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RESEARCH ARTICLE

A philosophical perspective about the origin, evolution and distribution of life in the Universe

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Abstract

The main idea is to present the general aspects of the origin, evolution and distribution of life in the Universe from a Philosophy of Science perspective. The methodology used to develop this paper was through the intersection of favourable and unfavourable arguments from practitioners of science in the field of modern Astrobiology. The results were quite interesting and the historical crossover between the different arguments provides a great perspective on the research programme for the search for extraterrestrial life. Finally, although there is in fact no evidence that extraterrestrial life exists, the search for extraterrestrial life should not be considered as mere speculation. In the end, there are increasing indications that something extraordinary may be about to be found, whether on Mars, Europa, Enceladus or on some exoplanet.

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Introduction

Modern astrobiology is defined as the area that is concerned with issues related to the origin, evolution and distribution of life in the Universe (Blumberg, 2003). Despite all the biodiversity that exists on planet Earth, most of us, including children, are able to distinguish living from nonliving things. However, it is not possible to know if all the life existing in the Universe – if there are other forms of life – are identical or even similar to those that exist on this planet. After all, will we know how to identify and define a pattern of extraterrestrial archetype as life?

This aspect of the search for a uniqueness, so far, has been one of the obstacles that has made it impossible to answer the Socratic question 'What is life?'. This remains a major open issue for three distinct reasons. First, would it be possible to know if there was success in detecting extraterrestrial life without having a proper definition of life? Second, in looking for and trying to understand the origin of life, would we be able to tell when the transition from chemistry to biology took place even without a definition of life? Third, is it possible to decide how and where we look for life beyond Earth, without a universal definition? Finally, is it possible to talk about the origin, evolution and distribution of something that does not have a definition?

The term 'life' is part of the essence of the conceptual statement that defines the field of Astrobiology. Because of this, then, before starting discussions about the 3 terms – origin, evolution and distribution – that are the foundations of Astrobiology, it is necessary to develop a non-exhaustive digression on some aspects that involve the concept of life, even without intending to provide an answer to the problem.

Fundamentally, there are numerous concepts that have been enunciated in different ways throughout history that sought to answer the question 'What is life?'. However, all models that seek to represent the general aspects of life from a universal definition, at some point or in some way, proved to be flawed (Schrödinger, 1944; Johansson *et al*., 1978; Margulis and Sagan, 1995; Stenholm, 1997; Anbar, 2001; Bennett *et al*., 2003; Ruiz-Mirazo *et al*., 2004, 2010; Zhuravlev and Avetisov, 2006; Schulze-Makuch and Irwin, 2008; Carroll, 2009; Fry, 2009; Strick, 2009; Tsokolov, 2009; Benner, 2010; Damiano and Lisi, 2010; Deamer, 2010; Gayon, 2010; Kolb, 2010; Popa, 2010; Tirard *et al*., 2010). Even so, the different perspectives on the concept of life can be divided into two groups: Reductionist and Holistic.

What is life?

In general terms, when trying to look for definitions about life, it is possible to notice that most – if not all – start from a reductionist perspective. Reductionist concepts suggest that the basic and integral components of living beings have specific patterns and functions, which must be possible to obtain and understand when reduced scale by scale, observing the phenomena from micro to macro (Driesch, 1908; Sagan, 1967; Sober, 1999; Schneider and Sagan, 2005). On the other hand, the other perspective called holistic or systemic had its origin in the year 1926, when the South African statesman Jan Christiaan Smuts coined the term, in his book Holism and Evolution, he writes: '*the unity of the parts can be greater than the sum of the parts, which not only gives a conformation or structure to the parts, but relates and determines them through a synthesis where their parts are altered; synthesis affects and determines the parts so that they function and address the whole*'. Given the reductionist and holistic perspectives, how is it possible to think of conceptual representations of life in a universal definition?

In a reductionist way, the Chilean neurobiologist, critic of mathematical Humberto Maturana, along with the philosopher and biologist Francisco Varela, would answer that life could be defined as an organizationally closed system, in which all components are both a product and a producer of the network. For both the universal concept of life would be described by the principle of autopoiesis: '*the network of components that corresponds to the living system would be closed in organizational terms, but open in material and energetic terms, that is, it is always exchanging matter and energy with the external environment.*' (Maturana and Varela, 1973).

Although this reductionist perspective proposed by Maturana and Varela has its advantages for distinguishing living beings from non-living beings through the ability to reproduce in an organized way, being a closed system, but which interacts with the external environment, in which wood taken from a tree, rocks, viruses and several other specimens would no longer be considered life by this definition. However, the Brazilian astrophysicist Augusto Damineli would argue unfavourably saying that natural phenomena such as storms, cyclones and many others are organized in a closed structure and exchange energy and/or matter with the external environment.

