Life on Mars? Will we find it? Will we colonize the Red Planet?

Since the dawn of the Space Age, the planet Mars has been the focus of two ambitious projects. One is the search for life forms native to the planet; the other is human colonization.

For decades, Mars colonization advocates have been promising potential settlers that the time for leaving Earth is nearing. In fact, in terms of producing the actual space hardware—the capability to transport large numbers of passengers into space and the engines and life support to ferry them safely to Mars—we're not much closer to a Mars colony than we were in 1972, when the last *Apollo* lunar mission returned to Earth, so don't sell your house on Earth just yet. On the other hand, we've had one mind-blowing discovery after another about Mars as a result of unmanned exploration conducted over the last decades by NASA.

The evidence that the planet is home to microscopic lifeforms—something akin to Earth's bacteria—has been accumulating slowly, but consistently. While few astrobiologists are ready say that, yes, there's life there, until we have a photo of microorganisms swimming in the microscope field, that moment is really approaching. And we'll probably get to it long before the first astronaut boots cast their prints into the Martian surface dust.

Humans living on Mars still in the dream stage

For the last 43 years, human space exploration has been limited to low Earth orbit (LEO), just a few hundred kilometers above the surface of Earth. Traveling on NASA's new spacecraft, Orion, which is now going through tests, small groups of astronauts will finally be traveling into deep space again soon, this time with international participation. Eventually, this new approach could lead to a human Mars mission.

But as for a human Mars colony, that will be a much longer wait. A Dutch company called Mars One has been recruiting on-line for Mars settler candidates. Selection is being run like a TV reality show. In fact, just two days ago one of the semifinalists was announced, a software engineer from Massachusetts, and he's quoted in the Boston Globe with some very optimistic words.

"The whole thing is a dream come true," the semifinalist exclaimed, after learning that he'd been selected from among thousands of applicants planetwide. At age 51, he's just perfect, one might conclude. Mars One expects to land the first settlers in 2026, and at age 62 the candidate (if selected as a finalist) will be able to retire from his job and go to Mars with a pension. "I can totally see myself . . . in that habitat, working with my team and working every day to make sure our systems are functioning and our resources are sufficient."

That 2026 target date is roughly a decade earlier than NASA expects to get the first astronauts to Mars, using the *Orion* craft that's already going through testing (and which is expected to take humans back to the moon and to near-Earth asteroids over the next ten years); a ginormous booster system that's also under development; and advanced nuclear propulsion technology, possibly nuclear fusion. If all goes well, liftoff could come by the beginning of the 2030s. Fusion propulsion could allow astronauts to spend just 30 days in transit between Earth and Mars, instead of several months, thereby reducing significantly their exposure to deep space radiation that could induce cancer and render space travelers infertile.

In comparison to NASA's projects, Mars One doesn't have much pre-mission testing to do, because they have neither a spacecraft nor a booster system. But they are still selling the "idea". Thus, recently, a high profile critic emerged, former Canadian astronaut Julie Payette who wrote:

> Nobody is going anywhere in 10 years..We don't have the technology to go to Mars, with everything we know today, so I don't think that a marketing company and a TV-type of selection, is sending anybody anywhere. So, if you meet any of those people, don't tell them they're courageous because the only courage they had was to sign up on a website.

It's very blunt, and perhaps meant for its shock value, but Payette's statement is backed by several engineers at MIT who say basically the same thing. Even if you had the needed funding, which Mars One does not, the hardware development takes time, at least if you want to get to your destination in one piece.

Microscopic life forms

For the first 75 years of the 20th century, people interested in the prospect of finding native life forms on Mars took a major roller coaster ride. Based on his observations through a mountain telescope in Arizona, astronomer Percival Lowell reported seeing overt evidence, not only of rudimentary Martian life, but of a civilization of intelligent beings capable of forging huge systems of canals that he guessed had been built to carry water from the planet's polar caps to highly populated, water-deprived cities.

Most space scientists doubted Lowell in his own time–many people considered him a quack. And this doubt only deepened over the next decades as telescopes improved. Up until the 1960s it was expected that Mars harbored vegetation on the surface. That hope dissipated in 1971 when the NASA probe *Mariner 9* orbited Mars and sent back detailed pictures showing what seemed to be a barren surface, more like that of the moon.

Then, came Project *Viking*, which delivered two NASA probes–*Viking* Landers 1 and 2 (VL1 and VL2) to the Martian surface with a plethora of instruments in 1976. Included was an one for chemical analysis and a "biology package" consisting of three experiments to be conducted on dirt samples, scooped from the surface of the landing sites by a robotic arm.

