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Disciplinary nature of astrobiology and astrobioethic's epistemic foundations

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Abstract

Astrobioethics is an emerging discipline that studies, evaluates and analyses the moral, legal and social issues of the search for life in the Universe. As a new field of study, it requires an epistemological foundation to be able to be recognized as an academic discipline. In order to achieve this, it is important to understand the disciplinary nature of astrobiology as a transdisciplinary form of research, above the multi and interdisciplinary levels, although this does not necessarily mean discarding them. In addition, the questions and topics of each subdivision of astrobioethics studies are specified and explained in this paper.

Astrobiology is a science responsible for studying the possibility of life on other places than on the Earth, for example, on planets in our own Solar System or most importantly, given their numbers, on exoplanets. However, this definition is quite general and does not allow us to directly understand its disciplinary nature. In fact, it can be said that some of the controversies and debates about astrobiology as a legitimate science may come from the epistemological ignorance about it. It is for this reason that astrobiology should not be understood from a traditionally monodisciplinary approach, but, instead, requires a different way of perceiving and approaching science.[2]

How come astrobioethics appears in the disciplinary scenario? For it we need to consider the theoretical framework of geoethics first. Within the International Association for Geoethics, we read: 'studies on planetary geology (sensu lato) and astrobiology also require a geoethical approach' (International Association for Geoethics, 2016). In addition, in the same organization, they point out that geoethics faces new ethical dilemmas that should be addressed by astrobiology, so astrobioethics emerges as a need to be able to face these new scenarios. As any new scenario, it requires the organization and categorization of the objects of study and define the way to address them.

It is fundamental to understand, hence, that science is part of the society, thus, part of the culture and therefore subject to modifications over time. Knowledge changes and is transformed over time because people do change too. In other words, science, being a cultural product, will be subject to the needs of humankind. The concepts of science change over time, according to the mentality of a given generation that hosts it. The concepts of science that Newton perceived are not the same that the ones we perceive in the present days. Therefore, in order to understand astrobiology and its derived problems in an epistemologically valid dimension, it is essential to recognize it with eyes that go well beyond the classical scientific specializations.

The disciplinary nature of astrobiology

Here it is essential to distinguish three concepts: multidisciplinarity, interdisciplinarity and transdisciplinarity. Multidisciplinarity refers to the ability of the disciplines, acting as organized units of knowledge, to interact with each other in order to address a common goal. When they interact, solutions can emerge that have not been seen before by isolated disciplines. 'Multi-disciplinary approaches to research involve collaboration between two or more disciplines on a research project; however, each discipline maintains its own assumptions, values, and methods' (Leavy, 2011).

The scope of the multidisciplinarity will depend on the capacity of interactions of the disciplines in question. For example, if we talk about studying the mental health of a population, we will have to go not only to medical specialists and psychologists, but also anthropologists, environmental specialists, etc. The capacity for response as a whole will be highly related to the predisposition and attitude of each specialist to open up to others. After all,

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[2]And this, incidentally, can help us to include the term Astrobiology in the nomenclature of Unesco, which is the great absentee (Martínez-Frías and Hochberg, 2007).

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the specialist is a human being and his scientific sociability will influence the study, so his education and personal values will have a significant imprint. The disciplinary relationship in this approach is homogeneous.

In the case of astrobiology, as a scientific discipline, we must bear in mind that we will need a multidisciplinary approach on many occasions. We need astronomers, astrophysicists, planetologists, but also physicists, chemists, geochemists, biologists, botanists and even professionals within the social sciences as reflected in the Astrobiology Strategy 2015 (Hays, 2015). For example, if we want to elaborate a theoretical framework of astrobiology, the multidisciplinary point of view will be more than necessary, but will not be enough. If we want to examine the influence of different planetary environments for the possible development of life, we will see that another type of approach is needed, like the implementation of certain biological knowledge for physics. We thus require interdisciplinarity.

Interdisciplinarity considers a vertical approach in the sense that there are disciplines that will lead the direction of research. The multidisciplinary work team becomes interdisciplinary from the moment in which all efforts are focused on meeting the goals and objectives of a 'leading discipline'. This leading discipline delimits all others that may be following it. The epistemological result of interdisciplinarity is the acquisition of a high degree of specialized knowledge (Piaget *et al.*, 1973). If we try to transfer this concept to astrobiology, we can appreciate that interdisciplinarity is applied in different stages and circumstances.

At some point, interdisciplinarity may require inputs from biophysics to understand the relationship between microgravity and the development of living organisms; at another time, it could address issues related to astrophysics as setting the scene from a more general point of view, and so on. But as can be seen, the high specialization of interdisciplinarity supposes at the same time a great advantage and a disadvantage because it does not provide the platform to interconnect other knowledge.

