Comments on the contending hypotheses about the origin of life

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The problem on the origin of life is one of the most challenging and fascinating of the whole science. Understanding how living organisms have arisen from the abiotic conditions believed to prevail in most of the Universe is a formidable and exciting enigma. A great deal of effort has been devoted to concoct a plausible chain of events to explain how, from the abiotic conditions of the primitive Earth, the basic building organic molecules could arise, a proposal often referred to as Oparin-Haldane hypothesis, and whose plausibility has been partially shown by the Miller-Urey experiment. Furthermore, thanks to the understanding of DNA's structure and the genetic code we can map out the history of evolution all the way back to single celled life. However, this brings a problem as the DNA is a quite efficient way to store information, but cells to function rely on other molecules, proteins, to replicate, grow and survive. Proteins, on their hand, are efficient molecular machines to keep cells alive and healthy, but they are unable to store information or to make copies of themselves as for that they require the DNA. Thus, DNA needs proteins to function, and proteins need DNA to exist. So, which came first? Which molecule made life possible? Scientists have proposed various scenarios about the primeval set of biomolecules. In fact, there is a third type of molecule that may hold the answer: RNA.

Many scientists think that RNA may have been the primeval molecule, as besides being able to carry genetic information, it can also serve as a protein-like chemical catalyst, speeding up certain reactions. Indeed, the enzymatic properties of the RNA strongly suggested that it might have played a fundamental role in the chain of events that led to the most basic features of life. This "RNA world" is believed to be a quite plausible hypothesis [1], even though, it has never been completely shown. Nevertheless, recent results due to John Sutherland and collaborators [2] have demonstrated that showing the RNA hypothesis might be within reach. This is supported by the complementarity of the nucleotidic bases (which promotes an exact replication, as one sequence serves as a model for the other), and also by the discovery of ribozymes, RNA molecules that have the ability to catalyze specific biochemical reactions. For this reason, ribozymes, viroids and virusoids are regarded "molecular fossils" of the RNA World.

It is true that organic molecules and aminoacids can be, for instance, ensembled in interstellar clouds as shown by spectroscopic evidence [3,4], however, estimates show that their concentrations are rather low and thus they do not seem to provide suitable conditions for further development. Moreover, life on Earth is fundamentally dependent on the presence of water, which, although present in space, does not seem to be particularly abundant. Indeed, in the solar system, for instance, besides Earth, only Europa and Enceladus do show evidence of the existence of oceans underneath their frosty surface. Titan, for example, although rich in gaseous and liquid organic compounds, shows no traces of water. Of course, the discovery of more than 4000 exoplanets (about 6 x 10^9 are believed to exist in our Galaxy) make the search for a suitable combination of molecules and of niches of life much more exciting, however, at present no reliable means are known to directly access the relevant information.

For sure, the vastness of the Universe and the multiplicity of conditions that it may host could, in principle, lead to better changes for nurturing the appearance of life than the ones that existed in the primitive Earth. Indeed, rather general invariance physical principles such as Lorentz invariance, local position invariance and the Equivalence Principle do suggest the universality of the laws of physics (see e.g. Ref. [5]) from which follows the universality of the ensued laws of chemistry and hence the assumption that if life has appeared on Earth, it can appear elsewhere [6]. Naturally, the reverse is also true and therefore, the hypothesis of the appearance of life on Earth or elsewhere, the Panspermia hypothesis, should not be regarded as contradictory, but in fact as complementary.

The Panspermia hypothesis posits that life formed on at least one site elsewhere Earth, being then spread to planets such as ours, assuming that this delivery process is faster than local biotic generation. Furthermore, as discussed by Wickramasinghe [7], an important claim of Panspermia is the discovery of extra-terrestrial biotic material on meteorites. However, this material lacks fractionation, i.e. it presents all kinds of molecules, while it is natural to expect from biotic chemistry clear signs of selection [8]. This makes for a strong argument against Panspermia. Another often mentioned marker, the existence of chirality in meteoritic biotic material, taken by some as evidence of biotic selection, might be accounted by alternative abiotic explanations [9]. As for the so-called "micro-fossils", claimed to be present in the Murchison meteorites, their validity as indicators of life is quite controversial. In fact, these fossils were observed three decades after its fall, a time-scale that was shown to allow for all sorts of contamination [10]. Furthermore, even if the observed resilience of primitive forms of life observed on Earth[1] suggests that travelling and delivery might not be a problem as suggested by Panspermia, the challenge of achieving the basic features of life from abiotic conditions remains unanswered.

[1] Organisms from the Archaea domain are single-celled, ubiquitous on Earth, and include extremophiles that can survive environments such as the deep sea, hot springs, permafrost, salt lakes, and arid regions; some have been shown to withstand simulated space conditions [13]

Therefore, the conundrum of explaining the origin of life is not at all resolved by the Panspermia hypothesis. In fact, in many respects, it raises more questions than it apparently solves.

So concerning Ref. [7] a few questions are in order:

1. Liquid water has many peculiarities that confer it quite special properties: the ability to connect hydrogen connections, a high polarity and a high dielectric constant. In the presence of liquid water, large organic molecules struggle between hydrophobic and hydrophilic groups. This duality can generate interesting situations, such as a stereoselective aggregate of short peptide sequences of hydrophobic residues - alternative hydrophilic in thermostable β sheets, dotted with chemical additivity. Liquid water is also a powerful hydrolytic agent. As such, it allows for features that have no match in any organic solvent [11]. Thus, the interrelation between water and the origin of the first life forms on Earth is physically natural. It is also known that there is no evidence of the presence of large amounts of water in space except on the environments we mentioned above.

Hence, in an environment where water does not seem to be particularly abundant, how was it possible to overcome the hurdle of creating biotic conditions from pre-biotic ones?

2. We find that the arguing against local biogenesis presented in Ref. [7] misses a great deal of relevant details. For instance, it puts forward too many unexplained assumptions, such as setting the spontaneous assembly of a ribozyme, a 300-component long molecule, as a first step. Another questionable point is the presented amplification factor for the interstellar transfer of life, which lacks a derivation and a proof of sufficiency. Only after rigorously modelling the local processes leading from abiotic to biotic molecules, either in planets or in space, and the amplification provided by interstellar transfer, one could properly answer if assembling the first molecules life on our planet is more likely or not than assembling them in space. More specifically, while the number of initial spreaders is related to the first factors of Drake's equation, the dynamic processes that follow are complex and more closely resemble network propagation models [12].

Therefore, we ask: how can one properly compare the likelihood of Panspermia in comparison to the one of local biogenesis?

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