the bricks of every form of life as we know it – is more common and simple than we would have expected. In fact, following Hoover's interpretations of empirical data, we can conceive of the possibility that a considerable amount of organic components were spread out across the universe in the depths of rocky fragments which originated from the massive explosions of dying stars. It is not known, however, how long these rocky formations wandered through the space before landing on the Earth, Mars, Venus, Jupiter, etc., and their satellites.

We know that billions of years ago the Earth and the other planets were subjected to heavy rains of comets and meteorites, which could have provided water and organic materials. The hypothesis that this turbulent period of the Solar System was pivotal for the origin of life on Earth is extremely fascinating. However the existence of alleged biological fossils in meteorites does not rule out the scenario that aminoacids and other organic constituents of living organisms were already present – at least in traces - on our planet. In addition, it is debatable whether the conditions necessary for life were better in the inner core of comets and asteroids or on the terrestrial surface, or even in the depths of the oceans. Moreover, the evidence that the organic material found in meteorites constitutes fossilized biological remnants of microorganisms like bacteria is far from being conclusive. The tests conducted on meteorite samples only prove that elements compatible with life are present in certain rocky fragments fallen on Earth. At present, it is not possible to affirm that comets and asteroids bear germs of life, nor that the organic elements identified were solely produced by metabolic activities of living organisms. Even the comparison between images of terrestrial bacteria and those obtained from the meteorite samples in order to distinguish filaments for motility and globules – possibly identified as heterocysts – is somewhat hazardous.

Arguably, we need stronger evidence to conclude that what has been found in meteorites are fossilized traces of very ancient biological microorganisms. Specifically, we would welcome as less controversial evidence the discovery of protein residuals associated with biological functions, such as metabolic activities. If the globules identified by Hoover are truly fossilized heterocysts, only the discovery of such protein remnants within their structures could resolve the controversy in favor of the alien life beyond any doubt.

The implications that life is everywhere, and that life on Earth may have come from other planets (Joseph 2010; Wickramasinghe 2011), is not justified by the relatively small samples on which the analyses were conducted.

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15. Cyanobacteria on Terrestrial Meteorites and Stromatolites on Mars

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The Hoover paper (Hoover, 2011) is quite consistent and properly documented. The paper is very detailed and supported by a lot of high quality images at ultramicroscopic scale. Really the great news of these last findings is to have discovered in CI1 meteorites the remains of some microfossils very close in appearance to terrestrial cyanobacteria. The finding of these microfossils is very important since Hoover found not only "complex filaments", but also clear fragments of a cyanobacterial mat resembling the typical stromatolite structures (Precambrian Age) on early terrestrial forms of life (Pikuta, see commentary n. 12).

At the beginning of this saga, the possible existence of extraterrestrial life on meteorites was highly debated. Nagy et al. (1961) reported the occurrence of biogenic hydrocarbon in the Orgueil meteorite and, later, described some microstructures similar to microbial life forms on Earth (Nagy et al., 1963). Twenty years after, Engel and Nagy (1982) described some non-racemic aminoacids in the Murchinson meteorite that could be interpreted as possible evidence for a past extraterrestrial life. Fossil evidences of ancient microbial life was, originally, advanced by David McKay et al. (1996) on Martian meteorite ALH84001. McKay's hypothesis was, later, refuted by other NASA research teams in 1998 (McKay et al., 1998) but some years after was resumed by Robert Folk and Lawrence Taylor (Folk and Taylor, 2002) who stated that the carbonate globules in ALH84001 were fossil nannobacteria associated with Fe-oxide precipitation and, afterwards other researchers found on these carbonate discs a lot of magnetite nanocrystals probably added by biogenic processes (Thomas-Keprta et al., 2009). The latest findings, released by NASA and spread in internet by Spaceflightnow (HYPERLINK "http://spaceflightnow.com"http://spaceflightnow.com) have revealed that, besides ALH84001, there are two additional Martian meteorites, named "Nakhla" and "Yamato 593", with evident biological signatures of alien life on the Red Planet.

