Life at extreme solar system environments and beyond
A minisummary

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EXTREMOPHILES

Life exists almost all over Earth environments. We are familiar mainly the "normal" conditions where we find most of the living organisms. However there are various prokaryoticmicrobes and to lesser amount of eukaryoticorganisms that could tolerate and thrive in very severe and harsh places on Earth. These organisms that live at the edge of life are the **extremophiles**, they are tolerating and thriving in rough conditions (from our anthropocentric point of view). Some of them are not able to tolerate the "normal" environments. The extremophiles that resist various harsh conditions are:

Thermophiles–These microorganisms are among thesevere niches of high temperature from 40^{o}C to80^{o}C(where the dwellers are thermophiles, or hyperthermophiles); Psycrophiles–in other environmentsgrow microbes at very lower temperature from 10^{o}C to -20^{o}C(their organisms are the cryophilic microorganisms, known from Antarctica or from permafrost areas in Siberia, northern Arctic).

pH effects (Acidophiles-Alkaliphiles) - The acidophilic organisms live in low pH ranges areas, such in hot acidic springs (pH 0-5) such as in Yellowstone National Park (Wyoming, USA), while other microbes, the alkaliphiles live at higher levels on the pH scaled (ranges 9 to 11) as in some Africa lakes.

Halophiles - there are several places on Earth where the water or soil contain a large amount of salts and in this saline area (which can reach up to saturated saline solution) are the halophiles, or hyper-halophiles (ahyper saline environment is the Dead Sea [Israel] or in the Great Salt Sea (Utah, USA), where their water contain ~ 30% salts). In these saline waters grow species bacteria and Archaea (Oren, 2002).

Barophiles - In the subsurface of land (see further the nematodes), or under high hydrostatic pressurebacteria tolerates ~1000 hydrostatic atmospheric pressuresin the bottom of the oceans. Deep beneath the ocean floor scientists have described the existence of a potential vast realm of life (Keim B, 2013). Also around the hydrothermal vents at the ocean's depth live organisms under a high pressure (Horikoshi and Tsujii, 1999).

Anaerobes - the Prokaryotes and Eukaryotes microbes thrive in niches with very low levels or absence of oxygen (Altenbach et al. 2012). They have their own metabolism that is difference from the aerobic organisms.

Dormancy and Desiccation – bacteria were detected dormant enclosed insects for 40 million years embedded in amber. When exposed they could have been revived (Cano and Borucki, 1995). Likewise bacteria were isolated from a 250 million years'environment enclosed inside an ice crystal in salty cave and then revived (Vreeland et al., 2000). This show us the ability of long time of dormancy of life, which could also exits extraterrestrial in places that had perhaps once some life.

Polyextremophiles

Many extremophiles could grow in more thana single stress factor; they are the polyextremophiles(Horikoshi and Grant, 1998; Horikoshi and Tsujii, 1999; Seckbach et al., 2013; Stan-Lotter and Fendrihan, 2012).

Some examples of Polyextremophiles are the following:
Cyanidium caldarium and its cohorts (which are red unicellularacidothermalalgae) thrive at pure CO_2, at elevated temperature (57^oC) at very acidic solutions (pH 0-4), with a ubiquitous distribution (Seckbach et al., 1970, Seckbach, 1994).

Nematodes (multicellular round worms) discovered subterranean more than a kilometer underground at oxygen-starvation, hot and inhospitable conditions.Similar to *Halicephalobusmephisto*nematodes in deepest gold mines (in South Africa). They are 0.5 mm long discovered at 1.3 km down at 37^oC, while another nematode species was found at 3.6 km down at 48^oC. (Drake, 2011).

UV radiation resistance - Some **bacterial species tolerate a high dose of UV radiation,** amount that is lethal for other organisms. One of the most resistance groups to ionizing radiation (IR), ultraviolet (UV) radiation, oxidative stress, and desiccationis the extremophilic bacterium*Deinococcusradiodurans*,. These bacteria can survive cold, dehydration, vacuum, and acid, and are therefore known as polyextremophiles and thus, *Deinococcus*is the world's toughest bacterium (de Groot et al., 2005). They have a system for DNA repair and it has been been reported that *D. radiodurans* can recover from exposure to γ-radiation at 15 kGy, a dose lethal to most life forms.

Tardigrades - water bears - they are small, water-dwelling, segmented animals with eight legs. Four segmented, length of their body is 1 mm, and their distribution is omnipresent from the ice capes to the equatorial zones, from 6000m above the sea level up to 4000 m under the sealevel, they could survived at $-273^oC$and at 151^oC and under strong radiation which kills every other animal. They could survive desiccation conditions almost for ten years. They are also able to last in the space vacuum (Schulze-Makuch and Seckbach, 2013).

