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A philosophical and historical perspective about terms Astrobiology, Exobiology, Cosmobiology, Xenology and Bioastronomy

*Uma perspectiva histórica e filosófica sobre os termos Astrobiologia,
Exobiologia, Cosmobiologia, Xenologia e Bioastronomia*

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Abstract

The main idea here is to present reflections on the general aspects that structure the conceptual conception of the field of search for extraterrestrial life. The methodology developed to conceive this article was based both on aspects of historical contexts and on the concatenation of philosophical arguments that could establish a perspective on each of the terms - Cosmobiology, Exobiology, Xenobiology, Bioastronomy and Astrobiology - that currently exist. It was possible to conclude that the nominalist problem about the term that should represent the tradition of searching for extraterrestrial life, as a scientific field, should not necessarily consider the conceptualization of the term and the respective conception in its etymological formative structure, but in the statement that expresses the definition of the term. After all, Astrobiology is no different from any other scientific field.

Keywords: Philosophy of Science, extraterrestrial life, plurality of worlds, universality

Resumo

A ideia principal deste artigo é apresentar reflexões sobre os aspectos gerais que estruturam a concepção conceitual do campo de busca de vida extraterrestre. A metodologia desenvolvida para sua concepção baseou-se tanto em aspectos de contextos históricos quanto na concatenação de argumentos filosóficos que pudessem estabelecer uma perspectiva sobre cada um dos termos – Cosmobiologia, Exobiologia, Xenobiologia, Bioastronomia e Astrobiologia – existentes atualmente. Foi possível concluir que o problema nominalista sobre o termo que deve representar a tradição de busca de vida extraterrestre como campo científico, não deve necessariamente considerar a conceituação do termo e a respectiva concepção

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em sua estrutura formativa etimológica, mas sim a declaração que expressa a definição do termo. Afinal, a Astrobiologia não é diferente de nenhuma outra área científica.

Palavras-chave: Filosofia da Ciência. vida extraterrestre. pluralidade de mundos. Universalidade.

Introduction

The search for a second genesis is a *research tradition* originating from a philosophical question in ancient Greece, known as the *plurality of worlds* and expressed by the question: “Is there life out there?”. *Research traditions* are made up of a set of properties that contribute to generating investigative processes or methods used to solve problems, but should not be considered predictive or directly testable. In general, through research traditions, delimitations of applications of their constituent theories are made, indicating what is appropriate in each given field.

The research tradition of searching for extraterrestrial life has always intrinsically generated a very wide range of questions, such as: “How did life begin?”, “Is there life outside Earth?”, “Are there other planets like Earth?”. All these and other questions have always been seen and considered as coming from the esoteric field.

Therefore, there was a need for some reformulations that could forge an acceptable research program within the scientific field. In this way, the search for extraterrestrial life ceased to be the main *actor* in contemporary research and began to develop research that took as a standard the archetypes that exist on Earth, such as the conditions of our own planet, to try to formulate a kind of *scientific research program* that would justify the possibility of searching for other worlds that could harbor life beyond Earth.

It is important to highlight that, in a different mode of Thomas Kuhn and Imre Lakatos, who suggested a set of rigid and immutable entities - Kuhn (1970) through his *paradigms* and Lakatos (1976) through the *hard core* -, the change between entities that govern a research tradition does not automatically reflect on the production of a tradition completely different from its predecessor. The reason this does not happen is essentially simple. A research tradition, according to Laudan

(1978), comes from comparing the adequacy between classes of assumptions existing in the ancient tradition with those that constitute the most recent versions.

In this way, information about terrestrial archetypes came to be considered as representative standards of what one should look for outside the Earth. Fundamentally, based on the characteristics existing in these terrestrial archetypes, models considered analogous began to be created, which began to be used to compare them with other worlds, and from that, the process of measurements and analyzes in this field originated from *research tradition* of the search for extraterrestrial life.

Provenance of the term and its respective concept in the scientific field of searching for extraterrestrial life

Since the beginning of the space era, in the middle of the 20th century, several terms have emerged that have tried to organize the structure of concepts that involve the conception of the possibility of life outside Earth. However, for a long time, research on the search for extraterrestrial life, until the early 1990s, was seen as an area that was based on great speculation, but unable to provide observations about its object of study.

