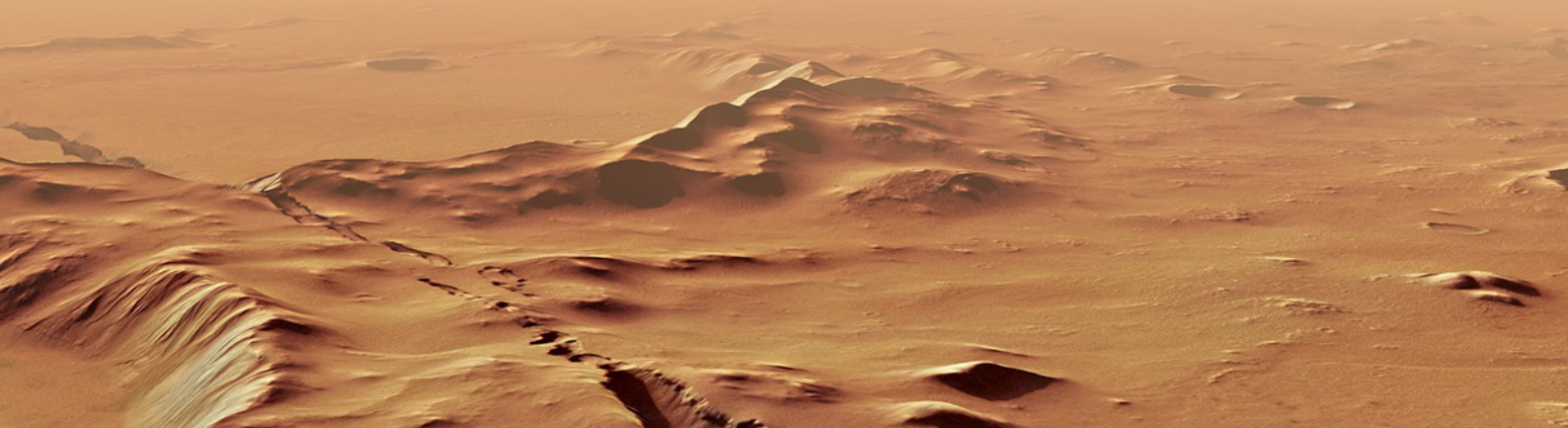
All About Space

IS LIFE FROM MARS?

By Jonathan O'Callaghan



Is life from MARS?

Could we all be Martians? We put the theory that life on Earth is of extraterrestrial origin under the microscope

Written by Jonathan O'Callaghan

Around 4 billion years ago the chemical constituents of life stewed in a primordial soup on Earth. Gradually, over time, this formed primitive single-celled microbial life, which later evolved into multi-cellular life. Over the next few billion years this life gradually evolved into the species that inhabit the Earth today, from plankton to people. Those first ingredients of life formed on Earth itself, with no external input.