Several reports have been advanced that the apparent microbial structures shown by Hoover may be the result of a contamination process which has affected the meteorites over time (Brasier et al., 2002). At the same time other scientists have pointed out that there are good reasons to believe that there is no contamination. We briefly recall: 1) the accuracy of sampling, sealing and conservation, well documented at least for one of these meteorites (Murchison); 2) the biological features of microbial life in the meteorite was restricted to freshly fractured interior portions of the stones exposed only after cracking and, therefore, with no contact with the terrestrial environment; 3) the short time of at air exposition in comparison to the massive occurrence of cianobacteria; 4) the long time of bacterial coexistence is proved by their permineralisation; 5) the cohesive nature of condrites, generally cracking along new surfaces, as confirmed by the rupture of a pre-existing microfossils; 6) the massive presence of forms of life, not limited to the simple surface of investigation; 7) the absence of such form in a lot of other examined meteorites, over a long time exposed to the air contamination in spite of their natural fracturing. Indeed, the absence of nitrogen as well as the lack of several crucial aminoacids, is a good evidence against the possibility of any terrestrial biological contamination. Brasier (Brasier, see comment n. 9) suggests morphological similarity for some of such forms to the Ambient Inclusion Trail (AIT) and further investigation to exclude their possible abiogenicity. Nevertheless we have to observe that the proposed similarity is roughly referred to the external shape and it seems not supported by their quite different fine microfabric.

