Introduction

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The aim was to search for microbial life on Mars. Each *Viking* lander robot carried three experiments to detect metabolism, which is perceived as an indicator of life, and a fourth experiment to find organic molecules to confirm potential findings. In one experiment, something strange happened. This experiment added certain nutrients to the soil and the nutrients were marked with radioactive carbon 14. Thus, if there are microorganisms on Mars, they should metabolize and emit gas containing radioactive carbon 14. This radioactive gas was *indeed emitted*, and another control experiment with sterilized soil released no radioactive gas – as if Martian microbes were now dead because of the sterilization. At face value, these results looked like a *positive detection of life*. The biology team was stunned. They couldn't explain these results in terms of any known chemical process, biological or non-biological.

Nevertheless, it was finally concluded that the cause of this result need not have been biological material, on the basis of the anomalous (for Earth microbes) results and, most importantly, the failure of the *Viking* landers to find any organic molecules in the soil. So, for now, no life has been considered found on Mars.[1]

Our imagination and definition of life highly influence what we look for, and hence what we can find. Any irregularity in experiment and observation can be a pointer to something for us to learn. Was this experiment an example of such a learning occasion on the nature of life? We would know better, if we would know what life is. Most life scientists assume they know or they avoid the issue altogether. For many, the secret of life has been unveiled and it is often regarded as nothing other than physical chemistry. But is this all that can be said about it? One could also ask if one could define life at all. NASA's working definition, "life is a self-sustained chemical system capable of undergoing Darwinian evolution" (Joyce *et al*., 1994, xi) explains as much as it leaves open for discussion. At least, by mentioning evolution it incorporates the historical dimension intrinsic to life.

What is life, then? In this book, this question serves as the central topic where different attempts at answers will be given. The focus is of course scientific, yet

includes perspectives from philosophical and theological angles as well. Some topics in the philosophical and theological part are more speculative, like the potential impact of postbiological superintelligence, the idea that all life is to some extent intelligent, or the implications of intelligent extra-terrestrial life for theology. We learned from Immanuel Kant that we need to balance speculation with critical thought. Yet we do not know what we will find if we reach for the stars. That's why the second part of the title of the book was chosen to be *On Earth and Beyond*.

The book is divided into three parts, beginning with a science section as part I, which provides the reader of the book with an up to date account of the scientific foundations of the topic. This part is followed by philosophical considerations in part II, and finally theological questions as part III. The body of the book is therefore compiled by an interdisciplinary group of authors from biology, astrophysics, philosophy and theology. The reader will realize that they have partly divergent opinions, which are encouraged by the editor; evidence of this is also the sceptic's afterword by Antonio Lazcano. Presupposition of a dialogue is to take the other one's discipline and position seriously, yet not to agree on everything. While a conflation of the disciplines – as in the case of creationism claiming to present scientific insights – has to be avoided, scholars involved in the dialogue of all three of these disciplines know about the differences, yet also tend to witness some fruitful interactions.

In this context, one thing needs to be mentioned: almost every academic theologian regards creationism or intelligent design as nonsense (not only from a scientific, but also from a theological point of view). However, scientists and philosophers don't always seem to know about this. Some even conflate *any* idea of creation with creation*ism*. Yet the problem lies in the early-twentieth-century phenomenon of creationism, not in the idea of creation, which on a fundamental level actually was even able to further the development of science, because it deemed "the book of nature" worthy of research while not taboo (in other religions it was regarded as Divine itself) (Hooykaas, 2000; McGrath, 2003, pp. 53–4). Only *after* Darwin's tremendous achievements it is of course unwise to stick to a literal reading of the beginning of the Bible, while at its time the Genesis account may have been a good approximation to "science" (Arber, 2012). The creation story of the Bible, focusing on one creator God, rendered almost any entity like Moon and Sun or the Leviathan as creation instead of regarding it like the Babylonians (in their *Emuna Elish*) as Gods themselves, so it had a *demythologizing* intent. Likewise, Earth was not regarded as a Goddess anymore, but considered to have received its obvious creative potential from the creator ("Let the earth bring forth grass", Gen 1:11 KJV). Similarly, Anglican clergyman and writer Charles Kingsley pointed out that God "made all things make themselves" and Charles Darwin liked this theological interpretation of evolution enough to refer to it in his *Origin of Species*

from the second edition on (Browne, 2003, pp. 95–6). Also, generally, the idea of evolution entails a more or less linear progression through time, an imagination originating from Jewish and Christian thought.

As previously mentioned, the focus of part I of the present book, composed of the first four chapters, is scientific. The question of the origin of life, the search for another Earth in other solar systems, a way to find potential signs of extra-terrestrial life on Mars and the history of the research into the origins of life are presented and discussed in a way understandable for the non-scientist. This summary is further elaborated as follows.

We still do not know much about life's origins on Earth. Despite the immense interest in this topic, it remains an unanswered side-question in modern scientific research. In the first chapter of this book, Marie-Christine Maurel sets herself on the track to explore the traces of life's origins. By that, she understands the *source* from where matter got its primal actions. Maurel is trying to avoid the opposition of mechanism and vitalism. Is it possible to find another path close to biological reality, both material and living? She stresses that the origin and the evolution of life coincide; there was no creationist start from nothing. What about Darwin's famous "warm little pond"? Maurel presents several scenarios for how the beginning of life could have happened, derived from astrophysics, astrochemistry and geochemistry, furnished with further elements from speculation and from laboratory experiments.

