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Microorganisms employing hydrogen peroxide: a possible reinterpretation of the Viking results

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Many of the results of the Viking life detection experiments remain puzzling to this day. Here, we present a hypothesis that would explain the Viking observations remarkably well: putative Martian organisms might incorporate H_2O_2 into their intracellular liquids as adaptation to Martian environmental conditions.

Contrary to common belief, H_2O_2 is used by many terrestrial organisms for diverse purposes, e.g., metabolism (*Acetobacter peroxidans*), as defense mechanism (Bombardier beetle), and also to mediate diverse physiological responses such as cell proliferation, differentiation, and migration. This adaptation would have several advantages such as a providing a low freezing point, a source of oxygen, and hygroscopicity, allowing an organism to obtain water vapor from the Martian atmosphere. It would explain many of the puzzling Viking observations such as (1) the lack of organics detected by GC-MS, (2) the lack of detected oxidant(s) to support a chemical explanation, (3) evolution of O_2 upon wetting (GEx experiment), (4) limited organic synthesis reactions (PR experiment), and (5) the gas release observations made (LR experiment).

The chemical explanations to account for all observations involve both, oxidants to explain the evolution of O_2, and reduced carbon compounds to explain the incorporation in the soil samples of ^{14}C from added CO_2. Moreover, upon wetting the samples in the GEx experiment released CO_2, whereas in the LR experiment CO_2 was reabsorbed upon a second injection of nutrient, apparently signifying basicity of the soil. The observations by the Viking Lander biology experiments are explained by the

hypothesis that Martian biota would employ a H_2O_2-H_2O mixture in their intracellular fluid. Because of the hygroscopicity, the putative organisms hyperhydrate rapidly when exposed to an atmosphere saturated with water vapor at a relatively high temperature. Supposedly, the failing organisms metabolize their cellular contents, and some organic compounds in the nutrient mixtures. The GEx experiment has shown that O_2, CO_2 and N_2 evolve at a time scale of a few hours. The LR experiment has shown that some of the simple organic compounds in the nutrient mixture were metabolized in the first few tens of hours after partial wetting of samples.

Another unresolved aspect of the Viking results is that the putative biological response is severely diminished upon heating to temperatures of around 50 ^{o}C and above, which limits severely the possibility of an explanation by inorganic compounds that would be present in the Martian environment. Moreover, samples stored in the landers for a few months at temperatures of around 10-18 ^{o}C also show a severely diminished activity, which limits the possibilities for a non-biological explanation of the results still further. In contrast, the biological explanation based on the H_2O_2-H_2O hypothesis has no such difficulties, while the determination of a precise biochemistry requires more sophisticated experiments.

Our hypothesis of Martian organisms that would utilize a H_2O_2-H_2O mixture as an intracellular liquid is of great consequence for future missions searching for extant life on Mars such as the Mars Phoenix, ExoMars, and the Mars Science Laboratory missions, and future sample return missions. Rather than exploring in the equatorial belt, where temperatures might allow liquid water to exist for only brief periods of time, life may well exist in temperate or sub-arctic regions, where temperatures are lower and the atmosphere contains more water vapor.