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Potential adaptations of an *E. coli* colony on the surface of Venus

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Abstract
The conditions of the surface of Venus are extremely harsh, and there is no naturally evolved life on Venus. *E. coli* is a bacteria with a number of subtypes and adaptations to varying environments. This paper covers a number of adaptations a theoretical colony of *E. coli* bacteria could evolve, based on pre-existing adaptations of *E. coli* to its natural environments.

Keywords: *Extra-terrestrial Life; Biology; Astrobiology; Bacteria; E.coli; Evolution; Venus*

Introduction

Venus is the second planet from the Sun, and is subject to extremely harsh conditions, compared to those observed on Earth [1]. Earth extremophiles are organisms (mostly microorganisms) which have evolved to survive some of the most extreme environments on the planet [2]. However, this paper does not focus on these extremophiles, but on the possibility of a population of *E. coli* evolving to withstand conditions similar to those found on Venus, based on adaptations to less extreme conditions already present in *E. coli* bacteria.

Why *E. Coli*? Why Venus?

The *E. coli* (*Escherichia coli*) bacterium was chosen as the specimen for this paper for its wide range of adaptability to various environments on Earth. There are a number of *E. coli* subtypes, each of which is adapted to environments including the human intestine [3].

Despite the inhospitality of Venus, there has been a great amount of discussion on the planet's potential habitability, especially in regards to microbial life [4]. One subject of this debate is the possible presence of phosphine (PH_3) in Venus's clouds, which was claimed to be in a higher amount than what could be produced through non-biological means. There have been a number of articles published supporting or opposing this result, although no true consensus has been reached yet as to whether this phosphine detection is a genuine biomarker of life, or just a misreading on part of the scientists involved [4].

Acidity resistance

The atmosphere of Venus consists mostly of carbon dioxide and sulphuric acid [1]. Strains of *E. coli* bacterium which inhabit the human gut are able to withstand pH levels as low as 2.5. This is due to four different systems of acid resistance present in the bacteria [5], one of which is presented in Figure 1. In this mechanism, proteins which could be damaged by low pH bind to molecules known as chaperone proteins, which allow the structure of the damaged protein to be reformed [6]. Since this machinery is already present in *E. coli*, it is possible that it could evolve, through random mutation in DNA, to withstand even lower pH levels.

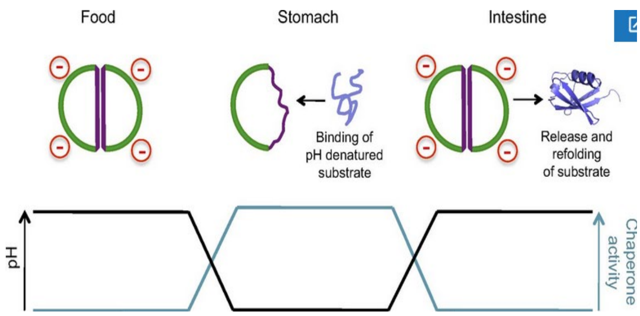

Figure 1 – One of the mechanisms *E. coli* uses to withstand low pH levels. Proteins which are destroyed by acidic conditions bind to chaperone proteins. This enables the structure of the proteins to be protected [6].

Pressure extremes
The surface pressure of Venus is about 90 atmospheres (90 times the pressure of the Earth's atmosphere at sea level). This pressure is comparable to a mile below the ocean [1]. Although this pressure may seem to be only suited to extremophiles, some samples of *E. Coli* have been observed growing even at pressures over 40 megapascals (MPa), or 400 atmospheres. There have been guided evolution experiments carried out, which have produced *E. coli* strains with pressure tolerance not present in the original bacteria [7].

Temperature extremes
The surface of Venus can reach temperatures of 475°C [1]. On Earth, the highest temperature that an extremophile has been able to grow and reproduce in is 122 °C, by *Methanopyrus kandleri*, a microorganism that lives in the Central Indian Ridge [8].

E. coli is generally considered as being heat-sensitive. However, some strains of the bacteria have been reported as being able to survive for as long as 10 minutes in temperatures as high as 60°C [9]. This is generally due to the structure of their membrane, with more heat resistant strains containing more saturated fatty acids (fatty acid molecules with no carbon-carbon double bonds) than heat-sensitive strains [9]. *E. coli* also has other mechanism of heat resistance, such as producing a thick layer of colic acid outside the cell, which provides additional protection for the molecules on the bacterial surface [9]. However, due to the aforementioned record of extremophile heat resistance, it is unlikely that these heat resistant strains could evolve to withstand the much higher temperatures present on the surface of Venus.

Conclusion
Survival of any organism on Venus would be faced with immense challenges. It is no surprise that there is no life on Venus found to this date. Some conditions of Venus, temperature in particular as we have seen, exceed the limits of even the hardiest of Earth's extremophiles, while others (such as pressure) are close to those found on Earth. While the *E. coli* bacteria has a range of adaptability, and in one case has already evolved to survive some of the conditions we would expect from Venus, it is still very unlikely that the bacteria could adapt to others.

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