The interdisciplinarity as well as the multidisciplinarity are approaches that complement the monodisciplinary approach and broaden our conception of the possible. In astrobiology, there is both, multidisciplinary and interdisciplinary work, but it cannot be reduced to only being one of them. In addition, astrobiology like astrobioethics should be considered within another disciplinary nature that encompasses both visions.

We refer to transdisciplinarity, which is the strategic and orchestrated way in which different disciplines can work together. One of the essential characteristics of the transdisciplinary approach is that it is an *a posteriori* methodology. The multi and interdisciplinarity can have methodologies within the phenomenon of study prior to the incursion, because they inherit the phenomenon from the disciplines and they do not have relevant methodological exchange. However, this changes with the vision of transdisciplinarity, because by having methodological exchange, the modus operandi will obtain its personality during the research process.

The social background of transdisciplinarity can be traced in the different social phenomena that have been emerging, such as the struggle for equal rights, the problem of environmental pollution, globalization, etc. (Leavy, 2011). The need to propose new strategies and to manage knowledge in new ways has generated a way of approaching the objects of reality in an interconnected manner, where no discipline is more important than another one, but simply more relevant. The relevance is determined by the *in situ* need, according to what you want to study. For example, suppose a tourist area where we are inside a bus and each passenger represents a particular discipline.

During the tourist circuit, the geologist can explain the nature of the minerals found in the area. At another time, the botanist can tell us that due to these minerals, certain plants have a certain colour. Later, as we move forward, the zoologist can explain the diversity of animals that exist in the area because of the vegetation; the anthropologist can explain the rituals and myths about the local fauna and so on. As we move along the tourist circuit, each discipline will gain relevance according to the needs that arise along the way, but none of them knew in advance what exactly they were going to see. In the end, we can obtain as a result, a body of information that goes beyond the multidisciplinarity because each discipline not only shared their opinions, but the way to approach the object of study was never determined *a priori*.

Let us extrapolate this to a more concrete level. In the development of a space mission, for example, the recent Mars rover missions. In the case of finding life, we still do not have a theory about life in a different context than Earth because we have not found any to date. However, if given that case, each discipline will have to contribute a part of it to complete the puzzle. The transdisciplinarity does not suppose a methodological reductionism, but a methodological interchange as a function of the necessity of the investigators. It can be said then that transdisciplinarity has a strong practical component, but that as it grows develops theories that nourish and advance its various disciplines.

A multidisciplinary approach could not do that; its objectives are rather punctual and do not always imply the subsequent development of a methodology that interconnects the other disciplines. It may be the case that a multidisciplinary team has traits at some point, or that it even becomes transdisciplinary, but this will be largely conditioned by the quality of the disciplinary relationships they have and especially by the proposed institutional objectives. Within the three disciplinary options that more creativity and fertility can contribute to astrobiology and astrobioethics, transdisciplinarity takes the first place, because it connects ideas, contexts, problems and situations in a way that independently, multi or interdisciplinarily could have not happened.

It is, therefore, essential to encourage transdisciplinary research projects because their contribution to formative research prevents us from reductionism in unnecessary cases. On the other hand, the disciplinary nature of astrobiology does not imply a simplification of all the disciplines involved; it is not a methodological reductionism. This can also be mentioned by Leavy (2011):

> Transdisciplinarity approaches to research help researchers to transcend the limitations of disciplinary forms of knowledge-building, organization and dissemination. Because information, data, theories, and methodologies from multiple disciplinary viewpoints are bought into the process, and are respected and combined in order to create something new that is irreducible to the disciplinary components that initially were brought to bear, transdisciplinarity goes beyond disciplines.

This refers to the unity in diversity. Going beyond disciplinary constraints allows us to have different approaches in the construction of a new one. In order to understand transdisciplinary interaction, the set of principles and rules that characterize a discipline must be taken into account. It could also be called a nomological network, because it is a network made up of principles, rules and laws.

This is one of the main reasons why astrobiology cannot be understood as a unified science, due to the fact that its methodological diversity cannot be reduced to only one. What we have, however, is a methodological reductionism, not an ontological one. This is one of the epistemological challenges of astrobiology that can pose a difficulty when it comes to understanding its nature.

In addition, this permanent interconnection allows the creation of new ideas and to rethink problems already seen in a different way, following the definition of transdisciplinarity of the United Nations Educational, Scientific and Cultural Organization (UNESCO, 1998): Transdisciplinarity is the 'intellectual space' where the nature of the manifold links among isolated issues can be explored and unveiled, the space where issues are rethought, alternatives reconsidered and inter-relations revealed (IV).