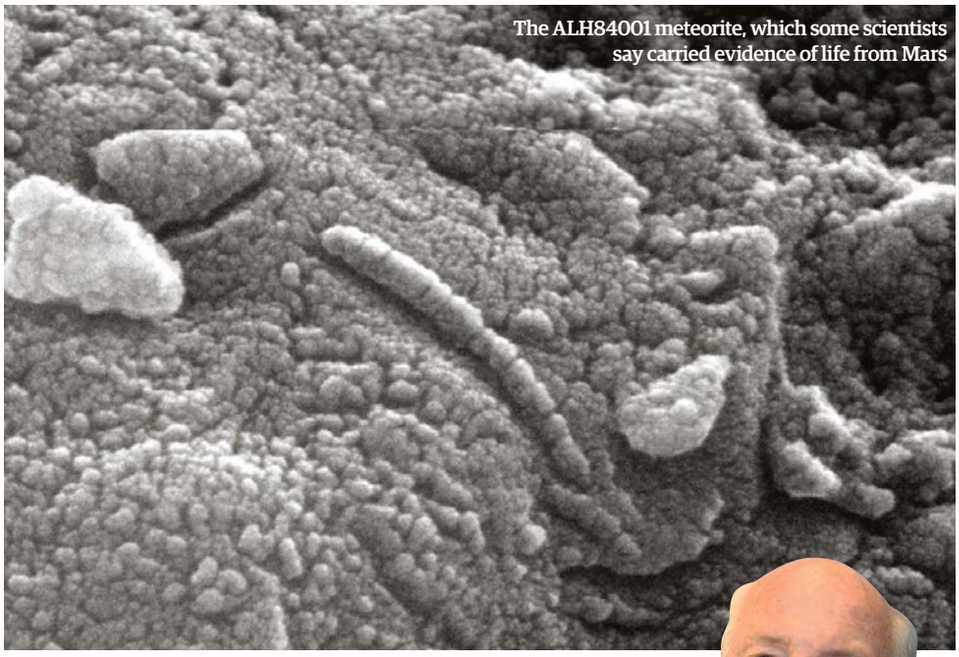
That's the widely accepted theory as to how life on Earth began, but not all are convinced. Some are sure that life on Earth began elsewhere, being transferred to Earth by comets or asteroids, where it gained a foothold and evolved into modern life forms. One theory that has risen to the fore in the last few years is that this life originated on Mars, given credence by the discovery made by NASA's Curiosity rover that the Red Planet was almost certainly wet, and possibly habitable, long ago in its distant past.

It's a theory that has been met with harsh criticism at worst, and mild trepidation at best. 'Extraordinary claims require extraordinary evidence,' is an oft-quoted retort to such theories, but some scientists are convinced that such extraordinary evidence is not beyond our reach.

One of the main proponents for life originating on Mars is Professor Steven Benner of the Westheimer Institute of Science and Technology in Gainesville, Florida, USA. Presented at the Goldschmidt Meeting in Florence, Italy earlier this year, Benner described how the early conditions on Mars might have been more suited to the building blocks of life than the young Earth.

Life as we know it requires three crucial ingredients, namely RNA, DNA and proteins. RNA, or ribonucleic acid, forms through a difficult process of 'templating' atoms on the crystalline surface of minerals. The minerals required for this templating to occur would likely have dissolved in the seas of the young Earth if it was covered in a global ocean, as has been suggested, but they could have more easily existed on a drier Mars according to Benner. "I would certainly give my odds of life originating on Mars as right now about 50:50," explains biochemist Dr David Deamer of the University of California, Santa Cruz, USA. "I think Mars, at one point, based on recent observations, had the kind of conditions that would allow simple replicating systems to appear. The question of whether these then were delivered to Earth is much more problematic, and it's a possibility although I don't think necessarily a plausibility."

Benner's research is based around the assumption that Earth was once wholly covered in water. This might sound conducive for life but, in fact, it is quite the opposite. Life is dependent upon polymerisation chemistry, which is the



The ALH84001 meteorite, which some scientists say carried evidence of life from Mars

"I would certainly give my odds of life originating on Mars as right now about 50:50"

