(Stronger) Signs of Life on Mars

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? Standing water and an energy source.

? Five basic elements: carbon, oxygen, hydrogen, phosphorus and nitrogen.

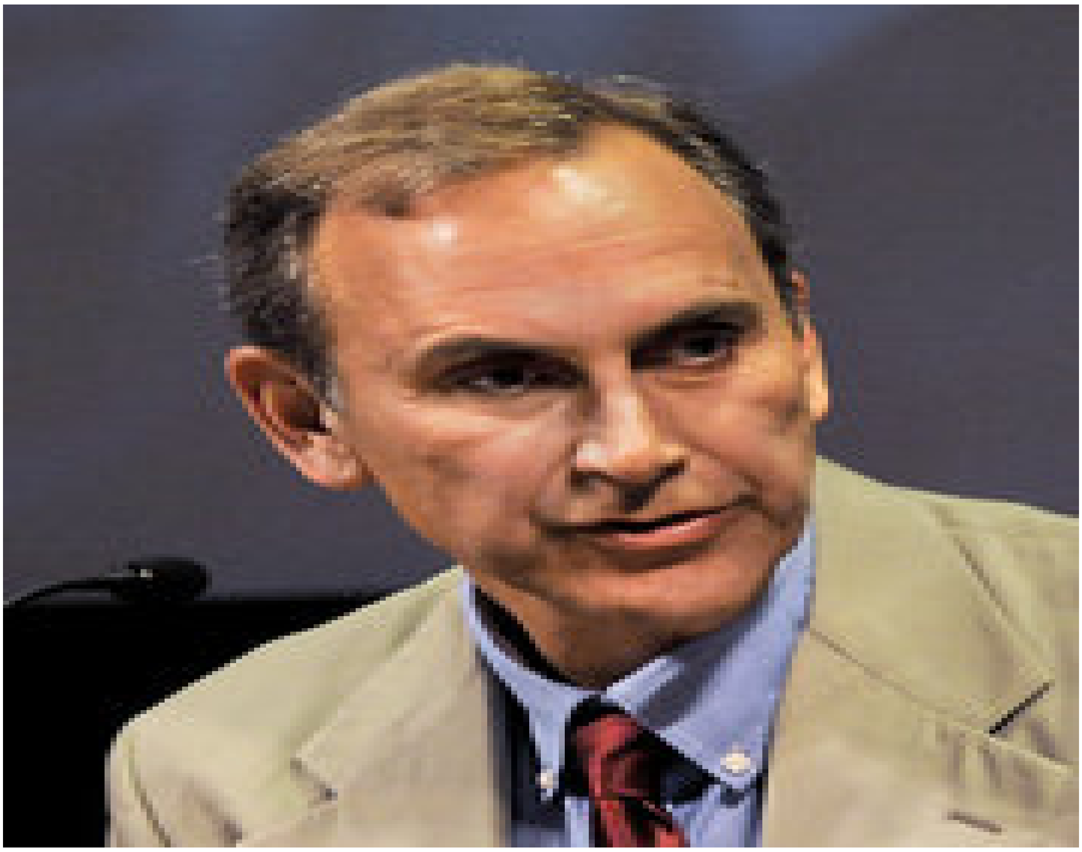
? And time, lots of time.

In its search for environments where life might have started on Mars, the Curiosity rover has nailed the standing water, the energy and the key elements with the right atomic charges. As a result, scientists have concluded that at least some of the planet must have been habitable long ago.

But the period when all conditions were right was counted in hundreds to thousands of years, a very small opening by origin-of-life standards.

That has now changed. John P. Grotzinger of Caltech, the project scientist for the mission, reported at a news conference on Monday that the rover’s yearlong trek to Mount Sharp provided strong new evidence that Gale Crater had large lakes, rivers and deltas, on and off, for millions to tens of millions of years. The geology shows that even when the surface water dried up, plenty of water would have remained underground, he said.

Photo



John Grotzinger, project scientist for the Curiosity rover mission said Monday,

"Mars is looking very attractive to us as a habitable planet."

Credit Michael Tullberg/Getty Images

Moreover, the team concluded, numerous deltalike and lakelike formations detected by orbiting satellites are almost certainly the dried remains of substantial ancient lakes and deltas. None of this proves that life existed on the planet, but the case for an early Mars that was ripe and ready for life has grown stronger.

“As a science team, Mars is looking very attractive to us as a habitable planet,” Dr. Grotzinger said in an interview. “Not just sections of Gale Crater and not just a handful of locations, but at different times around the globe.”

And John M. Grunsfeld, a former astronaut who is NASA’s associate administrator for science, said that after almost 28 months on Mars, Curiosity has given scientists insight into how and where to look for clues of ancient life. “We don’t know if life ever started on Mars, but if it did, we now have a better chance of discovering it” on future missions, he said.

Another missing piece of the story has been the inability to detect organic compounds — the carbon-based building blocks of life.