Thus, many science practitioners became skeptical about the feasibility of carrying out verifications of the existence of life outside Earth. They became extremely critical and against the supply, commitment and expenditure of resources to develop this type of research. Biologist George Gaylord Simpson (1964), for example, used to refer to this type of research as “*a 'science' that had not yet demonstrated whether its object of study existed!*” and the evolutionist Ernst Mayr argued that: “*this type of research program was “waste of time”, “hopeless”, and that we had to deal with realities - not with dreams*” (Garber, 1999). For Mayr, the possibility of finding life beyond Earth was so unlikely - for practical purposes - that it could be considered equal to zero.

However, astrophysicists Christopher Chyba and Kevin Hand (2005) argue in favor of developing this research program saying that:

If Exobiology (or Astrobiology) were understood only as the study of extraterrestrial life – which it is not – Simpson's criticism would remain strictly true, but it would not invalidate the research and this could seem

bizarre to many astronomers or physicists. However, astrophysicists spent decades studying and searching for black holes before amassing the current evidence that they exist...

Based on the arguments proposed by Chyba and Hand, the research tradition of searching for extraterrestrial life is an activity that develops similar to others that are considered to belong to the scientific field. It is important to emphasize that although we have no evidence to support that life beyond Earth exists, nowadays, it is possible to point out indications - such as the discovery of exoplanets - that allow us to develop this type of research as plausible. If the scientific community began to validate the search for extraterrestrial life, providing credibility, social legitimacy and consolidated it as a field of modern science. It becomes necessary, then, a name that defines and makes it possible to distinguish this recent scientific field from other pseudoscientific ones.

The search for a term that establishes conceptual nature, that allows us to define the field of search for extraterrestrial life, cannot be - at least it should not - be done through an arbitrary decision. Even though Shakespeare's famous quote from Act II, Scene II of *Romeo and Juliet* ("What's in a name?") is sometimes misinterpreted as meaning the arbitrariness of the nomenclature. It is important to emphasize that there are etymological differences between the names attributed to this research tradition. Thus, with the aim of obtaining a broader perspective on the development on this scientific field, we will take care here to develop a methodology that - in a non-exhaustive way - contemplates the historical context, together with the philosophical/philological arguments that were used as assumptions for the construction of the different names that currently exist.

Cosmobiology

Cosmobiology was the first term coined historically to designate the search for life beyond Earth. The physicist and philosopher of science, John D. Bernal (1901-1971), at a conference of the British Interplanetary Society, in 1952, stated that "*the Biology of the future would not be limited to Earth*", arguing that Cosmobiology would then be responsible for developing this activity.

However, the former American engineer at NASA Gilbert V. Levin (1965), pointed out that the term was inappropriate due to its relationship with a

philosophy of nature, which preaches a universal culture of biology, in which such practice is associated with the search for breaching Earth's borders by conquering other planets and stars. Levin in his words expresses his objection saying that: *“Purcell, presents what appears to be an irrefutable case against the possibility of manned space travel far beyond the solar system.” Levin goes on to say that: “the tremendous energies that are required for manned interstellar space travel make such travel extraordinarily unlikely.”*

The American philosopher, Brooke Holmes (2014), despite finding the cosmos sympathetic to life, would probably agree with Levin's claims. André Brack, in addition to agreeing, would express his objection to the term saying that: *“Cosmobiology is not adequate to designate the field of search for extraterrestrial life, as it is associated with Russian Cosmism”* (Brack, 2012). Thus, the term cosmobiology soon fell into disuse.

Exobiology

Shortly thereafter, Joshua Lederberg (1960) coined the term exobiology in an article to describe *“biology both on Earth and of extraterrestrial origin”*. Lederberg, argued that: *“the main objective of Exobiology would be to compare the different models of chemical evolution of the planets, emphasizing the dominant characteristics present in each one of them”*. In February 1963, the first International Symposium on Exobiology was held at the NASA Jet Propulsion Laboratory, in the preface to the symposium Mamikunian & Briggs (1965) wrote: *“Biology outside the terrestrial environment was defined as Exobiology by Professor Joshua Lederberg, from Stanford University, while others prefer the term Cosmobiology to refer to the study of the Biologies present in the Solar System, in the galaxy and even in extragalactic systems”*.