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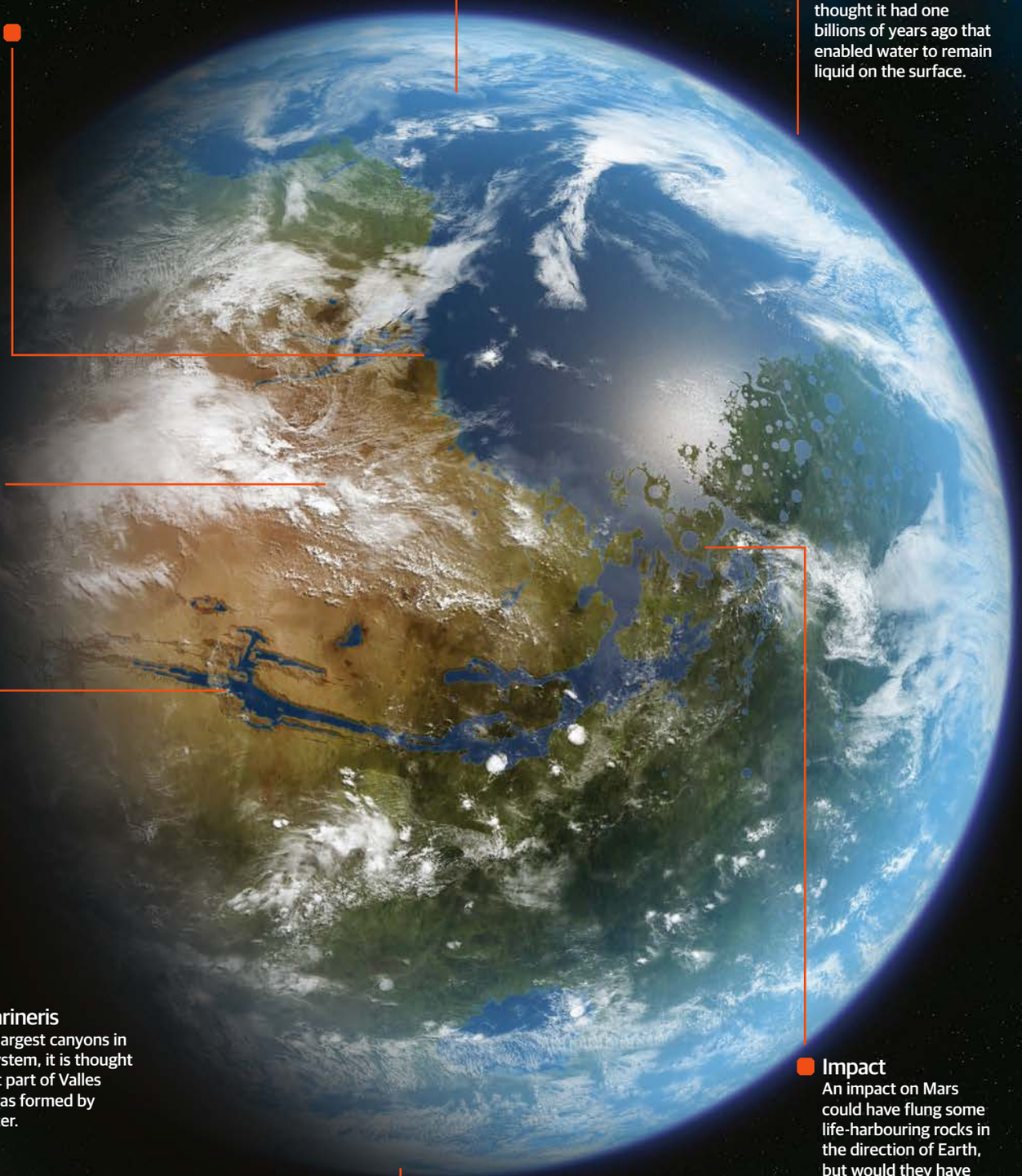
NASA's Curiosity rover found evidence of an ancient streambed on Mars, supporting the postulation that the Red Planet was once wet and habitable

Is this what Mars once looked like?



Northern hemisphere
The northern hemisphere of Mars is at a much lower elevation than the southern hemisphere, leading some scientists to speculate it was once the location for a huge ocean.

Atmosphere
Mars has since lost its atmosphere, but it's thought it had one billions of years ago that enabled water to remain liquid on the surface.

Wet and dry
Life would have more easily formed at the boundary of water and land where it could have gone through the wetting and drying process needed to evolve.

Volcanic activity
Research suggests that many of the land masses at higher elevation we can see on Mars today were formed by volcanic activity in its past.

Valles Marineris
One of the largest canyons in the Solar System, it is thought that at least part of Valles Marineris was formed by flowing water.

Impact
An impact on Mars could have flung some life-harbouring rocks in the direction of Earth, but would they have survived the journey?

Poles
Evidence for water on Mars remains at the poles, where large quantities of ice are still present in the modern day.

5 reasons life might have come from Mars...

1 Earth was too wet

If Earth was indeed once covered in a global ocean, it would not have been able to support the constituents of life as they would probably also require dry land.

