

Ancient bacteria might lurk beneath Mars' surface

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Deinococcus radiodurans (affectionately known as “Conan the Bacterium”) is particularly well-suited to surviving Mars' harsh environment. In experiments, it survived astronomical amounts of radiation in the freezing, arid environment. Credit: Michael J. Daly/USU

In a first-of-its-kind study, a research team, including Northwestern University's Brian Hoffman and Ajay Sharma, found that ancient bacteria could survive close to the surface on Mars much longer than previously assumed. And—when the bacteria are buried and, thus, shielded from galactic cosmic radiation and solar protons—they can survive much longer. Thus, when Mars' first samples return to Earth, scientists should be on the lookout for ancient sleeping bacteria.

These findings strengthen the possibility that if life ever evolved on Mars, its biological remains might be revealed in future missions, including ExoMars (Rosalind Franklin rover) and the Mars Life Explorer, which will carry drills to extract materials from 2 meters below the surface.

And because the scientists proved that certain strains of bacteria can survive despite Mars' harsh environment, future astronauts and space tourists could inadvertently contaminate Mars with their own hitchhiking bacteria.

The paper will be published on Tuesday (Oct. 25) in the journal *Astrobiology*.

"Our model organisms serve as proxies for both forward contamination of Mars, as well as backward contamination of Earth, both of which should be avoided," said Michael Daly, a professor of pathology at Uniformed Services University of the Health Sciences (USU) and member of the National Academies' Committee on Planetary Protection, who led the study. "Importantly, these findings have biodefense implications, too, because the threat of biological agents, such as Anthrax, remains a concern to military and homeland defense."

"We concluded that terrestrial contamination on Mars would essentially be permanent—over timeframes of thousands of years," said Hoffman, a

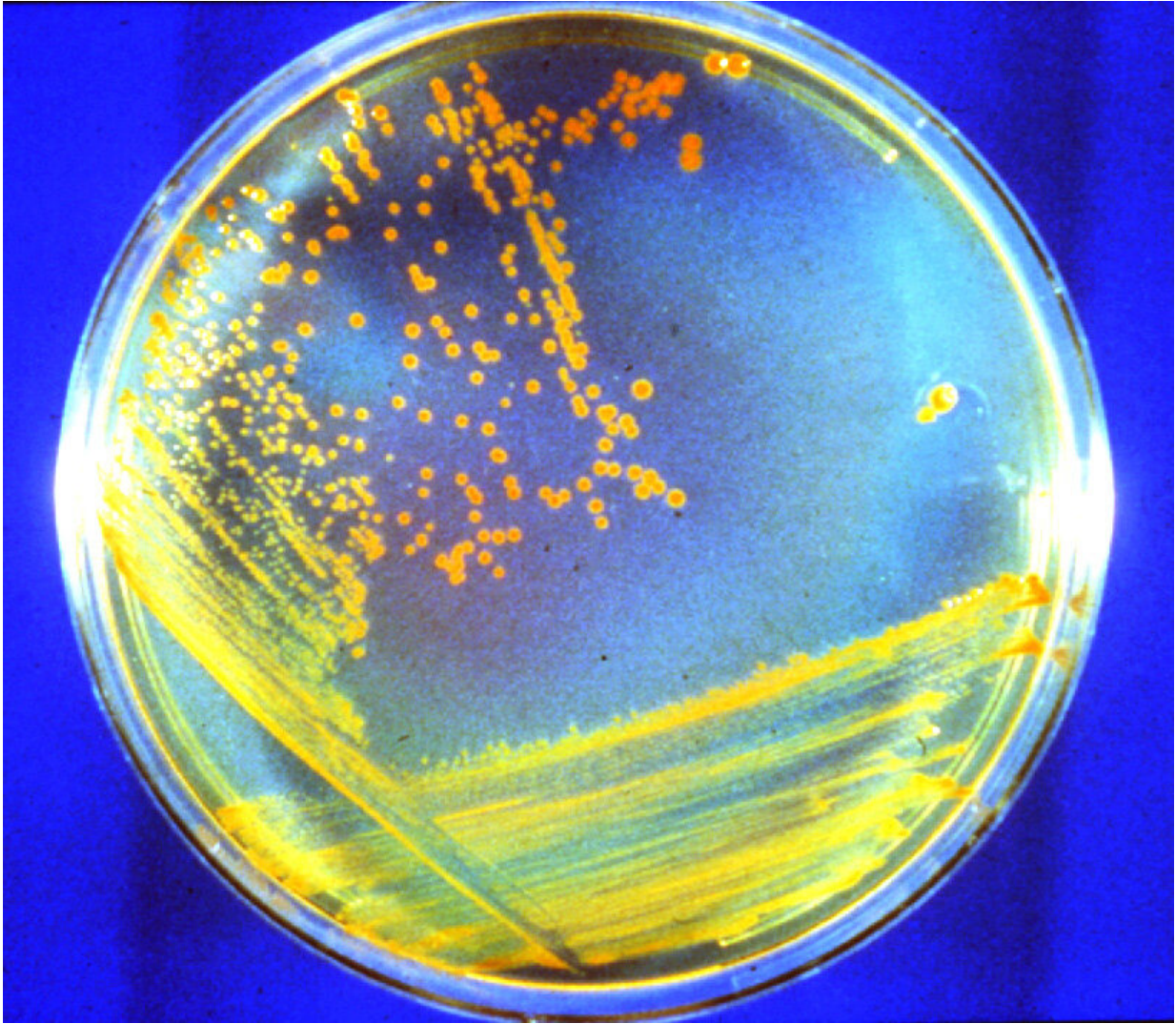
senior co-author of the study. "This could complicate scientific efforts to look for Martian life. Likewise, if microbes evolved on Mars, they could be capable of surviving until present day. That means returning Mars samples could contaminate Earth."