However, George Gaylord Simpson (1964), at that time, already argued unfavorably to the development of research in the search for life beyond Earth and ironized the use of the term Exobiology, scorning colleagues who called themselves exobiologists, often provokingly dubbing them as “ex-biologists”. There are several reasons, but the main objections were: (1) the “exo” prefix (2) and the pseudo-object. As for the first, the objection was not only against the adulteration of the English language from newly created words, but also because of the literal

interpretation of the prefix "exo" as meaning "outside or outer layer". Regarding the second objection, it is worth reflecting on the field of (Exo)Biology being a study of extraterrestrial archetypes - in other words, pseudo-objects. However, how is this possible if there is no evidence about the existence of extraterrestrial life. This term, by all indications, lacks something else to keep in force. However, unlike what happened with cosmobiology, the term exobiology continues to be used.

Beyond the USA, the historical pioneers (Germany and France) were in favor of keeping Exobiology, but newcomers (UK, Spain, and Italy) preferred Astrobiology, considered as more fashionable and modern according Brack, (2012). A plausible argument - at least as far as the US is concerned - would be best expressed by Bruno Latour's *Actor-Network Theory* principle for this case (Latour, 1996). It is possible that since Lederberg, American and winner of the Nobel Prize in Physiology, published an article in which a term was coined that "became American", during a time when the Cold War was taking place, it seems that American resistance to the term perhaps it goes beyond linguistic adequacy to scientific concepts, but it is possible that this is due to the competing term *astrobiologiya* (астробиология) being of Russian origin.

Even with strong criticism from science practitioners skeptical of the emerging field, at that time, NASA established its Exobiology program in 1960 (Billing, 2012). Logsdon says: In an August 11, 1964 memorandum to NASA Associate Administrator for Space Science and Applications Homer Newell on "future goals of the space science program," the SSB recommended that NASA adopt as its goal of space science most important for 1971-1986. "the exploration of planets with particular emphasis on Mars" (Logsdon 2001, p. 170-173).

Xenology

From this scenario generated by NASA managers, the American NASA engineer Gilvert Levin (1965), made the inference that the best way to designate this emerging scientific field would be Xenology (Xenobiology). For Levin, due to the "contamination" of the previous terms - Cosmobiology and Exobiology - it would be considered the most adequate to define the search for extraterrestrial biology by Xenology for semantic reasons. In Levin's words, he argues that: "*the prefix "xeno" connotes "strange or foreign"*".

In the words of chemist Harold Abbott Wooster: "in my opinion, "xeno-" is the best choice from a derivation point of view". He argues that: *"the prefix "ex-" or "exo-" has its own major shortcomings and means many things. Merriam-Webster Unabridged lists about 200 words which using the prefix "ex-" or "exo-", and among them are many of the most common words in English..."* and goes on to say: *"but "xeno-" and "xen-" have only seventy entries, none of which which is a common word [...] it is more sensible to use this almost virgin prefix to designate non-terrestrial things, concepts and fields of study, as it will minimize conflicts of meaning"* (Woosuffixoster, 1961).

However, terms with prefixes "xeno-" which derives from Greek and has a definition associated with foreigner or strange, that is, something or someone who is not part of a certain group, this alludes to something outside (the Earth). For this reason, both the terms Xenology and Xenobiology have become less and less used. In this way, as with Cosmobiology, the terms Xenology and Xenobiology also fell into disuse, mainly due to the lack of etymological emphasis on research with terrestrial organisms - from the point of view of critics and skeptics of this type of research.

