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CAN EXTREME BACTERIA TEACH US ABOUT EXTRATERRESTRIAL LIFE?

Carolyn Wang [1*], ***Briley L. Lewis*** [2] ***and Kristina Beblo-Vranesevic*** [3,4,5]

[1] *Department of Statistics and Department of Public Affairs, University of California, Los Angeles, Los Angeles, CA, United States*

[2] *Division of Astronomy and Astrophysics, Department of Physics and Astronomy, College of Physical Sciences, University of California, Los Angeles, Los Angeles, CA, United States*

[3] *Institute of Aerospace Medicine, German Aerospace Center (DLR), Cologne, North Rhine-Westphalia, Germany*

[4] *German Aerospace Center (DLR), Cologne, North Rhine-Westphalia, Germany*

[5] *Department of Radiation Biology, Institute of Aerospace Medicine, German Aerospace Center (DLR), Cologne, North Rhine-Westphalia, Germany*

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ABIGAIL
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AGE: 14


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AGE: 14

Have you ever wondered if there is life beyond Earth? Scientists have been studying this topic for a long time and believe the answer might lie in extremophilic microbes, small organisms that thrive in extreme environments. In a 2022 study, scientists took extremophilic microbes from an analogue environment, or place on Earth similar to Mars, and put them in simulated Martian conditions. After exposing them to higher ultraviolet radiation levels, low oxygen levels, a dry atmosphere, and moisture-free Mars-like soil, these microbes still were able to survive. This research is important in helping us understand if Mars can house life and give us clues into what that life might look like beyond Earth.

IS THERE LIFE BEYOND EARTH?

Are there living beings on other planets? Scientists have wondered about this fascinating question for many years, and they still have not found a definite answer. Over the past century, new technologies have helped scientists to learn more about other planets in our solar system and have discovered that those planets are very different from Earth. For example, Mars, Earth's red-colored neighbor, has a typical temperature of −80° F. That is even colder than the average temperature of Antarctica, the coldest place on Earth!

Because other planets are so unlike Earth, scientists predict that **extraterrestrial life**, or life beyond Earth, might look completely different from the plants, animals, and humans we are used to seeing on our planet. One form of life that could survive and even thrive on planets with extreme conditions is **extremophilic microbes**. These are microscopic living beings that love crazy conditions like super-hot or super-cold temperatures, high levels of acidity, or low amounts of oxygen [1]. As scientists learn more about these extreme-habitat-loving microorganisms, they are coming to believe that understanding extremophilic microbes could be essential to our search for extraterrestrial life.

EXTRATERRESTRIAL LIFE

Any life that exists outside of Earth.

EXTREMOPHILIC MICROBES

Micro-organisms that thrive in extreme conditions, such as high/low temperatures, acidic pH levels, high levels of salt, and limited oxygen.

ORGANIC MOLECULES

Chains of carbon and other atoms that form chemical compounds. Organic molecules are the building blocks of all living things.

UNMANNED ROVERS

Machines we control from Earth that can explore other planets and collect information that can teach us about the Martian climate and terrain. Unmanned rovers on Mars include *Perseverance* and *Curiosity*.

ANALOGUE ENVIRONMENTS

Places on Earth that may have conditions similar to those present on Mars now or in the past.

MARS AND ITS COPYCATS ON EARTH

Many scientists think that Mars is one of the planets most likely to house life. Scientists have found clues that Mars once had the necessary components for life: liquid water and **organic molecules**, which are chains of carbon and other atoms that make up the building blocks of all living things. Pictures taken of the surface of Mars show gullies, which are carvings on the surface that look like they were made by running water (Figure 1). Scientists also discovered that Martian soil has similar elements to the soil found on early Earth, including carbon and other organic molecules [2].

Because Mars has a relatively high chance of having life on it, scientists are trying to learn more about the planet. However, it is difficult to travel to Mars because it is hundreds of millions of miles away. We have sent some **unmanned rovers**, or machines that we control from Earth, that roam around the surface of Mars. We have also sent spacecrafts to orbit around Mars. All of these missions are very expensive and time-consuming. Sending humans to Mars is an exciting possibility, but it could still be many years before this dream becomes a reality.

The next best thing to being on Mars is finding environments on Earth that are similar to Mars, which are called **analogue environments**. These Martian copycats are easier to access for experimentation and exploration. Scientists have already identified some Mars analogue environments like the dry, dusty plains of Tibet, China and the icy cold

Figure 1

This image, from NASA, shows gullies on the surface of Mars. These gullies are clues that there may have been running water on Mars in the past (Photo credit: https://mars.nasa.gov/resources/22353/complex-gullies-in-a-crater/).