That too may soon change. Last spring, several Curiosity team members reported the detection of some simple organics that appeared to be Martian. The findings were not definitive, but NASA has scheduled a news conference Dec. 14 at the annual meeting of the American Geophysical Union with “new information” about the search for organics. “Our original interpretation — that there was a good chance the organics we were seeing are Martian — hasn’t changed,” said Daniel P. Glavin of the Goddard Spaceflight Center, an author of the earlier paper. “This interpretation will be expanded on at A.G.U.”

Curiosity does not carry life-detection instruments, in large part because there is no consensus on what such an instrument might be. A finding of life based on what at first appeared to be metabolic activity, detected during the Viking missions of 1977, was so controversial that NASA ultimately rejected it. So scientists have been using a variety of tools — from geology and other earth sciences, organic and mineral chemistry, atmospheric measurements and sophisticated cameras — to determine whether life could have arisen and survived in Gale Crater and other locations with similar characteristics.
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Another member of the Curiosity team, Roger Summons of M.I.T., says that findings from that rover and previous missions suggest that early Mars may have been quite similar to early Earth.

For the first billion years, he said, both planets had stable environments that could support life for substantial periods, and both still share the same chemistry and processes for altering rocks. There is a general scientific consensus that life began on Earth some 3.8 billion years ago, and Dr. Summons said it was clear that the same could have happened on Mars. Or as Dr. Grunsfeld put it, “What I get excited about is imagining a Mars 3.5 to 4 billion years ago, a planet with a thick atmosphere, maybe a blue sky with puffy clouds and mountains and lakes and rivers.”

Many similarities disappeared after Mars, a much smaller planet, lost much of its protective atmosphere by the end of its first billion years. So searching for possible Martian life involves digging deep below the surface or detecting microbial remains billions of years old. Identifying ancient microbial life has proved extremely difficult and controversial on Earth, and the challenge on Mars is considerably greater.

For that reason, scientists have long called for a mission to bring rock and soil samples back to Earth for sophisticated analysis. The Mars mission scheduled for 2020 would begin the effort by experimenting with methods to select, lift and store promising samples.

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Interactive Feature

Mars Curiosity Rover Tracker

A selection of images from NASA’s Curiosity rover as it drives toward Mount Sharp.

OPEN Interactive Feature

But there are no Mars samples now — except those that arrive as long-traveling meteorites — so astrobiologists have to conduct their search for life using other methods and teasing out hidden evidence.

The search for water on Mars, for instance, goes back decades and many missions. But scientists were never certain that the carved canyons and deltas were results of water running long ago, or perhaps lava or frozen carbon dioxide. Because of Curiosity, there is now a wide consensus that early Mars had much water.

This conclusion has been difficult to square with climate models, which point to a colder early Mars with a thin atmosphere that could not have supported large bodies of standing water, or rivers that ran for millions of years. But faced with mounting evidence of longstanding water and consequently warmer conditions, the climate scientists have gravitated toward two interwoven explanations — both with implications for early life.

The first is that frequent volcanoes and meteorite impacts heated the planet substantially; volcanoes also emit gases known to synthesize into organic compounds. The second is that to explain the substantial water cycle required to keep many Martian lakes filled and rivers flowing, the planet needed a substantial ocean in its northern half. Large swaths of Mars north of its equator are one to three miles lower than the so-called southern highlands, and scientists have proposed that an ocean may have filled and molded the vast depression. Others disagree on several grounds, including that no remnant shoreline has been detected.
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“We don’t have hard evidence of a northern ocean, but our models require that much water to explain what the geologists have now confirmed,” said Michael A. Mischna of the Jet Propulsion Laboratory, another Curiosity team member. “What Curiosity has done is to bring together atmospheric and climate information with the findings of the geologists and geochemists, and created a broad and consistent story of a very wet early Mars.”

While the evidence for water has become increasingly clear, the question of organic compounds is in flux. Such chemicals fall onto Mars all the time in interstellar dust and meteorites, as they do onto Earth. Yet none have been definitively detected.

But on this mission, team members knew to look for a salt called perchlorate that has been demonstrated on Earth to destroy or transform organics in the presence of heat. Substantial amounts of perchlorate were found in Gale Crater, suggesting that if early Mars had organic chemicals and they survived eons of radiation bombardment, they are long since gone or they will remain very difficult to detect with current techniques.

The Sample Analysis at Mars instrument is designed to identify relatively simple organics that burn off as gases in its oven. But it also carries nine cups with a solvent that can alter more complex molecules (like amino acids and nucleic acids) in ways that protect their signature.

This “wet chemistry” has been awaiting the finding of a sample rich in organics. A further problem is that one of its cups leaked, causing enormous headaches and making team leaders wary.

But Dr. Glavin, a member of the team, hopes the spilled solvent will itself be used to test previously collected Martian samples, making it the first wet-chemistry experiment ever on another planet.

Clearly, the search for life on Mars — past or present — will be neither straightforward nor swift.

Marc Kaufman’s new book, “Mars Up Close: Inside the Curiosity Mission,” is published by National Geographic Books.