The astrobiological aspects of Titan: A new vision from Cassini-Huygens

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Since the discovery of the presence of an active organic chemistry in its atmosphere, Titan is considered as a planetary body of prime astrobiological importance. The very first fly-bys of Titan by the Cassini spacecraft a few months ago, and the in situ exploration of its atmosphere and surface thanks to the Huygens probe, on January 14th 2005, are providing us new and spectacular data on Titan's environment.

Some of the astrobiological consequences of these new data will be presented and discussed.

Biologically enhanced energy and carbon cycling on Titan?

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With the Cassini-Huygens Mission in orbit around Saturn, the large moon Titan, with its reducing atmosphere, rich organic chemistry, and heterogeneous surface, moves into the astrobiological spotlight. Environmental conditions on Titan and Earth were similar in many respects 4 billion years ago, the approximate time when life originated on Earth. Life may have originated on Titan during its warmer early history and then developed adaptation strategies to cope with the increasingly cold conditions. If organisms originated and persisted, metabolic strategies could exist that would provide sufficient energy for life to persist, even today. Metabolic reactions might include the catalytic hydrogenation of photochemically produced acetylene, or involve the recombination of radicals created in the atmosphere by UV radiation. Metabolic activity may even contribute to the apparent youth, smoothness, and high activity of Titan's surface via biothermal energy.

Our calculations indicate that biothermal melting would be a possible explanation for the smooth surfaces observed by the Cassini-Huygens mission. Given the low temperatures, the biological effect on Titan, if it exists, should be larger than on Earth. In conditions where the ability to sustain liquid microenvironments is a key limitation on survival, then adaptive pressures could lead to a larger percentage of the free energy of exothermic metabolic reactions going towards heating the immediate environments of organisms living close to the freezing point. On the other hand, much energy has to be expended to reach the liquid state. If volcanic activity or other energy sources are present and significant, it would increase the chances for life on Titan by elevating temperatures and providing potentially habitable geothermal areas and gases that could be used for metabolism. Any liquid water-ammonia mixture is lighter than the surrounding ice and will float if produced at depth.

Given the current sample size of one biosphere upon which astrobiologists must base their theories and speculations, our ideas about life elsewhere must remain fluid and not too heavily based upon the specific metabolisms, strategies and structures of terrestrial organisms. The basic requirements of life, as they are understood today, are all present on Titan, including organic molecules, energy sources and liquid media.