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Is the Universe teeming with life?

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Abstract. Although its philosophical and social implications are somewhat overstated, the issue of the existence or not of extraterrestial life is a legitimate scientific issue. The possibility that other planets were inhabited has been addressed since classical antiquity. However, more often than not, prior to the 19th century these discussions were speculations that rested on the idea of a uniform Universe but with little or no empirical basis and no understanding, for instance, of the nature of planets and other celestial bodies. Although it is tempting to assume that the emergence of life is an unavoidable process that may be continuously taking place in the Universe, we have not been able to demonstrate that it exists in places other than the Earth. Unfortunatly the search for extraterrestial life is high on speculation and low on facts and, in spite of its scientific allure, it has been shaped by a number of unjustified assumptions on the deterministic nature of the origin and evolution of planetary systems, the appearance of life and the emergence of intelligent life forms.

Key words. Astrobiology – Extraterrestrial life

1. Introduction

The possibility of extraterrestrial life has been addressed, sometimes in considerable detail, by naturalists and philosophers alike, for over two thousand years. The list of writers that have engaged in this issue is quite impressive and includes Anaximander, Lucretius, Bruno, Descartes, Bergerac, Huygens, Herschel and many others. Although many have assumed a scientific continuity between these ideas and the contemporary search for life in other parts of the Universe, a detailed analysis shows that more often than not these were speculations that rested on the idea of a uniform Universe.

In fact, at least three major epochs can be recognized in the study of extraterrestrial life. The first one corresponds to the philosophical discussions of the idea of the plurality of worlds, and its beginnings can be traced to the writings of Western thinkers from classical antiquity down to the middle of the 19th century. The second one begins around the second half of the 19th century, with the birth of modern observational planetology, and continued until the start of space exploration. The 1957 launching of the Soviet Sputnik marks the origin of a third epoch, that continues until today -although, of course, the issue of the existence of extraterrestrial life remains an open one.

In 1886 the distinguished physicist Ludwig Boltzmann wrote that "if I am asked if our century should be called the Iron Age or the Steam Century or that of Electricity, I can respond immediately and without hesitation for a moment: it will be known as the Century of the Mechanical Vision of Nature, the Century of Darwin" (Broda 1983). Boltzmann's statement summarizes the fascination that 19th century scientific and technological development awoke in many. As shown by the number of scientific societies, public lectures, and creation of museums, planetariums, and the foundation of private and public observatories that where created during that period, the popularity of astronomy and, with it, the idea of extraterrestrial life. This allure is also demonstrated in the extraordinary editorial success of the books of different authors, especially Camille Flammarion, whose works circulated profusely.

The influence that Flammarion, Lowell and others had in science fiction and in some current discussion on extraterrestrial life elsewhere has been documented and discussed in considerable detail by Basalla (2006). However, with very few exceptions, the reaction of 19th century from life scientist to these ideas have been largely overlooked. Based on his monistic idea of the unity of Nature, Haeckel proposed what may be the first scheme of the now popular idea of cosmic evolution, which started with Kant's nebular hypothesis for the origin of the Solar System and lead to the origin of the first cells, which he assumed where the outcome of a process of spontaneous generation (Haeckel 1876). Haeckel described the formation of the Earth and the condensation of a primitive hydrosphere after which was essential for the appearance of the water rich protoplasm. As he wrote, "[w]e can therefore, from these general outlines of the inorganic history of the earths crust, deduce the important fact, that at a certain definite time life had its beginning on earth, and that terrestrial organisms did not exist from eternity, but at a certain period came into existence for the first time" (Haeckel 1876).

2. Follow the water!

Based on his views on the origin of life and on his acceptance of the plurality of planetary systems, Haeckel had no problem in developing the idea of extraterrestrial life forms, as long as liquid water was available. As he stated in his 1899 book *The Riddle of the Universe at the close of the nineteen century*, "the analogy that we find in the life of all cells ... justifies the inference that the further course of organic evolution on these other planets has been analogous to that of our own earth-always of course, given the same limits of temperature which permit water in a liquid form. In the liquid bodies of the stars where stars can only exist in the form of steam and on the cold extinct suns where it can only be in the shape of ice such organic life as we know is impossible" (Haeckel 1899).

