HABITIABILITY OF OTHER WORLDS AND THE

SEARCH FOR EXRATERESTRIAL LIFE

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3/13/2023

MCB 3703 Astrobiology

**Abstract**

**Introduction**

Finding life on other worlds is an exciting prospect for people all around the world. Scientists have spent years trying to find signs of life elsewhere in the universe and have created methods for detecting planets and moons which have the potential to support life. Research has also been performed on earth to try to explain how life was created and to determine the limits of what organisms can endure in extreme environments. Space missions have also been conducted to detect signs of life elsewhere in the universe.

The first step to finding life beyond earth is to establish what environments organisms can survive in. Experiments can be completed on earth to determine optimal conditions for life to thrive and what the limits of life are. Using this data, the next natural step is to create models to estimate what planets could support life. Many researchers have created different indices to narrow down the search for habitable worlds from thousands of confirmed exoplanets to just tens of potentially habitable worlds. Narrowing the search can then allow space missions to focus their time on exoplanets which are habitable.

**Limits of Life**

Earth has an extremely diverse range of extreme environments, and organisms are found in nearly every single one. Extremophiles are organisms which live in extreme environments on earth which can give researchers information about what life could look like on other planets and what worlds are even habitable.

*Thermophiles*

Thermophiles are organisms found in high temperature environments, above 50 ℃, such as solar heated soil and water, geothermal and hydrothermal sites, and even man-made industrial processes [1]. Three subclasses of thermophiles can also be defined based on how extreme the environment: thermophiles between 50 ℃ and 64 ℃, extreme thermophiles between 65 ℃ and 80 ℃, and hyperthermophiles above 80 ℃ [1]. Living in harsh environments has forced natural selection in these organisms relating to codon usage in mRNA and amino acid composition. At high temperatures protein stability is important for survival which caused evolution to favor different amino acids compared to mesophiles, organisms which live in moderate temperatures. Singer and Hickey concluded that thermophiles would favor glutamine since it adds to the thermostability of proteins [2]. Other researchers have also found that increasing purine levels may explain changes in amino acid composition to promote thermostability, but others have found that purine may just be a minor factor since tyrosine contributes to protein stability despite its codons not being purine-rich [2, 3]. Thermophiles must also utilize extremozymes as their enzymes since they operate in the extreme environments that thermophiles do. These enzymes also have stabilization factors to help operate in these temperatures such as, increased number of ion pairs, smaller loops, reduced surface area to volume ratio, and changes in amino acids [4].

*Barophiles*

*Psychrophiles*

*Anhydrobiosis*

*Radiation*

**Finding Other Worlds**

The search for other habitable worlds requires a couple steps to determine whether a location could support life. Firstly, the world needs to be discovered. Then, the exoplanet needs to be analyzed to determine whether it is potentially habitable. It turns out that discovering exoplanets is quite hard due to them not producing light. Therefore, detection relies on advanced observation and data processing methodology.

Since most telescopes are earth-based, corrections must be made to data collected to account for atmospheric effects, temperature and pressure variations, and stellar magnetic activity. Along with the physical struggles, astronomers cannot observe stars whenever they want due to limited telescope time, limited night time, and limited time that the star is actually in the sky above the telescope [5]. Due to these limitations, very few exoplanets have actually been discovered since searches began in the early 2000s: just over 5300 as of March 2023 [6].

*Discovering Exoplanets*

While it is possible to directly observe exoplanets with telescopes, it is a rare method compared to other indirect methods. It is more common to use methods observing the exoplanets transit in front of its star, the wobble of the star as its pulled by the gravity of the exoplanet, the Doppler shift from the star as it wobbles [5].

A feature of planet-star systems is that the star wobbles or orbits around the center of mass of the system as the planet orbits the star. This is taken advantage of in a few observation methods. The first method takes advantage of the Doppler effect and observes the blueshift and redshift of the star as it orbits the center of mass. Using the variation in velocity of the star, characteristics of the exoplanet can then be predicted [5].

Methods designed to detect exoplanets by observing their transit came later in the search for exoplanets. This method requires the continuous observation of thousands of stars and detects a dimming effect as an exoplanet transits in front of the star [5, 7].

*Determining Habitability*

**Searching for Indications of Life**

*Observing Indicators of Life*

*Past, Present, and Future Missions*

**Conclusions**

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**Figures and legends**