Topic: Mars Biology, G12
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The Biology of Mars

> "If there is, or ever was, life in our solar system beyond the Earth, then Mars is the most likely place to search for evidence of this life." [3]

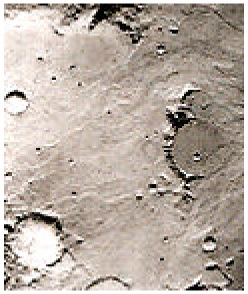
Throughout the annals of recorded time, man has pondered and answered many a perplexing and baffling question: questions of evolution, questions of gravity, questions of creation. Yet, perhaps the most mystifying and bewildering of all has yet to be determined: are we alone? Spanning the gamut over the past three decades, our curiosity has grown exponentially as the missions to Mars have done nothing less than added fuel to our flames of inquiry. Unfortunately, for as much effort that has been invested in this, one of our greatest universal unknowns, the results of our laborious research have rendered inconclusive evidence necessary to justify an answer.

Today, Mars surface appears to have had no life. However, the presence of fluvial provides proof that liquid water was once presence on planet Mars. In comparison to Earth, life originated on Mars earlier perhaps during the end of the late bombardment (McKay, Christopher). This overview of Mars Biology provides evidence that there was once life on Mars and there is still life on Mars. Life is not only a human being but also living organisms. A living organism can range from bacteria, plants, cells, fungi, and a number of compounds and elements.

Throughout the course of this paper, we hope to present what is known about the biology of Mars. We will begin to realize the difficulties behind the idea of life on Mars when we first observe the present day conditions of Mars, and if there is anywhere on Earth to which to compare them. Next, we will delineate several theories of possible life on Mars, so that finally, we'll cover where the future is taking us in the search for life on Mars. This particular area is pertinent to our HEDS-UP group, for it will be necessary to understand the biology of Mars if our robot is to conduct any experiments. This paper will also discuss biology and planetary engineering on Mars, ALH84001, The Possibilities for life on Mars, Origin of Life's Cellular Components, Past and Present Life on Mars Past and Present Life on Mars, Search for Past Life on Mars: Possible Relic

Upon questioning the possibly of life anywhere outside of Earth, perhaps the first thought to enter a scientist's mind is: given the proliferation of life on Earth, how exactly can life exist without water, essential gases, and carbon? Initially, we brush aside ideas of life on a barren, deserted planet, yet a closer look at the physical features of Mars might amend conventional thought. For example, Julian Hiscox in his paper, "Biology and the Planetary Engineering of Mars," outlined seven characteristic attributes of Mars: low pressure, low temperature, water, radiation, oxidants, carbon dioxide, and the presence of no organic material [6]. Each of these traits (or lack thereof), he upholds, to be the main reasons for a deficiency of life on Mars.

First and foremost, we must take a look at the physiology of the planet itself. Networks of dendritic valleys on the oldest Martian surfaces look like those on Earth formed by running water. The water may have come from atmospheric precipitation or "sapping," released from a crustal aquifer. Regardless of where it came from, liquid water undoubtedly played a role. The valleys' dendritic structure indicates that they formed gradually, meaning that water once may have flowed on Mars's surface, although we do not observe such signs today.



CATASTROPHIC OUTFLOW CHANNEL

Evidently, catastrophic floods, bursting from below the planet's surface, carved out great flood channels. Based on this evidence, liquid water should exist several kilometers underground, where geothermal heating would raise temperatures to the melting point of ice. Mars also has had rich energy sources throughout time. Volcanism has supplied heat from the earliest epochs to the recent past, as have impact events. Additional energy to sustain life can come from the weathering of volcanic rocks. Oxidation of iron within basalt, for example, releases energy that organisms can use.

