CORRESPONDENCE

Interstellar Panspermia Reconsidered Again: In Defense of Life's Evolution on Earth

In a recent JBIS paper, it has been stated that because there are no free-living organisms present now or in the fossil record that are simpler than bacteria, pre-bacterial life must have evolved off the Earth. The present writer argues in favour of the origin and early evolution of life on Earth, pointing out that while life may have been transported between worlds, it did not necessarily have to evolve elsewhere.

Sir, Robert Zubrin [1] has stated that "The absence of free-living microorganisms simpler than bacteria on Earth is evidence that life did not originate on Earth, but immigrated." Further, he stated, "…while bacteria could not have been the first life, both the fossil record and current biological surveys strongly assert that bacteria were in fact the first life *on Earth*. The only way to resolve this situation is to hypothesize that bacteria did not evolve on Earth, but arrived here fully evolved from space." While I respect Dr. Zubrin's views, his arguments have several gaps, and his hypothesis is not the *only way* to resolve this situation.

Free-living organisms smaller than bacteria are not necessarily absent from the modern terrestrial biota. Although controversial [2], several researchers have described free-living nanobacteria [3, 4], which are much smaller and simpler than eubacteria or Archaea. If the structures found within the ALH84001 meteorite really are fossilized Martian microbes, they would also be nanobacteria-like in their sizes [5]. However, the nanobacteria hypothesis also has its problems. Taking into account the sizes of macromolecules and intracellular structures of modern bacteria, the most-accepted minimum size for a bacterium is a sphere of 200-300 nm in diameter [6, 7]. (This may be the minimum size for eukaryotes as well [8]). In particular, ribosomes, the sites of protein synthesis, are approximately 50 nm in diameter. Thus, a 200 nm cell would barely have enough room to enclose its genome, a ribosome and a few hundred essential macromolecules. If 200 nm is the minimum size of life, then the jump from non-living to living would have to be a broad one, regardless of where it originated.

Are ribosomes absolutely necessary for life? As we know it, yes. But another piece of research shows how pre-ribosomal protein synthesis might have worked. Saito *et al.* [9] described a tRNA-like molecule that is capable of aminoacylation—the joining of an amino acid to tRNA, which is the first step in the translation of proteins. In modern cells, protein enzymes—aminoacyl transferases—do this process. While this research does not preclude the necessity of ribosomes, it shows that simpler processes could have evolved first. Stretching this conjecture a little further might show how nanobacteria exist by utilizing non-ribosomal means of protein synthesis. Over time, the evolution of the ribosome might have caused the extinction of other, less accurate, methods of protein synthesis.

A similar argument has been made for the evolution of the modern DNA genome. Most evolutionary cell biologists believe that early life and/or proto-life was RNA-based [10, 11]. RNA has both genomic and enzymatic qualities [12], and thus could be self-replicating with fewer outside components as compared to DNA. There is even a possibility that something else preceded RNA during the evolution of life [13, 14]. What happened to RNA life? Most likely, it became extinct as early DNA-based organisms developed more accurate means of genomic replication. Due to its double-stranded nature, DNA→DNA replication is less plagued by mutations than RNA→RNA replication. Precursors to modern bacteria may have simply become extinct when they could not adapt to the ever-changing environment. For any number of reasons, including the development of the ribosome [15] and/or the use of DNA [16], the direct ancestors of modern bacteria could have out-competed purported pre-bacteria, which is why they are not found today.

Zubrin also states that the fossil record does not provide any indication of pre-bacterial life. The problem with this particular statement is that bacteria do not fossilize well. In general, fossils are derived from organisms with relatively resilient structures like bones or exoskeletons. Virtually all of the most ancient microfossils known to date are of filamentous and colonial bacteria [17, 18]. Fossils of single cells probably rarely formed, and would be difficult to locate. Fossils of organisms that are smaller than bacteria would be more difficult to locate, if they were formed at all. For example, to my knowledge, there have been no fossilized viruses even though the largest viruses (Poxviridae) are of approximately the same size as the putatively smallest bacteria (200 nm). Thus, one of the reasons why we do not have fossil evidence of pre-bacterial life is that the fossils never formed even if the pre-bacteria existed.

Most of Zubrin's arguments against the evolution of pre-bacteria on Earth are based upon things that have not been found. How many times have biologists said that certain organisms and processes could not exist, only to find them later? Hyperthermophiles and chemoautotrophs are just two examples of such findings from the twentieth century. Could life on Earth have come from another planet? Possibly, but at present, we have no conclusive evidence for it. However, Zubrin's article makes a good case for mechanisms of transfer between planets. Was panspermia a requirement for life on Earth? No—most of the evidence to date (though there are gaps) still indicates that life on Earth originated on Earth.

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