Introduction: the history and philosophy of astrobiology

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Introduction: The History and Philosophy of Astrobiology

On the 11th of November 1572, the Danish astronomer Tycho Brahe (1546–1602) saw a new, very bright star in the constellation Cassiopeia. The sidereal heaven no longer seemed to be something unchanging and eternal, as Aristotelian cosmology had taught. On the contrary, this observation made it possible to think about change and creation not only with respect to Earth, but also to the universe. Receiving in 1575 the island of Ven in the strait of Öresund in fief from the Danish king, Brahe there constructed the biggest and most advanced observatory in the world of the time, Stjärneborg (Stellæburgum), and turned his face towards the sky to look with his naked eyes for distant stars and other worlds.

Brahe's measurements and determinations of the positions of the heavenly bodies became indispensable for his disciple Johannes Kepler's formulating of the planetary laws of motion. In his turn, Isaac Newton brought together Kepler's laws and Galileo's mechanics into the gravitational theory of classical mechanics. And in the end, the gravitational theory is what enabled us to detect the first exoplanets in the 1990s. Thus, it may be argued that on the island of Ven one important keystone was laid for the scientific search for extraterrestrial worlds.

September 27–28, 2011, on the island of Ven that now belongs to Sweden, the conference "The History and Philosophy of Astrobiology" was held just a short walk from the remains of Stjärneborg. The conference was arranged by the theme group "Astrobiology: Past, Present and Future" at the Pufendorf Institute for Advanced Studies, Lund University, Sweden. The aim of the conference was to bring together researchers from all over the world to share their results and insights into the wide fields of the history and philosophy of astrobiology. Being the result of the presentations and discussions that took place on Ven, this present special issue of *Astrobiology* aims to give a rough outline and some samples of this new branch of astrobiological research. Hopefully, this may stimulate future research in this area.

What, then, is the history and philosophy of astrobiology? What lines of research are there, and what has been accomplished? And why history? Why philosophy? Granted, studies in the history and philosophy of astrobiology do not provide any new empirical data on extraterrestrial worlds. Rather, stemming from the human sciences, this research branch concerns the human being itself. The history and philosophy of astrobiology is about humankind's endeavor to find life in the universe, and it is about human hopes and fears, human theorizing, concepts, and imagination. We hope that this special issue will clarify why history and philosophy are important for the self-understanding of astrobiology; how it has developed and what deeper fundamental problems it faces. The first paper of this collection, STEVEN DICK's review paper, gives a broad overview of the field and shows the vast diversity of research questions that have been put forward and are still waiting to be explored. Dick's paper, which sums up what has been achieved, but also what critical issues still need to be tackled, can be used as a starting point for future historians and philosophers of astrobiology.

The History of Astrobiology

Human beings have wondered about the stars above them since the dawn of our species. Is there life out there? Are we alone? The question of life in the universe can be traced back to antiquity, to philosophers and authors like Aristotle, Epicurus of Samos, and Lucian of Samosata. Since then the astrobiological question has fascinated scientists and philosophers, and been discussed by religious thinkers and utopian authors. Increasingly, the question has gone from something we do not have any answer to, something we can only imagine, to something that we can actually study. With the "discovery of space" during the scientific revolution in the sixteenth and seventeenth century, the superlunar world, the universe beyond the Moon no longer was something closed and unchanging, instead, it turned into something vast and changing. With Copernicus's heliocentric system Earth became a planet like the other planets; when Galileo aimed his telescope towards the Moon and found it rugged and uneven, like our Earth, with perhaps mountains and oceans like our planet; then scientists and philosophers asked themselves: Why cannot these sidereal bodies also harbor life? Earth is not something unique. These discoveries made it possible to formulate scientifically grounded arguments leading to the conclusion that the conditions for life are not restricted to our planet. Newton's theory of gravity made it possible to calculate the motions of the bodies, that finally today have let us discover planets in other solar systems. "The discovery of time," that the Earth has a long history and has gone through various geological processes, expanded the time frames. Other crucial discoveries that led to the astrobiology of today are, for example, spectroscopy and Darwin's explanation of the evolution of life in the nineteenth century, and genetics and the molecules of life, the space program, the discovery of extremophiles and exoplanets in the twentieth century. But contemporary astrobiology is not just a result of discoveries and new theories; it is also formed by societal factors, collaborations, institutions and technological change.