Another alternative would be the principle of biosemiotics, suggested by the philosopher, linguist and mathematician Charles Sanders Peirce, in which the process of life could be seen as a semiotic phenomenon. Pierce starts from the principle of trying to understand life not only through the organization of molecules, but also through the interaction they have with each other. In Peirce's terms '*interpretation between signs*'.

For Peirce (Charles Sanders, 1958), a sign is something that refers to something else, in some of its aspects. The effect of a sign on the system that interprets it is called the interpretant. In this way, the action of the sign (semiosis) occurs through a triadic relationship between the sign (the element that mediates the relationship between object and interpretant), an object (what is represented in the

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sign) and an interpretant (the effect of the sign) about the interpreter. It is worth mentioning that this is a new field of knowledge in the philosophy of biology, biosemiotics.

This perspective is proposed by Peirce, although it has the advantage that we do not need to decide on a particular property or set of properties as necessary and sufficient. In practice, it is not simple to adequately reproduce the identification of a series of characteristics that are associated with life. This proposal from Pierce even has some similarity with the proposal called family resemblance, which argues that no living being has all the properties and for certain living beings they do not need to share the same characteristics, as long as they have some of the characteristics of the cluster. However, how to identify these characteristics and which ones are relevant?

Richard Dawkins would answer that the characteristics of life, which could be understood and as relevant characteristics, should be taken into account the aspects of the replicators (RNA and DNA), so that these specimens would be distinguished from a cladistic process (Dawkins, 1983). Although this seems to be a good way out, the methodology would work fundamentally well only for simple examples that are relatively consistent (archetypes like books, chairs, tables, dogs, cats).

However, life on Earth is much more multifaceted. Now, when we go looking for life on other planets, it is possible that there are examples that could be very different from life as we know it on Earth. For example, they can have a triple helix DNA structure, a biochemistry based on silicon instead of carbon, use another nitrogenous base to form amino acids or even be the same nitrogenous base as ours, but be composed of other amino acids that, life as we know it, does not use.

It is not easy to provide an appropriate 'universal' definition of life, if that is possible! The attempt to define something so complex sometimes ends up including or restricting the concept too much, adding or leaving out considerable archetypes. Ernst Mayr would argue that: '*such efforts are simply futile, for it is now perfectly clear that there is no special substance, object, or force that can be identified with life.*' (Mayr, 1974).

Serhiy Tsokolov would endorse sustaining with the argument that, '*it is not possible to say categorically what life is, because there are three important epistemological difficulties for the definition of life: (1) the bad definition of terms; (2) difficulty in combining descriptions; (3) the problem of arbitrating a minimal system to be characterized as life in a non-contingent way.*' (Tsokolov, 2009). Is the lack of ability to develop holistic perspectives the unfavourable factor to build a universal definition of life? Or would it be necessary to find other specimens outside Earth so that it is possible to deepen, detail and improve our definition of life? Or is it really possible to generate a definition of life that is not contingent on Earth?

Perhaps, not knowing how to define life is not such an urgent problem for Astrobiology to develop its research practice. For example, (1) the extraterrestrial specimens found, if they have the same structure or constituents very similar to the archetypes of terrestrial beings, (2) if the extraterrestrial specimens, despite having both morphological structures and different chemical composition, are intelligent and communicators. In both cases, it would be possible to distinguish living from non-living.

The problem will arise, then, most likely, when we find some specimen that is not intelligent, that has no communicating and does not have chemical compositional structures similar to life as we know it. In these cases specifically, we will indeed be confronted with a major empirical problem. However, this should not be taken as an alarming factor, as every problem is nothing more than a new puzzle, or in other words, a new challenge to the practitioners of science. After all, the role of science is to solve open-ended problems.

Disregarding the possibility that there are extraterrestrial beings that do not have communication or that have completely different characteristics from the examples that exist on Earth, would it be possible to obtain some contribution to the question of the origin of life on Earth? Or, conversely, if ETIs have communication or the chemical composition of ETs is similar to Earth archetypes, is it possible to get some contribution to the question of the origin of life on Earth?

Origin of life

Numerous questions have been asked throughout human history, seeking to understand what type of mechanism would explain the feasibility of changes from one thing to another, not being this process a simple succession so that it could be possible to verify that *something permanent* still exists in common between what was and what has become. In modern astrobiology there are two hypotheses for this – endogenous and exogenous – that compete with each other, seeking to foster plausible clarifications about the origin of life on Earth.