2 Mars was once habitable

Evidence suggests that Mars not only had water in its past but also a thicker atmosphere, which would have enabled life to form on its surface.

3 Rare bacteria

Some rare forms of bacteria have magnetite that can be used as a biological compass to follow the magnetic field of Earth. They have also been found in the Martian Allan Hills meteorite.

4 Meteorites reach Earth

We know that meteorites (some from Mars) regularly make it to Earth, even in the modern day and much more so in the past. Could one of these have brought the ingredients for life?

5 Volcanic activity

Mars is thought to have been volcanic in the past, which would have provided land upon which primitive life could form.

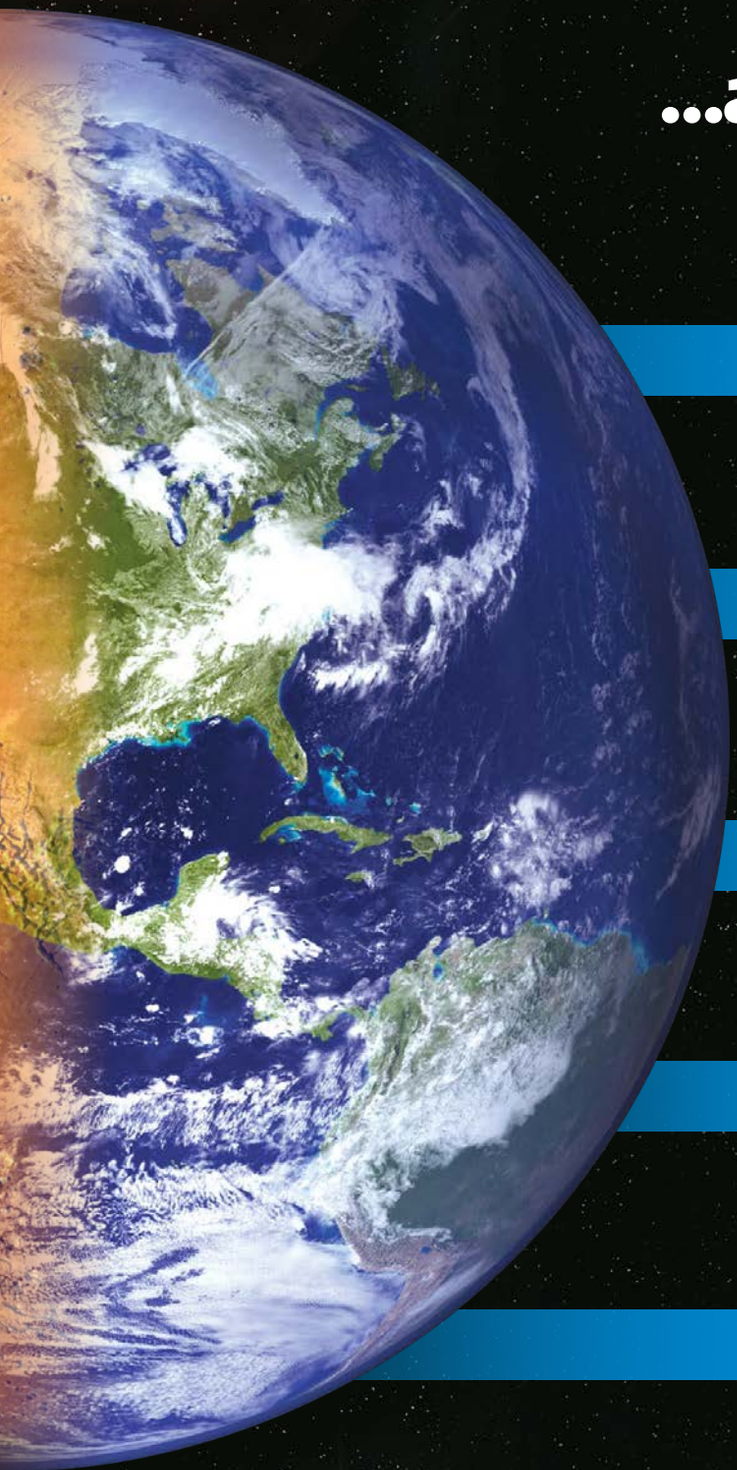
process through which simple monomer molecules are reacted together to form complex polymers. In basic terms, life forms through the bonding of simple molecules, such as amino acids and nucleotides, into more complex polymers such as proteins and nucleic acids respectively.