Pressure– temperature effects: at the bottom of the ocean.At the hydrothermal vents are growing halophilicmicrobes at high temperature and under elevated pressure. Other microbes could be found at cold saline surrounding at the ocean’s depth under high pressure. Similar bacteria and other organisms are thriving at various temperatures ranges under high pressures or in saline environments.

ASTROBIOLOGY

Astrobiology is a new science that is concerned with the origin, evolution, distribution and destiny of life in the universe (Chela-Flores, 2011). There are several synonyms for this vast field of research, such as bioastronomy, exobiology andcosmobiology. One way to approach the cosmic distribution of life is to search for evidence on planets, and moonswithin the Solar System, or beyond it (de Vera and Seckbach, 2013). We shall briefly refer to these two possibilities below. One of the primary requirements for life“as we know it”to existelsewhere (or in planets with Earth-life conditions), is the presence of liquid water, oxygen in its atmosphere, some nutrients for growth and an energy source.

Mars

Mars is currently a prime extraterrestrial candidate if looking for life. We know that it is dry, cold- deadly, CO_2, and methane in its atmosphere, has icy water in its polar caps and liquid water be found beneath its surface. Recent information from rovers on the surface of Mars and from flyby spaceships over celestial bodies points out that there is some chance to discover past, or even current life. The resent NASA's Mars rover **Curiosity**is among other exploring robots to discover the building blocks for primitive life on the Red Planet.Currently,Curiosity is probing the Martian surface in order to search for liquid water, as well asfor biomarkers.

Multiple images and panoramic views of the Martian surface show contours of riverbeds, shorelines, lakes, canyons and other water bodies. Many scientists conclude that Mars was wetter and warmer, the air thicker and the surface more habitable in its past history. Then it fell over a climatic cliff to extinction.

Is there an analogue of Mars on Earth? Terrestrial life may thrive in most severe habitatsthatare similar to Mars. The chilly districts of Antarctica may be compared to the Martian surface. In the Atacama Desert (Chile)there are places that resemble Mars. Parts of the Atacama Desertare the only places on Earth that are devoid of life.

Extremophiles live on Earth in very harsh conditions, such as in the terrestrial boiling point under some oceanic thermal vents, the acidic hot springs, super-briny seas, even pools of nuclear waste—all, amazingly, harbor some environments. In this context, Earth could be a good proxy for Mars. Since very barren terrestrial environments, such as the Atacama Desert, are home to simple butthriving ecosystems,it has been suggested that life could indeed survive on the red planet (Kargel, 2004). Similarly, even though the temperatures and the barren conditions that exist in the Dry Valley Lakes, Antarctica, it has also been suggested that the permanently ice-covered lakes can be analogues of the icy satellite of Jupiter, Europa to which we shall return below.

Europa

Another candidate for hosting life is Europa, the satellite of Jupiter. This Jovian satellite is comparable in size to the Moon. From several measurements by the instruments on board of the Galileo Mission (1995-2003)it has been possible to predict the possible existence of a subsurface saline ocean under the icy layer. It is not excluded that some of the surficial morphology and non-ice elements may be due to anunderlyingoceanthat isinhabited (Chela-Flores, 2006; Chela-Floresand Seckbach, 2011). Vostok Station, in Antarctica is the Russian Base. A subsurface lake of salty water was discovered 4 km underneath the icy surface near Vostok Station. Drilling down from the surface of this lake has shown that there are organisms along the way down in the icy layer.A possible analogue of the Vostok Lake, Antarctica might be the subsurface icy Europan ocean.(Greenberg, 2005).

Enceladus and titan

Enceladus is a satellite of Saturn in which the Cassini Missionhas identified asubsurface ocean.In addition, this mission still orbiting Saturn and its satellites, has discovered surface lakes of methane and ethane inTitan where its surficial temperature is very low (-180^{o}C). This satellite may host novel extremophilic microorganisms capable of surviving in such inhospitable (with respect to the terrestrial environment.

FURTHER VENUES FOR LIFE: EXTRASOLAR PLANETOLOGY

Life beyond the Solar System may exist orbiting around stars of our galaxy. This possibility has arisen thanks to the instrumentation that has become available—the NASA Kepler Mission at present in an heliocentric orbit—and also due in the short term to forthcoming space missions: (a) FINNESSE, Fast INfraredExoplanet Spectroscopy Survey Explorer, (Swain, 2010), (b) EChO, ExoplanetCharacterisation Observatory (Tinetti et al, 2012), and (c) TESS, Transiting Exoplanet Survey Satellite (Ricker et al., 2010), together with the*Giant Magellan Telescope*, as well as with NASA's James Webb Space Telescope.To sum up, it may be possible in the foreseeable future to suggest ways of anticipating, organize and interpret the data that is provided by Kepler, as well as the data that is to come in the post-Kepler era (Chela-Flores, 2013).

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