

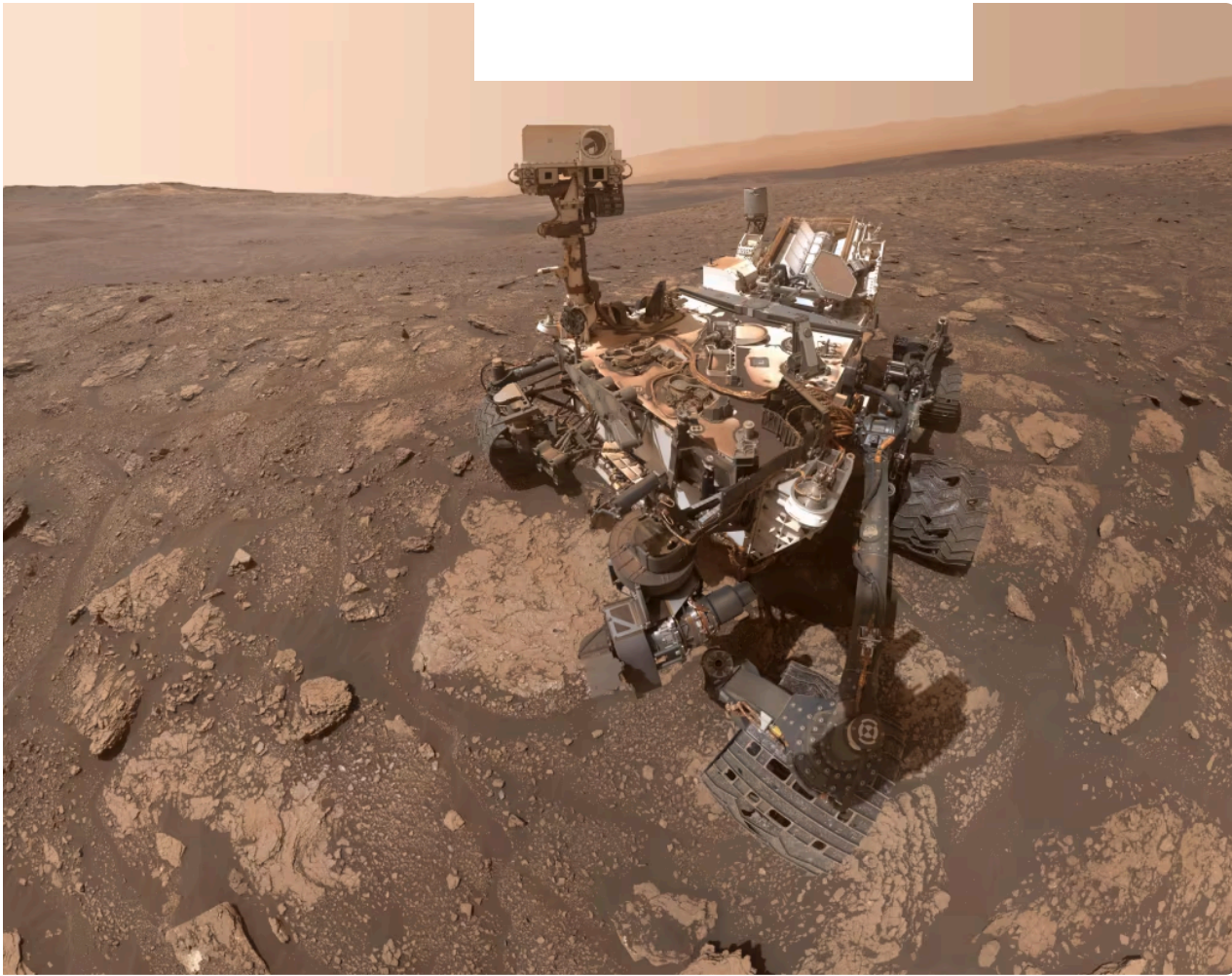


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Curiosity rover detects building blocks of life in first-ever experiment on Mars

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By  Ashley Strickland



The Curiosity Mars rover takes this selfie in 2020 after drilling a rock sample from a site named after British paleontologist Mary Anning. (JPL-Caltech/MSSS/NASA)



The **Curiosity rover** has uncovered the most diverse array of organic molecules ever found on Mars, including seven that had never been detected before on the red planet.

These carbon-containing compounds are the same building blocks that enabled life to emerge on Earth.

The results, published Tuesday in the journal **Nature Communications**, came from a first-of-its-kind experiment on Mars: The rover collected a rock sample and dissolved it in a chemical solution to unlock the secrets of its composition.