Haeckel happily accepted the possibility of evolutionary processes that could lead in other parts of the Universe, to "some higher animal stem, which is superior to the vertebrate in formation, higher beings have arisen [on other planets] who far transcend us earthly men in intelligence". However, he had little patience with the speculations of Flammarion, whose ideas he promptly dismissed by describing him as "equally distinguished by exuberant imagination and brilliant style, and by a deplorable lack of critical judgment and biological knowledge" (Haeckel 1899).

Percival Lowell's descriptions of a hypothetical Martian civilization capable of major engineering feats also failed to impress Alfred Russel Wallace, the co-discoverer of natural selection. Wallace was rather skeptical of Lowell's highly publicized claims on the existence of a complex network of artificial Martian canals, and in his small book Is Mars Habitable? he summarized the major flaws in Lowell's scheme. "[T]hough I wish to do the fullest justice to Mr. Lowell's technical skill and long years of persevering work", wrote Wallace, "which have brought to light the most complex and remarkable appearances that any of the heavenly bodies present to us, I am obliged absolutely to part company with him as regards the startling theory of artificial production which he thinks alone adequate to explain them". Wallace politeness did not stop him from stating, after a thorough meteorological, physical, engineering and biological analyses of Percival Lowell, "that animal life, especially in its higher forms, cannot exist on the planet. Mars, therefore, is not only uninhabited by intelligent beings such as Mr. Lowell postulates, but is absolutely UNINHABITABLE." (Wallace 1907).

3. Towards a new understanding of the origin of life on Earth

Although the idea of life as an emergent feature of Nature was widespread towards the end of the 19th century, it was not until Oparin (1924, 1938) who proposed that the first living entities were heterotrophic microorganisms that were the outcome of the evolution of abiotically synthesized organic compounds and the formation of a self-sustaining supramolecular systems that the origin of life was transformed from a purely speculative discussion into a workable research system (Lazcano 2016a). Together with the development of planetology and organic chemistry, the availability of a theory that linked the on the origin of life to the evolution of the primitive planet became one of the key issues that gave some ground to the discussions on the possible existence of extraterrestrial life forms.

In the early 1950's is was generally accepted that

(a) living beings could be divided into three major (Haeckelian) kingdoms (plants, animals and microbes);
(b) microbes were generally seen as pathogens or parasites, but not as ancestors of extant life;
(c) the oldest fossils were about 600 million years old;
(d) the emergence of the biosphere had been a lengthy process involving billions and billions of years;
(e) proteins played a major role in genetic continuity;
(f) the formation of planetary systems was rare; and
(g) that space exploration was unlikely.

It was within this context in which the Miller-Urey experiment, which demonstrated 1953 that the easiness by which amino acids and other compounds of biochemical significance could be synthesized in a CH_4, NH_3, H_2O and H_2 atmosphere simulating the prebiotic environment (Miller 1953), provided strong support for Oparin theory (1924, 1938). The scientific and public impact of the Miller-Urey cannot hardly be overstated. A few weeks after the publication of the Miller experiment, the Society for Experimental Biology in Cambridge convened a special meeting, that was followed by a 1955 meeting in the Brooklyn Polytechnic in New York and, a year later, by one organized by the New York Academy of Sciences. The most significant symposium, however, was the 1957 Moscow Meeting on the Origins of Life, organized by Oparin, and which signaled the possibility of scientific exchanges with the USSR following the death of Stalin.