Astrobiology uses knowledge from other disciplines for its own purposes, or as Cockell mentions in an interview made by Chon Torres (2016). 'Intellectually it is a unifying science but it will always use a wide variety of methods to connect specific issues. These do not need to be unified' (p. 30). In fact, if one thinks of astrobiology as only a set of procedures applied to study certain phenomena associated with the possibility of life on other worlds, one might think that it is not necessary to speak of it as a proper scientific discipline. However, if we appreciate it from the transdisciplinary approach and consider that science is constantly evolving, then we see that astrobiology is a scientific discipline that is gradually generating its own theoretical framework and modus operandi. Evidence of this can be seen in the courses and graduate programmes that include astrobiology within their curricula, as, for example, at the Florida Institute of Technology, they offer an Astrobiology Degree, and at the University of Edinburgh, they develop PhD Projects in Astrobiology.

The nomological network of astrobiology makes it necessary to appreciate astrobiology in a transdisciplinary way, and the same would happen with astrobioethics. The difference is that, with astrobioethics, we have an academic discipline that is closer to the humanities but whose source comes from astrobiology. The ethical aspect of astrobioethics is quite useful for these purposes, given that ethics involves a dialogue and understanding the position of the other. Just as astrobiology has its own scientific and epistemological challenges, astrobioethics has its own too. Stoeger *et al.* (2013) offer us a lot of clarity in this regard:

> Exploration of the ethical implications of astrobiology is not as esoteric a pursuit as it might at first appear. It follows directly from the established considerations of other interdisciplinary fields like bioethics and environmental ethics. The advances in biology, biotechnology, and medicine have prompted a new urgency in applying theories of ethics to practical problems such as the boundaries of life… Astrobiology moves such applications further to considerations of how we might behave as we explore new worlds or create new life in the laboratory, or interact with extraterrestrial life-forms (p. 2).

The notion of transdisciplinarity of UNESCO (1998) can be well reflected in what the authors in question propose. In fact, if one examines the disciplinary nature as it is done in this article, one realizes that astrobiology would belong to the field of transdisciplinary sciences, as it was also pointed out by Santos *et al.* (2016):

> Astrobiology fits perfectly well to this scenario: it is a relatively new-born transdisciplinary field (in its modern formulation) and it carries, among its core propositions, the dynamism and the intention of pointing to broad questions demanding multiple talents. It is not just a tool to unite researchers or a fashionable label to obtain research grants, but a new kind of emerging science, in which the whole is greater than the sum of its parts (p. 255).

It is for this reason that astrobioethics has a disciplinary nature, which is going to incorporate the reflexive characteristic of philosophy through ethics as a philosophical branch. Regarding astrobioethics and the main problems it addresses, three pillars pointed out by Chon-Torres (2018) can be identified: the legal aspect, the moral aspect, and the social aspect. We will explore some significant cases for each of these pillars in light of the epistemic foundation made in relation to astrobiology.[3]

Considering the disciplinary nature of astrobiology, it is now important to focus this perspective on the different objects of study of astrobioethics. This must be considered as an essential complement to be able to understand the complexity of the legal–ethical–social problem represented by the challenges of this discipline. In what way does this represent a novel contribution to the work carried out on the same subject?

To begin with, the present work makes explicit the need for a way of approaching problems of study with a modus operandi that needs to be explained, which we consider to be transdisciplinary and not only multi and interdisciplinary. Any attempt to develop a code of ethics should consider its disciplinary approach; otherwise we run the risk of replicating a reductionist perspective, as we have already done in the Earth itself, with negative effects for the environment, for example.

The argument of Peters (2018) about preserving life is important, but for this, a constant evaluation is required if we do not want to be confronted with our own creation. According to Peters (2018), postmodernism would represent an inconvenient on the definition of life because of its relativity as a position, but the definition of transdisciplinarity sustained here would help us to establish disciplinary connections that help us to update our definition and protocol towards the possibility of extraterrestrial life. While the increase of the complexity in the astrobioethics subject is increasing, it requires a dedicated place in particular.

Randolph and McKay (2014) propose that a code of ethics for astrobiology should be established through consensus. The possibility of considering the extraterrestrial life through an intrinsic and instrumental moral approach is evaluated. They also sustain that we all have life in common, and that if we start from there, we could achieve an appropriate ethical framework for astrobiology. However, if we look at the proposal presented in this paper, astrobiology requires a transdisciplinary approach and it is not enough to consider that we all have life in common, since life is also a social movement and this conditions the worldview of all of us. The transdisciplinarity in astrobioethics helps us to establish bridges between the point of view of the natural sciences and that of the social sciences, avoiding, again, reductionist perspectives.