The research team believes the organic molecules identified in the rock have been preserved on Mars for 3.5 billion years, said lead study author Dr. Amy Williams, associate professor of geological sciences at the University of Florida and a scientist on the Curiosity mission.

“These findings are important because they confirm that larger complex organic matter is preserved on Mars over geologic time periods, despite the harsh radiation environment,” Williams said. “This supports the search for habitable environments on Mars, which is defined as a place where life would have wanted to live if it was present.”

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The outcome complements Curiosity’s previous detections of organic compounds and adds support to the idea that Mars was likely once a habitable planet billions of years ago, as opposed to the frozen desert it is today.

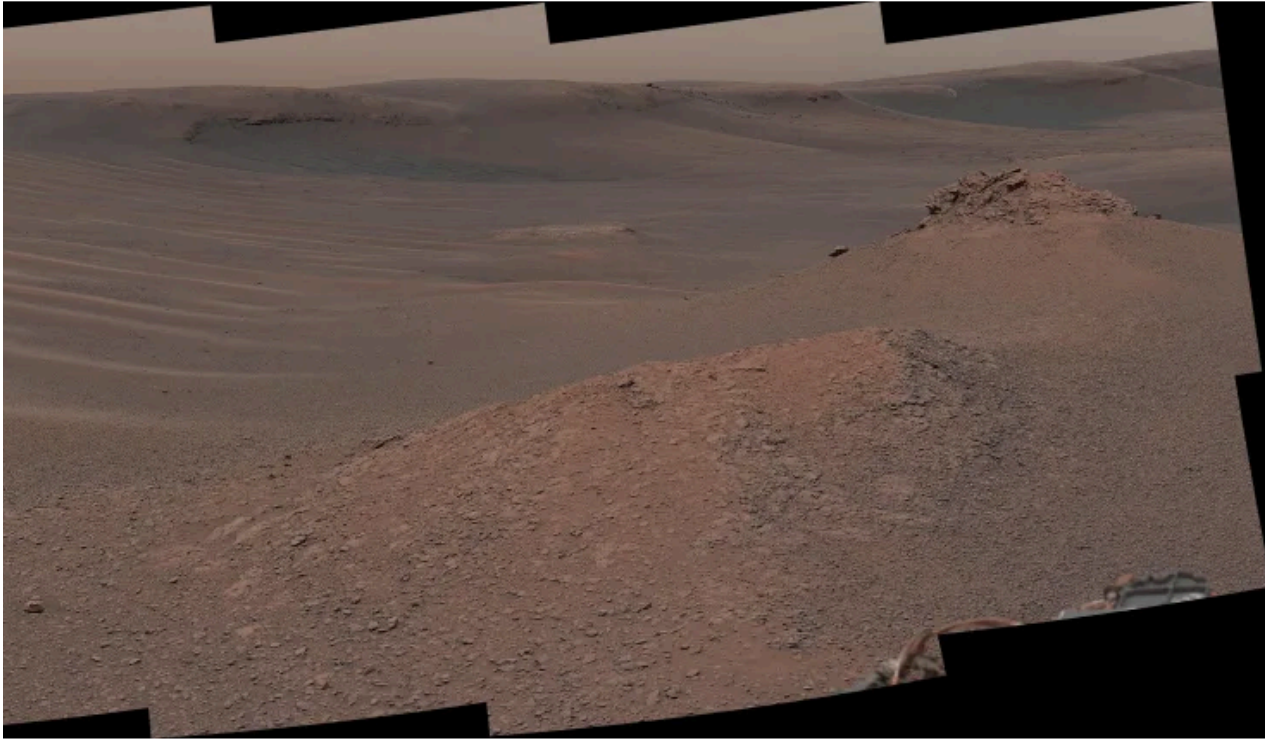
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“The revelation of the mission to me has been not just that Mars was habitable,” said study coauthor Ashwin Vasavada, Curiosity’s project scientist at NASA’s Jet Propulsion Laboratory in Pasadena, California. “It’s just how amazingly habitable it was.”

The milestone wet chemistry experiment was not designed to distinguish whether the molecules act as signs of ancient life on Mars, whether the molecules were delivered to the red planet by meteorite impacts or if the organic material was simply the result of geologic processes.

But the findings highlight a rallying point for many planetary scientists. To determine definitively whether life ever existed on Mars, rock samples need to be returned to Earth.

