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EARLY APPEARANCE OF LUCA ON EARTH AS A RESULT OF PANSPERMIA FROM A FASTER-COOLING MARS

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ABSTRACT

Recently, Moody et al. (2024) reported that the Last Universal Common Ancestor (LUCA) of life appeared on Earth 4.21 ± 0.12 billion years ago, just 300 ± 120 million years after the Moon forming impact. Since Mars cooled faster than Earth and the timing coincides with a period of heavy bombardment by asteroids, we consider the possibility that LUCA was delivered to Earth in the interior of a rock from Mars.

1. INTRODUCTION

Based on divergence time analysis of precursor gene duplicates, calibrated using microbial fossils and isotope records under a new cross-bracing implementation, Moody et al. (2024) reported recently that the Last Universal Common Ancestor (LUCA) of life appeared on Earth 4.21 ± 0.12 billion years ago. This is just 300 ± 120 million years after the Moon forming impact.

2. LUCA FROM A FASTER-COOLING MARS

Earth formed 4.57 billion years ago (Dalrymple 2001). Following the collision that spawned the Moon when Earth was 60 ± 10 million years old (Canup et al. 2023), the surface temperature of Earth reached thousands of degrees, too hot for liquid water to support the chemistry of life as-we-know-it (Betts et al. 2018). It took tens of millions of years for Earth to cool significantly. The discovery of zircon crystals enriched in ^{18}O from 4.4 to 3.91 billion years ago (Mojzsis et al. 2001; Peck et al. 2001; Wilde et al. 2001; Pearce et al. 2018), confirms the presence of liquid water during the inferred appearance time of LUCA. These clues suggest that the period of the Large Heavy Bombardment (LHB) by asteroids (Bottke & Norman 2017) was not intense enough to sterilize Earth from life by vaporizing all reserviors of liquid water on its surface, consistently with the uncertainties discussed in recent studies (Reimink et al. 2023; Boehnke & Harrison 2016; Ryder 2002; Hartmann 2019).

The DNA of all living organisms today, from *E. coli* to humans, can be traced back to LUCA. Moody et al. (2024) shows that LUCA was a complex organism, not very different from modern prokaryotes, and it possessed an early immune system to fight viruses. The early start of life on Earth suggests that it could have started quickly under similar conditions on Mars.

The radiative cooling of a planet scales with its surface area, whereas its heat content scales with its volume. Mars is smaller than Earth and so it cooled faster because of its larger surface to volume ratio. There is definitive evidence that early Mars hosted an atmosphere and vast bodies of liquid water similarly to Earth (Grotzinger et al. 2014; Grant & Wilson 2011; Kite 2019), and that its heavy bombardment stopped 4.48 billion years ago (Moser et al. 2019). The early appearance of LUCA on Earth (Moody et al. 2024) suggests that life could have started even earlier on the faster-cooling Mars (Sauterey et al. 2022). Here, we consider the possibility that LUCA formed first on Mars and then transferred to Earth in the interior of rocks.

3. PANSPERMIA FROM MARS DURING LHB

The bombardment of Mars by asteroids during the LHB would have naturally resulted in the ejection of numerous rocks from the surface of Mars. Grazing impacts on Mars could have lifted rocks without substantial heating (North et al. 2023), that would have sterilized LUCA in their interiors.

The feasibility of the transfer of life between Mars and Earth, labeled 'panspermia' (Lingam & Loeb 2020), is demonstrated by the Martian meteorite ALH84001 which was discovered in Antarctica in 1984. The interior of this meteorite was never heated above 40 degrees Celsius (Weiss et al. 2002), implying that the rock was always below room temperature even before it was kicked out of Mars as a result of an asteroid or a comet impact about 15 million years ago. A higher temperature would have broken the magnetic coupling between lattice electrons and demagnetized the rock, in conflict with its detected magnetism (Weiss et al. 2002). Given a low level of heating, a Martian LUCA could have survived in the interior of a similar rock that was ejected in a similar way during the first hundreds of millions of years in Mars' history.

The delivery of LUCA from Mars to Earth could have occurred long after LUCA emerged on Mars. Mars lost its magnetic field dynamo 3.9 billion years ago (Steele et al. 2023), and lost its atmosphere and liquid water 1-2 billion years later (Grotzinger et al. 2014; Grant & Wilson 2011; Kite 2019).

If LUCA was delivered to Earth from Mars, then all terrestrial lifeforms are Martian in origin. In such a case, Moody et al. (2024) may have traced the timing of the appearance of LUCA on Mars and not on Earth. The first solar system astronaut may have been LUCA in Martian rocks, long before Yuri Gagarin ventured into space in 1961.

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