The endogenous hypothesis follows the idea that the Earth has always had chemical and environmental conditions to generate life. However, what is the origin of replicating systems, under what conditions would life have arisen, out of nowhere? What is the role of chance and necessity in the origin of life in the universe? The Brazilian chemist, Dimas Zaia, would answer the first question by saying that life would not arise from nothing, but in an abiotic way through interactions between simple chemical compounds that would combine to generate the first cells that would give rise to the first living organisms. In the words of Dimas:

> '…first, from simple molecules (e.g. methane, ammonia, water, hydrogen) that reacted with each other, the accumulation of biomolecules (amino acids, lipids, sugars, purines, pyrimidines etc.) of many millions of years; later, these biomolecules began to combine with each other to form biopolymers (giant molecules made by repeating single units, such as proteins, which are synthesized from amino acid units); A few more million years passed, and then these biopolymers began to combine, forming what Oparin called coacervated structures, which are very reminiscent of today's cells. Over the years (millions of them), within these coacervated structures, increasingly complex reactions continued to take place until we could say that we had the first living thing. Here we define a living organism as one that uses substances from the environment to extract energy (metabolism), generate similar ones (reproduction) and be able to change (evolve). (Zaia, 2003).'

Regarding the second question, the Belgian biochemist and Nobel Prize winner in Physiology Christian de Duve would probably respond: '*The origin and evolution of life on Earth did not occur by chance, but rather as a consequence of the laws of chemistry*'. Now, if life on Earth had its origin from this endogenous process, would it be possible for this same process to be repeated on other worlds? Is the universe tuned for life? Is there a link between biology and cosmology?

Dimas Zaia would answer the first question by saying that this process would open up the possibility of the existence of life on other planets besides ours. In the words of Dimas: '*we will have a Universe full of life if we have in many places (other planets in other solar systems) the right conditions, both for the beginning of the formation of essential molecules, as for all the subsequent stages*' (Zaia, 2003). However, he does not fail to point out that a Universe full of life would only occur, in his words: '*if none of the stages of the entire process of origin of the living being is extremely rare.*' (Zaia, 2003).

Regarding the other two questions, the British naturalist Alfred Russel Wallace (1823–1913) would answer that the cosmological formation is an important and active player and cannot be considered a mere decoration. The British cosmologist and astrophysicist Martin Rees (2011), who was the president of the Royal Society, endorses this position with arguments described in his book Our Cosmic Habitat (2003): '*A universe hospitable to life – what we might call a biophilic universe – has to be very special in many ways. The prerequisites for any life – long-lived stars, a periodic table of elements with complex chemistry – are sensitive to physical laws and could not have emerged from a Big Bang with a recipe that was even slightly different.*'

The problem of the origin of life, as you can see, is quite complex and involves many different aspects. Prebiotic Chemistry, it seems, has a very important role for Astrobiology in this regard. However, so far no one has been able to produce a living being in a laboratory from *inanimate matter*. In this way, science practitioners opposed to the idea of life arising abiotically from endogenous aspects, suggest the possibility of the origin of life through exogenous.

The exogenous hypothesis proposes the idea that chemical compounds or even living extraterrestrial microorganisms could accidentally seed life on Earth. In other words, Earth could be a place with habitable conditions to harbour extraterrestrial life that could have been brought in by meteorites or be a propitious environment for extraterrestrial chemical compounds to synthesize the first protocells and give rise to life on the planet. In this way, compounds of chemical or biological origin could, from this perspective, reach the planet and spread life. Thus, there are two subsets of exogenous hypotheses: chemical exogenous and biological exogenous.

So, let's start with chemical exogenous, which despite having a conception similar to the ideas of terrestrial prebiotic chemistry, does not need all its chemical compounds to be produced from a single planetary source. In this case, these chemical compounds may have been formed part during the birth of the star (CHONPS), or come from the phase of formation of the planetary disc, or from the formation of the planet itself and/or they could simply come from outside from comets, asteroids and coming to Earth in the form of meteorites.

There are several indications that are favourable to this perspective since all 20 types of amino acids have already been observed, in addition to all 5 nucleobases (adenine, guanine, cytosine, thymine and uracil) that form RNA and DNA, which are part of the structure of all living organisms on Earth in carbonaceous meteorites (Oba *et al*., 2022). Experimental chemistry or Astrochemistry, nowadays, has an instrumental basis to develop both observational and experimental research on the feasibility of complexification of simple molecules present in the interstellar medium to be able to generate complex molecules. However, the problem about the impossibility of generating a living organism or knowing how it would be generated, whether on Earth or off it, remains an obstacle. So, if the origin of life is still not able to be explained from a reductionist chemical mechanism, would life on Earth have occurred due to an accidental event of extraterrestrial microorganisms falling on our planet?

This idea was first proposed by the Swedish chemist Svante Arrhenius (1903), who inferred that it was possible that spores could have seeded life on our planet. Today this biological conception of exogenous, is known as panspermia. In favour of this perspective, British astronomer Fred Hoyle and Indian astronomer Chandra Wickramasinghe argue that: '*For bacteria in interstellar molecular clouds, ultraviolet radiation poses no problem. Only a thin layer of carbonaceous material condensed around a bacterium would protect it from potentially harmful radiation.*' (Wickramasinghe, 2010).