Scientists monitoring one of the landed biology experiments, called the Labeled Release Experiment (LR), observed that when mixed with a nutrient solution, consisting of small organic compounds (think of it as a little snack for possible little life forms), the dirt broke up the nutrients and released a gas. However, when heated prior to the experiment for three hours at 160 degrees (enough to kill most microorganisms in soil on Earth), the nutrients did not break down into gas.

Based on tests of the LR using Earth soils prior to the launch, VL1 and VL2 tests suggested positive results for the LR experiment on Mars. However, the chemistry analysis of dirt samples taken from the same landing sites showed a lack of organic compounds. Without organic matter in the dirt, it was hard to see how there could be life, despite the results of the LR, so most of the *Viking* science team considered the LR result to be a false positive, resulting from some unknown chemistry on the planet's surface that mimicked life's effects on the nutrient solution and also could be deactivated by heat.

To this day, in paper after paper, the LR principal investigator, Gilbert Levin, has maintained his belief that his LR instrument did detect some kind of microorganisms. The bulk of planetary scientists and astrobiologists has remained cautious, but over the years, more probes were sent to the planet and the surface no longer looks to be as hostile to life as the *Viking* team originally concluded in the 1970s. At the same time, the Viking chemistry studies have come under scrutiny. While the *Viking* chemistry instrument found none of the organic chemicals that would have been expected in connection with life, it actually did find small amounts of two organic compounds: chloromethane and dichloromethane.

"That gospel of the Viking results has influenced our perspective on life of Mars for 35 years," according to NASA's Chris McKay. But now the perspective may have to change.

To be sure, McKay has said many times that a new perspective on Martian organic material is not evidence that Levin's LR detected Martian life. But the perspective on the prospect of Martian microorganisms—detected or not detected by the Viking LR—certainly has been evolving over the last few years. In 2008, a NASA Mars probe called *Phoenix* detected a class of organic chemicals called perchlorates in Martian dirt samples. Using dirt samples from Chile's Atacama desert (considered to be an Earth environment similar to Mars), McKay and some colleagues of his then showed that perchlorates in soil heated the same way as samples tested by *Viking* actually produce chloromethane and dichloromethane, the very same organic chemicals that VL1 and VL2 detected.

This does not prove that the LR biology experiment actually detected life, but it may require that the entire rationale used to dismiss the LR results as false positive be reassessed, particularly as more information comes in suggesting that Mars may be more habitable than we used to think.

Since 2008, other findings have added to the case that Mars could be a living planet. One big finding came last year, when NASA's *Curiosity* rover detected fluctuations in the gas methane (natural gas) coming from the Martian dirt (I've been using the term "dirt", not soil, because soil includes an abundance of organic compounds, rather than just broken up rock, a substance that on other planets is known as regolith).

On Earth, various microorganisms produce methane and it's possible that the measured fluctuations on Mars could be the result of life. Another finding, released just this month, involves results from *Curiosity*'s first "wet lab" chemistry tests. In the dirt samples analyzed, results show the presence of a particular organic compound known as a fatty acid. You may know all about this class of compound in the context of nutrition, as we need certain fatty acids in our diet. What's also vital is that fatty acids are key to the structure of the membranes that surround cells. Just this week, based on data from the same instrument on *Curiosity* that made the methane finding, the finding of another ingredient for life was announced: fixed nitrogen. That's a form of nitrogen that on Earth, usually comes from certain microorganisms and plants.

Cautious optimism

As with *Viking* during the 1970s, the *Curiosity* researchers involved in the methane and nitrogen studies are being careful to point out that the finding does not prove the existence of Martian life. But, when you consider everything together, the evidence for native life on the planet is certainly mounting. All and all, the scientific search for Martian life is moving along at a steady rate and it's very exciting. Martian life would give us a new perspective on biology, because it could work differently than Earth life. Its genes could use a different genetic code than we do for example, its DNA could use different nucleotides, or maybe it uses something other than DNA to store genetic information. Any of those cases would mean that Martian life emerged separately from Earth life, but even if we find that it works the same as Earth life (that both began through a common origin event), any life form on Mars would be more different at the biochemical and genetic level than the difference between any two lifeforms on Earth, simply because its ancestors would have been separated from their Earth cousins for billions of years.

Thus, Martian life would constitute a second datum in biology, with all of Earth's life constituting the first. That, in turn, could provide us unprecedented insight into what life is, how it comes about in nature, and how we can control it. That advantage seems huge, compared with a few decades of setbacks in the development of technology to plant humans on the Red Planet. In fact, by the time that humans actually do travel to Mars, the mission could be much more exciting than it would be today, since the travelers would be going there knowing, with full certainty, that they're going to study Martian life.

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