3 Questions: Sara Seager on the discovery of a 'new' form of life

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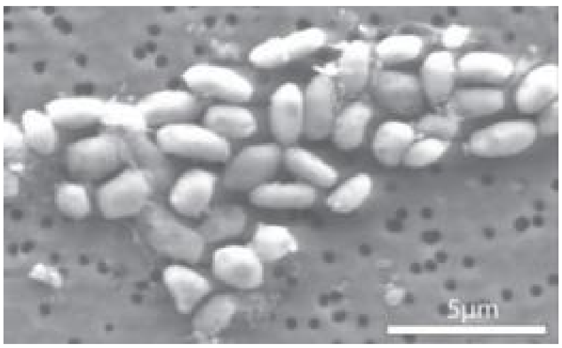

An image of GFAJ-1 grown on arsenic. Image: Science/AAAS

Yesterday, NASA announced the discovery of a bacterium that can grow on a diet of arsenic and thus doesn't share the biological building blocks traditionally associated with all life forms. The discovery raises the possibility that organisms may exist in configurations that weren't previously thought possible — either here on Earth or elsewhere.

Sara Seager, the Ellen Swallow Richards Professor of Planetary Science in MIT's Department of Earth, Atmospheric and Planetary Sciences and professor in MIT's Department of Physics, studies organisms known as extremophiles that can live in extreme environments (like the one announced this week), as part of the effort to search for life on planets outside the solar system, or exoplanets. She discussed the discovery — and what it means for finding life elsewhere in the universe — with MIT

News.

Q. How might this finding impact our current understanding of how life on Earth began?

A. The new finding is about bacteria that can substitute arsenic for phosphorus in a cell's fundamental building blocks. Arsenic and phosphorus are chemically similar. The arsenic is associated with nucleic acids and proteins in a way that led the researchers to suggest arsenic is swapping out for phosphorus in the DNA backbone. Extraordinary discoveries require extraordinary evidence, however, and so more detailed data will be required for more robust conclusions.

In and of itself, the new finding does not suggest anything new toward understanding the origin of life on Earth; the arsenic as a biochemical building block is almost certainly an adaptation rather than a remnant of a different origin-of-life scenario. The finding is, however, truly breathtaking by showing that life can exist outside the traditional truths that have been conventionally accepted up until now.

Researchers will undoubtedly search for evidence supporting a "shadow biosphere," a microbial biosphere with life with forms we don't yet recognize because they could have radically different biochemistry. A shadow biosphere would mean a "second genesis" — an independent origin and evolutionary pathway to the rest of life as we know it.

Q. What does this finding mean for finding life on exoplanets? Will researchers start to look for arsenic in exoplanet atmospheres? Will this affect the kinds of planets that researchers will look for?

A. The new finding fuels our motivation to think as broadly as possible about what kinds of environments are suitable for life. The discovery will not change the kinds of exoplanets we are looking for in the search for life on other worlds; in that regard, we are limited by technology and the number of nearby stars. The discovery supports the notion that life on exoplanets might be very different from life on Earth. We aren't concerned with what life on exoplanets is made of, just what life does and the byproduct biosignatures life generates. Even though arsenic is not a biosignature gas, the finding is a clear reminder that there are likely unrecognized biosignature gases, and we need to get to work to identify them.

Q. What are extremophiles, and how do they relate to biosignatures, or signs of life?

A. Extremophiles are life that can exist in extreme environments. Some organisms actually thrive in extremes that would kill most other kinds of life including humans. Some examples include thermophiles that flourish in temperatures above water's boiling point, barophiles that live at the high pressures at the bottom of the ocean floor, and acidophiles that exist in highly acidic conditions. The new discovery involves bacteria that live in an arsenic-rich lake — a lake that is also high in salt concentration and very low in acidity.

Extremophiles, like all life, have metabolic byproducts. For remote sensing of life on distant planets, we are interested in metabolic byproduct gases that accumulate in a planetary atmosphere and can be identified. We call such gases biosignatures. Extremophiles are so varied in the chemicals that they eat and breathe such that they produce a wide range of gases that could be potential biosignatures on other worlds.

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