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Scientists identify exoplanets where life could develop as it did on Earth

August 1 2018

This artist's concept depicts a planetary system. Credit: NASA/JPL-Caltech

Scientists have identified a group of planets outside our solar system where the same chemical conditions that may have led to life on Earth exist.

The researchers, from the University of Cambridge and the Medical

Research Council Laboratory of Molecular Biology (MRC LMB), found that the chances for life to develop on the surface of a rocky planet like Earth are connected to the type and strength of light given off by its host star.

Their study, published in the journal *Science Advances*, proposes that stars which give off sufficient ultraviolet (UV) light could kick-start life on their orbiting planets in the same way it likely developed on Earth, where the UV light powers a series of chemical reactions that produce the building blocks of life.

The researchers have identified a range of planets where the UV light from their host star is sufficient to allow these chemical reactions to take place, and that lie within the habitable range where liquid water can exist on the planet's surface.

"This work allows us to narrow down the best places to search for life," said Dr. Paul Rimmer, a postdoctoral researcher with a joint affiliation at Cambridge's Cavendish Laboratory and the MRC LMB, and the paper's first author. "It brings us just a little bit closer to addressing the question of whether we are alone in the universe."

The new paper is the result of an ongoing collaboration between the Cavendish Laboratory and the MRC LMB, bringing together organic chemistry and exoplanet research. It builds on the work of Professor John Sutherland, a co-author on the current paper, who studies the chemical origin of life on Earth.

In a paper published in 2015, Professor Sutherland's group at the MRC LMB proposed that cyanide, although a deadly poison, was in fact a key ingredient in the primordial soup from which all life on Earth originated.

In this hypothesis, carbon from meteorites that slammed into the young

Earth interacted with nitrogen in the atmosphere to form hydrogen cyanide. The hydrogen cyanide rained to the surface, where it interacted with other elements in various ways, powered by the UV light from the sun. The chemicals produced from these interactions generated the building blocks of RNA, the close relative of DNA which most biologists believe was the first molecule of life to carry information.

In the laboratory, Sutherland's group recreated these chemical reactions under UV lamps, and generated the precursors to lipids, amino acids and nucleotides, all of which are essential components of living cells.

"I came across these earlier experiments, and as an astronomer, my first question is always what kind of light are you using, which as chemists they hadn't really thought about," said Rimmer. "I started out measuring the number of photons emitted by their lamps, and then realised that comparing this light to the light of different stars was a straightforward next step."

The two groups performed a series of laboratory experiments to measure how quickly the building blocks of life can be formed from hydrogen cyanide and hydrogen sulphite ions in water when exposed to UV light. They then performed the same experiment in the absence of light.

"There is chemistry that happens in the dark: it's slower than the chemistry that happens in the light, but it's there," said senior author Professor Didier Queloz, also from the Cavendish Laboratory. "We wanted to see how much light it would take for the light chemistry to win out over the dark chemistry."

The same experiment run in the dark with the hydrogen cyanide and the hydrogen sulphite resulted in an inert compound which could not be used to form the building blocks of life, while the experiment performed under the lights did result in the necessary building blocks.

The researchers then compared the light chemistry to the dark chemistry against the UV light of different stars. They plotted the amount of UV light available to planets in orbit around these stars to determine where the chemistry could be activated.

They found that stars around the same temperature as our sun emitted enough light for the building blocks of life to have formed on the surfaces of their planets. Cool stars, on the other hand, do not produce enough light for these building blocks to be formed, except if they have frequent powerful solar flares to jolt the chemistry forward step by step. Planets that both receive enough light to activate the chemistry and could have liquid water on their surfaces reside in what the researchers have called the abiogenesis zone.

Among the known exoplanets which reside in the abiogenesis zone are several planets detected by the Kepler telescope, including Kepler 452b, a planet that has been nicknamed Earth's 'cousin', although it is too far away to probe with current technology. Next-generation telescopes, such as NASA's TESS and James Webb Telescopes, will hopefully be able to identify and potentially characterise many more planets that lie within the abiogenesis zone.

Of course, it is also possible that if there is life on other planets, that it has or will develop in a totally different way than it did on Earth.

"I'm not sure how contingent life is, but given that we only have one example so far, it makes sense to look for places that are most like us," said Rimmer. "There's an important distinction between what is necessary and what is sufficient. The building blocks are necessary, but they may not be sufficient: it's possible you could mix them for billions of years and nothing happens. But you want to at least look at the places where the necessary things exist."

According to recent estimates, there are as many as 700 million trillion terrestrial planets in the observable universe. "Getting some idea of what fraction have been, or might be, primed for life fascinates me," said Sutherland. "Of course, being primed for life is not everything and we still don't know how likely the origin of life is, even given favourable circumstances—if it's really unlikely then we might be alone, but if not, we may have company."

More information: P.B. Rimmer el al., "The origin of RNA precursors on exoplanets," *Science Advances* (2018). DOI: 10.1126/sciadv.aar3302 , advances.sciencemag.org/content/4/8/eaar3302

Provided by University of Cambridge