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DO INDIGENOUS MARTIAN BACTERIA HAVE PRECEDENCE OVER HUMAN EXPLORATION?

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ABSTRACT

This paper is a summary of a debate between the authors on the question: "Is it ethical for humans to terraform Mars, even in the event that microbial life is found to exist there?". Zubrin takes a "yes" position and McKay takes the "no" position. The evening debate at the 2000 Mars Society Convention was an historical event pitting the extremes of the broad spectrum of Mars exploration views. It first appeared in On to Mars, Apogee Books, 2002

If we discover living or dormant organisms on Mars and these forms represent a different type of life than the life we have on Earth, then we should not bring life from Earth to Mars. Instead, we should alter the Martian environment so that this native Martian life can expand to fill a planetary scale biosphere.

There is general agreement within the Mars research community that if Mars is indeed a lifeless planet then there is potential scientific, cultural, and human value in bringing life from Earth to Mars. The re-creation of habitable conditions on Mars is within our technological reach. To a Mars long since dead, Earth could give the gift of its genome: a biological heritage encapsulating billions of years of evolution. For Mars this would represent a jump start back into a biological future.

Based on the limited knowledge we do have about Mars, I would conclude that it is presently lifeless even if it did have life during a warmer, wetter period early in its history. While there may well be active subsurface volcanism, it is unlikely that hydrothermal ecosystems have maintained biological continuity over time. There is no evidence for a globally connected subsurface hydrothermal system on Mars. Hence, microorganisms from a distant hydrothermal system would not be able to travel to a new site. Natural radiation from the elements uranium, thorium, and potassium would limit the expected life span of dormant cells on Mars to less than a billion years. Thus, any microbes remaining at a site would likely be dead when a new hydrothermal system erupted. Similarly, organisms frozen in the permafrost since an early habitable epoch on Mars would have received many times the lethal dose even for the most resistant strains like Deinococcus radiodurans.

But we are not sure that Mars is lifeless and we must consider the ethical implications of discovering life on Mars. In these considerations, we must differentiate between the case in which life on Mars is genetically related to life on Earth and the case in which life on Mars represents a separate form of life.

If there is life on Mars, it may be identical to Earth life. Indeed, given our current understanding of the history of these two planets, this is the most likely case. We now realize that the Earth and Mars are not biologically isolated from each other. We have on Earth more than a dozen rocks that came from Mars. The thermal and shock processing of these rocks has not been strong enough to sterilize them. Thus, any microorganism deep inside such a rock would have been able to survive the ejection and reentry events. In the debris from a large impact there would be some rocks that would follow trajectories that went between the planets rapidly and microorganisms inside such rocks could be expected to survive the journey.

Thus the most likely result of finding life on Mars is that it would be biochemically and genetically related to life on Earth. In this case I believe that no serious ethical issues arise. We currently share the Earth with many diverse microorganisms including aerobes, anaerobes, thermophiles, halophiles, pathogens and so on. We could do the same on Mars.

Studies of life on Earth have long indicated that all life on this planet is biochemically similar. Obviously finding life based on a different biochemical pattern would indicate a separate and independent origin of life. Furthermore, recent work has extended our knowledge of life on Earth to show that all life on this planet is genetically, as well as biochemically, related and therefore descendent from a common ancestor. It is possible to imagine a life form that is biochemically identical to Earth life but is genetically different. This would also indicate a separate origin. (Incidentally, genetically different but biochemically identical life, would support suggestions of the universality of the biochemistry in Earth life.) Methods for genetic analysis are sophisticated enough that it would be straightforward to determine if a Martian organism was genetically related to Earth life and could therefore be mapped on the known tree of life. It is interesting to note, however, that to do this analysis requires access to Martian organisms, be they either dead or alive. Fossils cannot provide an answer to this question. Frozen microorganisms in the permafrost can be used to address this question even if they are long dead from radiation.

A more interesting case arises if the life forms found on Mars are not part of the Earthly tree of life. They would then represent a second genesis – an independent origin of life.

If there is indigenous life on Mars, then it is not doing well. We can quantify what it means for a planetary biosphere to do well by looking at the Earth. On Earth, biology dominates the cycles of most of the biogenic elements (C,H,N,O,P,S). On Mars this is clearly not the case. There is not a global scale biosphere on Mars or it would have obvious and planet-wide effects on the atmosphere of Mars – and such effects are not observed. Indeed some have argued, based on the Gaia hypothesis, that life on a planet is either present globally or not at all, and since Mars obviously lacks a global biosphere it lacks any life whatever. Nonetheless we cannot exclude the possibility that there are limited subsurface refugia that still harbor the remnants of an indigenous Martian biota.

We can consider three possible responses to the discovery of indigenous life on Mars. First we could leave it alone. Secondly we could alter Mars to enhance the chances of that biota to become a global scale biology. A third possibility is to collect samples of this life for laboratory preservation, and then replace or augment it with terrestrial life forms. Each of these three options has distinct ethical and scientific aspects that are important to consider in full.