Figure 1

climate of Antarctica [3]. Mars analogous environments can also be created in the lab, where scientists can simulate the harsh conditions of the planet.

EXPERIMENTING WITH EXTREMOPHILIC MICROBES ON EARTH

To test whether extremophilic microbes could survive on Mars, a team of European scientists collected samples of extremophilic microbes living in analogue environments. *Buttiauxella* and *Salinisphaera shabanensis* are strains of bacteria that thrive in extreme conditions and are part of the extremophilic microbe family. *Buttiauxella* was isolated in Southern Germany from cold springs with limited oxygen and *Salinisphaera shabanensis* came from the salty Red Sea.

The scientists allowed these bacteria to grow in the lab and then placed these samples in an artificial environment that was similar to the environment on Mars. The scientists first dried out these extremophilic microbes and decreased the oxygen levels to mimic the dry, low-oxygen atmosphere on Mars. After three months, the scientists checked on the microbes in the Mars-like environment. Their observations showed that a sizable fraction of both extremophilic microbe samples survived over the three months! The scientists also mixed the two species of bacteria and allowed them to grow together. When mixed, the extremophilic microbes actually experienced higher rates of survival in the artificial Mars conditions.

Then, the scientists added in other Mars-like factors. They exposed the extremophilic microbes to Martian levels of ultraviolet light, the amount of high-energy radiation that Mars gets from the Sun. UV levels are much higher on Mars compared to Earth because Mars has a thinner atmosphere, without protective gas like Earth to block UV

rays [3]. They also put in low-moisture soil from Earth that is similar to the dry soil on Mars, which we call **Martian regolith** (Figure 2). The extremophilic microbes continued to survive under these conditions. In fact, adding the soil actually increased the survival rates of the microbes. Scientists predicted that this happened because the dry soil protected the extremophilic microbes from the higher UV levels.

MARTIAN REGOLITH

Dry, dusty soil that covers the surface of Mars.

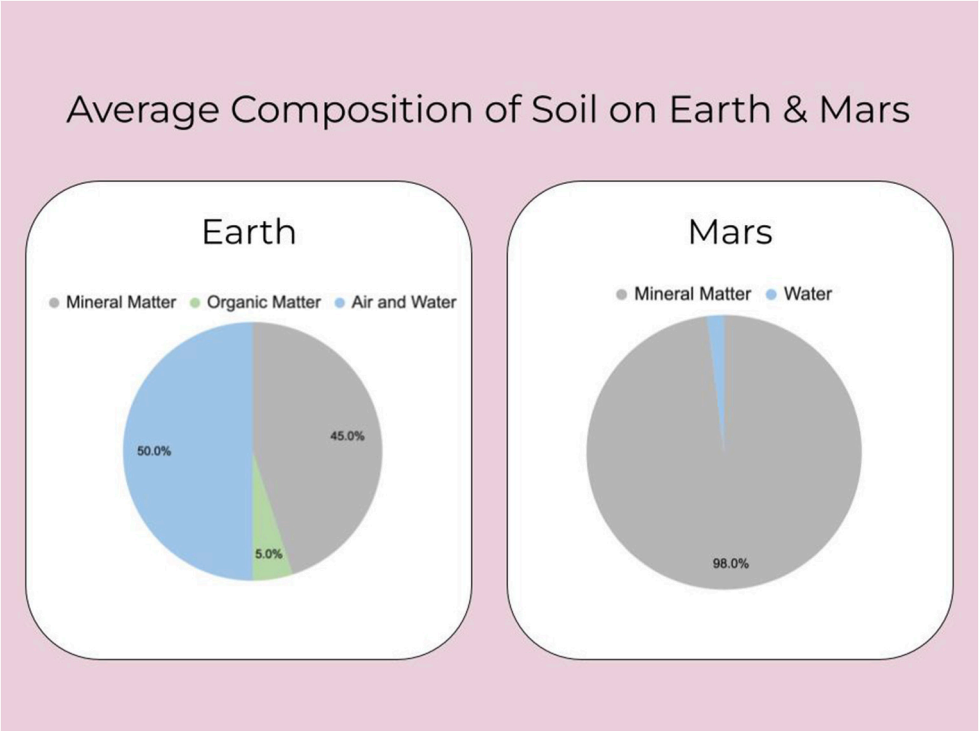

Figure 2

Martian regolith has a much different composition than soil on Earth, especially in its water percentage. Scientists found Earth soil with low moisture and used it in the experiment to copy soil from Mars. Inspired by http://tomatosphere.letstalkscience.ca/Resources/library/ArticleId/5302/soil-on-mars.aspx with data from NASA.

