Speaking of Science

Colonizing Mars: The Age of Planetary Engineering Begins

The National Aeronautics and Space Administration (NASA) seems determined to find life on Mars—even if earthmen have to put it there themselves. Or so it might seem with the recent issuance of a NASA report entitled *On the Habitability of Mars: An Approach to Planetary Ecosynthesis*.*

Thinking small had no part in the report, which summarizes the results of a study coordinated by Robert MacElroy of NASA's Ames Research Center during the summer of 1975.† No sequestering of colonists in domed cities was on the study committee's agenda, for example. Instead, the recommended approach was to make the entire planet fit for human life by altering the martian environment to provide the oxygen, water, moderate temperature, and protection from ultraviolet radiation that earthly life forms have grown accustomed to. Few science fiction authors have thought in such audacious terms. The report writers call it planetary engineering.

A closer reading of the report, published last November, reveals that Mars is in no immediate danger of colonization. The seven-man study committee attempted to assess the habitability of the red planet, and the basic conclusion reached was that "No fundamental, insuperable limitation to the ability of Mars to support terrestrial life has been unequivocally identified." (See Table 1.)

First to be evaluated was the possibility of establishing colonies of hardy microorganisms, such as the blue-green algae that can survive in the dry, cold valleys of Antarctica, on Mars. These organisms would be set loose to generate, by photosynthesis, oxygen for the martian atmosphere. Says the study panel, "Thus photosynthesis is expected to have the *capability* of generating oxygen in the amounts necessary to make Mars habitable," provided that there is sufficient water available and that the microorganisms can withstand the fierce ultraviolet radiation.

The biggest problem is that the process could take about 100,000 years, according to a computer model created for the study. Raising the average temperature of the martian surface could speed up the rate of oxygen generation considerably. Say the would-be planetary engineers, "Temperature manipulation particularly seems the key to unlocking the potential of Mars for human habitation."

As has been suggested previously by Carl Sagan of Cornell University, one way to bring about this warming is to increase the amount of sunlight absorbed by the martian surface by decreasing its surface reflectance. The heat would vaporize the polar ice caps, and trigger a climatic instability leading to a higher average temperature. This could be accomplished if sand or dust were spread over the poles for a period of about 100 years, conclude the panel members. To complete the climatic changeover could still take 10,000 to 100,000 years, however.

In order to reduce the time scale for planetary engineering to one more interesting to humans, the committee proposed two strategies. The first would involve expenditure of considerable amounts of energy to speed up the sublimation of carbon dioxide from the polar caps. The second, a much more breathtaking suggestion, is to increase the rate of oxygen generation by using genetic engineering techniques to create a super microbe that could thrive in the existing martian environment well enough to have a vastly increased rate of photosynthesis. The study panel modestly avers that, "Indeed, in principle, the entire gene pool of the Earth might be available for the construction of an ideally adapted oxygen-producing photosynthetic Martian organism."

The panel members also recognized that it is not sufficient to introduce only a single species to carry out the oxygen generating task because, just as on Earth, biological recycling of the various elements needed for life—that is, an entire planetary ecological system—must be provided for. But the panel humbly concluded, "While not minimizing the enormous complexity of designing a planet-wide, efficient, steady-state microbial ecology . . . this task does not seem to be insuperable."

MacElroy was encouraged to develop the planetary engineering thesis when NASA began gathering ideas for possible space missions beyond the year 2000. Money was found, and a study team was recruited, although not without a little difficulty—some scientists thought the idea too absurd to spend time on. Further development of the concepts now awaits considerably more sophisticated models of ecological systems and of atmospheric dynamics, as well as more data on Mars.

MacElroy thinks that there probably will be no motivation to follow through with planetary engineering on Mars until strong economic incentives can be found, and, at present, none are in sight. Besides, he smiles, he has received several phone calls from earthlings claiming to have been contacted by Martians—Martians who are ready to challenge any environmental impact statement NASA can come up with.—ARTHUR L. ROBINSON

Table 1. Comparison of limits to life with selected martian environmental parameters (adapted from *NASA SP-414*).

Parameter	Range compatible with life	Mars
Temperature (°K)	Growth: 255 to 377 Survival: < 79 to 377	140 to 300
Ultraviolet radiation (erg cm^{-2} sec^{-1})	3×10^5	7×10^3
Oxygen (pO_2) (%)	0 to 100	0.1 to 0.4
Liquid H_2O (% by weight)	10 to 100	Unknown
Salinity (% NaCl)	0 to 35	Unknown
pH	0 to 13	Unknown
Mechanical abrasion	Abrasive particles < cell size‡	Dust in storms ≈10 to 50 μm§
Nitrogen	Absolute requirement	N_2
Sulfur	Absolute requirement	SO_3
Phosphorus	Absolute requirement	Not yet found
Carbon	Absolute requirement	CO, CO_2
Oxygen	Absolute requirement	H_2O, O_2
Hydrogen	Absolute requirement	H_2O

‡Larger particles cause mechanical damage to living cells. §This is the size range of many microorganisms.

NASA SP-414, M. M. Averner and R. D. MacElroy, Eds. (National Technical Information Service, Springfield, Virginia 22161, 1976); $5.25.
†In addition to MacElroy, participants were M. M. Averner, Southern Oregon College; S. Berman, State University College, Oneonta, New York; W. R. Kuhn, University of Michigan; P. W. Langhoff, Indiana University; S. R. Rogers, Dartmouth College; and J. W. Thomas, California Polytechnic State University, San Luis Obispo.