Hoffman is the Charles E. and Emma H. Morrison Professor of Chemistry and professor of molecular biosciences in Northwestern's Weinberg College of Arts and Sciences. He also is a member of the Chemistry of Life Processes Institute.

Simulating Mars

The environment on Mars is harsh and unforgiving. The arid and freezing conditions, which average -80 degrees Fahrenheit (-63 degrees Celsius) at mid-latitudes, make the Red Planet seem inhospitable to life. Even worse: Mars also is constantly bombarded by intense galactic cosmic [radiation](#) and solar protons.

To explore whether or not life could survive in these conditions, Daly, Hoffman and their collaborators first determined the ionizing radiation survival limits of microbial life. Then, they exposed six types of Earthling bacteria and fungi to a simulated Martian surface—which is frozen and dry—and zapped them with [gamma rays](#) or protons (to mimic radiation in space).



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Credit: Michael J. Daly/USU

"There is no flowing water or significant water in the Martian atmosphere, so cells and spores would dry out," Hoffman said. "It also is known that the surface temperature on Mars is roughly similar to dry ice, so it is indeed deeply frozen."

Ultimately, the researchers determined that some terrestrial microorganisms potentially could survive on Mars over geologic timescales of hundreds of millions of years. In fact, the researchers discovered that one robust microbe, *Deinococcus radiodurans* (affectionately known as "Conan the Bacterium"), is particularly well-suited to surviving Mars' harsh conditions. In the novel experiments, Conan the Bacterium survived astronomical amounts of radiation in the freezing, arid environment—far outlasting *Bacillus* spores, which can survive on Earth for millions of years.

Radical radiation

To test the effects of radiation, the team exposed samples to large doses of gamma radiation and protons—typical to what Mars receives in the near subsurface—and far smaller doses, which would occur if a microorganism was deeply buried.

Then, Hoffman's team at Northwestern used an advanced spectroscopy technique to measure the accumulation of manganese antioxidants in the radiated microorganisms' cells. According to Hoffman, the size of the radiation dose that a microorganism or its spores can survive correlates with the amount of manganese antioxidants it contains. Therefore, more manganese antioxidants means more resistance to radiation—and more enhanced survival.

In earlier studies, previous researchers found that Conan the Bacterium, when suspended in liquid, can survive 25,000 units of radiation (or "grays"), the equivalent to about 1.2 million years just below Mars' surface. But the new study found that when the hearty bacterium is dried, frozen and deeply buried—which would be typical to a Martian environment—it could weather 140,000 grays of radiation. This dose is 28,000 times greater than what would kill a human.

Although Conan the Bacterium could only survive for a few hours at the surface while bathed in [ultraviolet light](#), its lifetime improves dramatically when its shaded or located directly below Mars' surface. Buried just 10 centimeters below the Martian surface, Conan the Bacterium's survival period increases to 1.5 million years. And, when buried 10 meters down, the pumpkin-colored bacterium could survive a whopping 280 million years.

Looking to future missions

This astonishing survival feat is partially thanks to the bacterium's genomic structure, the researchers found. Long suspected, the researchers discovered that Conan the Bacterium's chromosomes and plasmids are linked together, keeping them in perfect alignment and ready for repair after intense radiation.

That means that if a microbe, similar to Conan the Bacterium, evolved during a time when water last flowed on Mars, then its living remains could still be dormant in the deep subsurface.

"Although *D. radiodurans* buried in the Martian subsurface could not survive dormant for the estimated 2 to 2.5 billion years since flowing water disappeared on Mars, such Martian environments are regularly altered and melted by meteorite impacts," Daly said. "We suggest that periodic melting could allow intermittent repopulation and dispersal. Also, if Martian life ever existed, even if viable lifeforms are not now present on Mars, their macromolecules and viruses would survive much, much longer. That strengthens the probability that, if life ever evolved on Mars, this will be revealed in future missions."

The study is titled "Effects of desiccation and freezing on microbial ionizing radiation survivability: Considerations for Mars sample-return."

More information: Effects of desiccation and freezing on microbial ionizing radiation survivability: Considerations for Mars sample-return, *Astrobiology* (2022). [DOI: 10.1089/ast.2022.0065](https://doi.org/10.1089/ast.2022.0065)

Provided by Northwestern University

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