The transdisciplinary proposal might be a good complement for Wilson and Cleland's (2015) proposal about how should we behave regarding extraterrestrial life. They suggest a secular position considering the existent religious plurality, and before the diversity of philosophical positions on what is considered moral, the recommendable thing is to have a case-by-case treatment according to the nature of the object in question, as if, for

[3]Meltzer (2011) also talks about the legal and moral aspect of space exploration in relation to the possibility of life in the universe, however, in this article the social dimension is added so we can cover the entire astrobioethic spectrum from an epistemic study.

example, the extraterrestrial living being is non-social, if it manifests intelligence or not, or if it manifests sensitive abilities. The epistemology of astrobioethics transdisciplinarity could help us to be prepared for a possible similar situation. In the same way, it might help to elaborate mental experiments such as those proposed by Milligan (2016) on our ethical position that we should take in the face of the dilemmas about the expansion of terrestrial or non-terrestrial life in the Universe.

The transdisciplinarity could establish scenarios and ways of approaching these situations, by now imaginary, that imply astrobioethic challenges such as our duty to expand human life, to expand the presence of life forms and the duty to extend life as such (Milligan, 2015). In the same way, transdisciplinary might work well for Race and Randolph (2002) in the development of the operating guidelines and a decision-making framework applicable to the discovery of non-intelligent extraterrestrial life. All mentioned authors problematize on the ethical challenges in the space exploration related to the search of extraterrestrial life, but all of them do it from approaches that must be organized and categorized, as it is established in Chon-Torres (2018): the legal, moral and social aspects, and also help to complete their theoretical framework with an epistemological foundation that meets the disciplinary needs of this great project.

Topics of discussion within the legal aspect of astrobioethics

The legal aspect of astrobioethics refers, for example, to the Outer Space Treaty of the UN (United Nations, 2002). Although this treaty does not address issues of life sciences in space, it does represent an important background for a legal basis on how we should behave in outer space in relation to potential non-terrestrial living beings. However, the developments that are taking place in the Committee on Space Research, also known as COSPAR (Kminek and Rummel, 2015), are of great value given that they can significantly contribute to the creation of a new treaty that involves astrobiological aspects, as is the case of the Planetary Protection Protocol. About the legal function of astrobioethics, there is still much to be done, as the NASA Astrobiology Strategy 2015 points out (Hays, 2015):

> Astrobiology research takes place in an environment of diverse and evolving laws regarding both exploration and technology. Laws regarding space and biotechnology, in particular, are rapidly changing. Astrobiologists should be informed about the relevant laws and treaties, while lawyers and policy makers should be informed about the current state of the art and potential developments in astrobiology (p. 158).

The feedback developed among legal professionals and astrobiologists is of great importance in order to establish new treaties and principles. The Astrobiology Strategy presents us with a series of interesting scenarios that are currently part of mental experiments that help us clarify and rethink some of the definitions we use every day without thinking too deeply about their scope and impact on the sciences of life in space. In the NASA document, there are questions and aspects that are also seen in COSPAR and in the Outer Space Treaty: 'How do they shape the types of research that can be done? How effective are they in preserving environments for astrobiological research?' (Hays, 2015, p. 158). The document also asks about the legal implications of the eventual discovery of life in space. While it is true that some elements of the laws that apply on Earth for international areas can be taken as a reference, it is important to underline the differences because after all it is a different planetary environment.

This brings us to the following approach within the legal sphere of astrobioethics, the elaboration of protected planetary areas. As well as there are protected areas for the preservation of nature for different reasons, one of those reasons can be to study them scientifically as Martian analogues, as in the case of Lanzarote on Earth (Martínez-Frías, 2016). Cockell and Horneck (2004) raises a series of rules to be applied in a Martian Planetary Park:

> no spacecraft/vehicle parts to be left within the park; no landing of unmanned spacecraft within the park; no waste to be left within the park; access only on foot or surface vehicle along predefined routes or landing by rocket vehicle in predefined landing areas; all suits, vehicles and other machines used in the park to be sterilized on their external surfaces to prevent microbial shedding (p. 294).

These considerations would be within the different types of parks posed by the author, from Polar Parks to the Park of Hellas, since each place on Mars has different values that must be respected for their nature and uniqueness, like for instance, the value of a planetary park because of its historical value (Cockell and Horneck, 2004, p. 294). All these parks would be part of the Special Regions (Meltzer, 2011), that is, places of astrobiological interest.

Of course, the legal aspect of astrobioethics can only advance if we apply a transdisciplinary perspective avoiding reductionism, that is, avoiding reducing all other disciplinary points to a few. What can start as a research programme may well evolve later into a new discipline, which is not surprising, since the disciplinary fertility of transdisciplinarity allows it.