Undoubtedly however, the temperature and pressure differences on Mars are enough to cause problems. The surface temperature oscillates from a low of 140K to a high of 300K, while the pressure averages 6.1 mbar. Consequently, scientists know of no microorganisms from Earth acclimated to a comparable temperature and pressure environment [8]. Mars is also an average of 52.5 million miles farther away from the sun. Thus, Mars receives significantly less radiant energy from the sun, as the sun's energy is proportional to the distance squared away [2]. Another significant difference lies in the gravitational forces of the two, Earth possessing a grasp of 9.806 ms^{-2} while Mars pulls with 3.735 ms^{-2}. However, comparatively speaking, Mars and Earth do hold three places in common. According to Dr. A. Mendez of the University of Puerto Rico:

> Mars has two possible habitable zones. At two meters

Although currently it seems unfeasible to undertake scientific experimentation five kilometers below the surface of Mars, much experimentation on Earth has been done where our planet most emulates the conditions of Mars. Antarctica, because it has a particularly tremendous environment similar to Mars, has been the prime location on Earth to conduct Martian microorganism experimentation. Not only does the arid climate and plummeted temperature resemble that on Mars, for a brief moment in December and January, the sun never sets, allowing Antarctica to receive the longest period of direct sunlight [1]. This period allows scientists to conduct experiments on the effects prolonged light or darkness on the microorganisms they theorize could exist on Mars. Still, despite the similarities and discrepancies in the physical features of Mars to Earth, some scientists would like to look at life from evolutionary perspective. They uphold that because it took a vast amount of time on Earth for evolution to begin, there could have at any point in time be nothing more than simple prokaryotes on the surface of Mars [11].

But a fossilized prokaryote would be all it would take to appease the inquisitive minds still searching for life on Mars. Hence, scientists have hypothesized several potential veins for life on Mars, including the search for fossilized remains, the possibility of subsurface life, and theories on permafrost life.

First, many scientists uphold the likelihood of life based on countless studies from fossilized rock. Dr. Jack Farmer of the Arizona State University implores that fossilization, albeit perhaps the best sign of life, may be difficult to find on Mars. For instance, the medium for preservation is vital to the preservation of the biosignature. On one hand, ice provides an excellent mode of conserving life and sustaining it relatively unscathed, while at the same time, it can easily lose its biological evidence at the first seasonal thaw [5]. Additionally, another fine medium for preservation dependent upon its fundamental strength is rock. While fossilized evidence of life on Earth exists in carbonate form, rather than in a silica or phosphate form, “the tendency of carbonate minerals on Mars to undergo recrystallization during diagenesis often leads to the loss of important microstructural details” [5].

Having vanquished thoughts of life on the surface of Mars, some scientists believe in the conjecture of subsurface life on Mars. Among them, theories of geotransmitting elements and essential requirements for life are rampant, as they feel there could be an active biosphere underground Mars. As justification, one proponent offers the following:

> A small fraction of the photochemically produced CO and H_2 may diffuse downward into the soil to be oxidized by a subterranean biosphere. These are by far the most

Having rejected the “assumed” ideas of surface life on Mars, we can see how the proposal is feasible.

Finally, one last possibility masks itself among the studies of permafrost conditions. Unlike the fleeting nature and inconsistency of ice on Mars, permafrost environments have several advantages. First, the vivacity of the microorganisms for several Ma can justify claims that life can be transferred from one planet to another. Next, the permafrost conditions might render the possibility of extinct life on Mars, allowing scientists to differentiate the long-living creatures resistant to environmental extremes. Finally, studies in permafrost conditions might give scientists the opportunity to discover the genomes of already extinct species from the surface ecosystem [9]. Also, when combined with an experiment called aminostratigraphy, scientists might even be able to determine the age and location of permafrost microorganisms on Mars [4]. Although no life has been evidently discovered thus far, these theories offer a small sampling of where our current scientific research is taking us.

Recent analysis of Martian meteorites found on Earth has led many scientists to conclude that life may have once thrived on Mars--based on fossil remnants seen within the rock. Yet this evidence does not definitively indicate biological activity; indeed, it may result from natural geochemical processes. Even if scientists determine that these rocks contain no evidence of Martian life, life on the red planet might be possible. Just in another unsearch location. To draw a definitive conclusion, we must study those places where life (or evidence of past life) will most likely appear.