Seeking the perfect target



Curiosity's Mastcam captures this mosaic in 2019 of a region on Mount Sharp with many clay-bearing rocks. (JPL-Caltech/MSSS/NASA)

The Curiosity rover landed in Gale Crater on Mars in 2012 with the goal of determining whether the planet were ever habitable. For years, the rover ascended a feature called Mount Sharp within the crater, aiming to reach clay-rich layers that orbiters circling the planet had spied.

The clay layers, which can preserve organic molecules, suggested that water was not only present on Mars in the distant past, but that it disappeared and reappeared at the site over time.

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Curiosity took six or seven years after landing to reach the clay layer in the Glen Torridon region of Mount Sharp, but the wait was worth it, Vasavada said. The rover came across evidence of mudstones from ancient lakes as well as sandstone where moving water once trickled into the lakes.

Members of the rover's vast team came together to decide the best possible spot for Curiosity to drill a sample to test for organic material. The rover only has two wet chemistry cups on board, so the team members wanted to make the experiment count. They decided on a site they named **Mary Anning**, after the pioneering 19th century British paleontologist.

Curiosity drilled the clay mineral-containing sandstone sample in 2020, pulverized it and placed it within the SAM, or Sample Analysis at Mars, instrument, located in the rover's belly.

SAM can heat samples in a small oven and use other apparatuses within it to detect the gases released by minerals as they break down due to heat. The instrument has been used to make other key organic chemistry findings on Mars.

The rover dropped samples into a small cup of tetramethylammonium hydroxide, or TMAH. The corrosive solution can break apart large molecules that would be hard to identify and reveal otherwise invisible molecules, the University of Florida's Williams said.

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The team was able to identify 21 carbon-containing molecules, including the newly detected nitrogen heterocycle, or a ring of carbon atoms that includes nitrogen — a structure that serves as a predecessor to RNA and DNA, or nucleic acids coded with genetic information.

“That detection is pretty profound because it shows the chemical precursors to more complex nitrogen-bearing molecules,” Williams said. Nitrogen heterocycles have never been found before on the Martian surface or confirmed in Martian meteorites.”

The results also revealed the presence of benzothiophene, a carbon- and sulfur-bearing molecule typically found in meteorites, which could have collided with planets like Earth in the past.

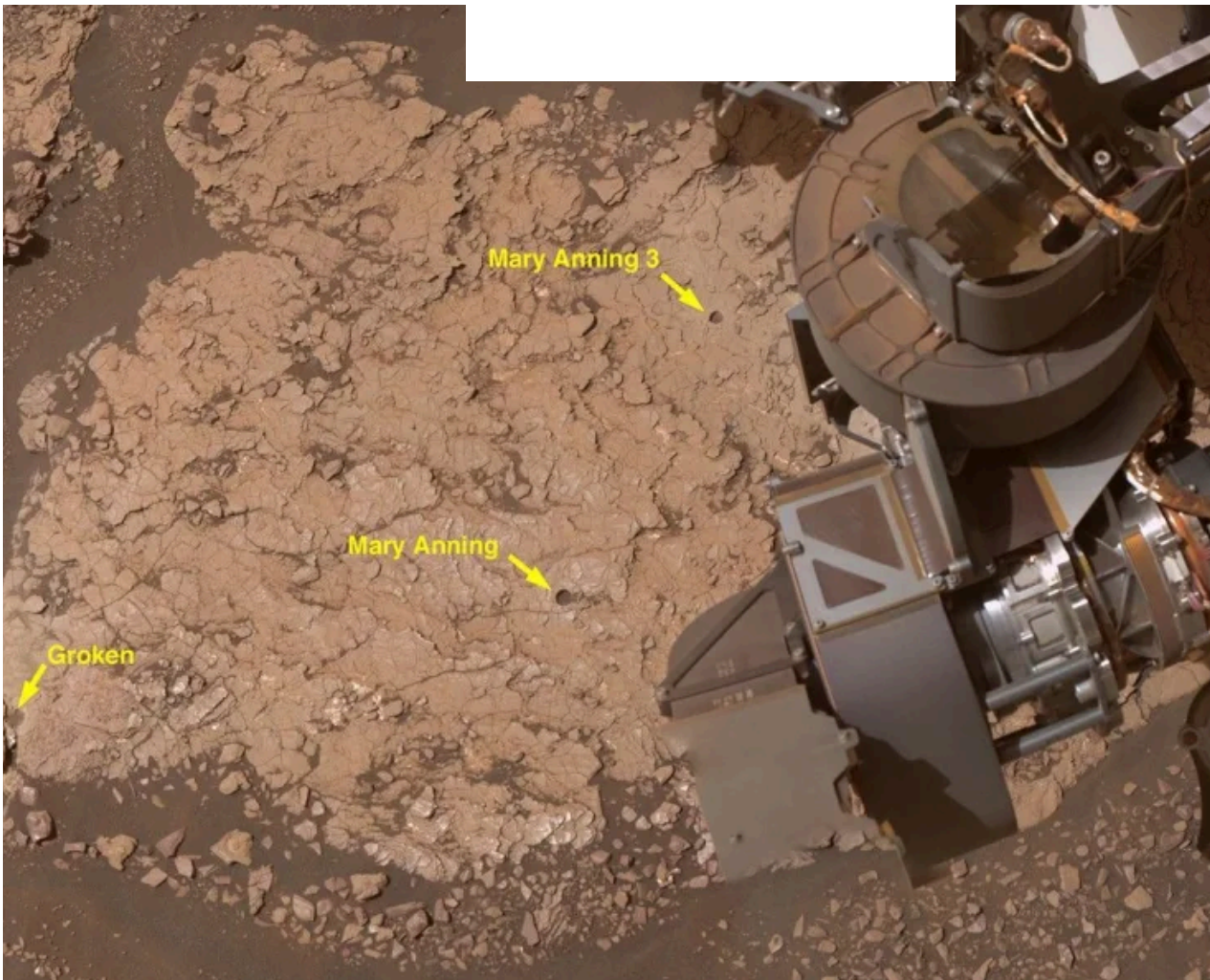
“The same stuff that rained down on Mars from meteorites is what rained down on Earth, and it probably provided the building blocks for life as we know it on our planet,” Williams said.