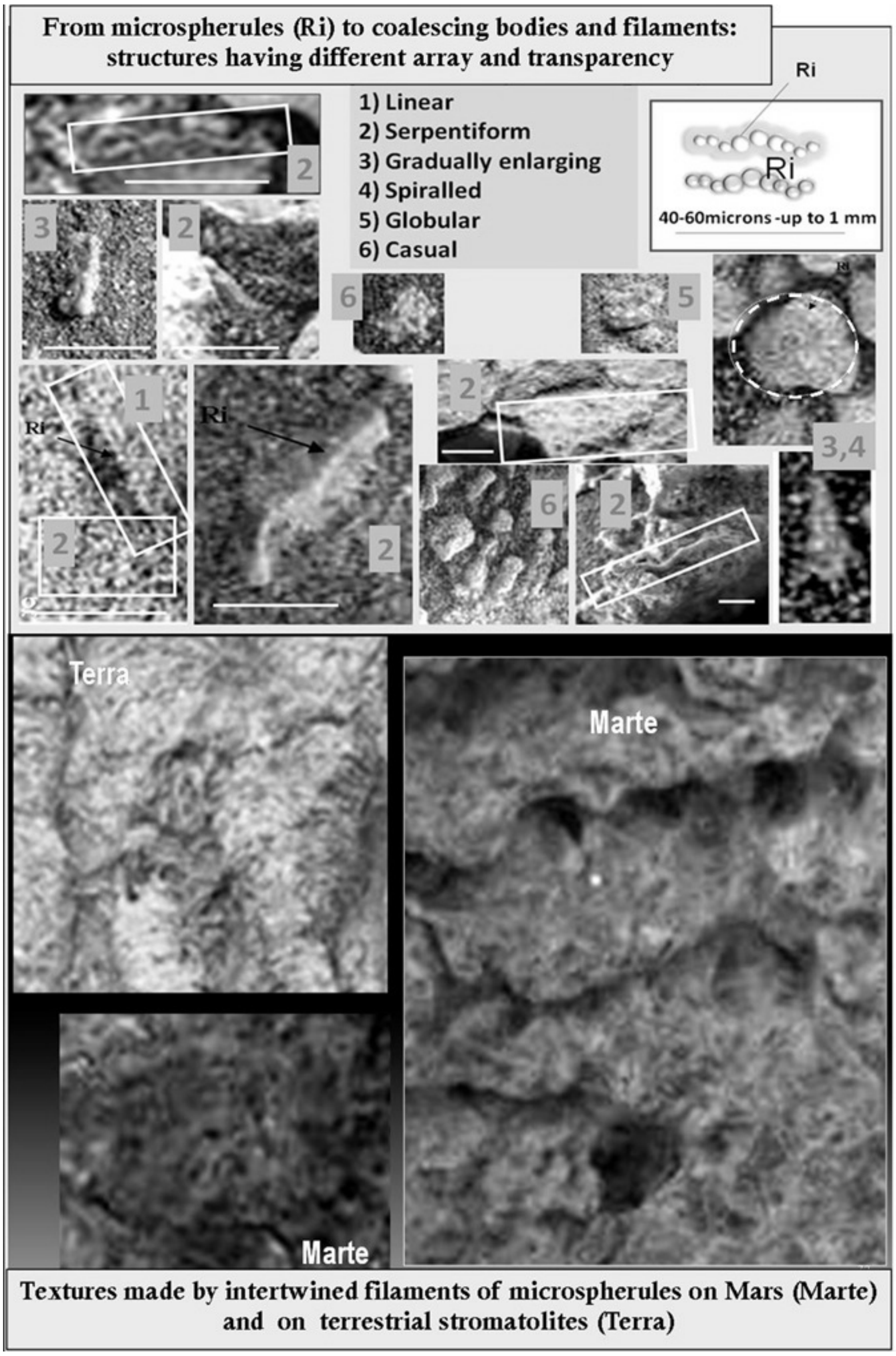

Figure 1. Microspherule aggregation on Mars are resembling terrestrial stromatolites structures, forming various kind of aggregates and filaments (above) and texture of intertwined filaments (below). Bars represent 1 mm. (see Rizzo and Cantasano, 2011).

At the end, we have to consider that criticism are posed for each single-separate feature, and that most of them are feeble and lay as general statements; as well their altogether convergence is relevant, too and more. Suspects and possibilities are not proves. Then, we are looking forward to the search results deepening proposed by sceptics, in order to prove -without any reasonable doubt- to the scientific readers that their criticisms are right. At the moment considering the careful procedures used for sample's analysis, the nature and the history of their biological contents, we totally agree with the interpretation given by Hoover in his article.

In fact, in our studies (Rizzo and Cantasano, 2009a; Rizzo and Cantasano, 2009b; Rizzo and Cantasano, 2010; Rizzo and Cantasano, 2011 in print), analyzing a selected set of NASA REM MI imagery shot by Rover "Opportunity", we have found a lot of similarities, both at microscopic and macroscopic scale, between Mars sediment's structures and those of terrestrial stromatolites. Similarities include occurrence of microspherules aggregates, somewhere linked in filaments, in sheet, in larger spherules known as "blueberries" and in other massive bodies made by intertwined filaments textures (figure 1). Such possible microbial structures somewhere contain encapsuled aggregates (like those of sheathed colony of cyanobacteria) and other peculiar forms recalling biological structures (as are tubules, threads, chambered bodies ..etc; figs. 2a-c). At larger scale similarity include laminated sediments, regressive sequences, columnar and planar structures. Both laminated sequences, blueberries and other massive bodies could be explained by peculiar planar/spatial microspherules aggregation and/or by their internal growing, whose basilar mechanism pointed out.