The issue of extraterrestrial life was not addressed at the Moscow meeting, but an exchange between Oparin and Olga B. Lepeshinskaya, an associate of Lysenko and a friend of Stalin, can be read as an indication of the ideological issues underlying discussions on the origin of life in the Universe. Based on a simplistic and dogmatic interpretation of Engels' claims of the universality of dialectical materialism, Lepeshinskaya stated that although she accepted Oparin's proposal that the origin of life could not be associated with the emergence of a single, living molecule, "we cannot, however, agree with A. I. Oparin's other proposition that forms of life similar to the original ones cannot exist under natural conditions at the present time ...". This valuable exchange of ideas leads us closer to the conclusion that the material of life is protein which can develop and determine development. And then we remember again with thankfulness the words of Frederick Engels: *"Life is the mode of existence of albuminous bodies"*. (Lepeshinskaya et al. 1959). Oparin's response to this criticism, which could be safely stated by then, was that, indeed, forms of life similar to primordial entities can exist under natural conditions at the present time, but not on Earth, where the emergence of life led to an irreversible modification of the terrestrial environment, but elsewhere in the Universe, where the processes that led to the origin of life could be taking place (Oparin & Fesenkov 1961).

Unbeknownst to the attendants to the 1957 Moscow meeting, the USSR was about to launch a few weeks later the Sputnik. In the context of the Cold War atmosphere, the Sputnik can be seen as technological feat that provoked political and scientific impacts that continue to reverberate to this day. In July 1958 the USA government created a number of advisory boards, including the Space Science Board (SSB) chaired by Lloyd V. Berkner. He was a promoter of the International Geophysical Year, and the SSB contact with the State Department. One should not be surprised by this. As reviewed by Wolfe (2002), during the postwar period, USA scientists "working with the National Institutes of Health, the National Science Foundation and, of course, the Atomic Energy Commission all cooperated with institutions that, with or without their knowledge, supported secret projects and research. More to the point, all of these programs, with their emphasis on economic growth and national achievement, served the national interest ... the contradictions that characterized early American exobiology are typical for a period in which the boundaries between civilian and military interests were blurred almost beyond recognition". Thus, in the wake of the launching of the Sputnik, and as a result of a complex mixture of social, political, military and scientific interests, "on July 29, 1958 President Eisenhower signed the National Aeronautics and Space Act, creating NASA as the US space agency ...".“ ...NASA was formed in 1958, [and it can be seen as] the epitome of Cold War science institutions ..." (cf. Strick 2004).

As discussed by Wolfe (2002), the academic interests of Berkner, whose work in the evolution of the Earth's atmosphere included the recognition of the role of cyanobacteria, of Joshua Lederberg and others rapidly bought exobiology to the forefront of USA space policy. Although Lederberg's initial concern was the microbial contamination of the Earth or other planets, he rapidly realized the scientific potential of a space program. Could it confirm, wrote Lederberg, that "the intimate biochemical information in which we are really most interested? Can it tell us the composition of the indigenous amino acids, or whether the amino acids (if any) are D- or L-?" (cf. Wolfe 2002). NASA stopped defining life-sciences as merely a "man in space" program, space biology as an issue of space medicine, physiology at high altitude or contamination, and became committed to exobiology, which was seen as the study the origin, evolution and distribution of life in the Universe. The timing was good: as reviewed elsewhere, the growing interest in planetology and in the geochemical history of the Earth, stimulated the emergence of a loosely defined group of scholars that included senior scientists like the paleobiologists Elso Barghoorn and Preston Cloud, as well as young researchers from a wide variety of fields with a strong interest in the origin and evolution of life and its complex intertwining with Earth's history. Their youth, intellectual boldness and scientific drive were major assets, as were the new funding policies that were being implemented in USA universities (Lazcano Peretó 2017). It is this context that the role of NASA as a major promoter in the study of the origin of life on Earth and elsewhere was amplified, transforming the field into the highly articulated network of scientists, laboratories and students that we see today.