Bioastronomy

With regard to the term Bioastronomy, it in the 1980s, from the XVIII General Assembly of the International Astronomical Union (IAU), in Patras (Greece) (Lemarchand, 2010). According to Papagiannis (1980), it was during this IAU meeting that Commission 51 was created, which became responsible for holding international conferences and trying to consolidate the *research tradition* of the international search for extraterrestrial life. However, this term also quickly fell out of use, as the term "Bio" associated with the term "Astro" was not seen as linguistically appropriate. Wooster and other practitioners of the sciences argued (Wooster, 1961): *"that "astron" is a star - and stars are the least likely places to find life, culture, etc."*

Astrobiology

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). However, it is worth noting that this modern field of science has had its conceptual foundations reformed, with the aim of encompassing the archetypes that exist on Earth as part of its research program - as previously mentioned, they are used to design models based on their characteristics. However, if Astrobiology aims to investigate the existence of life outside Earth based on terrestrial archetypes, it seems that there is a pretension of agents in this field to develop *universality* between the concepts that constitute the bases of the research tradition of search for extraterrestrial life.

But what can be said about *universality* from a philosophical perspective? The universality of the application of concepts is based on the objectivity of its factors or on the ability to develop the expansion of the extension of representations involved in a given situation or even for different situations. It should be noted here that whenever a thorny problem arises around issues related to concepts and representations, help is usually sought in Philosophy or Philology - although this is not always seen with good eyes by the scientific field. Another important point that needs to be addressed is related to the use of analogous models - for example, analogous and extremophile environments - in which the analogy used in the formation or extension of concepts is based on a relationship of similarity. In other words, the set of shared characteristics - not being necessarily the same characteristics for all - according to the Austrian philosopher Ludwig Wittgenstein, is given the name of family resemblance. Even the historian of science Steven J. Dick would say:

Astrobiologists who deal with the microbiological parts of the subject make heavy use of analogy in the most general sense: since we have no extraterrestrial microorganisms, we use terrestrial microorganisms as analogues (...) it is plausible to say that astrobiology would not exist without this more general use of analogy. In other words, the withdrawal of analogy as an argument form would be an existential threat to the survival of Astrobiology as a discipline. (Dick, 2013)

Although this type of inferential procedure mentioned by Dick is used in a logical inductivist way and is based on behaviors or characteristics of known objects

to speculate and expand the representations involved about what is unknown - if it really exists. This task is not simple! In fact, for it to be possible to carry it out, it is necessary to have an adequate methodology for this purpose, as well as the conceptual and linguistic apparatus needs to be properly fine-tuned so that it is also possible to capture the subtleties involved in such a project. In more concrete terms, we delve here into the problem of conceptual schemes and into the problems of defining concepts as well.

What is postulated as necessary for the effort of this research tradition to be considered reasonable is that the term that defines the field be able to encompass our concepts based on what we know, but that this term does not only address structures delimited by our limited experiences of what exists on our planet. In other words, the search for extraterrestrial life should not be carried out by concepts that are applicable only to terrestrial autochthons or those that exist only on planets that have similarities with Earth. In this case, would it be necessary to develop a conception of the concept of living organisms that allows us to identify both instances similar to those we know, as well as those that are completely different? Including, would it also be necessary to involve those that were not even imagined by us until the present moment?

As for the first question, based on the classical **conception of concept** (Laurence and Margolis, 1999), it would be necessary to have a certain concept of concept, so that there is the possibility of defining an entity as something concrete and intelligible. In other words, it would be necessary to have a conception of a defined concept, so that it is possible to have an understanding of what is being approached and investigated. The development of this mental activity for these circumstances in the field of Astrobiology is an arduous and extremely complex task. The crucial point, in fact, is to know whether, regardless of the limited information of our knowledge, it is possible to establish an identification of living organisms, when instances are observed that were not even imagined by us. After all, if this is possible, the first question would be involved in this second case.

Thus, regarding the second question, if agents in the field of Astrobiology intend to develop universality between the concepts that constitute the bases of the tradition of research in the search for extraterrestrial life. So the answer would be yes! It would be necessary to develop a conception of the concept of living organisms that would also allow us to identify those instances that were not even imagined by

us until the present moment. Otherwise, we would be building a generalization of concepts from terrestrial archetypes, instead of a universality. After all, if in the future we detect, observe and verify the existence of some extraterrestrial archetype that is not involved by these concepts. So our conceptual design building and initial efforts would be flawed.

