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Life in extreme habitats: implications for astrobiology

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Life exists practically all over on Earth. Most organisms dwell in "normal" environments (such as in mild temperature ambient atmosphere), while others may thrive in harsh conditions. The microorganisms thriving in severe habitats are called Extremophiles (from our anthropocentric point of view). They consist mainly of prokaryotes and to a lesser extent of eukaryotic organisms that have adapted to their severe habitats. The extremophiles occur in various temperature ranges (thermophiles vs. cryophiles or psychrophiles), Others live at lower pH ranges (acidophiles) or at the higher pH levels (alkaliphiles), while those organisms living in high salt solutions are the halophiles (some surviving also at saturated salinity). In the depths of the oceans and in subterranean depths are the pressure bearing organisms (barophiles). The anoxic microorganisms (both prokaryotes and Eukaryotes) live at anaerobic conditions and utilize anaerobic metabolism, or even thrive under various gaseous atmospheres (such as CO_2, ammonia, or methane). It is well known that some bacteria had already lived for millions of years in a dormant desiccated status before being revived in the laboratory. Recently some extremophilic bacteria were detected that exchange phosphorous with arsine in their DNA.

In this presentation we will survey specific extremophiles in some detail; e.g., bacteria and eukaryotes (such as Cyanidium caldarium, and the water bears Tardigrades).

All the above extremophiles could serve as models for extraterrestrial life. They show us the wide distribution of life on the Earth and prompt us to speculate within the science of astrobiology regarding the possibility of extraterrestrial life.

Astrobiology also concerns itself with possibilities for finding traces of life outside the Earth, mainly in the Solar System. Mars is the most promising target for the search of life. The considerable number of recent images of the Martian surface, together with the knowledge about its surface conditions provide us with reliable insights into its past and current geophysical features. Recent observations (from flyby missions and from rovers) on its surface have shown that the Red Planet was warmer and wetter in the past. The present surveys reveal contours of rivers, canyons, lakes, and other dried water bodies. It has recently been reported that Mars contains water, perchloride, methane, and other constituents of life. It may be that microbial life from the past has remained dormant, as non-active spores, or that Martian life is limited currently to the subsurface, where it is protected from the lethal surface conditions.

We have gained reliable information of the surface and subsurface of Europa, Ganymede, and Callisto, the Galilean moons of Jupiter. The icy surface of the Jovian moon Europa is mysteriously striated by cracks and streaks. It has been inferred that a subsurface salty ocean might exist on Europa, as well as on other moons of the giant planets.

We raise the question that if Earth microbes can thrive in extreme terrestrial-like environments, could it not be that in the future similar microorganisms might also be observed in the above-mentioned celestial bodies? Furthermore, if bacteria are known to survive for millions of years below glaciers in Antarctica, why would they not thrive underneath the ice caps of Mars, and on the Europan ocean?