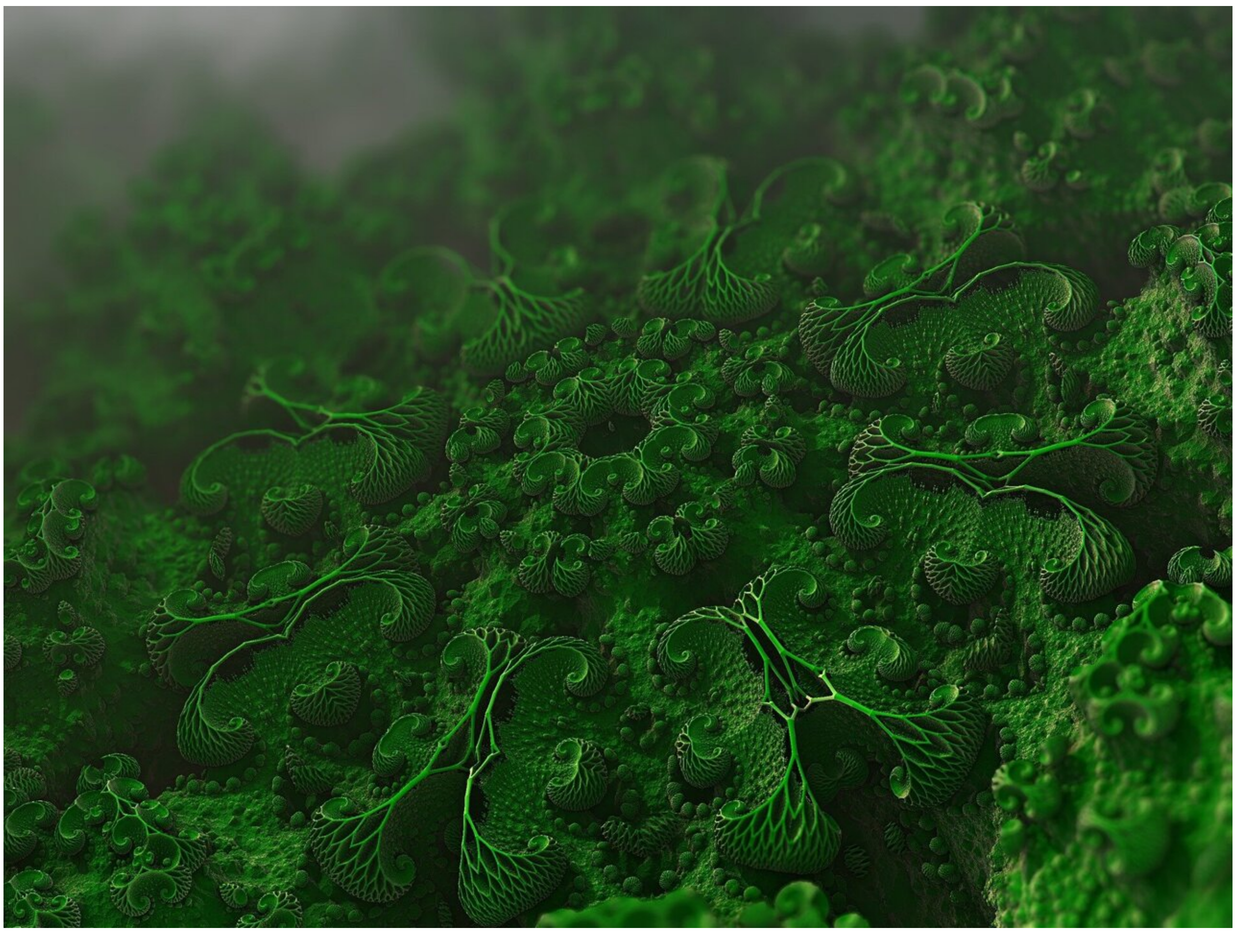
How microbes could aid the search for extraterrestrial life

September 25 2023, by Kartik Aiyer



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In the quest to address fundamental questions about the nature of the universe and the search for extraterrestrial life, space has been an important frontier for human exploration. Microbes, among the earliest forms of life to appear on Earth, have survived the ravages of time, withstood inhospitable conditions and shaped the planet in unique ways, prompting research and intrigue about the plausibility that somewhere, some sort of microbial life might exist beyond Earth.

Space is an extremely inhospitable habitat, which begs the question—could microbes even survive there? One of the earliest experiments exploring microbial ability to persist in space environments involved a Russian satellite carrying strains of E. coli and Staphylococcus to space, in 1960. The study concluded that these particular microbes could survive microgravity. Over the next years, NASA conducted experiments that concluded that not only could some microbes survive the hostile conditions of space, but they could also thrive in them.