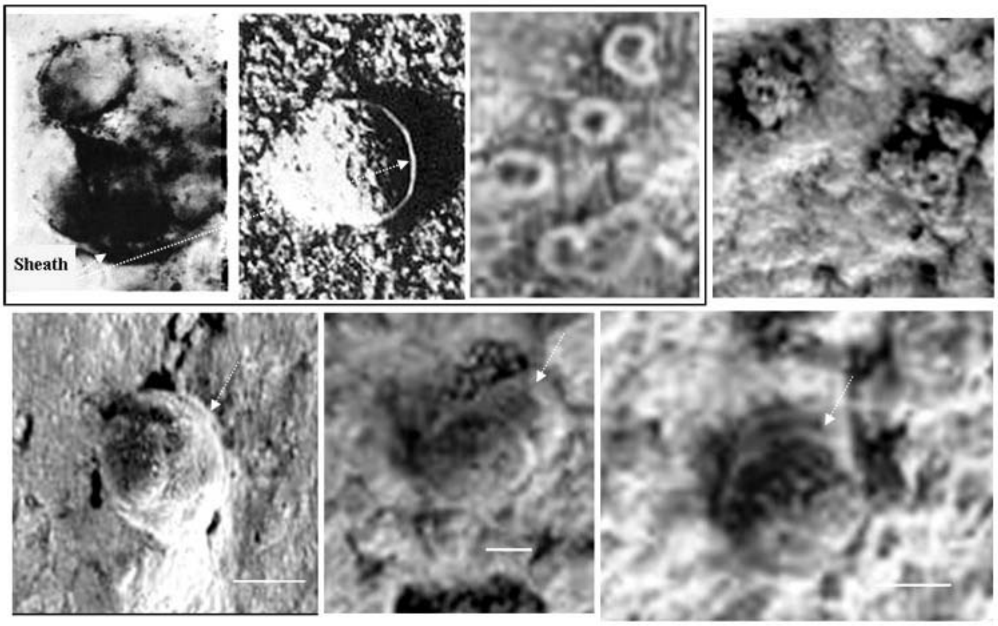

Figure 2a. Possible incapsulated colonies of microbes on Mars (down and up on the right) and similar sheated colonies of terrestrial cianobacteria (within the frame, top on the left. From Schopf, 1967). Bars represent 1mm; arrows show sheats made by different material. (see Rizzo and Cantasano, 2009).

Are they other morphological coincidences? Considering manifold parallels at so different scales, they are relevant data and further clear evidences of –still no proved- extraterrestrial life. In fact, we have to consider that our results are based only by morphological evidences on the analysis of microscopic imagery of the rovers. Nevertheless, our scale of work is quite different from those of Hoover investigated samples, because the field of observation range from about 60- 80 micron to 3cm. This is a range of work where the complex form of life are more differentiated and evident in respect to the abiotic ones. We have also to consider that: 1) on the base of Lyell postulate, the sedimentation cannot generates "intertwined filaments"; 2) a secondary texture of postsedimentation mass movement is in contrast with the very thin mm-laminated structures of the same outcroppings. In fact both structures are typical of stromatolites. Should it be considered proved?