It has been argued that our primary ethical obligation to life on Mars is to leave it alone. In this case we would quarantine that life so as to prevent any unnatural changes to the Martian environment by the introduction of Earth life and to prevent the contamination of the Earth's biosphere by Martian life. However, I believe this approach is too limited and not consistent with the clear biological potential of Mars. If we do nothing to either assist or harm indigenous Martian life we deprive that life and ourselves of the opportunity given by a global scale biological system on Mars. Our experience on Earth strongly suggests that the maximum richness and diversity of life is achieved when life has become fully global and dominates the biogeochemical cycles of a planet. Absent this, Mars cannot be said to be a living planet. It may be, and perhaps would remain, a planet with life, but it would not be a living planet. Furthermore, we deprive ourselves of the scientific and aesthetic value that we could obtain from observations of a second biosphere populated by life forms of a distinctly different origin.

I suggest that if we found a limited Martian biota it would be advantageous to us, and to that biota, to alter the planet Mars in a way that allows that biota to become a global biological system that controls the biogeochemical cycles on that planet. Given the similarities in the early history of Earth and Mars, it is likely that any indigenous Martian life would have had ecological requirements similar to life on Earth: sunlight would be the primary energy source, liquid water the reaction medium, and carbon the key building block. Thus enhancing the habitability of Mars for its indigenous life is likely to be the same task that we envision in making Mars habitable for anaerobic Earth life.

It is very unlikely that we would drive to extinction any native Martian microorganisms in the process of extending the habitability of Mars. As we know from Earth, specialized microorganisms are able to live in small localized environments within a global biosphere. The greatest environmental change in the history of the Earth – the rise of oxygen – did not destroy the anaerobic microbial life that preceded it. In a newly habitable Mars some species of the indigenous Martian life may dominate the expanded biosphere, but it is likely that all the previous environments would still be represented at some scale in the new world. Biologically speaking, Mars would grow without loss and begin a new and separate evolutionary trajectory. It would be of enormous scientific interest to us to be able to observe this process: a second life form creating a second biosphere.

I argue strongly against the third alternative, namely preserving the indigenous Martian life in captivity and establishing a biosphere on Mars based on Earth life. I believe that, first and foremost, this approach is inconsistent with ethical standards. Further, I believe it does not optimize the knowledge we can gain from Mars in biology and ecology. And finally, I believe that supplanting an indigenous Martian biota is not critical to the progress of human expansion beyond Earth. With some difficulty, human expansion can continue without Mars. Human intelligence and drive are large enough and robust enough to move ahead even if Mars is already taken.

The ethical issues arise not because of any necessary respect for microbes per se. It is a respect for a second type of life, a second genesis. Clearly when we take medicinal antibiotics we try our best to exterminate microorganisms by the millions. However, in doing so, we are not exterminating an entire type of life or depriving that system of life of a chance to express its biological and evolutionary potential. It is the difference between killing a single deer and killing all deer. It is the difference between putting one deer in a zoo and putting all deer in zoos. And the difference is amplified by the fact that this is not just another species but another type of life. I see no ethical basis for assuming that indigenous Martian life is of less value and deserving of less consideration than life forms on Earth, especially given that the introduction of Earth life on Mars is not a compelling need but just a discretionary step in the expansion of life beyond the Earth. The incremental gain to humans and life from Earth in displacing indigenous Martian life is small in proportion to the loss of a second type of life and a second independent biosphere.

We do not know if we could inhabit Mars and still leave ecological room for an indigenous Martian biota. Cohabitation is unsupported by our experience on Earth. Earth microorganisms have expanded into every possible niche and would be expected to do so on Mars. Thus Earth microorganisms would probably compete ecologically if not biochemically with the Martian microbes. Ecological principles suggest that one or the other system would eventually displace the other, the two life forms could not both occupy the same ecological space for long. However, this can only be resolved by careful study and experimentation, and it could be that we are able to determine that Earth life on Mars is not inconsistent with allowing an independent indigenous Martian life to thrive.

It has been argued that human actions are as much a part of nature as the origin of life and its inexorable drive to expand. In this view, human actions need not be subject to ethical constraint. Our introduction of life is not any more unnatural than a meteorite carrying a microorganism from Earth to Mars. My personal view is that this is not a valid argument. Humans have accepted that our unique (as far as we know) capabilities include a responsibility to judge and control even our purely biological impulses. Purposeful actions by humans, for example causing the death of other humans, are ethically restricted even if the same actions occur naturally.

Clearly, I am presenting a personal view: there are no absolute criteria for assigning value to life and diversity or for comparing the value of a human outpost against the removal of an indigenous Martian biota. In actuality we may not have to face the dilemma of how to treat indigenous Martian life. Nonetheless, we should be intellectually prepared to face this issue and to defer to indigenous Martians – however microscopic – and even assist them in regaining biological control of their planet. We will be the better for this in both ethical and scientific terms.