Although today there is a range of experiments in which it is possible to observe these inferences made by Hoyle and Wickramasinghe (1981), the stigma against panspermia remains. The reasons are two: (1) if life was sown by an extraterrestrial microorganism, why so far we have not been able to detect traces, traces or any kind of sign of its primary origin? (2) If life originated from an extraterrestrial microorganism, what mechanism gave rise to this specimen?

As for the first, Chandra Wickramasinghe responds by admitting that: '*A direct demonstration that viable microbes exist within cometary material is needed.* […] *Such in-situ space experiments are in fact underway as a long-term goal of Space Science*'. (Wickramasinghe, 2003). Regarding the second, it remains a strong question and leads to numerous debates, including generating aspects that point to chemical exogenous or endogenous itself as a complementary way to these speculations about the origin of life in a universal context. It is worth mentioning that, although there is an international society that brings together a substantial number of practitioners of science, all over the world, interested in the most varied aspects of the problem, called the International Society for the Study of the Origin of Life.

Evolution and the distribution of life in the Universe

The various narratives exposed here trying to explain the origin of life, consequently end up stimulating curiosity not only about how life evolves, but also about the possibility of it being able to exist and be distributed in other worlds. In these matters, evolutionary biology has become the great protagonist. After all, whether this scenario is purely metaphysical or not, some questions end up being asked and are quite interesting both from a theoretical perspective of evolutionary biology, and for practices in chemistry and biology laboratories. (1) the planetary environmental condition exerts influence as a limiting factor for the existence of extraterrestrial life? (2) Are extraterrestrial beings very similar or very different from us? (3) Is there a law of universal selection?

Life as we know it – as already mentioned – depends on certain conditions for its existence, establishment and development. Thus, environmental factors can be quite limiting for humans and other living organisms that have similar adaptive mechanisms. In other words, beings considered mesophiles that depend on suitable conditions of temperature, pressure, salinity, PH and radiation rate, in addition to liquid water. So, would the planetary environmental condition be a limiting factor that would influence the non-existence of extraterrestrial life?

American palaeontologist Peter Douglas Ward and NASA astronomer Donald Eugene Brownlee argue that the emergence of complex multicellular (metazoan) life on Earth required an unlikely combination of astrophysical and geological events and circumstances. Ward and Brownlee, describe in their work *Rare Earth: Why Complex Life Is Uncommon in the Universe* (2000), the thesis that physical factors indicate the uniqueness of the Earth as a possible abode for complex life and that biological factors demonstrate the few chances and almost unlikely macroevolutionary reproduction in complex life on other worlds.

Palaeontologist George Gaylord Simpson would respond by endorsing the view that while simple microbial life is likely to be ubiquitous throughout the Galaxy, complex biospheres such as Earth's are very rare due to the exceptional combination of many distinct requirements. Simpson says:

> 'There are four successive probabilities to be judged: (1) the probability that suitable planets exist; (2) the probability that life arose in them; (3) the likelihood that such life evolved in a predictable way; and (4) the likelihood that such evolution would eventually lead to humanoids. … the first probability is reasonable, the second much smaller but appreciable, the third extremely small, and the fourth almost insignificant. … The product of these probabilities, each a fraction, is probably not significantly greater than zero.' (Simpson, 1964).

This is Simpson's '*real*' argument, where probabilities (3) and (4) in the above quote contain what is normally labelled the evolutionary contingency argument. However, Simpson does not distinguish complex metazoans as a critical stage in evolution. On the other hand, Simpson calls it '*the probability that such life evolved in a predictable way*' without explaining it further.

After all, what would be predictable? There are two different ways to interpret Simpson's probability (3): (1) as being a Weak Convergence Principle, where there is a tendency for extraterrestrial beings to converge on other structures that might not have a humanoid morphology, despite being approximately similar (e.g. bilateral symmetry). In contrast, it could be seen from (2) Strong convergence principle, in which it would be based on macroevolutionary processes, implying that upon detecting any intelligent extraterrestrial being, even indirectly, we would have the right to conclude that it resembles ourselves, that is, they are humanoid.

Another important point that was mistakenly developed by Simpson and needs some attention is the term humanoid that appears in probability (4). Simpson was not naive! On the contrary, he left such naivety to a few other optimistic practitioners of science. For example, for Conway Morris (2009) a humanoid would be, in his words: '*…a natural, living organism, with intelligence comparable to man in quantity and quality, therefore, with the possibility of rational communication with us.*'

Simpson presents his scepticism against naive inductivist optimists from the argument: '*The assumption… that once life begins anywhere, humanoids will eventually appear is clearly false. The chance of duplicating man on any other planet is the same as the chance that the planet and its organisms have had a history identical in all respects to that of Earth for a few billion years.*'

The statement made by Simpson in his above argument, which is directly related to probability (4), is based on the contingent nature of terrestrial biological evolution, made famous in the Wonderful Life of palaeontologist Stephen Jay Gould (1990). The most important point to note here is that Simpson (consciously or not) plays on the ambiguity of the definition of humanoids. After all, in the previous passage 'humanoids' appears in the first sentence of the quote and then the term 'man' is used in the second.