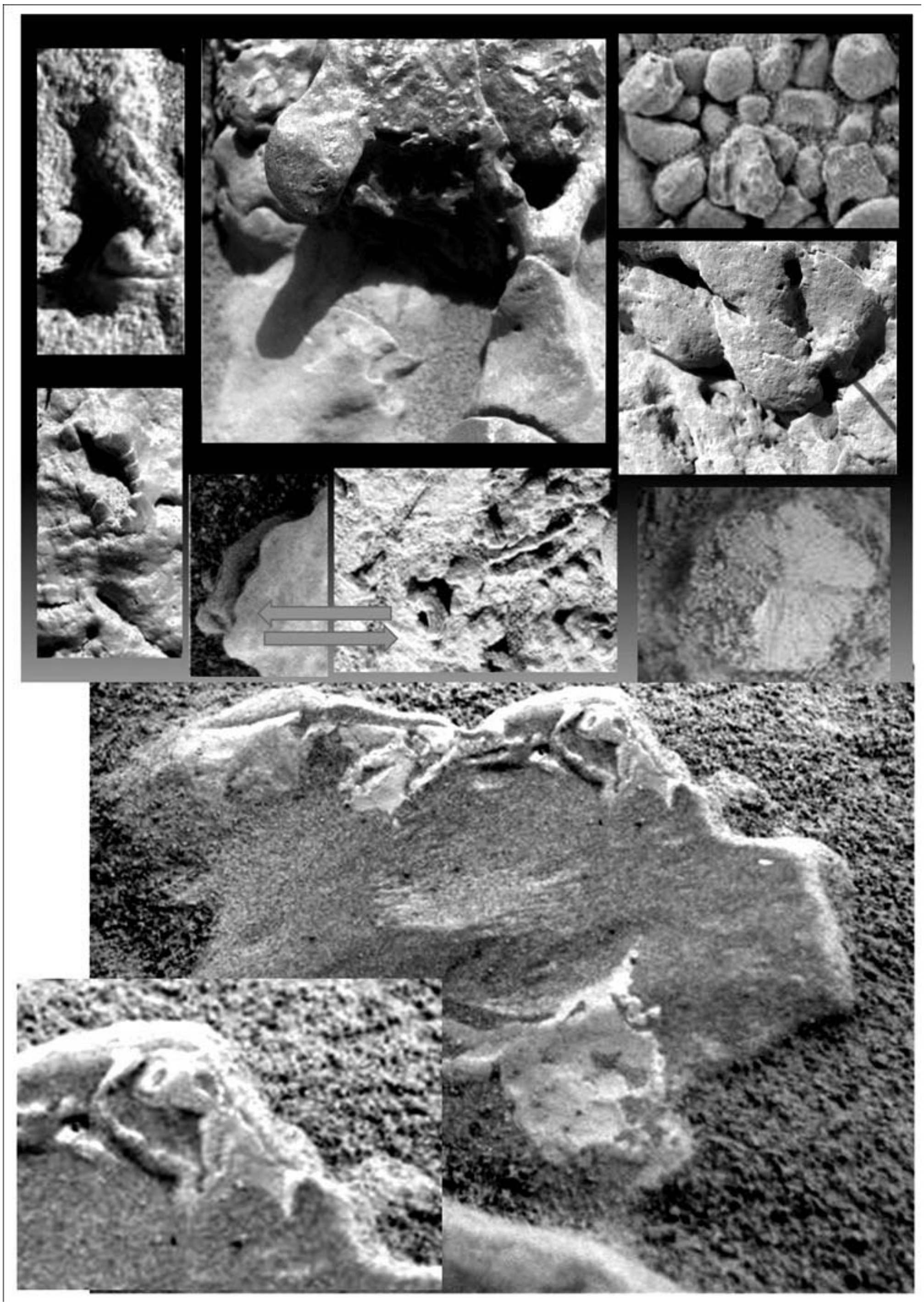

Figure 2b. A set of complex structures, possible form of past life (see Rizzo and Cantasano, 2009).

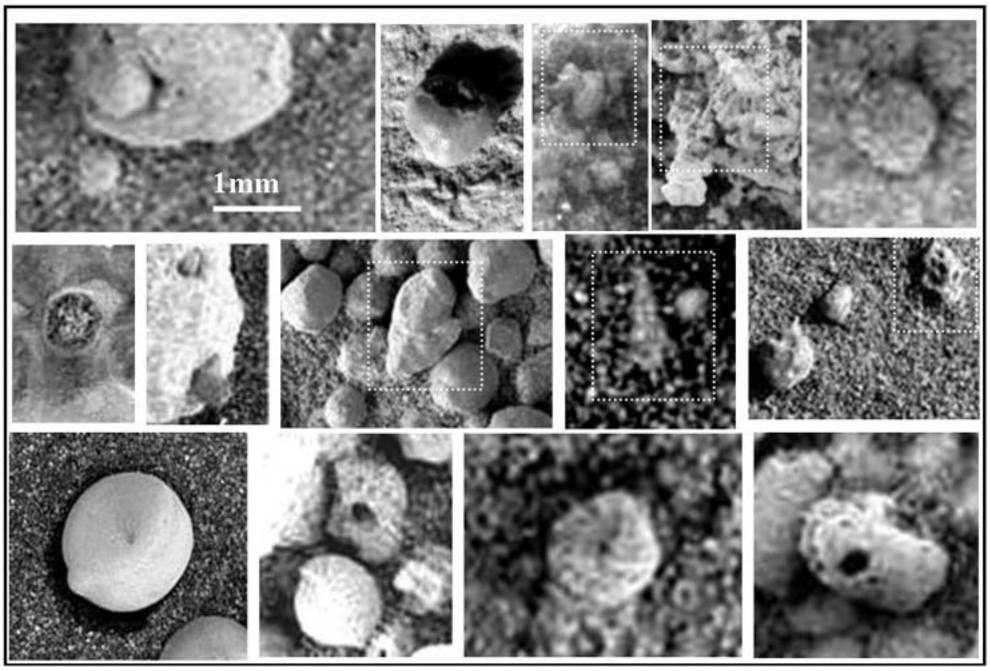

Figure 2c. A set of complex structure, possible microfossils (see Rizzo and Cantasano, 2009).

The response, considering that the Earth is not the geometrical centre of Universe, at the state of knowledge should be easy and evident, without any reasonable scientific doubt; but it has strong cultural implication. Then, probably, we could have a definitive proof of extraterrestrial life only studying sample return. I suspect that, also in this case, inclusion and microbial contamination will be still questioned.

So, we believe that the music of the Universe plays always with the same first notes and Panspermia (Wickramasinghe, 2011) is a credible theory: microbial life is everywhere and travel trough the cold space. Finally, we believe on the relevance of data convergence about extraterrestrial life and we think that Richard Hoover has taken an important step in that direction.