For this to happen, however, water molecules need to be pulled from between monomers. If Earth really was once covered in a global ocean, as Benner suggests, then this would have been incredibly unlikely to occur. For monomers to form polymers, there needs to be a wetting and drying environment, something a completely wet Earth could not provide. Benner says that while Earth was covered in a global ocean, Mars was not. The Red Planet instead only had shallow oceans where the minerals essential for the origin of life would have been more likely to occur.

Dr Deamer, however, isn't so convinced by this aspect of the theory.

Our observations of Mars heavily suggest that it would have had volcanic activity that would have caused land to rise up from the oceans, producing large land masses on the Red Planet

"Many meteorites from Mars have landed on Earth, having undertaken journeys of millions or billions of years"



...and 5 reasons it might have begun on Earth

1 Life could have formed here

Most evidence suggests that Earth had a volcanic beginning just like Mars, which means it would have had land masses upon which life could form.

2 It was habitable

Unlike Mars we know for certain that Earth was and still is habitable as we're still here and there's evidence for life stretching back to the earliest of days.

3 The distances are extreme

Life travelling from Mars on an asteroid to Earth would have to make a daunting journey of 225 million kilometres (140 million miles), which leads us to...

4 Harmful radiation

The journey from Mars to Earth is fraught with peril, not least from the huge amounts of radiation that would kill any unprotected life attempting to migrate.

5 We're yet to find extraterrestrial life

Theories of life existing elsewhere, let alone originating there, are pure conjecture. So far there is only one world in the universe we know to have life, and that is Earth.

where life could form. Benner's assumption is that this same volcanic activity did not occur on Earth 4 billion years ago. "My disagreement arises from his assumption that Earth was covered by a global ocean," says Dr Deamer. "Mars had volcanic activity without a doubt, but I don't see any reason why those same volcanic activities would not have occurred on Earth and that volcanoes would have arisen out of the early ocean."

Evidence for this occurring on Earth is apparent due to islands such as Hawaii and Iceland, so Dr Deamer suggests "it's likely that we had volcanic activity producing land masses above the global ocean, and this was likely the case on Mars as well."

If this was the case, there's no reason that life could not have begun on Earth. In fact, Dr Deamer and his team are currently in the process of finalising some groundbreaking research into producing life akin to what might have been on Earth 4 billion years ago. "We're now at the point where we can put together in the laboratory systems of molecules that have some of the properties of a primitive form of life," explains Dr Deamer. "We haven't got that to reproduce yet, but I can see looking just a few years in the future that the progress is such that we will have a laboratory demonstration of a replicating chemical system that has the properties of life." Benner's theory continues that, assuming life did begin on Mars and not Earth, there is then the issue of how this life was transported to our planet. Many meteorites from Mars have landed on Earth, having undertaken journeys of millions or perhaps billions of years, and it is on these meteorites that Benner suggests life could have been transported.

One such meteorite, known as Allan Hills (ALH) 84001, is a popular piece of evidence

In January 2013, scientists on NASA's Astrobiology Icy Worlds team ran experiments to see if organic molecules could be brewed in a simulated ocean like that found on the young Earth

favoured by proponents of the 'life from Mars' theory. The meteorite, which was discovered in Allan Hills, Antarctica in late December 1984, was thought by some to contain microscopic fossils of Martian bacteria. The presence of this fossilised bacteria, however, is the cause of much contention. If true, it would confirm that life really could have begun on Mars and, perhaps, the ingredients for life on Earth could have been transported by an asteroid. The theory is that ALH 84001 was blasted from the surface of Mars around 4 billion years ago before making its journey of 225 million kilometres (140 million miles) to Earth.