4. Extraterrestrial life: much ado about nothing?

The search for extraterrestial life is high on speculation and low on facts. It is true that many extrasolar planetary systems are known today, but even if planetary environments capable of supporting life may be common, this does not in itself support the notion that life is common in the Universe (Cleaves & Chalmers 2004). The major arguments in support for the existence of other forms of life include

(a) the diversity and abundance of extraterrestrial organic compounds, including many which are precursors or intermediates in Miller-Urey type experiments, which are found in the interstellar medium and in comets and meteorites;

(b) the robustness of abiotic syntheses, which suggest that prior to the origin of life the primitive Earth already had a wide array of organic compounds of biochemical significance;
(c) the evidence of a rapid origin of life on Earth;
(d) the evidence that early Martian conditions were conducive to the appearance of life; and
(e) the high numbers of Solar-type stars and extrasolar planetary systems.

The above supports the conclusion that the formation of planets and the origin of life are natural outcomes of evolutionary processes, but do not imply that they are unavoidable outcomes of evolution. In the absence of unambiguous proof for its existence, almost nothing can be said about extraterrestrial life about which the opposite is not also true (Lazcano 2012). The case for extraterrestrial intelligent entities is even weaker. As argued by a number of authors, is tainted by a series of social prejudices and unsustained expectations. It is based on the unwarranted extension of the Mediocrity Principle, and tainted by an anthropomorphic perspective of cosmic evolution that includes a utopian, escapist solution for environmental and health issues (including immortality!) under the assumption of the universality of progressive technology, as well as uncomfortable religious overtones (Ward & Brownlee 2000; Shermer 2001; Wolfe 2002; Basalla 2006; Morange 2007; Lazcano 2012). Much to the dismay of the followers of the idea of advanced extraterrestrial civilizations, many astrobiologists are now more interested in the search for extraterrestrial microbial biological activity, since it is more likely that improved astrophysical techniques can provide information on the presence and chemical composition of atmospheres of extrasolar planets.

Following the interest in the Martian meteorite ALH84001 (McKay et al. 1996), President Clinton declared that the United States would "put its full intellectual power behind the search for further evidence of life on Mars". The debates on the ultimate origin of the structures and organic compounds in the ALH 84001 Martian meteorite demonstrated that we not only lack a definition of life, but also a universally accepted definition of what is evidence of biological activity. Nevertheless, following the interest created by the analysis of the ALH 84001 meteorite, in 1997 NASA announced the first round of competition for its NASA Astrobiology Institute (NAI).

Astrobiology was thus born, and what was meant to be a reorganization of NASA funding policies, was rapidly welcomed as a new, grandiose unifying field of research. Like "astrobiology", NASA's "exobiology" was also a funding program, committed basically to the study of origin and early evolution of life, and was rarely considered as a "new science". There are major differences between exobiology and astrobiology. Perhaps one of the significant one is defined by the changes in the the scientific environment and funding policies, which are dramatically different from what they were when exobiology was first established 50 years ago. Exobiology had, in practice, a more limited scope than astrobiology and kept a very healthy distance from science fiction scenarios and avoided religious overtones. Even more worrisome, the redefinition of astrobiology's public relationships has brought with it a confusion between academic expertise and celebrity, together with the lowering of scientific standards that has led to unfortunate episodes including claims on the existence of arsenic-containing DNA and the presence of cyanobacterial fossils in meteorites.

5. Conclusions

The existence of extraterrestrial life is a legitimate scientific and philosophical issue. The distinguished American evolutionist George Gaylord Simpson once said that "exobiology is still a science without any data, therefore no science". Depending on the definition we advocate, the same can be true of astrobiology. It is of course difficult to evaluate the role of historical contingency in the origins of life on Earth, but we cannot discount the possibility that even a slight modification of the primitive environment could have prevented the appearance of life on our planet. Perhaps not surprisingly, some of the most distinguished contemporary evolutionists like George Gaylord Simpson, Ernst Mayr, Lynn Margulis and Theodosius Dobzhansky, were also some of the harshest critics of the teleological schemes advocated by those convinced of the abundance of intelligent life in the Universe. Their healthy skepticism is a lesson we must keep in mind (Lazcano 2016b). However unpalatable this conclusion may be, life may be a rare and alas, perhaps a unique phenomenon in the Universe.

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