ALH84001 is a Martian meteorite, a coarse-grained orthopyroxene containing relatively large amounts of carbonate, with a crystallization age of 4.5 Gyr. Carbonate globules within fractures in the rock are dated at 3.6 Gyr. Fractionation of carbon has taken place to enhance C-13 consistent with terrestrial biogenic process. PAHs also appear on interior fracture surfaces in excess of 1 ppm. They present extensive tests and discussion to show that they are confident that these are all indigenous to the meteorite and do not represent contamination. Mass spec studies show these PAHs are complex not simple and suggest a biogenic source. They then discuss TEM studies of the Fe/S fraction in the meteorite. Nanometer sized magnetite and Fe-sulfide phases are associated with Mg-Fe-rich carbonate. These observed either inorganic or biogenic processes could explain structures and concentrations. Scientist argue that the range of conditions (PH) for inorganic precipitation is unlikely to have occurred on Mars, whereas biogenic processes seem to offer a more natural explanation for the detailed structures observed, and they are apparently similar to terrestrial magnetofossiles (remains of bacterial magnetosomas). SEM studies of carbonate globules are then discussed (typically ovoid and 100 nm across). Origin of the ovoid and other observed textures is unclear, but they may be related to terrestrial microfossils, or they may be erosional features due to partial rock by fluid leading to possible organic deposits of minerals along veins (2) formation of the carbonate globules much later than the formation of the rock itself, (3) SEM and TEM images of the globules that resemble terrestrial biogenic structures, (4) magnetite and iron sulfide particles that could have been formed biogenically. The authors feel that the cumulative effect of these points is to provide "evidence for primitive life on early Mars".

But where exactly are scientists pioneering for the future of Mars exploration? Well, one of the most pervasive proposals incorporates actually bringing life to Mars. According to Christopher McKay's essay, "Bringing Life to Mars," "Mars is currently too cold, too dry and its carbon dioxide atmosphere too thin to support life. But these parameters are interrelated, and all three can be altered by a combination of human intervention and biological change." If the atmosphere of Mars is tweaked just slightly, it is theorized that the change would initiate a transformation enough to yield the planet habitable for plants.

Basically, it would work like this: if we could add a significant amount of CO_2 to the atmosphere, the surface temperature would rise above well above the planet's current low of 140K. As the levels of CO_2 rise, the planet would develop a natural "green-house effect," and by adding a small amount of oxygen to the atmosphere, the CO_2 and O_2 could create a minute but existent ozone layer. Finally, by adding nitrogen to the mix, plants would be able to survive on this new, revitalized Mars. Such a restructuring of Mars is estimated to take ten years [7].

As for our robot, the requirements for life on Earth imply that liquid water is the critical requirement for life on other worlds of the Solar System. Operationally, the search for past or present life is therefore a search for past or present environments where liquid water may be (or may have been) found. There is direct evidence that Mars once had liquid water on its surface, and indirect evidence that even today there may be subsurface Martian aquifers and/or hydrothermal systems. The search for fossils -- either biochemical or structural- would focus on aquatic depositional environments, such as sedimentary deposits from former lakes or hydrothermal systems. Chemical analyses of samples formed under habitable conditions can offer insights into biologically relevant chemistry that may have occurred in these environments. Both the selection of sites bearing evidence of habitable environments (past and present) and the in-situ analysis of surface materials will enable a sample return program that effectively addresses astrobiology goals.

Implementation of our robot towards the investigation for life on Mars:

- Continue to collect Martian meteorites and conduct comprehensive analyses of them.

- Develop geophysical methods to remotely characterize the potential for subsurface liquid water on Mars.

- Develop technologies for accessing broad areas of the Martian surface.

- On Mars access to sediments deposited in lakes as well as potential subsurface hydrosphere requires sampling capabilities beyond the current state-of-the-art. To reach paleolake sediments it would be necessary to get through the aeolian dust, which may extend to depths of 10 meters, and access to depths of 5 or more kilometers may be required for hydrosphere. The long terms goals in the search for extant and extinct life on Mars thus rely in large extent upon broadening the sphere of Martian exploration through advanced mobility and drilling technologies. Even in the short term, greater access will allow sample returns with greater relevance to life. These returned samples will help us look more effectively for life elsewhere. In the long term, increasing the sphere of exploration will set the stage for the human assisted search for past or present life on Mars.

Yet, despite the amazing possibilities that remain only in theory, the cold, stark fact still remains, we do not know if there is life on Mars. Throughout the duration of this paper, we have explored the necessary elements for life on Mars by comparing them to life on Earth. We have delineated several possibilities from what we know of the current Martian environment, and we have seen one way to actually spark a biological environment on the red planet. Unfortunately, in as much as we can hypothesize about the possibilities or relate the conditions of Mars to those found on Earth, we still have no clear-cut evidence of the existence of life. However, rest assured, our insatiable desire to appease our inquisitive minds will never allow us to settle for an inconsistent answer to one of NASA's most perplexing questions.

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