To better illustrate these aspects that may prove flawed for the development of the universality of concepts, it is possible to evoke the famous mental experiment by Hilary Putnam (1973), in which there would be a Twin Earth and a substance practically identical to the water on our planet, only with the chemical composition changed - instead of H₂O, the chemical formula of the substance would be XYZ. Obviously, it is not the same substance, but that does not mean that the inhabitants of this Twin Earth do not use the same concepts to refer to this substance that exists on our planet.

Furthermore, would it not be possible to use the same concept for both substances, due to their similarity? If a scientific council reunites and decides that it is possible to use the same concept for both substances - the concept of water would cease to be specific, there would be no universality, but it would become more widespread. In this case, the decision is not totally objective, but neither is it totally conventional and much less subjective, since it involves external factors that determine, in part, the extension of the concept both to one and the other substance, based on the phenomenological similarity and functionality that exists between substances.

Nevertheless, would the agents who work in this field of Astrobiology be able to build a conceptual conception based on universality, establishing solid and resistant foundations to the term that defines the research tradition of searching for extraterrestrial life? Hypothetically, yes, this is possible! As philosopher Erik Persson would say: *“We cannot expect life on other planets or moons to be exactly like life on our own planet. On the other hand, extraterrestrial life must have some things in common with life on Earth to be called life.”* (Persson, 2013).

Thus, from the assumptions expressed by Persson, life or the processes that express the characteristics of an organism considered alive, must share certain aspects that can enable us to infer by analogy that the extraterrestrial archetype is a living being - So, constructing a concept on the basis of universality should be possible. For this perspective to be contemplated in an accessible way, it will be

necessary to develop at this moment a mental experiment, in which we will use the following assertive analogical expressions: (1) in which living organisms would be like water and (2) the activity of the dynamic systems of the living things or the processes that keep organisms alive would be like the current.

Imagine now, for a moment, that the agents who work in the field of Astrobiology do not have the knowledge of what water is made of, as well as they do not have any knowledge regarding its structural form. From this conception, perhaps it becomes noticeable how it would be an extremely arduous task - not to say almost impossible - to try to study it through chemistry or through the looks of physics, without this information.

However, even if these agents do not have this information, they could formulate physical and chemical hypotheses, studying the water through its development process, that is, observing and analyzing the current. In other words, observing and analyzing the process that keeps an organic being alive would be like appreciating and weighing in relation to the current, in which its form and structure are only expressions of its visible exterior, which has an extremely mobile balance of processes, physical and chemical processes that occur in it incessantly throughout its life.

As it may have been possible to perceive, that theorizing is a task that agents who work in this research tradition could carry out - despite being arduous and complex. However, it is important to note that metaphysical assumptions need to be considered so that fine-tuning can be properly developed. As the philosopher Kristina Sekrst (2022) would probably say, although the objectives of Astrobiology are more general than Philosophy, there is a region, an area, a field of knowledge in common with Philosophy - In fact, Philosophy has a whole history of discussion about concepts and representations that should not and cannot be disregarded.

Finally, the term Astrobiology, which has now come to define the tradition of searching for extraterrestrial life as a scientific field and to distinguish it from other pseudoscientific fields. It remains under attack by skeptics, either because of its validity as a science, or because of the etymological construction of the construction of this term in relation to the concepts it involves.

As for the first objection, although there is no evidence that extraterrestrial life exists. Since 1995, when the first exoplanet orbiting a solar twin star was discovered, observed, and verified, it can be said that we have our first indication

that there are places that can harbor extraterrestrial life. In this way, Astrobiology despite not yet being - as Thomas Kuhn would say - a mature science, and even though it is still in its adolescence, it should no longer fear similar objections to this one. It is important to say and emphasize that there is no intention here to base the validity of the field of Astrobiology using numerological arguments or the argument of ignorance (*Argumentum ad ignorantiam*). At this moment, it is only being proposed here that the *plurality of worlds* today is a fact and no longer mere speculation. However, the other question remains open. We still need to know whether these other worlds, if any of them, will provide a positive answer to the question, "Is there life out there?"

