HABITABILITY OF EUROPA: POSSIBLE DEGREE OF EVOLUTION OF EUROPAN BIOTA;
Julian Chela-Flores *ICTP,* Miramare P.O. Box 586; 34100 Trieste, Italy and *IDEA,* Apartado 17606 Parque Central, Caracas 1015A, Venezuela.

Within the present program of exobiology in Solar System exploration, we have proposed that the time is ripe to emphasize the life sciences, besides geophysical aspects. This should allow us to test the hypothesis of the ubiquity of eukaryogenesis in the case of the Jovian satellite Europa[1]. A second, more evident candidate in such a program on the search for extraterrestrial eukaryotes (SETE) is Mars[2]. Previous work has suggested that through tidal and radiogenic heating on Europa, an internal ocean has been formed (underneath a relatively thin ice cover) through dehydration of silicates[3] (the heating source due to tidal heating is expected to be of the order of 52 erg $cm^{-2}s^{-1}$ with an additional 8 erg $cm^{-2}s^{-1}$, due to radiogenic heating[4]).

For the above reasons it was estimated that the temperature underneath the icy crust could be $4^{o}C$ [5]. From the similarity of the processes that gave rise to the solid bodies of the Solar System, we may expect that hot springs may lie at the bottom of the ocean. The main thesis of the proponents of the existence of a Europan biota is that, as Jupiter's primordial nebula must have contained many organic compounds, then possibly, organisms similar to thermophilic archaebacteria can evolve at the bottom of Europa's ocean. The previous argument [5] correctly pointed out that the most important requirements for the maintenance of life in Europa are the above mentioned conditions (water, an energy source and organic compounds). However, the analogous Earth ecosystems considered by them excluded eukaryotes. The case of the acidophilic and thermophilic cyanidiophycean algae[6] is a warning that we should keep an open mind while discussing the possible degree of evolution of Europan biota. We may add that the divergence into the three domains, arising from the evolution of the earliest ancestor of all living organisms is not well understood.

Indeed, plate tectonics has obliterated fossils of early organisms from the crust of the Earth. Additional factors arising from current experience with eukaryotes may contribute to clarify the case for not excluding nucleated cells from the microorganisms to be searched in new Solar System environments; three arguments militate in favour of the ubiquity of eukaryogenesis in other ecosystems of the Solar System:

Firstly, a critical step in the diversification of single-celled organisms may have been the loss of the ability to manufacture a cell-wall biomolecule (peptidoglycan). Without the constraint that this biomolecule imposes on cell shape, both Archaea and Eukarya have been able to diversify beyond the Domain Bacteria. Secondly, in spite of the fact that eukaryotes and archaebacteria have both lost peptidoglycan, we can nevertheless distinguish between them, as all eukaryotes have ester lipids in their membranes, whereas archaebacteria have ether lipids.

Finally, Earth-bound eukaryotes are not extremophiles, but their diversification may share a common thread with archeabacteria. Eukaryotes, in spite of not being able to exploit fully all the extreme environments may, nevertheless, invade to a certain extent those niches normally at the disposal of the extremophiles. We have remarked that the identification of primitive eukaryotes is not straightforward; another difficulty is that the simplest criterium to recognise them, namely the search for a membrane-bounded set of chromosomes, does not help to identify unambiguously eukaryotes, as there are prokaryotic organisms, that do have a membrane-bounded nucleoid [7].

In addition, work[8] on prokaryotic symbionts of protozoans having proteins typical of eukaryotes, and silicification experiments of certain microorganisms[9] suggest that the identification of eukaryotes at the morphological or molecular levels, particularly during the process of fossilization, may lead to some confusion. To sum up, at present we lack experience with parallel evolution in an extraterrestrial environment. This induces us to stress that present and future efforts concerning Europa should not be confined to the possibility of designing equipment capable of recognising exclusively analogues of the lowest domains of Earth biota (Archaea and Bacteria).

Consequently, we have proposed[1] that tests for recognising eukaryotes (a SETE programme) should also be envisaged in the mission that the Exobiology Program of NASA is currently discussing. If *living microorganisms* are found either in Europa (or in Mars), one may adopt a gene-centered approach[7], in order to search for cellular replication in relation to a delay in replication of chromosome segments. Such a phenomenon would confirm that the chromosomes maintain the condensed state during interphase, a eukaryotic hallmark. If frozen or fossilized organisms are encountered, then we need to consider[10] the differences between primitive eukaryotes and members of the other two domains.

REFERENCES:

(1) Chela-Flores, J. (1996a), *A Search for Extraterrestrial Eukaryotes: Biological and Planetary Science Aspects*. In: *Astronomical and Biochemical Origins and the Search for Life in the Universe.* Eds.C.B. Cosmovici *et al.* Editrice Compositore: Bologna (in press).

(2) McKay, C.P. (1996), *Oxygen and the rapid evolution of life on Mars.* In: Chela-Flores, J. and Raulin, F. (Eds.). (1996). *Chemical Evolution: Physics of the Origin and Evolution of Life.* Kluwer Academic Publishers, Dordrecht, The Netherlands. p. 177-184.

(3) Reynolds, R.T., Squyres, S.W., Colburn, D.S.and McKay, C.P.(1983), *On the habitability of Europa,* Icarus, **56**, p. 246-254.

(4) Reynolds, R.T., McKay, C.P. and Kasting, J.F. (1987). *Europa, tidally heated oceans, and habitable zones around giant planets*, Adv. Space Res., **7**, p. 125-132.

(5) Oro, J. Squyres, S.W., Reynolds, R.T., and Mills, T.M. (1992), In: *Exobiology in Solar System Exploration*. G.C. Carle, D.E. Schwartz, and J.L. Huntington, eds. pp. 103-125.

(6) Seckbach, J. (1972), *On the fine structure of the acidophilic hot-spring alga* Cyanidium caldarium: *a taxonomic approach,* Microbios, **5,** p. 133-142.

(7) Chela-Flores, J. (1996b), *First steps in eukaryogenesis: Origin and evolution of chromosome structure.* Origin and Evolution of the Bioshpere (in press).

(8) Rosati, G., Lenzi, P., and Franco, U. (1993), *'Epixenosomes': peculiar epibionts of the protozoon ciliate* Euplotidium itoi: *Do their cytoplasmic tubules consist of tubulin?,* Micron, **24**, p.465-471.

(9) Westall, F., Boni, L.and Guerzoni, E. (1995), *The experimental silicification of microorganisms*. Paleontology, **38,** p. 495-528.

(10) Chela-Flores, J. (1996c). *A Search for Extraterrestrial Eukaryotes: Physical and Biochemical Aspects of Exobiology.* 11th International Conference on the Origin of Life. Orleans. Book of Program and Abstracts, p121.