What is history of astrobiology? Just to give a few examples:

i) History of science: The first question of the history of astrobiology concerns how and why astrobiology has emerged as a scientific field of research. What crucial factors made it possible and how has it developed to become a solid, well-established empirical science.

ii) History of exploration: It is about the exploration of our universe. What instruments, methods and technology have been used and made this endeavor possible? The invention of the telescope, and besides that the microscope and other devices that let us peer into the microcosm, and further the spectroscope that let us analyze the light from other stars, the radio telescope, the space probes, etc. The history of astrobiology is to a large extent a history of technological change. MICHAEL PERRYMAN tells about the history of exoplanet detection, what instruments and methods have been used.

iii) History of theories: What theories, explanations and models have been put forward? As mentioned, the heliocentric worldview and the theory of gravity should not be underestimated. STEPHEN R. KANE discusses the concept of habitable zone and extreme planetary orbits. The idea of seeds of life in space, the panspermia theory, is historically treated by RENÉ DEMETS in relation to Darwin's contribution to the idea; and THOMAS BRANDSTETTER analyzes the idea of crystalline life and the limits of knowledge. In all, these articles give clear examples of the development of astrobiological theories.

iv) History of scientific organization: How has astrobiology been organized with institutions, laboratories, journals, space programs and international collaborations? As a research field, we find that astrobiology has expanded immensely the last decades with well-established journals, conferences, research groups, etc.

v) History of science and society: Astrobiology as a science does not exist in a vacuum; it involves also society, and relates to what we sometimes regard as extra-scientific factors like politics, economy, religion, and public communication. MARGARET RACE's and KATHRYN DENNING's article discusses cultural, societal and psychological implications of astrobiology research and exploration. LINDA BILLINGS' article explores the conceptions of astrobiology in scientific culture and popular culture, the role or roles that astrobiology plays in popular culture.

vi) History of imagination: History of astrobiology is also, finally, about imagination. How do we human beings think about that which we know nothing about; how do we imagine the unknown, extraterrestrials and distant worlds? Our human imagination says little about what actually is out there; instead the history of imagination tells about the authors' contemporary world, the dreams, imaginations of their cultures, what was possible to think, the boundaries of their imagination. Studies in the imaginary voyages might not be so informative for the history and development of astrobiology as a science, but they have generated historically valuable documents that aid in our understanding of the dreams and imagination of a historical period, and of the time these early thinkers were living in, its conceptions, ideas and endeavors. THORE BJØRNVIG's essay is an analysis of the Danish silent movie "Himmelskibet" (The Sky Ship) from 1918, and gives striking examples of what an imaginary Martian voyage reveals about the thoughts and beliefs around the time of World War I. Since ancient times the extraterrestrial life debate has been strongly influenced by religious concerns and beliefs.

The list of historical research questions can of course be longer, and just a small fraction of this vast territory is explored in this issue. But in all, the study of history of astrobiology can shed light upon the problems that are involved in the emergence of a scientific field. But astrobiology is not only of interest for the history of science, but also for a general history of ideas, how people in history formed their ideas about the surrounding environment, how they used their cognitive capacities in order to place humanity in a universal context.

The Philosophy of Astrobiology

Astrobiology raises a number of philosophical questions that can only be answered with a thorough philosophical analysis. There are a number of fundamental issues that are taken for granted in astrobiological research, which themselves are seldom discussed in any detail. Yet, they form the basis of what we think we know. So, what is the philosophy of astrobiology? Among various philosophical questions we find:

i) Philosophical self-conception: What is a human being? What is humankind's place in universe? A main reason why astrobiology is so intriguing, and so popular with the general public, is that it raises existential questions, challenging our everyday conceptions of ourselves as human beings in the universe. Ever since the days of the Ancient Greek motto *gnōthi seauton* ("know yourself"), human self-conception has been a front and center topic of philosophy.