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Now, seeking greater precision in the use of the language to be expressed, humanoids and humans despite having similarities to each other, in essence, are terms that denote objects or things that are different from each other. The set of humans of the species Homo sapiens is a subset of all humanoids both in the morphological sense and in the media sense (using 'poetic license', the latter follows a biosemiotic sense). After all, ellipses are not defined as identical to circles. Thus, even admitting the possibility of an accidental slip of the pen, in general, it is important to understand that the usual argument of biological contingency is ambiguous in the way it has been arranged.

After this non-exhaustive exposition on the arguments in favour or not of life existing outside Earth, it is then possible to admit – and we no longer need to conjecture – that there are many possible abodes of life in our Galaxy (following not only probability (1), as also the results of observing more than 5000 exoplanets), and how Simpson himself – one of the biggest, if not the biggest, sceptics – did not find biogenesis unlikely under the right conditions (2). In this way, it is possible to debate, in the light of these premises, other perspectives on the planetary environmental condition being a limiting factor that could exert some influence on the existence of extraterrestrial life.

On this first question, despite the environmental factor, it seems to be a limiting factor for human beings. There are other terrestrial specimens that have the ability to survive, live and even some of them depend on conditions considered hostile to humans to exist. In June 1965, American microbiologist Thomas Brock observed microscopic organisms – *Thermus aquaticus* – that had adaptive mechanisms that provided them with the ability to thrive in hot springs in Yellowstone National Park, USA (Brock, 1967). Since then, there has been an explosion of observations around the world. These microorganisms came to be recognized by the term extremophile from the Latin *extremus* which means 'extreme' and from the Greek *philiā* (φιλία) which means 'love' (Gupta *et al*., 2014).

So, if there are terrestrial specimens capable of supporting and even living in conditions considered extreme for human beings, then perhaps planetary environmental conditions do not exert a great influence for extraterrestrial life to exist. However, what would extreme environmental conditions be? Are all definitions of extremophiles subjective to human survival conditions? Is it possible to define extremophiles objectively and without contingencies with the terrestrial environment?

As for the conditions of an environment to be considered extreme, obviously, the first way to think is human-centred. Biologist Charles Gerday says that they are places that: '*have extreme conditions compared to the physicochemical characteristics of the normal environment of human cells: the latter belonging to the mesophilic or temperate world.*' (Gerday, 2002). However, NASA astrobiologists and microbiologists Lynn Rothschild and Rocco Mancinelli would disagree with accepting this approach, probably as it emerges from an anthropocentric perspective and around mesophiles as '*organisms that like what we like*' (Rothschild and Mancinelli, 2001).

This model is subjective and can even be considered of low scientific rigour due to contingent characteristics high enough to generate inconsistencies, empirical and conceptual problems in the future. From this perspective, one can then seek answers about the feasibility of having definitions about extremophiles that are not dependent on the survival conditions of mesophiles. It is important to highlight that on Earth, living beings are unevenly distributed in several dimensions, which may reflect their contingent history, poor sampling, fundamental limits, among other factors.

British astrobiologist and microbiologist Charles Cockell, however, would say that '*Life on Earth is limited by physical and chemical extremes that define the "habitable space" within which it operates.*' (Cockell *et al*., 2013). From this perspective, an extremophile would be one that exists in conditions where life is quite rare, being called *Statistical Rarity on Earth*. In other words, extremophilia would be related to the concept of rarity in terms of organisms that thrive in conditions hostile to most life on Earth, not being restricted to mesophiles as a parameter.

The positive conceptions for this approach are initially related to the fact that extremophiles are relatively rare organisms. However, statistical definitions of rarity have unintuitive consequences. Statistical rarity is generally based on the Earth's contingent natural history. Therefore, even if life thrives in a certain environment, it may never be able to expose itself in other planetary scenarios within the Solar System itself (Venus, Mars or the icy worlds).

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To date, all the perspectives mentioned have problems related to the subjectivity of their concepts, whether due to anthropocentric aspects or contingencies with terrestrial perspectives for the formulation of a definition of extremophiles. So, regarding the third question about defining extremophiles objectively, Rothschild and Mancinelli would alternatively use criteria based on concepts related to '*physical extremes (e.g. temperature, radiation or pressure) and geochemical extremes (e.g. desiccation, salinity, etc.)., pH, oxygen species or redox potential)*.' It could be argued, further along with Rothschild and Mancinelli, that extremophiles could also – perhaps even should – include '*organisms that thrive at biological extremes (e.g. nutritional extremes and extremes of population density, parasites, prey, and so on).*'

Unlike previous definitions, the objective limits explanation here seems to apply even if humans, or even all life, had never existed on Earth. However, most terrestrial specimens do not come close to the limits of temperature and radiation level in the universe. Thus, in these cases a small adjustment would be necessary, specifying some demarcation within these limiting factors or degree of extremophile (i.e. 'anything within 10% of the extreme is an extremophile' or 'organism X is a degree Y extremophile').