One microbe with unique properties to survive intense gamma radiation in space is Deinococcus radiodurans. Experiments designed to test the ability of D. radiodurans to survive space conditions involved zapping the bacteria with intense gamma radiation, oscillating temperatures at specific intervals and reducing pressure to a space-like vacuum. Despite this barrage of intense stressors, the microbes not only survived, but could also replicate and grow.

While the mechanisms of survival are not fully understood, small-molecule proteome shields and synthesis of novel proteins capable of withstanding oxidative damage are thought to be involved in conferring D. radiodurans the ability to survive space. Furthermore, researchers demonstrated that D. radiodurans could survive in the space station for three years.

Such results have fueled speculations about whether microbes like D.

radiodurans could survive on another planet, as the adaptations that help D. radiodurans survive in space could potentially also be useful in aiding survival on other planets.

Bacteria can get weird in space

Since those initial experiments, NASA has sent several microbes to space, including in missions Apollo 16 and 17. However, their results were puzzling. On some occasions, microbes, including E.coli and Staphylococcus demonstrated increased resistance to antibiotics in space. On other occasions, however, when Staphylococcus was grown in bioreactors simulating microgravity, the virulence decreased significantly, though enhanced biofilm formation was observed. While responses to space stressors varied from microbe to microbe, the bacteria undeniably seemed to be evolving strategies to survive and replicate in space.

Scientists demonstrated that, much like on Earth, changes in the microbes' physical environment triggered the microbe to switch on appropriate genes to compensate for the changes. One of the hypothesized triggers for increased antibiotic resistance was fluid shear, which is the property of a fluid to exert a pressure on the microbe's outer membrane.

Researchers compared the genomes of microbes in space to those seen in Earth, and they discovered that multi-drug resistant efflux pumps, resistome (repertoire of genes encoding antibiotic resistance) and tolerance to metals was higher in space conditions. It was hypothesized that these adaptations, alongside physical changes in membrane composition, were responsible for aiding survival in space.

Discovery of microbes in the International Space

Station

It was discovered that the International Space Station now harbors a diverse array of microbes, including bacteria and fungi. Several bacterial and fungal phyla were present, including Acintobacteria, Firmicutes, Proteobacteria and Ascomycota and Basidiomycota. The results, published in 2019, showed that that several of these microbes were associated with the microbiome of astronauts, and some were opportunistic pathogens.

While scientists are happy to observe that these microbes can now exist in microgravity conditions aboard the ISS, it has led to some valid concerns about contamination, prompting the analysis and development of procedures to disinfect the spacecraft and protect astronauts from disease in space.

The search for extra-terrestrial life

Despite the hazards posed to astronauts, the ability of microbes to survive in space has made the search for extraterrestrial life more exciting, as the behavior of these microbes could provide clues about what mechanisms life could use to survive on other planets.

Magnetotactic bacteria like Magnetospirillum are known to regulate the iron biogeochemical cycle on Earth, and possess the ability to sequester iron as well as magnetite in their cells. As a result, scientists have hypothesized that the high amounts of magnetite present on the Martian surface may serve as a critical mineral when it comes to supporting life on the planet, though several other factors are necessary.

NASA's Perseverance rover, which landed on Mars in February 2021, is looking for rock samples to bring back to Earth to analyze for signs of ancient life. It is worth noting that iron, unlike carbon and sulfur, leaves behind a solid state isotope after heating and metamorphosis of rocks, making it an important timescale biomarker.

Magnetite crystals similar to those observed in magnetotactic bacteria on Earth were present on a Martian meteorite ALH84001, though the discovery was later classified as "consistent with life but not requiring life to explain it."

In light of increasing excitement about extraterrestrial life, countries are ramping up efforts to search for life on space missions. For example, India's premier space organization, the Indian Space Research Organization (ISRO), recently launched the lunar rover Chandrayaan-3, that landed near the South pole of the moon, a first in space exploration history.

One of the many goals of the moon lander, named Pragyan, is to study the thermophysical characteristics of the moon and compare them to Earth to find signatures for biological activity. NASA's numerous space missions have also yielded a wealth of information aiding the search for biological activity, with the Perseverance Rover specifically analyzing samples for signs of past microbial life.

With increasing information obtained across such missions, scientists are hopeful of finding alien life or at least helping life from Earth survive in other planets.

Provided by American Society for Microbiology