from the gravitational pull of Jupiter and its other moons. This opinion is widely accepted due to sightings of complex fractures that criss-cross Europa's surface which resemble features observed on the frozen Arctic seas on Earth. The fact that water is essential for the existence of life and that Europa appears to have a liquid subterranean ocean has led researchers to believe that this moon is an ideal place to search for extraterrestrial life.

In 2008, NASA plan to launch the Europa Orbiter space probe with the intention of locating areas on Europa's surface where its crust is thinnest. Ultimately researchers wish to send probes beneath the crust and explore for life in the water that may lie beneath. Planetary scientists believe that Europa is such a habitable place for microbes that to prevent possible contamination of the moon's surface with terrestrial



Europa Orbiter Space probe approaching Europa, Jupiter's sixth moon (Artist's impression courtesy of Pollard Creativity)

microorganisms it was necessary to destroy the space probe Galileo following completion of the Jupiter exploration. This was achieved in September of this year by sending it on a collision course with the planet. Researchers believed it might be possible for microbes to survive on Europa's icy surface in pools of water, warmed by radioactive plutonium used by the probe to generate electricity⁶.

Titan, named after the race of god-like giants from Greek mythology, is the only moon in the Solar System with an atmosphere. The surface temperature on Titan is approximately -180°C and its atmosphere is thought to be composed mainly of nitrogen and methane. Observations of Titan's surface are almost impossible because of the dense orange clouds that form in the upper atmosphere, however, during a brief pass the NASA probe, "Voyager" detected liquid methane and what are thought to be continents on the surface of the planet. It has been suggested that Titan is the only other place in the Solar System that has a liquid flowing on its surface. In this instance lakes and rivers are thought to be formed by liquid methane and ethane. Some planetary scientists believe

that the Earth was once like Titan and that early forms of life could exist on its surface or in pools of simple hydrocarbons. Although this may be the case some researchers feel that Titan is too cold to currently harbour life. It has also been suggested that in Titan's past it was warmer place and that microscopic life could have evolved, the remains of which may still be present on its surface. In July 2004 the Cassini probe will enter an orbit around Saturn. The study is expected to last for four

years in which time the Huygens probe destined to land on Titan will be launched. It is not known whether the probe will touch down on solid ground or in liquid so the probe has been designed for either eventuality.

Mars was probably the most studied planet in the Solar System, excluding Earth, before the 20th Century. One of the fundamental observations made by the Italian astronomer Giovanni Schiaparelli in 1877 led to the discovery of '*canali*' (channels) on the surface of Mars. The misinterpretation of the Italian canali for canal in the English speaking world is commonly considered to have motivated the belief by some astronomers that artificial canals may have been built by a Martian civilisation! Due in part to the interest raised by these channels more than 30 operations have been sent to investigate the red planet since 1960⁷. Although, of all the probes launched for the purpose of Mars exploration more than half have failed giving the impression that the red planet is in some way jinxed.

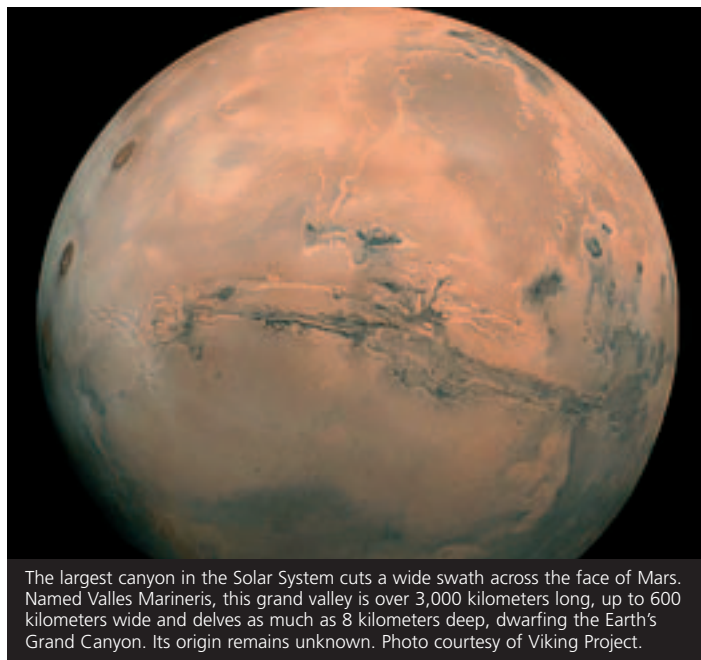


This artist's impression shows the Cassini-Huygens probe descending through Titan's thick atmosphere with Saturn setting dimly on the horizon. The probe is due to arrive at Saturn in July 2004. Artwork courtesy of Pollard Creativity