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16. Alien Microfossils? Criticism and Analysis
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Over all I appreciate Hoover's impressive work (2011) concerning the fossils of Cyanobacteria in meteorites. However, I cannot accept all the conclusion as some of the results are not what I would have expected or they are not clear from the data. It is my opinion the author should have put a synthetic caption at the bottom of each picture to better identify the contents, even if he explains them in other parts of the text. I would like to give criticism concerning the absence (or undetectable) Nitrogen in the meteorite filaments (see conclusions at pg. 29). The metabolism of Nitrogen in Cyanobacteria which would be expected is evident presence in the meteorite fossil filaments of the bacteria which supposedly resembles *Titanospirillum velox*. That fact complicates Hoover's arguments (see pg.30) related to the presence of liquid water of comet nuclei as the source for the origins of these putative organisms. I also have a problem with Table IV where the measures are not expressed by the same units. So there are difficulties fully understanding the concentrations, especially for GLY on Carbonaceous Meteorites in comparing to the other classes of Bacteria (living and fossils). Hoover's work is a remarkable achievement. However, I think his findings of what may be fossil Cyanobacteria and other bacteria in meteorites cannot give a definitive answer to the origin of the life in our Planet.

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17. Discovery of Cyanobacteria in Meteorites: Implications for Astrobiology and Cosmology
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Abstract: In 2003, it was predicted that cyanobateria would be found in extraterrestrial locations, indeed at many locations in the Galaxy where liquid water is present. It was argued that cyanobacteria originally evolved on a planet that was destroyed in a supernova explosion before the Earth was formed; a view later echoed and developed by others (Joseph 2009). The discovery of cyanobateria fossils in meteorites would confirm this prediction. Given the likelihood that Hoover (2011) has indeed discovered cyanobacteria in meteorites, what are the implications of this discovery for both one-celled life and intelligent life, existing elsewhere in the universe. And what are the implications for cosmology: the early universe implications, and the ultimate future implications? These issues are addressed in this paper.

Keywords: microfossils, cyanobateria, origin of life, origin of prokaryotes, origin of stars, the early universe, extraterrestial intelligence, ultimate future of the universe, unitarity

Implications In 2003, it was predicted (Tipler 2003) that cyanobateria would be found in extraterrestial environments. The arguments were based on the molecular complexity of cyanobacteria, and the fact that microfossils indistinguishable from modern cyanobacteria had been discovered in cherts 3.5 billion years old. Following William Schopf (1999, p. 98), I concluded that there was insufficient time for such organisms to evolve on the early Earth. If Hoover's interpretation of his observations is correct, then his work confirms my prediction.

However, caution is called for. Schopf devotes two chapters of his book *Cradle of Life* (1999) to a discussion of the evidence required before one can accept patterns in rocks as microfossils. Schopf recommends that one wait until one has some examples of cells in division before one can truly accept the proposed features as fossil bacteria. So although Hoover has done as much as is possible with his small sample, we cannot yet conclude that he has indeed seen fossil cyanobateria. I say this reluctantly, for I have a very personal interest in Hoover's claim of fossil cyanobacteria being correct.

But I would like to expand on my 2003 argument that we would expect that cyanobacteria evolved outside the Solar System, on a planet long dead. The universe is about 13.8 billion years old (Jarosik et al 2011). Since our Earth is only 4.5 billion years old, it is about one-third the age of the universe. We have not yet observed the first generation of stars; the Webb space telescope, scheduled for launch in 2014, should allow us to see these objects for the first time. The general opinion, which I share, is that the first star generation formed about 500 million years after the Big Bang (redshift $z = 10$). I would expect the second generation of stars, with sufficient heavy elements present to permit earthlike planet formation, to exist within one billion years after the first generation, so the first earthlike planets should have formed by roughly 11 billion years after the Big Bang, or about 6 billion years before the Solar System was formed. So there would be 6 billion additional years for cyanobacteria to evolve from its non-living precursors. The period before the Earth's formation had a supernova rate far above the rate today, and there is evidence that the Solar System material is the result of several sequences of supernovae. It is plausible that one of these supernovae blasted cyanobacteria off the planet upon which they evolved (Joseph 2009; Tipler, 2003). In 2003, I pointed out (Tipler 2003) that cyanobacteria are resistant to