Part of the new study also included verifying Curiosity’s results with extensive testing in labs on Earth. The researchers exposed a piece of the Murchison meteorite, which contains organic molecules, to TMAH. The meteorite’s larger molecules broke down into similar ones spotted in the Mary Anning sample, including benzothiophene.

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The Murchison meteorite, discovered in Australia in 1969, is more than 4 billion years old and contains organic compounds.

Answering a profound question



An annotated close-up shows three holes Curiosity drilled into Martian rock at the Mary Anning site in 2020. (JPL-Caltech/MSSS/NASA)

Within the past year, Curiosity has also detected the **largest organic molecules ever discovered** on Mars, while the Perseverance rover observed leopard spots on rocks that **ancient life may have made**. The observations, combined with the new results, are painting an intriguing portrait of what Mars was like in the distant past, Vasavada said.

“I’m not an organic chemist myself, but seeing a diversity of organics means that you’re sensing kind of the tip of the iceberg of a greater diversity that was there in the past,” he said.

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The experiment also paves a path for future missions that intend to carry similar chemical experiments to search for organic compounds across our solar system.

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Both the European Space Agency's ExoMars Rosalind Franklin rover, which will land on the red planet to explore a different region by the decade's end, and NASA's Dragonfly mission to study Saturn's moon Titan, will carry wet chemistry experiments on board.

"It was a feat just figuring out how to conduct this kind of chemistry for the first time on Mars," said study coauthor Charles Malespin, principal investigator for SAM at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "But now that we've had some practice, we're prepared to run similar experiments on future missions."

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The discovery is a clear demonstration that sedimentary rocks on Mars can preserve evidence of the organic material that was once on the planet's surface environments billions of years ago, said Dr. Briony Horgan, professor of Earth, atmospheric and planetary sciences at Purdue University in West Lafayette, Indiana. Horgan has been a coinvestigator and planner on the team for the Perseverance rover mission but was not involved in this study.

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“While we can’t yet say that these o starting to build up the data to answer that question,” Horgan said. However, to fully answer the question of whether or not these organics indicate life on ancient Mars, we’ll need to bring samples back from Mars to study in our labs on Earth. Returning the Perseverance samples from Mars remains the top priority of the planetary community.”

Congress canceled an ambitious but expensive plan by NASA and ESA in January to return samples collected by Perseverance to Earth, but scientists are not backing down from reinforcing why it’s the most crucial step to answer one of humanity’s biggest remaining cosmic questions: Has life ever existed beyond Earth?

Vasavada, who has witnessed NASA’s methodical approach to searching for evidence of ancient water and past habitability on Mars, believes returning samples is the only way to complete this multidecade quest for answers.

“This program that started in 2000 ended with a definitive experiment to figure out if life ever existed,” Vasavada said, referring to the proposed return of samples to Earth. “I want the story to finish.”

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