SUPERBUG -- MAKING A LIVING ON CURRENT-DAY MARS. Benton C.Clark., Lockheed Martin Astronautics, POB 179, Denver, CO 80201. E-mail: benton.c.clark@LMCO.com

Introduction: The martian surface environment is currently so inhospitable that survival and growth is deemed to be impossible. Certainly, no known terrestrial organism could succeed under the myriad constraints and ". . . the probability of growth of a terrestrial organism on present-day Mars is essentially zero." [1]. Yet, if life ever did exist on that planet prior to a pervasive but gradual evolution of the climate toward its current hostile form, that life may have evolved likewise sufficiently to find a mode of precarious, albeit not abundant, survival. This report considers some hypothetical possibilities by which it might be feasible for a highly adapted microbe to cope with the adversities presented it. Such a life form, super-adapted to Mars, would be called an extremophile by terrestrial standards, but would find most Earth habitats to be "extreme", and most likely fatal.

Limiting Factors to Life: On contemporaneous Mars, the environmental pressures are severe. Chief among these are the lack of liquid water, the possible lack of any chemical energy sources, and the presence of atmospheric and soil oxidants which are destructive to organic compounds.

Other factors often cited as providing limits to life on Mars are the ionizing radiation environment, soil toxicity, ionic strength, availablility of constructional nutrients, and the deleterious solar UV. However, these factors are not *a priori* limits that cannot and have not been overcome by numerous terrestrial organisms [2].

Overcoming Present Limits: First and foremost is the problem of obtaining H_2O, a scarce resource on Mars. Yet, polar regions contains frozen H_2O, as do surface frosts at high latitudes during wintertime. This begs the question of the apparent necessity of all known terrestrial microbes to acquire liquid H_2O. For Mars, there are several ways in which this problem may be rectified, although none are simple. Transient pockets of liquid may exist at the topmost surface grains in local summertime, but these are areas where ice deposits will naturally sublime away. In the shallow underground, a magmatic intrustion or residual heat from an impact event, may melt ice and create an impervious ice-soil roof which traps the liquid. Such locations are very restricted in size, which bodes ill for a long-term biota. Without access to surface gases, both a carbon source and an energy source are missing. Most exotic of all would be an organism which can create its own strong desiccant which robs the atmosphere of its humidity (which, in absolute terms is miniscule, at 1 microbar partial pressure of H_2O, but is potentially available since relative humidities at night can approach or exceed 100%). One such extremely deliquescent material is sulfuric acid. At a temperature of –50 deg C and even –74 deg C, two different eutectics of H_2SO_4 and H_2O solution remain liquid and also can capture H_2O molecules from the ambient atmosphere. Microorganisms which can live in highly acidic environments are well known on Earth, although the above extremes are not present, especially the extraordinarily low levels of water chemical activity, a_w. SO_3 to make H_2SO_4 is not currently present in the martian atmosphere, and it might therefore be incumbent on the martian superbug to manufacture its own acid. Other acids can also serve as anti-freezes, as can certain neutral salts and organic compounds.

H_2O is also possibly much more available during climatic swings, such as those expected by Mars' chaotically varying obliquity.

Energy could be provided by direct solar energy, so long as UV radiation is filtered out by a suitable material (possibly incompatible with a highly acidic internal environment). Other energy sources include those which result from photochemical production of disequilibrium species, as are well known to exist on Mars today. The recombination of the CO and O_2 within the martian atmosphere is one obvious energy couple. It has also been calculated that sulfate reduction and methanogenesis, via coupling the estimated H_2 abundance in the atmosphere with the abundant soil sulfates or atmospheric CO_2 / CO, are both near the threshold of biological energy payback for chemoautotrophs [2].

Surviving the strong oxidant species in the martian environment may be a matter of an inorganic barrier (shell, capsule, cell wall), backed up inside by enzymatic systems which defuse such damaging species in analogy with catalase and superoxide dismutase enzymes in terrestrial organisms.

Detection of Superbug: For any number of reasons, the Viking life-detection experiments might not have been expected to find evidence for such organisms. The GEX experiment flooded the sample with high a_w, low osmotic strength, and a variety of organics. The LR experiment detected release of gas from organic substrates, although such substrates are not expected in the contemporary environment. The PR experiment kept it samples most au naturel, but sealed the sample such that sufficient H_2 would not have been available to allow detection of metabolism at the level of detectability by the technique. All of the Viking life experiments, and even the pre-analysis storage, raised the samples to temperatures significantly above normal martian maxima. In terrestrial experience, many psychrotrophs expire when raised to only 10 or 15 deg C *below* "room temperature."

Summary: All-in-all, the challenges are daunting. It is may be beyond the realm of feasibility for current bioengineering technology to artificially develop such an organism. But life itself has produced evolutionary forms that almost no amount of breeding or bioengineering can yet rival. Life on Mars will have had, after all, 1E7 or so as long to do it as we will have.

References: [1] National Research Council, (1992) "Biological Contamination of Mars", Washington, DC.
[2] Clark B.C. (1998) *JGR*, *103*, 28,545-28,560.