WHAT DOES THIS TELL US ABOUT LIFE ON MARS?

The results of this experiment are exciting because they provide evidence that Mars could be a habitat for life. If these extremophilic microbes can withstand the conditions the scientists created in their experiment, they could also survive on Mars! The survival of *Salinisphaera shabanensis* and *Buttiauxella* in a Mars-like environment also confirms that extremophilic microbes are likely to be the forms of life we would encounter beyond Earth because other organisms would not be able to tolerate these extreme conditions.

MARS EXPOSED EXTREMOPHILES MIXTURE

A 2025 project where selected organisms will be sent to the International Space Station for experimentation.

Looking to the future, the scientists hope *Salinisphaera shabanensis* and *Buttiauxella* are chosen for the project called **Mars EXposed Extremophiles Mixture** (MEXEM) which is supposed to happen in 2025. The MEXEM project will choose some extremophilic microbes and bring them to the International Space Station, which is floating in orbit above Earth, to run more experiments on them over three months. Though the scientists learned a lot from the experiments they

did on Earth, studying these extremophilic microbes in space will allow them to fill in some gaps in their knowledge about the survival of extreme-habitat-loving microbes on Mars.

Though humans continue to explore the possibility of finding living beings beyond Earth, we now have an exciting direction for our search. Learning more about extremophilic microbes like *Salinisphaera shabanensis* and *Buttiauxella* could be one of the most important clues for solving the mystery of extraterrestrial life on Mars and beyond.

ORIGINAL SOURCE ARTICLE

Beblo-Vranesevic, K., Piepjohn, J., Antunes, A., and Rettberg, P. 2022. Surviving Mars: new insights into the persistence of facultative anaerobic microbes from analogue sites. *Int. J. Astrobiol.* 21:110–27. doi: 10.1017/S1473550422000064

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YOUNG REVIEWERS

ABIGAIL, AGE: 15

My favorite subjects are Mathematics, Physics, Political Science, and Astronomy. The system of stock market has been grabbing my attention lately. Music is a huge part of my life as I am a firm believer that music is therapy. Some of my hobbies include playing tennis, swimming, and dancing. I am adaptable, strong, and witty. I enjoy reviewing scientific articles for Frontiers for Young Minds.

JIARUI, AGE: 14

My name is Jiarui, and I am a 8th grader at a middle school. I won national prizes in English speech competitions and state awards for coding. I like piano, and have gotten the Grade 8 Certificate of ABRSM with a distinction score. I am very interested in physics, astronomy and life science. I also like baking and cooking. I love dogs and have two poodles.

DANIEL, AGE: 14

I love helping. I tutor students in my school. My passion for maths and sciences have earned me recognition in national competitions. I build devices and virtual objects. My projects include building mini robots using arduinos, creating a Mars base in Minecraft, designing a trail-mix sorter, rigging a portrait to bring it to life, and developing a robot that controls dispensing. I love soccer, kayaking, poetry, chess, and puzzles. I enjoy mystical books. I am glad to review scientific articles.

AUTHORS

CAROLYN WANG

Carolyn Wang is an undergraduate student at University of California, Los Angeles. She is pursuing a bachelor's degree in public policy and statistics and is interested in pursuing a career in the legal field. However, after taking the seminar "Astrobiology in Science Journalism" she has become extremely fascinated by astronomy and the potential for discovering extraterrestrial life. In her future, Carolyn hopes to take more astronomy classes, keep writing about science, and continue learning about the possibility of life beyond Earth. *carolynwang25@ucla.edu

BRILEY L. LEWIS

Briley Lewis is a Ph.D. candidate and National Science Foundation Fellow in the Department of Astronomy and Astrophysics at the University of California, Los Angeles. Her research interests are exoplanets, solar system science, infrared instrumentation, and science education. As a graduate student, she has developed and taught a new seminar on "Astrobiology in Science Journalism", where students write original pitches and articles with support to pursue publication. She is also a freelance science writer, with articles in Scientific American, APS News, SPIE

Photonics Focus, and more. You can learn more about her on her website: www.briley-lewis.com or on Twitter at @briles_34.

KRISTINA BEBLO-VRANESEVIC

Dr. Kristina Beblo-Vranesevic is a research associate in the Astrobiology Group (Department of Radiation Biology, Institute of Aerospace Medicine) at the German Aerospace Center (DLR). She studied biology with a focus on microbiology at the University of Regensburg and completed her Ph.D. there, in cooperation with DLR, on the topic of the survivability of thermophilic and hyperthermophilic microorganisms under simulated space conditions. Since 2011, she has been working on the question of whether and why microorganisms from Mars analog environments can survive Mars-related stress factors, in addition to other projects.