Anyway, it seems, environmental conditions do not exert much influence on the existence of extraterrestrial life, but would they be very similar or very different from us? Following Simpson's probability premise (2) and the extremophile specimens, it is possible – and nothing prevents – that specimens are found that have certain similarities with terrestrial extremophiles or even other mesophilic microorganisms.

However, regarding the evolutionary aspect of the generation of macroevolved beings very similar to humans, the American geneticist and Nobel Prize winner in Physiology George Wells Beadle is not in favour of the existence of human similarities in extraterrestrials, arguing that: '*The probability of evolution of some living system is probably high. That evolution would go in a particular direction is a different matter. Thus, the a priori probability of man's evolution must have been extremely small – for there were an almost infinite number of other possibilities* (Beadle, 1959).' He still shows little confidence that humanoids exist, when he says that: '*even the probability of an organism evolving with a nervous system like ours, I think, would be extremely small due to the enormous number of alternatives. Therefore, I am not at all hopeful that we will ever establish communication with living beings on other planets, although there may be many of these on many planets.*'

Simpson endorses this perspective by supporting the argument by saying that: '*Homo sapiens is the result of ±3 billion years of contingent evolutionary events, which is extremely unlikely to repeat itself anywhere else with a sufficient degree of similarity to us to be able to communicate meaningfully with us. So our SETI efforts are futile and useless*.' (Simpson, 1964).

The aforementioned arguments are based on the premise that the physical properties of the elements, the forms of energy available and the environmental conditions that would allow life to arise and evolve have an infinite number of alternative routes and with very severe conditions that limit the stability of the factors mentioned. Thus, it is suggested that a macroevolutionary process (metazoans) would be extremely small to establish, implying that it is practically insignificant and unfeasible to think about the existence of humanoids existing in other worlds.

However, oceanographer and ecologist Robert Bieri disagrees with this perspective. For Bieri (1964), man would fundamentally be the result of a series of great evolutionary problems, in which the routes available at each turn in the long evolution of abiotically produced organic matter would give rise to humanoids. For this he argues saying that: '*the phenomenon of convergent evolution is so widespread in the plant and animal kingdoms that it needs no special elucidation here. Suffice it to say that the evidence shows that, time and time again, animals and plants independently evolved not only similar structures but also similar biochemical systems and similar behavioral patterns as solutions to the same fundamental problems.*'

In fact, throughout Earth's history it is possible to see several specimens that have similar evolutionary characteristics from different ancestors. The case 'ichthyosaurs, dolphins and fish', in which respectively we have a reptile descendant of the *Diapsids*, a mammal descendant of the *Indohyus*, which lived mainly on the terrestrial surface, but took refuge in the sea to escape the persecutions

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of its predators and the third has marine ancestors, in which despite their ancestral differences they are all marine animals that have fins and fins. This is due to the principle of evolutionary convergence. Thus, the similarity between extraterrestrials and humans, despite not being possible to quantify in proportions, it is possible – even if it is considered unlikely, it should not be discarded – that humanoid characteristics develop outside the Earth.

It is important to point out that the humanoid morphology here is related to certain aspects such as symmetric bilaterality, the brain and other main sense organs do not migrate to distant parts of the body, terrestrial locomotion made by legs or paws (in the case of vertebrate 1 or 2 pairs), and on dactyls it is difficult to visualize a more effective arrangement than the hand and its fingers (mainly, the opposable thumb), at least for the purposes of a humanoid. The latter even seems to be a more suitable arrangement than claws, pincers, tentacles and other possible structures. However, after all, why not 4 arms like the god Shiva or 4 legs like a centaur? The answer to this question was provided by palaeontologist Samuel Wendell Williston, stating '*that parts of an organism tend to reduce in number and to specialize in function.*' This is also known as Williston's Law, one of the laws of modern biology.

Undoubtedly, many other possibilities can arise and the task of answering them is exhausting, if not unfeasible given the almost infinite possibilities. In particular, only scenarios with habitability conditions were considered here. Although other scenarios should not be ruled out, here the different temperature regimes, stronger and weaker gravitational systems, as well as many other possibilities were rejected or excluded (these being used only to develop the extremophiles cases as part of a representative sample of those that exists on Earth. However, it should be noted that they all maintain the same human biochemical structure, that is, based on carbon and dependent on liquid water).

Those who wish to suggest alternatives not considered here should realize that, their modifications that will be suggested to extraterrestrial humanoids must be seriously considered, from a reasonable set of evolutionary steps established to explain the final derived structures. This perspective developed here in this work tries to be consistent with aspects of natural selection and the theory of evolution. However, could natural selection be extended universally? In other words, is there a 'universal' law of selection?