Mars can be up to 378 million km away from Earth and although our nearest celestial neighbour, excluding the Moon, it is far from inviting. A single Martian year lasts the equivalent of 687 Earth days and temperatures can range from a mild 27°C in the summer to a chilly -133°C in the winter. The atmosphere is composed mostly of carbon dioxide and offers little protection on the surface from UV-rays as it is thinner than that on Earth with little ozone; only 0.13% of the atmosphere is oxygen. To all intents and purposes Mars appears very different from Earth. Despite these differences Mars is in fact more like Earth than any other planet in the Solar System. There is also solid evidence that Mars may have water on or near its surface, the presence of which is a subject of debate amongst planetary scientists. Mars is also the best mapped with more known about its climate and geology than any of the other planets.

Although, much is already understood concerning Mars, the interest in this celestial body endures because it is not known whether life has at any time existed there. In an endeavour to find life, as stated previously, four missions are currently making their way to the red planet now.

The first of these four missions was Japan's probe Nozomi, meaning "hope" in Japanese, which launched from the Kagoshima Space Centre on 4th July 1998. This space craft is expected to arrive later than originally planned due to damage received from a solar flare. If however everything else goes to plan Nozomi is expected to reach Mars in early 2004, where it will remain in orbit to study how the planet is affected by solar winds; the stream of charged particles emitted by the Sun⁶. The two



The largest canyon in the Solar System cuts a wide swath across the face of Mars. Named Valles Marineris, this grand valley is over 3,000 kilometers long, up to 600 kilometers wide and delves as much as 8 kilometers deep, dwarfing the Earth's Grand Canyon. Its origin remains unknown. Photo courtesy of Viking Project.

NASA spacecraft, Spirit and Opportunity, were launched in June 2003 from Cape Canaveral, Florida. Both spacecraft carry rovers that will be deployed on opposite sides of Mars. The probes will jettison the landers 300 metres above the surface allowing them to parachute to the surface encased in a cluster of airbags⁶. Once at a standstill solar-panel petals will deploy so that the landers can begin to explore. One of the rovers is scheduled to land in a region named Meridiani Planum which is rich in the mineral haematite; a form of oxidised iron that on Earth rarely forms in the absence of water. Using a high-power microscope the rover will collect evidence of how the compound formed by examining the size and orientation of haematite grains⁶.

The second lander is expected to touch down at Gusev Crater. This site was chosen by NASA scientists because of its resemblance to lakebeds on Earth. Using an array of equipment it is hoped that evidence of water having ever been present in this area might be found⁶.

Launched on Monday 2nd

June 2003, a few days prior to the first NASA mission, Europe's Mars Express commenced its journey to Mars from Baikonur Cosmodrome, Kazakhstan. This is the first European mission to Mars and is the sole operation that will deliver a rover to the surface of Mars and have a probe that will simultaneously orbit the planet. The probe is set to study the composition of the Martian atmosphere while the rover named Beagle 2, will

land in a similar way to the two NASA rovers, in a region called Isidis Planitia.

This area is a crater approximately 1,600 km wide that separates Mars' more cratered southern hemisphere from its flatter northern hemisphere. It is hoped that past volcanic domes and small channels may have preserved evidence of life. Beagle 2 carries a mass spectrometer that can measure the relative amounts of carbon isotopes in Martian rock samples⁶. Results from this type of sampling may indicate that life once existed on Mars.

The possibility of finding life within the Solar System remains hopeful and assuming that the missions to Mars are a triumph it may be as soon as 2004 that we find the evidence.

Where next? Well for some astrobiologists it would seem that we must look much beyond the confines of the Solar System. The best place to look for life may be the 37th brightest star in the constellation of Gemini, approximately 42 light years away from Earth⁸! □

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