"The main deal [with ALH 84001] was that things looked like they might be fossils," says Dr Deamer, "and that was done using a scanning electron microscope and, sure enough, there's stuff that looks like it might be fossilised bacteria. However, there are a bunch of minerals that can also look similar to that, and if you're going to make an extraordinary claim like 'this is a fossil', you must have extraordinary supporting evidence. When people looked at all that evidence critically they were not convinced. It was not sufficient to get the jury of peers who are critical and sceptical scientists to agree."

> "While true panspermia might seem a bit far-fetched, the possibility of life originating on Mars is one that certainly merits further investigation"

Another problem with the suggestion that life was carried to Earth on an asteroid is the enormous distances mentioned earlier. Space is a harsh environment; outside the protective magnetosphere of Earth, radiation from the Sun and outside the Solar System is deadly to almost all forms of life. Some meteorites are thought to have taken hundreds of millions or billions of years to reach Earth, and for any form of life to survive that long on an asteroid seems somewhat implausible. Some suggestions that life could reside inside such space rocks is also unlikely, as the relatively small size of asteroids would be unlikely to provide sufficient protection from harmful radiation.

This is where another theory of life on Earth being of extraterrestrial origin, true panspermia, has been met with unreserved scepticism. True panspermia is the theory that life did not originate on Earth, but nor did it originate on Mars; proponents of this theory suggest that life began elsewhere in our galaxy, perhaps in another planetary system, before being transferred here.

One proponent of this theory is the somewhat controversial astronomer Chandra Wickramasinghe, professor and director of the Buckingham Centre for Astrobiology at the University of Buckingham, UK, whose theories of true panspermia, which he formed alongside the late astronomer Sir Fred Hoyle, have been met with a critical reception.

"The total [number of exoplanets] has been reckoned by some NASA scientists at 144 billion Earth-like planets in our Milky Way alone," explains Wickramasinghe. "If you accept that estimate then the nearest Earth-like planet to us is only three or four light years away, which is sort of spitting distance in cosmic terms. So the position I have maintained is that life on Earth is most unlikely to have originated on Earth."

Wickramasinghe's view of true panspermia is that all life began at a similar time at the dawn of the universe, spreading between the planets and stars in the process. It's a contentious theory to say the least; there's not a lot of evidence to support it. "The whole process of the origin of life occurred maybe very early in the history of the universe, maybe in the first 100 million years after the Big Bang," he says. "This was when the universe was compact, much smaller than it is now, and communication between one planetary system and another was more intimate. I think life began not in a puddle on Earth, but in the totality of a planetary puddle that existed at the dawn of the universe. There's no way that life can be confined to one place, is my conclusion."

Dr Deamer, however, was quick to point out a key problem with true panspermia. "If you look at the distances involved in true panspermia, things getting to us from other solar systems in our galaxy, the mathematics make it virtually inconceivable that anything could travel those distances and stand up to cosmic radiation long enough to make it to Earth," he explains. "So you've really got to look at the maths and the physics of what would be required to get something even from the nearest star about four light years away travelling at way below light velocity to get here. These things would take billions of years to get here and they'd be exposed to all kinds of ionising radiation in the interim, so it just seems highly implausible that panspermia is going to stand up to that kind of critical analysis."

While true panspermia might seem a bit far-fetched for now, the possibility of life originating on Mars is one that certainly merits further investigation. As is the case with theories of this sort, however, Occam's razor often holds true: the simplest answer, in this case that life began on Earth, is normally correct.

"We do know that pieces of Mars get to Earth, we do know that organic compounds were probably on Mars and we do know that [those compounds] could come in a Martian meteorite," surmises Dr Deamer. "In scientific judgement it's still at a level of being implausible, but it's less implausible than true panspermia."

So, are we Martians? It'll take some extraordinary evidence to prove that we are but maybe, just maybe, that evidence is waiting to be found.

Could it have held life? Martian soil under the microscope of the Opportunity rover. The larger rocks are about the size of sunflower seeds