Therefore we can summarize some of the central problems of the legal aspect of astrobioethics, to which we will add some other ideas:

- Interplanetary regulation (antecedent: UN Outer Space Treaty and COSPAR).
- Interplanetary reservation parks (as proposed by Charles Cockell and his Planetary Parks for Mars).
- Study of the legal implications on the activity of astrobiology as a result of the possible discovery of life in space (as proposed in the NASA Astrobiology Strategy).

As can be noted, if we approach these axes of discussion only from the multi and interdisciplinarity, we will not be able to do it with the appropriate complexity given that we would be limited by the disciplinary dynamism that would restrict us, an issue that does not happen in transdisciplinarity. This does not mean that elements of multi and interdisciplinarity cannot be used at some point; we can, since the transdisciplinary does not exclude the other two.

Topics of discussion within the moral aspect of astrobioethics

In the moral aspect of astrobioethics, we have a rather wide field of action due to its speculative content. The legal environment restricts us to what is legally viable, but the moral can go further and raise a series of questions and ethical principles necessary to develop a theoretical framework of moral action. Some of this is reflected in Cockell (2005) when he discusses about originism as a new form of speciesism that derives in a 'biological imperialism'.

According to Cockell (2005), originism is 'a prejudice against life that has different origins' (p. 289). A prejudice that, one might think, comes from the biogeocentric paradigm (Aretxaga, 2004; Chela-Flores, 2001; 2009) in which we are immersed. Believing that we can discriminate other forms of life only because they do not have our origin supposes to assume an ethical position that must developed by astrobioethics. Life as we know it and how we look for it in space is searched in terms of what is known on Earth, and that in itself represents an inevitable bias, the question is to what extent this bias must intervene in the ethical stance assumed. For this, Cockell (2005) in the same article proposes the *teloempathy*, as the fact that 'We can respect microscopic organisms independently of their origins—a respect based on the fact that they are living creatures that are likely to exhibit the basic attributes of conation' (2005, p. 289). This basically means that we should take into moral consideration the microorganisms due to their intrinsic value, and what is more interesting, not to limit them to their biological components (that is why it is not bioempathy) but for the purpose they fulfil, by the *telos* they make:

> Consider, for example, a hypothetical world colonised by life forms that are biochemically utterly novel. The life forms have no DNA or any other genetic information-reproducing machinery that is recognisable to us, but they seem to do all the things that we recognise as being 'life': they reproduce, grow, live in particular environments, and to evolve and develop in response to their environment (Cockell, 2011, p. 85).

Why is it so important to talk about whether non-terrestrial microorganisms have moral value by themselves? What relevance can the search for life outside the Earth have on an ethical level? In fact, the ethical link and scientific activity considerably condition what we can get to know. The limits of our actions are conditioned by our ethical framework, or as Cleland and Wilson (2013) tell us:

> Ethical theory has the potential to provide scientists with morally significant normative principles about how they (and other human beings) ought to act in relation to various organisms. The intersection of these two fields is called bioethics. Astrobiology presents a new frontier in bioethics. The discovery of truly strange forms of extraterrestrial life would compel us to revise our Earth-centric concept of life in significant ways, which in turn would challenge our largely anthropocentric (and hence also Earth-centric) models of moral status (p. 30).

The question about what is our role in the Universe is affected by the detection or not of extraterrestrial life. This connects with another equally interesting and large question: Do we have or should we expand our own life in the Universe? To what extent does our world view of nature legitimate us to act as it suits us in relation to the presence of life in other non-terrestrial environments?

Meltzer (2011) gives us an example of how the human being, legitimized by his worldview, believes to have extraplanetary rights over environments that have little or no probability of harbouring life, an issue that interconnects with geoethics:

> Such an attitude seems to have been extended to parts of the outer space realm. Conquest and alteration of a celestial object certainly is acceptable to many people if the body does not harbor life. This attitude was apparent as far back as the Apollo mission. The waste that remained on the lunar surface to reduce liftoff mass was considered an acceptable price to pay for the science return.

Even the fact of leaving marks on the Moon was considered a triumph of the human being in the face of adversity. This position can be traced philosophically to the bifurcation of the human being with nature. At what point in our history have we perceived ourselves ontologically separated from nature? Why are there cultures, especially aborigines, who still feel part and even children of nature? The reification of nature was not an abrupt issue, but a gradual one. Up to three historical bifurcations can be identified that established this distancing, as indicated in Chon Torres (2012). The first would be the construction of an abstract world through the world of Plato's ideas. Although this notion did not imply a manipulation of nature as property, it gives us the concept that the terrestrial world is a copy and the world of ideas is the perfect world. However, here there is no desacralization of nature or a petrification of nature with the purpose of manipulation or modification. Here, the most important in the historical–philosophical sense is the separation between two worlds, the one we perceive with the senses and the one that goes back to the world of ideas.