ii) Conceptual analysis: A major part of the astrobiological literature is about concepts. More precisely, it is about defining and constructing concepts in order to handle the phenomena encountered. For example, probably the most debated and discussed philosophical question in astrobiology is the concept of life. What is life? Can we define it? Do we need a strict definition of "life"? If we are searching for "life," we should at least know what it is we are searching for, what kind of criteria we are looking for. Should these criteria pertain to metabolism, entropy, genes, reproduction, or perhaps something else? So far, the debate has intuitively employed an Aristotelian conception of definition, according to which a "definition" is a limited list of characteristics that are both necessary and sufficient for something to be of the type of object it is, and from which all the characteristics of the object originate. This debate could benefit from the insights of contemporary philosophy and cognitive science about human categorization. In our daily life, we do not use limited definitions in the Aristotelian sense, but cognitive prototypes. Dogs, cats, and horses may seem to be more typical representatives for "life" than arsenic microbes. Astrobiology deals with categorization not only with regard to life, but to such concepts as "habitable zones," "earth analogues," "exoplanets," "giant planets," "dwarf planets," etc. Future discoveries in astrobiology will most likely challenge our categorizations and definitions, that is to say, our *preconception* of what the world is and is not like. We should thus be prepared to re-categorize and redefine our concepts. Future exobiological systematics and taxonomy will face problems concerning categorization. The taxonomy of a future extraterrestrial fauna and flora will in a high degree be a product of the human mind.

iii) Ethics: The ethical issues have become increasingly more important and widely discussed, not in the least due to its concrete application in the space programs. Because it is we human beings who are dealing with astrobiology and exploring space, it is unavoidable that we have to make decisions concerning other lives. Our values are at stake. How should we behave if we find life, and have we human beings certain moral obligations toward other forms of life? ERIK PERSSON sets up in his article the problem of the moral status of extraterrestrial life. And what about planet protection and terraforming? Should we spread life, or should we avoid contamination of other planets with our microbes? Is it a good thing to expand human colonialization to other planets, to transform extraterrestrial environments, to start mining industries on other moons and planets, etc.? JACOB HAQQ-MISRA discusses how environmental ethics could be relevant to the broader issue of planetary engineering.

iv) Philosophy of politics: Astrobiology costs and involves political decisions. Who has the rights? Who owns the Moon, and future scientific discoveries of astrobiology? Why spend money on astrobiology, on the search for unknown life on distant planets, instead of using the money on the only life we know to exist?

v) Epistemology and philosophy of science: A much less explored philosophical territory is epistemology of astrobiology. How could we know what we think we know? For how long a time should we search without positive results before we give up? What is possible and not possible? The epistemology of astrobiology does not differ much from other branches of science, even though the limits of our astrobiological knowledge seem to be much more uncertain.

vi) Semiotics: Interstellar message construction and decoding raise a number of semiotic and linguistic questions. How can we code and decode interstellar messages? This is not just about constructing a vehicle for information transfer; it concerns what is needed for effective communication and symbolization of concepts. Interstellar communication, it could be argued, is less a scientific-technological problem than a communicative-semiotic problem.

vii) Cognitive science: What is intelligence and cognition, and are there universal laws for the evolution of intelligence? And what happens to the human mind in extraterrestrial environments?

The Future of Astrobiology

There are things we know. Even though life might not exist out there, it is we human beings with brains, bodies and cultures who are searching for it. The history and philosophy of astrobiology is centered on humans; or more to the point, the scientific endeavor's dependent on the human mind and human culture. Astrobiologists have brains, for sure; they are using cognitive tools that are a result of the bio-cultural co-evolution of human cognitive abilities. Certain cognitive processes are at work when astrobiologists encounter unknown things, when they interpret their observational data, when they gather and classify it. And this is not going on in subjective isolation, either. Astrobiologists live in a culture, in a certain time in history, in a specific research environment, and collaborate with other thinking beings.

Through the history of astrobiology, we find a certain common form of argumentation – analogy. In some sense, astrobiology as a whole is one single, great analogy. Starting from the one particular type of life we happen to know something about, namely, life on Earth, we proceed to search for life on other planets, predominantly looking for life as we know it: something needing oxygen, liquid water, being based mainly on carbon, inhabiting a planet of a certain magnitude that revolves at a certain distance from its sun, which in turn has to be of a certain size and capacity, and so on. In their most general form, analogical arguments may well be considered logically invalid. However, in providing us with some point of departure, they still hold some heuristic advantage in the search for life. But life might be very different from what we imagine. The history of science is actually a history of surprises; the world we are living in turned out to be very different from what we first thought: richer, more complicated, more advanced, more peculiar and more astonishing than what we could dream of. This will also be true for astrobiology. Future discoveries in astrobiology will surprise us completely.

If we find extraterrestrial life, we can be sure that this will change our way of thinking and how we perceive the world and our place in the living universe. In one way you could say that this special issue is not on the *history*, but on the *prehistory* of astrobiology. Should the day arrive, when we find extraterrestrial life on another planet in our solar system, or on an exoplanet orbiting another star, then begins the new history of astrobiology, and that will be a historical turning point in the persistent human search for life.

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