This reflexive questioning emerges almost naturally as a consequence of speculations about the existence of extraterrestrial beings. After all, are all evolutionary processes under planetary environmental conditions within habitable zones governed by 'universal' selection? What factors would integrate this law of universal selection? How could each factor contribute to this ultraDarwinism?

The British evolutionary biologist Richard Dawkins, regarding the first question, would answer: '*The generalization that can be made about life in the universe is that it will always be recognized as Darwinian life.*' In the opinion of Dawkins (1983), adaptive complexity, in essence, has as an intrinsic element always a selective mechanism for the development of its process to occur. Canadian psychologist and linguist Steven A. Pinker argues in favour of this idea by saying that: '*Natural selection is not only the best theory of the evolution of life on Earth, but it is almost certainly the best theory of the evolution of life anywhere in the world universe.* (Pinker, 2006, p. 132)'.

Apparently, where there is a replicator capable of passing on its characteristics to its descendants and there are 'nutrients' necessary for replication, for both Dawkins and Pinker, natural selection will take place and, consequently, evolution. Now, from this perspective, a 'universal' selection law would be a conceptual space of broad scope, which would seek to encompass an integrated network of different aspects that would allow the approximation between the selective, structural and functional vertices. In other words, it would be an integrative set between different aspects that would make it possible to locate biological generalizations (despite the historicity and contingency of life) that have been the cause of the appearance and evolution of the forms of living beings on Earth, but which could be in any habitable planet. But what factors would integrate this 'universal' selection law? Is it possible to suppose that the principles of natural selection would form part of the 'universal' law of selection?

The American philosopher Daniel Clement Dennett would reply that: '*Darwin's ideas about the powers of natural selection can also be taken from their biological basis*' (Dennett, 1996, p. 60). By this he means, then, that the factors that could generate the 'universal' selection process – under

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habitable conditions – are the same or very similar to those proposed by Darwin. Thus, it is important to remember that Darwin proposes that adaptive complexity happens: '*due to the powerful principle of heredity, every variety, the agent of selection, will tend to propagate its new modified form* (Darwin, 2004, *p. 19–20)*'.

In the words of Dawkins (1997, p. 102), regarding the variations expressed between individuals: '*there is an enormous well of variations, originally fed by a trickle of mutations*'. He even mentions that: '*mutations can already be reasonably old by the time natural selection starts working on them*'. Now, this means that there are a large number of variations that can occur at any time. But then this could be a problem, as both favourable and unfavourable mutations could occur during the process of adaptive complexity. How does the selection mechanism, or in Darwin's terms, how does the selection agent solve this?

Richard Dawkins would argue that reproduction, another factor proposed by Charles Darwin, would act in this regard. In Dawkins' own words: '*The role of sex, cited by him, is precisely to separate and unite different variations, thus finding the* ***genes*** *that work best together and discarding variations that are not beneficial, but that are "taken advantage of" of other beneficial mutations* (2017, p. 102, my emphasis).' He also emphasizes saying that sexual reproduction has a fundamental character, because: '*it allows the best variations to be found in the same individual who will be strongly selected for this very reason*.'

However, it is important to note that not all mutations are deleterious or synthesize some new function. The Japanese geneticist Mooto Kimura, proposed the so-called 'Neutral Theory of Molecular Evolution', in which certain mutations can be simply neutral. In general, this is a consequence of the 'founder effect' that occurs when a small group becomes separated from the original population because of some climate change or survives a catastrophe that decimated the rest of the species, or simply when a group that was stuck in a log ends up being taken across the sea or rivers and ends up in another location. This process is known by many as genetic drift (Futuyma, 1983, p. 139).

In the words of Dawkins (1996, p. 397): '*neutralists think – correctly, in my view – that these adaptations are the tip of the iceberg – probably most evolutionary change, considered at the molecular level, is non-functional*'. However, taking into account the nature of seeking a 'universal' selection law, this would not be a factor that could be accounted for, as Jacques Monod (1971) would probably say the aspects involved develop by *chance* and not by *necessity* through a selection itself. Thus, all possible ways of aspects that contribute to evolution that develop randomly, or as said before, at random, will be being rejected and excluded.

The reason for all this is simple! The factors for a 'universal' selection law must be consistent with processes of predilection, separation, distinction, which will be responsible for the development of mechanisms of adaptive complexities, in which they need to be in accordance with criteria of natural choices in environmental conditions of habitability planetary. Otherwise, there is no selection! The problem at hand here and now is another, then. Unlike variability and heredity, the *selection agent*, despite being characterized by its protagonism, being mentioned in both previous factors, has not yet been made explicit, what is it? After all, what is the *selection agent*?