Regarding the second objection, the etymological construction of the term Astrobiology, it is contested because its structure does not involve or is not able to relate to the concepts that the field proposes to develop. Thus, contesting argumentative assumptions are based, according to Harold Abbott Wooster (1961) on: "*that "astron" is a star - and stars are the least likely places to find life, culture, etc*". With a very similar argument, the French chemist, who works with questions about the origin of life, André Brack in his words says (2012): "*Astrobiology is etymological nonsense, as it literally means "life in the stars"*".

However, in fact, Astrobiology in its etymological structure does not seek to express in any way that the stars are places where life exists. This type of analogical composition is a gross categorical error, and it's a big mistake, which generates a category fallacy. After all, the concepts that involve the conception of factors that orbit the term Astrobiology, as a complement to NASA's Origins Program, were very well outlined in 1997:

Astrobiology is the scientific study of the living universe; its past, present and future. It begins with the investigation of life on Earth, the only place where life is known to exist, and extends to the far reaches of the cosmos. It varies in time from the big bang and continues into the future.

As mentioned above, It is possible to see there is no relationship with "life in the stars". In fact, Astrobiology is initially based on the stars, but not in this way. The investigations begin using terrestrial archetypes, and establishing parameters that can be used to find life outside Earth. First, stars similar to our Sun are sought, not to find "life in the stars", but stars that can harbor planets and that can be similar

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to Earth, in a way that they have conditions to harbor life. Thus, extraterrestrial life from Astrobiology is sought on planets that are revolving around stars - not precisely “life in the stars” but based “on the stars” or more precisely “planets on the stars”.

Therefore, it is possible to recognize an ambiguity in the etymological term “concept”, which may have generated all the categorical errors mentioned above. In one sense, “concept” means the simple conceptual representation of an object, while in another sense, it means a conception of the object. Thus, the categorical error for ontological reasons was developed by assuming that the “concept” would not resemble words that forge the structure of the term but would resemble statements that would be constructed from “conceptual conceptions”. Conceptions involving assertive aspects such as true and false can be more explanatory, as they function as conditional sentences that can guide agents in a search. Thus, it is important to know how to distinguish between concept (first sense) and conception (second sense). Finally, regardless of the denomination chosen to be used among science practitioners, as André Brack (2012) would say: “Astrobiology, Exobiology, Bioastronomy or Cosmobiology, [...] is a fascinating field of research that provides great emotion and requires imagination, as well as collaboration between scientists in Astronomy, Astrophysics, Planetology, Geology, Paleontology, Biology and Chemistry.

Conclusion

The tradition of searching for extraterrestrial life through mechanisms and procedures in the field of Astrobiology, are inextricably related to the human way of forming its representations and concepts. Therefore, this is a task that will be developed, almost inevitably, by making use of analogy, both in the formation of its concepts and in its inferential apparatus. So, this must be considered in the very structure of the term - Astrobiology - which came to be adopted as a way of distinguishing the values shared as scientific between science practitioners in research areas considered pseudoscientific. In other words, the use of terms from the analogical language is the essence of the representational bases of this scientific field in particular, still in its adolescence and in search of becoming a mature science.

Finally, it is possible to conclude that the nominalist problem of a prefix capable of encompassing all the characteristics involved with the tradition of searching for extraterrestrial life, did not become the one that necessarily had greater clarity and linguistic accuracy in relation to scientific priorities. The term Astrobiology, then, was accepted from the orientation of a system of constitutive rules, in which within this system institutional facts were created for application by the same linguistic operation in the form of a functional rule of conditional declaration, which came to be shared as a consensus among members of the scientific community, consequently validating the term socially. In other words, the term was adjusted, readjusted and declared, characterizing the field by the Astrobiology nomenclature, not due to a fine and adequate adjustment to reality, but "adaptation" of reality to the term and the term was adjusted so that there was a fit with scientific reality. Thus, Astrobiology, like any other science, is a social construction and develops from cultural expressions of society. In the end, Astrobiology is no different from any other scientific field.

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