The second great bifurcation is linked to religion, in the Western case specifically through Christianity and its relationship with nature. Watts (1958) would say that his impression, then, has been that there is a profound and extraordinary incompatibility between the Christian atmosphere and the atmosphere of the natural world. It seemed almost incompatible to relate God the Father, Jesus Christ, the angels and the saints with the Universe. Looking at the trees and the rocks, the sky with its clouds or its stars, the sea or a naked human body, this religion simply does not fit. '… Christianity suggests the urban environment rather than the rural one because in the first of them we are surrounded by works of thought' (p. 31).

Nature, in this sense, is not something sacred, so it is not even possible to sin against animals, we do not go to hell for killing an animal. If we extrapolate it to geoethics, we see that we will feel we have the right to modify the earth as we see fit without feeling any remorse; and if we extrapolate it to astrobioethics, we will see that the positions of great place will be for the biologicist imperialism, or the rather biogeocentric one. In this way, we see once again that the historical–philosophical background of culture permeates the science that is practiced today. So, astrobioethics as a critical form of thought is essential.

The third great bifurcation would have occurred during the Renaissance, when we begin to visualize the mathematization of the world, as perceived by Galileo Galilei, mathematics as nature's language. Later, the subject–object division of Descartes fulfils its part in this third great bifurcation, leaving the possibility that if nature can be conceived mathematically, then we can control it. Also added to this is the mechanistic view of the world; the division of knowledge into disciplines would begin to take shape from these bases.

> Living Nature was the dominant vision of the Renaissance stricto-sensu, of the fifteenth and sixteenth centuries. It was even the guiding idea of that period, so it is surprising the lurch that was the fact that, from the first third of the seventeenth century, came to dominate -in a way, also crushing- the other conception, the one that says Nature that in itself is devoid of life, by imposing the paradigmatic idea of a purely mechanical world, mere assembly of inert pieces[4] (San Miguel de Pablos, 2010, p. 111).

So, apparently, the desacralized vision of nature has passed to our days in the way we treat it. Incidentally, the environmental

[4]Author's translation.

problem has sources in this way of seeing the bifurcated world. This was sharpened by the industrial revolution until resulting in the environmental crisis we know today. Therefore, the moral aspect of astrobioethics has connections with ecological ethics, because astrobiology is the study of life in non-terrestrial environments, outside of the planet Earth. But we must not forget that other planetary environments, asteroids and other celestial bodies are still part of nature, so the treatment we have had or have with nature on this planet will be likely replicated in other areas.

That is why geoethics and astrobioethics share philosophical roots with ecological ethics; they all start from a way of seeing the natural world. This worldview has desacralized the environment by considering it study material, by considering a footprint on the Moon 'a great achievement' rather than an impact that threatens the local geography, or more importantly, considering the arrival on Mars an economic and/or political victory rather than a mission that has to be careful not to contaminate the possibility of life.

For this case, it would be convenient to extrapolate the prisoner's dilemma, the one postulated in 1950 by Merril Flood and Melvin Dresher: Astrobioethics wins if everyone cooperates. In this dilemma, there is an imaginary case between two prisoners who are asked to incriminate their partner in exchange for reducing the penalty; by doing so one of them would receive only 1 year in prison and the other 10 years. On the other hand, if both of them incriminate each other, they will receive 6 years each one. But if they both decide not to incriminate the other one, they will receive 1 year each one (Nowak and Highfield, 2011). Imagine this in a scenario of astrobiological relevance. If a nation wants to take advantage of another in the technological aspect, it will be careful with its procedures and protocols, including those with astrobiological interest. However, the other nations will think in the same way and in the end everything will be a competition for their own benefit. This is what happened with the sterilization and microbial survival techniques, for example, between the former USSR and the USA (Meltzer, 2011). On the other hand, if we all cooperate, as in the case of the prisoner's dilemma, the advantages may be greater.

However, these considerations do not enter into a legal framework, but they serve as fuel for ethical reflection that can result in greater care when establishing rules and principles for the actors involved in astrobioethical interests. Therefore, it is essential to start to update the legal scope, because as it is shown below:

> According to Pericles 'Perry' Stabekis, a long-time NASA contractor who has served on the staff of every one of the Agency's planetary protection officers, Planetary protection does not have, by policy, an ethical component. So as it stands, it is not there to protect the planets for the planets' sake. It is to protect the planets for preserving them as a target of biological exploration. [author's italics]… So clearly the mandate of planetary protection is not one that is based on the ethics of the question, but on preserving our ability to explore them biologically… to keep them… as pristine as warranted to protect that exploration…. It is strictly to protect science planets for the sake of science (Metltzer, 2011).

