THINKING ABOUT LIFE ON MARS: DANGERS AND VISIONS. A. H. Treiman. Lunar and Planetary Institute, Houston TX 77058. (treiman@lpi.jsc.nasa.gov)

It is dangerous to analogize and extrapolate from life on Earth to possible life in the poorly known environments of Mars. Our knowledge of Mars is basic; our knowledge of Earth life is growing; and nearly all past extrapolations to extraterrestrial life have been wrong. Inspired vision is needed to transcend the terrestrial paradigms and patterns of life, and conceive of biologies and ecologies that might have formed and evolved on Mars.

Without martian life or pre-biotic chemistry to study (until perhaps [1]), Earth and its life have formed the bases for analogies with, and extrapolations to, possible martian life. Comparisons with Earth life are inevitable, and date to the beginning of exobiology, e.g. [2] and

> " … to reason from what we see and are sure of to what we cannot, is no false logick. … [F]rom the nature and circumstances of the planet which we see before our eyes, we may guess at those that are farther distant from us." [3]

To understand possible life on Mars, analogies have been made with Earth life in the distant past [4], deep underground [5], and in extreme environments [6]. These analogies are powerful but must be applied cautiously; they can be both too encompassing and too restrictive.

DANGER. Analogies between Earth to Mars are seductive, but potentially misleading if significant differences between the planets are not recognized. It has been all too easy to ascribe inappropriate Earth-like properties to Mars (e.g., [7,8]);

> "… this word analogy is urged, as giving great force to thereasoning. But it must be recollected, that precisely the point in question is whether there is an analogy." [9]

For example, the earliest exobiologists inferred that the planets were inhabited by plants and animals, that some animals or plants were likely sentient, and that they likely had the same senses, virtues, and vices as does humanity [2,3]. P. Lowell analogized from Earth and the works of western civilization to conclude that Mars was an abode of sentient beings [7,8]. Seasonal color changes on Mars were ascribed to crops [7] and later to lower plants [10]. Spectral absorption bands have been ascribed to biologic compounds [11]. And the Viking Lander life science experiments, designed to detect metabolic processes like those of common Earth life, were ambiguous and are still being debated [e.g., 12].

VISION. Analogy between Earth life and Mars life assumes implicitly that both share similar chemical bases and physical requirements, and responded similarly to their environments (e.g., [4]). Taken to extreme, it might be argued that the only possible chemicals, mechanisms, and organizations of life are those of Earth life. On the other hand, chance and contingency may have been as significant in forging the pre-biotic basis for Earth life as they have been in selection and survival of Earth's biota [13]. If chance were important in pre-biotic evolution, then Mars life need not resemble Earth life in any aspect (except perhaps in carbon-based chemistry and in water as a solvent). One must then strain to conceive of extra-terrestrial biochemistries, how they might function, and how they might evolve in response to the poorly understood environments of Mars.

By analogy with the huge diversity of range of terrestrial organisms, here are a few ways that life on Mars could differ from the familiar patterns of life on Earth. {1} Cells might not divide. Most organisms on Earth grow by cell division, but individual funguses and kelp plants are multinucleate single cells [14, 15]. {2} Biochemical pathways might be unrecognizable. A current example is the archaeon *Methanococcus jannaschi*, in which ~62% of likely protein-coding regions for DNA are not known in other organisms, and so may represent unrecognized chemical processes [16]. {3} Biomolecules might not be homochiral. Biological activity in macro-molecules seems to require control of the chirality (handedness) of the precursor molecules (e.g., [17]). Earth life strongly favors homochirality – all precursors of the same chirality. However, controlled use of precursors of mixed chirality may permit formation of molecules with configurations and activities that would otherwise have been impossible or difficult. At least one biologically active polypeptide has specific D-amino acids among its dominant L-amino acids (p.127 of [18]). {4} Cells might not be necessary. Where oxidants, fuel, and nutrients are abundant, there might be little need for cell membranes to support selective transport of chemicals or electrons. Life might only need a substrate on which chemicals could be bound for reaction. {5} Genetic coding might be different. The coding for transcription of DNA to form proteins is nearly invariant for all Earth life. But the DNA code admits some variability– it organisms can specify

unusual amino acids (e.g., selenocystein [18]) or D-amino acids. This variability implies that the genetic code in current Earth life is only one of many possible codings. {6} Genetic material might be different. On Earth, the common G-C and A-T heterocycle base pairs in DNA are sporadically replaced or augmented by other bases [18]. How far could this substitution extend? Might other types of molecules act as nucleic acid bases, perhaps sulfur heterocycles in the sulfur-rich martian crust [19]? Might nucleic acids be only one of many organic systems that could serve as protein templates and genetic carriers? Very speculatively, might the genetic templates even be inorganic [20,21]?

CONCLUSION. Without martian life in hand, an understanding of its possible environments and lifestyles must rely on dangerous analogies with Earth life. Many analogies with life on Earth are certain to be legitimate. Other analogies will be found, in retrospect, to arise from prejudices inherent in having only Earth life as a model for biologic systems. For now, study of martian biology should embrace both jaundiced skepticism and ardent ingenuity.

The first version of this work was prepared for the 1995 LPSC; it was not submitted, and so lost any claim to prescient. I have gone far beyond my expertise, and apologize to those who bear the brunt of my simplicity. I also apologize, in advance, for both excesses of both my skepticism and imagination.

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