Expectation of extraterrestrial life built more on optimism than evidence, study finds

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(Phys.org) -- Recent discoveries of planets similar to Earth in size and proximity to the planets' respective suns have sparked scientific and public excitement about the possibility of also finding Earth-like life on those worlds.

But Princeton University researchers have found that the expectation that life — from bacteria to sentient beings — has or will develop on other planets as on Earth might be based more on optimism than scientific evidence.

Princeton astrophysical sciences professor Edwin Turner and David Spiegel, a former Princeton postdoctoral researcher, analyzed what is known about the likelihood of life on other planets in an effort to separate the facts from the mere expectation that life exists outside of Earth. The researchers used a Bayesian analysis — which weighs how much of a scientific conclusion stems from actual data and how much comes from the prior assumptions of the scientist — to determine the probability of extraterrestrial life once the influence of these presumptions is minimized.

Turner and Spiegel, who is now at the Institute for Advanced Study, reported in the Proceedings of the National Academy of Sciences that the idea that life has or could arise in an Earth-like environment has only a small amount of supporting evidence, most of it extrapolated from what is known about abiogenesis, or the emergence of life, on early Earth. Instead, their analysis showed that the expectations of life

cropping up on exoplanets — those found outside Earth's solar system — are largely based on the assumption that it would or will happen under the same conditions that allowed life to flourish on this planet.

In fact, the researchers conclude, the current knowledge about life on other planets suggests that it's very possible that Earth is a cosmic aberration where life took shape unusually fast. If so, then the chances of the average terrestrial planet hosting life would be low.

"Fossil evidence suggests that life began very early in Earth's history and that has led people to determine that life might be quite common in the universe because it happened so quickly here, but the knowledge about life on Earth simply doesn't reveal much about the actual probability of life on other planets," Turner said.

"Information about that probability comes largely from the assumptions scientists have going in, and some of the most optimistic conclusions have been based almost entirely on those assumptions," he said.

Turner and Spiegel used Bayes' theorem to assign a sliding mathematical weight to the prior assumption that life exists on other planets. The "value" of that assumption was used to determine the probability of abiogenesis, in this case defined as the average number of times that life arises every billion years on an Earth-like planet. Turner and Spiegel found that as the influence of the assumption increased, the perceived likelihood of life existing also rose, even as the basic scientific data remained the same.

"If scientists start out assuming that the chances of life existing on another planet as it does on Earth are large, then their results will be presented in a way that supports that likelihood," Turner said. "Our work is not a judgment, but an analysis of existing data that suggests the debate about the existence of life on other planets is framed largely by

the prior assumptions of the participants."

Joshua Winn, an associate professor of physics at the Massachusetts Institute of Technology, said that Turner and Spiegel cast convincing doubt on a prominent basis for expecting extraterrestrial life. Winn, who focuses his research on the properties of exoplanets, is familiar with the research but had no role in it.

"There is a commonly heard argument that life must be common or else it would not have arisen so quickly after the surface of the Earth cooled," Winn said. "This argument seems persuasive on its face, but Spiegel and Turner have shown it doesn't stand up to a rigorous statistical examination — with a sample of only one life-bearing planet, one cannot even get a ballpark estimate of the abundance of life in the universe.

"I also have thought that the relatively early emergence of life on Earth gave reasons to be optimistic about the search for life elsewhere," Winn said. "Now I'm not so sure, though I think scientists should still search for life on other planets to the extent we can."

Promising planetary finds

Deep-space satellites and telescope projects have recently identified various planets that resemble Earth in their size and composition, and are within their star's habitable zone, the optimal distance for having liquid water.

Of particular excitement have been the discoveries of NASA's Kepler Space Telescope, a satellite built to find Earth-like planets around other stars. In December 2011, NASA announced the first observation of Kepler-22b, a planet 600 light years from Earth and the first found within the habitable zone of a Sun-like star. Weeks later, NASA reported Keplers-20e and -20f, the first Earth-sized planets found

orbiting a Sun-like star. In April 2012, NASA astronomers predicted that the success of Kepler could mean that an "alien Earth" could be found by 2014 — and on it could dwell similar life.

While these observations tend to stoke the expectation of finding Earth-like life, they do not actually provide evidence that it does or does not exist, Spiegel explained. Instead, these planets have our knowledge of life on Earth projected onto them, he said.

Yet, when what is known about life on Earth is taken away, there is no accurate sense of how probable abiogenesis is on any given planet, Spiegel said. It was this "prior ignorance," or lack of expectations, that he and Turner wanted to account for in their analysis, he said.

"When we use a mathematical prior that truly represents prior ignorance, the data of early life on Earth becomes ambiguous," Spiegel said.

"Our analysis suggests that abiogenesis could be a rather rapid and probable process for other worlds, but it also cannot rule out at high confidence that abiogenesis is a rare, improbable event," Spiegel said. "We really have no idea, even to within orders of magnitude, how probable abiogenesis is, and we show that no evidence exists to substantially change that."

Considering the source

Spiegel and Turner also propose that once this planet's history is considered, the emergence of life on Earth might be so distinct that it is a poor barometer of how it occurred elsewhere, regardless of the likelihood that such life exists.

In a philosophical turn, they suggest that because humans are the ones wondering about the emergence of life, it is possible that we must be on

a planet where life began early in order to reach a point so soon after the planet's formation 4.5 billion years ago where we could wonder about it.

Thus, Spiegel and Turner explored how the probability of exoplanetary abiogenesis would change if it turns out that evolution requires, as it did on Earth, roughly 3.5 billion years for life to develop from its most basic form to complex organisms capable of pondering existence. If that were the case, then the 4.5 billion-year-old Earth clearly had a head start. A planet of similar age where life did not begin until several billion years after the planet formed would have only basic life forms at this point.

"Dinosaurs and horseshoe crabs, which were around 200 million years ago, presumably did not consider the probability of abiogenesis. So, we would have to find ourselves on a planet with early abiogenesis to reach this point, irrespective of how probable this process actually is," Spiegel said. "This evolutionary timescale limits our ability to make strong inferences about how probable abiogenesis is."

Turner added, "It could easily be that life came about on Earth one way, but came about on other planets in other ways, if it came about at all. The best way to find out, of course, is to look. But I don't think we'll know by debating the process of how life came about on Earth."

Again, said Winn of MIT, Spiegel and Turner offer a unique consideration for scientists exploring the possibility of life outside of Earth.

"I had never thought about the subtlety that we as a species could never have 'found' ourselves on a planet with a late emergence of life if evolution takes a long time to produce sentience, as it probably does," Winn said.

"With that in mind," he said, "it seems reasonable to say that scientists

cannot draw any strong conclusion about life on other planets based on the early emergence of life on Earth."

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