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CONTINUING THE BIOLOGICAL EXPLORATION OF MARS; Harold P. Klein,  
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Mars has been an object of interest for the better part of this century. To a biologist, Mars assumes special importance because many aspects of the "theory of chemical evolution" for the origin of life can be tested there. The central idea of this theory is that life on a suitable planet arises through a process in which the so-called "biogenic elements" combine to form increasingly more complex molecules under the influence of naturally-occurring energy sources ultimately resulting in the formation of replicating organic molecules. The "biogenic elements" are present on Mars today. Furthermore, the available evidence also strongly suggests that Mars may have had an early history similar to that of the Earth, including a period in which large amounts of liquid water once flowed on its surface and a denser atmosphere and higher global temperatures prevailed. This is important since many lines of evidence indicate that living organisms were already present on the Earth within the first billion years after its formation- at a time when the environment on Mars may have closely resembled that of the Earth.

Our current knowledge of the state of chemical evolution on Mars can best be described as paradoxical. Most of what we have learned has come from experiments performed on the Viking landers. The combination of planned investigations covered a broad range of techniques to detect signs of chemical evolution. The most surprising data from all of these was the absence of any detectable quantities of organic compounds at the two landing sites. On the other hand, the Viking experiments did indicate that the Martian surface samples contained unidentified strong oxidant(s) that could account for their absence. The identity and topographical distribution of this material on Mars are, at present, unknown. In the samples that were tested, its apparent concentration varied over a ten-fold range and was inversely correlated with the water content of the samples. If this correlation is correct, it would be important to identify sites on Mars where the oxidant(s) is presumably absent (e.g., in the "wet" polar regions) and then to probe there for the presence of organics. With regard to the possibility of finding replicating systems on Mars, no signs suggestive of a living biota were seen by the imaging team after analyzing hundreds of lander images. Nor was there unequivocal evidence for metabolic activity in any of the many samples that were tested in the Viking biology instrument. It is true that some of the data obtained in the metabolic experiments are consistent with a biological interpretation, but this is the case only when viewed without considering all of the Viking results and the ground-based studies that were carried out in efforts to understand the Viking data.

In contemplating future possible missions to Mars, we are left with almost complete ignorance on questions of fundamental importance to biology. What *was* the course of chemical evolution on Mars? Did organics survive on Mars long enough to be built into molecules of biological significance? Did such a process ever result in the formation of *replicating systems*? If this is so, was the resulting biota able to adapt to changing conditions as that planet gradually lost most of its atmosphere, dried out, and became "inhospitable"? That is, are there any specialized ecological "niches" on Mars where indigenous organisms may still be present? The Soviets, in describing their plans for the future exploration of Mars, appear to have placed a high priority on looking for such biological "oases" and on the subsequent search for living organisms at these sites. Recognizing the heterogeneity in the topography of the planet, and the implied potential for heterogeneous micro-environments, extrapolations from the Viking results to the entire globe can not be made with complete confidence. One need only recall that some micro-organisms on Earth have "retreated" into the insides of rocks in

Antarctica, where they have established an environment sufficiently different from the ambient environment to allow them to sustain their growth, or that others have adapted to a non-photosynthetic existence in or near submarine hot-springs that vent from the ocean floor at extremely high temperatures. One question, then, is whether conditions *anywhere* on Mars can still support the growth of organisms- if a biota ever existed there. Another scenario, however, seems more plausible: that chemical evolution on Mars may well have produced living organisms under more favorable conditions, but that these ancient organisms were unable to adapt to worsening conditions and became extinct. Thus, while Mars may now be a "dead" planet, it may still retain evidence for the earlier presence of organisms. This evidence may exist- as it does for the early Earth- in the form of fossilized specimens, preserved (or modified) organic materials derived from the ancient organisms, or carbon, nitrogen, or sulfur- containing materials that show isotopic ratios characteristic of biological processes. In this scenario, of critical importance is how much time might have been available for biological development and diversification. If suitable conditions were maintained for even of the order of a billion years on Mars, its biota could have been widely dispersed. On the Earth, microbial ecosystems were already well-established and well-distributed within this time period. Vestiges of an early biologic era on Mars will require considerable further preliminary exploration of the planet in order to identify potential sites for biological investigation. Much of the surface of Mars appears to be of ancient origins, going back to well within the first billion years of Mars' evolution. Sub-surface samples from such areas may be accessible and would be useful for study. Other features on Mars indicate that numerous channels were cut in its surface by flowing water, and extensive networks of valleys exist that also appear to be of ancient derivation. Moreover, some of the canyons within the large equatorial *Valles Marineris* canyon system on Mars appear to be made up of layered sedimentary material, suggesting deposition in standing bodies of water. Evidence for early biological processes may yet exist in these regions.

It will probably require many missions to Mars to adequately test our current theories about chemical evolution. Ultimately, we may find verification for these ideas on Mars. Conversely, we may find no persuasive evidence to support the theory. In this case, we may learn- or deduce- why the process was prevented or aborted on Mars, and we would then be left with an essentially unverified theory. It is also possible that, in the end, we will have found no evidence to support this theory- without identifying any specific contravening factors. Such a conclusion would have a value unto itself: it would call into question the basic premises upon which the theory of chemical evolution rests.