Therefore, the effort to develop the ethical aspect of astrobiological research should be intensified (Rummel *et al.*, 2012). The development must gather the opinion of different experts, so that with their knowledge, we can complete the astrobioethic map and generate, at last, an astrobiological ethical code, an issue that will be explained later in this article. This is linked to the questions that UNESCO also poses for ethics in space and Michael Meltzer emphasizes it in his book about the history of NASA's Planetary Protection:

1. Do we have an ethical obligation to preserve a planetary environment to the same degree that we seek to protect our Earth's environment?
2. Does this obligation hold, even if there is no life on the planet?
3. Or, since environmental ethics seek to benefit and enhance life, do we have an obligation to see that terrestrial life expands onto lifeless planets? (Meltzer, 2011).

On the first point, the axiological categorization that we have of the terrestrial life in comparison with the non-terrestrial life must be discussed in the light of the possibility of finding life in other worlds, and even without having detected it, of knowing how to value and care the places where it can potentially exist. Obviously, in this moment, the assessment of terrestrial life is not the same as the non-terrestrial one, but in order to establish a criterion: Would it be of the same level as the life on planet Earth? Possibly not in some aspects, but in others, must be established in the astrobioethic debate.

The second point mentioned is related to geoethics. Of course, if a planet or moon is valuable because of the scientific knowledge that we can draw from it, adding the presence of life makes it even more precious. What happens if it does not have signs or presence of confirmed life? To what extent can we modify the environment at our convenience? Can we do everything we want with it? What happens if the planet in question has no life but had it in the past, will it have less astrobioethic value? (Dunér *et al.*, 2013). This last question can be answered by saying that the astrobiological value of the environment in question does not diminish, because we can explore its past to understand the nature of life outside the Earth. Up to what point? There is no definitive answer that one will be established in the course of the investigation, and according to consensus, there lies the transdisciplinary epistemological characteristic *a posteriori* that was pointed out at the beginning.

The third point mentioned is related to the position indicated above about our moral obligation to expand in the Universe, which we could call guardians of the Universe. This approach is circumscribed to the time and place from which we put it to debate. There is no definitive solution since it is a philosophical question; the real value here is the arguments that are shown and the consensus reached. However, sooner or later, it will be necessary for us to expand in the Universe not so much for a moral obligation, but for survival. That being the case, the criteria for expanding in the Universe will change and other aspects will be prioritized, such as preserving the only way of life that we know, if by that time, we continue to be empirically alone in the Universe.

Topics of discussion within the social aspect of astrobioethics

In the Astrobiology Roadmap (Des Marais *et al.*, 2008) and in the Astrobiology Strategy of NASA (Hays, 2015), we can find the relevance and importance of the social aspect of astrobiology. The need to connect the astrobiological interest with society in different facets is explicit in these documents. For example, the third and fourth principles of the Astrobiology Roadmap are quite direct when emphasizing the social interest of discovering other forms of life and the importance of taking this opportunity to educate the population, which is why the social aspect of

astrobioethics embraces the educational aspect. 'The intrinsic public interest in astrobiology offers a crucial opportunity to educate and inspire the next generation of scientists, technologists, and informed citizens; thus a strong emphasis upon education and public outreach is essential' (Des Marais *et al.*, 2008, p. 716). In order to better understand the role of education and astrobiology, we must mention that we can recognize three levels of science communication.

The first level (or last, the order is irrelevant) must be the specialized communication, aimed at the public that has established research topics. This level of communication does not have broad access to the public due to its high scientific jargon. This would correspond rather to a mature level of astrobiological research if we analyse it epistemologically. On the other hand, however, there is communication at a moderately informed level, which is addressed to different disciplinary audiences. This group can include university students, postgraduate and various areas of knowledge. The educational power of astrobiology here refers more than anything to the ability of relating one discipline to another, which allows for broad transdisciplinary opportunities to be generated, as ideas begin to connect. This level is of interest to the epistemology of astrobiology.

It is the third level that provides a lot of interest not only astrobiologically but astrobioethically in the social–educational aspect, because it is our responsibility as scientists, subjects that make up a society, to educate the population on topics that for millennia has approached the mind of humanity and that can now be tried to be answered scientifically: Are we alone in the Universe? This question has been answered by religion and by pseudoscience. As for religion, beliefs should be considered personal and in that sense would not have to collide with knowledge at the scientific level as long as it does not try to compare them.