There are some answers, although there is no consensus. It is important, first of all, to say that it will not be discussed in depth about possible levels that the selection could act on and there are two very simple reasons why this is not done here. The first is that it would most likely be impossible to cover everything, as this is a topic capable of occupying entire shelves. The second is that for the context of this work it is unnecessary, as it would not generate influences on the scenarios outlined to be addressed.

So, after this brief digression, it is possible to attack the problem that exists related to the concepts that involve the selection agent. Fundamentally, not even Charles Darwin throughout his work Origin of Species (November 24, 1859) makes explicit what the agent of selection would be. In Darwin's words he adopts Herbert Spencer's expression as the most adequate to provide the concept of natural selection, saying: '*the expression that Mr. Herbert Spencer employs,* '*the persistence of the fittest', is more exact and sometimes more comfortable*' (Darwin, 2004, p. 76).

However, this stance does not explain everything – if it explains anything – and therefore it is necessary to obtain a perspective that produces a solution to this conceptual puzzle generated by the term selection agent. A biochemical perspective was developed for this conceptual problem by Richard Dawkins, in which, in his version, the agents of selection would be the genes. In Dawkins' words: '*Each gene is selected for its ability to cooperate effectively with the population of other genes it tends to find in bodies*' (Dawkins, 1997, p. 251). From this perspective, an organism should concatenate the functioning of all its parts, in which a change in one gene could generate evolutionary pressure on the others and vice versa.

According to Richard Dawkins (Dawkins and Davis, 2017, p. 36), the *selection agent* would be that, an entity capable of making copies of itself, that is, a *replicator*. For Dawkins, an error in replication would not necessarily be something that would generate unfavourable characteristics, on the contrary, it could generate an even more powerful replicator. To do so, Dawkins lists 3 distinct aspects that could foster a more powerful replicator: (1) fecundity, (2) longevity and (3) fidelity. The first term is related to the ability to reproduce copies of itself, the second term is linked to its durability and finally, the third and last term is linked to the ability to guarantee a greater number of copies of itself, closer to its predecessor. Now, does it make sense, after all, if there wasn't this normative property that children looked more like their parents than the average of the population, would it be possible to talk about natural selection or adaptive evolution?

Another perspective for this conceptual problem would be the complex systems approach of the American physician and theoretical biologist Stuart Alan Kauffman, who studies the origin of life on Earth. For Kauffman the agent of selection would be the anti-chaos. For Kauffman (1991), the concept of anti-chaos can be defined as the property of highly disordered systems to spontaneously crystallize in a high degree of ordering. In other words, Kauffman believes that there is an intimate relationship between the selection process and self-organization.

The idea of a law of universal selection is still seen as speculative, metaphysical and although it is empirically very difficult to prove, it is no longer a mere curiosity, but began to be debated in the light of the scientific field both by theoretical means and through search of observations that can be made from a discovery of the existence of extraterrestrial life somewhere in our galaxy. In Dawkins' words: '*This is not to say that nowhere in the universe could there be some strange life system in which embryology was preformationist*' (Dawkins, 1996, p. 434). Although there is no evidence that natural selection occurs equally on other worlds, is it possible to imagine how each factor could contribute to this ultra-Darwinism?

The American philosopher Daniel Clement Dennett would answer that the factors are: '*part of an algorithm that produces a certain kind of result whenever it is "put to work"*' (Dennett, 1996, p. 52). So, I could assume that these factors contribute through a procedure that can be broken down into small steps, simple enough for a selection mechanism to be completely mechanical, following and always arriving at the same result. In Dennett's words, he called 'project accumulation' (Dennett, 1996, p. 71).

However, by this he in no way meant that evolution is always directed towards the same result. It is possible to think of this process in an analogical way, as if it were 'heads and tails' or an 'odd or even' match, in which there will always be a winner, but that does not mean that the winner will always be the same. Victory is a consequence of being part of the game in dispute, there is only one winner, because in a dispute in the game of life, such as heads and tails, even or odd, a winner will always be generated. In this game of life, there are no draws!

Conclusion

In conclusion, for philosophy, astrobiological questions can bring reflections to old questions from new perspectives. On the other hand, for astrobiology, philosophical methods give new insights to questions that are outside the scope of empirical science but nonetheless central to the enterprise of understanding life: its origins, its distribution and its future.

It is worth mentioning that if we are unable to communicate with beings from other planets, it will not be because they are fundamentally different from us, but because they may have far surpassed our state of technology and have no interest in communicating with us or have not yet reached our state of advancement and are therefore unable to do so. This is probably the key factor that would greatly reduce the number of such populations trying to communicate with us.

In the end, although it is not a fact, but still mere speculation, if we manage to communicate with extraterrestrial humanoid beings in outer space, it is unlikely that they have the shapes of spheres, pyramids, cubes or pancakes. Given all that has been exposed, they may be more like us, perhaps even more than we are capable of imagining.

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