However, on the pseudoscientific side, astrobioethics does have a lot of work to do. Building an authentic culture of peace requires doing so from the base of the truth, which can be achieved if the position of the scientist as a person is willing to collaborate with his peers in a strategy of reaching the people effectively by asking the question: Are we alone or not in the Universe? And this is something not only moral, we must consider that we live in a democracy and the demands of the society direct the destiny of the nations. 'Astrobiology receives public and governmental support in part due to common enthusiasm for the exploration of life and space. This leads to unique opportunities for scientific education and outreach, but also calls for critical assessment of whether and in what ways astrobiologists answer the questions the public is asking' (Hays, 2015, p. 156). The impact and influence of scientific dissemination in astrobiology is vital to ensure government support through the demand of the population to seek answers to the possible presence of life in the Universe.

What has just been mentioned can serve as a connection with a proposal made by Race *et al.* (2012) when developing a Societal Roadmap for astrobiology: Herein lies a challenge for astrobiologists: How can we develop a systematic research agenda that focuses on both the implications of astrobiology on society and the potential effects of society on astrobiology? (p. 958). This project aimed to establish the principles and objectives for the equivalent of NASA's Astrobiology Roadmap but with an emphasis on the social aspects of astrobiology. As it is observed in one of its reflections:

> Research on communication and education will be important for broad understanding of the realistic possibilities associated with astrobiology sciences and associated risks, in contrast to popular views of aliens, UFOs, and interaction mythologies. It is equally important to acknowledge that discoveries in astrobiology science will not necessarily eliminate the need or desire for examination and interpretation consistent with religious or cultural traditions (Race *et al.*, 2012, p. 961).

The Astrobiology Societal Roadmap contains several elements that are of study interest for astrobioethics. The project had great ideas to be developed as Focus Group. But after a brief communication with the authors of the project, they said that unfortunately it could not be continued. However, the ideas that are manifested in the project have been following different paths. The SoCIA or 'Social and Conceptual Issues in Astrobiology' deals in a professional manner with social aspects related to astrobiology, such as ethics and education. These initiatives and others must be framed epistemologically within an Astrobiology Code of Ethics.

Finally, other aspects of the social field of astrobioethics can be seen in Cockell (2008), on the social challenges that future long-term space missions would face towards, for example, Mars. The author tells us, for instance, that unlike terrestrial conditions, those found on Mars would force us to have, up to a certain point, a major control with reduced liberties in a societal level.

> But it is a necessary condition of extraterrestrial environments that, in order to control crime, reduce poverty and ensure that the basic survival needs of all individuals are met, the distribution of private property must be monitored and controlled within a far greater diversity of activities and systems of production than they are on the Earth (Cockell, 2008, p. 269).

The problems posed in this social astrobioethic dimension adjoin the legal one, and it is normal, since politics can be responsible for guiding the administration of societies.

Philosophy is important because it adds social astrobioethic elements. That is, there will be a need to establish a philosophy that justifies the social behaviour of the inhabitants of these future places in a non-terrestrial coexistence. It is essential to develop a type of philosophy oriented to a specific non-terrestrial society, although one can use the classic social philosophers anyway.

> There will be a driving deeper urge to establish a new branch of philosophical thinking that is specific to them and their extraterrestrial societies, thinking that they can claim as their own, and that more readily reflects their particular social predicament (Cockell, 2008, p. 270).

Again, the need for an astrobioethics code is crucial, so the debate can be directed in a way that meetings and discussions can be managed and organized in an orderly manner. This will be useful both to the astrobiological institutions and to the individuals.

Glossary

The following glossary has been made to help understand the concepts in this paper.

Astrobioethics – branch of astrobiology and ethics that studies the moral implications related to the presence of extraterrestrial life.

Monodisciplinarity – approach that consists in interpreting objects of study from a single discipline.

Multidisciplinarity – is the contribution of several disciplines on an object of study. There is a low degree of methodological interchange between disciplines involved.

Interdisciplinarity – orientation approach of one or several disciplines towards the focus of one of them. The 'leading discipline' is

the principal beneficiary in this approach. The case of the philosophy of astrobiology is an example, since it does not produce scientific results but rather the implications or philosophical content of it.

Transdisciplinarity – is the interaction of several disciplines in an equitable way and the formation of a methodology that is consolidated during the research process. Its nature is *a posteriori* and as such there is no one exclusively transdisciplinary way of doing things, so it can be applied to both social and natural sciences, or both as a whole.

Methodological reductionism – reduces the methodology used by different disciplines to one with the purpose of trying a disciplinary unification.

Nomological network – a set of principles and rules that characterize an academic discipline.

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