Is there life beyond Earth? Positively answering this question, Joshua Krissansen-Totton and David Catling argue, would challenge our self-understanding dramatically. Earth would not be special any more but, in exchange, our universe would be much richer. Chapter 2 argues that the question of life elsewhere will likely be answered within the lifetime of readers of this book. This has to do with the relatively recent discovery of exoplanets, circling stars other than our Sun. For now, the vast majority of them have been detected by using indirect methods, yet the authors perceive direct imaging as a more promising technique for the potential discovery of life on other planets, as life may modify its environment on a planetary scale. Nevertheless, they suggest that the more traditional Search for Extra-Terrestrial Intelligence (SETI) using radio telescopes should not be dismissed too easily.

If we refocus our attention to our solar system, Mars is the closest candidate for potentially carrying or having carried life. Beda Hofmann argues in chapter 3 that there is a way Mars missions could hint at previous or present microbiological life on Mars, namely by searching for fossils in the extra-terrestrial matter. We are talking about microbial life here. On Earth, conditions for life exist in numerous places, not only on the surfaces of the continents and in the oceans, but also in sediments and hard rocks. Fossilized microbial fabrics, that is to say the remnants of

slime, can indeed be used as an easily visible expression of fossil life. Hofmann discusses several common types of morphologies preserved in rocks and resulting from prokaryotic microbial life. Nevertheless, such fabrics typically need corroboration by other methods, a feature currently still unavailable in our attempts at Mars exploration.

In chapter 4, we turn back to the history of life on Earth and follow Antonio Lazcano's portrayal of the story of how biological research on the origins and nature of life made progress. An evolutionary framework derived from Darwin's ideas has led to the most fruitful approaches. Ernst Haeckel enlarged the scenery for this story by including cosmic evolution, and his idea of a *unity of nature* invoked the imagination of an evolutionary continuity between the inorganic world and living entities. It was Oparin who pointed out likewise that life is not characterized by any special properties but by a definite, specific combination of these properties that is the outcome of a historical process. The appearance of life on Earth should hence be seen as a non-progressive evolutionary continuum that seamlessly joins the prebiotic synthesis and accumulation of organic molecules in the primitive environment, with the emergence of self-sustaining replicative chemical systems capable of undergoing Darwinian evolution. History's contingency is of the essence to understand the nature of life.

Part II is about philosophical contributions to the theme of the book. It has already been asked: can one set up a definition of life? And is there a way philosophy can assist science today? We should recall that, initially, science was considered "natural philosophy". Also, the idea of life beyond our planet is philosophically an old one: the starry skies above us did not only induce Immanuel Kant's interest in extraterrestrial life (Losch, 2016b), philosophers from the early Atomists on have speculated on the issue (Crowe, 1986).

Yet how is the situation today? Chapter 5 is a contribution to the dialogue between biologists and philosophers at the beginning of the twentyfirst century. Michel Morange considers recent transformation of biological knowledge and shows how they raise major issues on the "nature of life". The emergence of molecular biology dramatically transformed the question "What is life?". The subsequent fading of the informational vision and the search for a minimal genome resulted in surprising outcomes: an ecological vision of life and the return of the question about whether viruses are alive. The border between living and non-living seems to be more porous than expected. Regarding the projects of synthetic biology, Morange predicts that separation between life and non-life will hence not be a simple border, but a territory the geography of which is still poorly defined. Life is a contingent process, so the characteristics of an organism are not the simple result of the action of natural selection, but also of the constraints linked to the progressive construction of this organism.

Chapter 6 returns to the most fundamental question, "What is life?". We can only detect life on other planets and gain insights about its origin, if we know to some extent what life really is. But this condition does not seem to be fulfilled; rather, various definitions of life have been proposed, none of which has achieved consensus. Claus Beisbart thus proposes to step back and to analyse the meaning of the question more closely. Starting from a few requirements that any answer to the question should obey, he arrives at the conclusion that attempts to define life face a dilemma. A definition of life is either unprincipled or to some extent stipulative. Beisbart proposes explication as suggested by Carnap as a sensible framework to discuss the question. His suggestion is to replace our notion of life for the purposes of *scientific* inquiry with a notion that strikes a fair compromise between Carnap's desiderata of similarity, exactness, fruitfulness and simplicity.

Is the origin of life a fluke? Differing from convictions of prominent biologists, our author Christian Weidemann argues, in chapter 7, why the chance hypothesis does not need to mean siding with creationists and why it should not be dismissed too quickly. Many believe that even if all hitherto proposed theories on the origin of life were shown to be false by new evidence, the justification for believing the emergence of life on Earth was not due to a mere fluke would remain largely unaffected. Weidemann is convinced that this belief is ill founded. He gives two reasons, the *vast cosmos argument* (given a sufficiently big and variegated ensemble of universes, any finite chance of life emerging will suffice to guarantee its formation) and the *indifferent nature argument*, meaning that there seems to be no conceivable reason to suppose that processes by which complex molecules arise are more likely to be biased towards life-producing molecules. Unless a plausible alternative explanation is available or other life that has emerged independently is discovered, the chance hypothesis remains a serious contender for him.

In chapter 8, Milan Ćirković defends the ongoing astrobiological revolution. He rejects several contemporary fallacies about astrobiology, such as those he labels as old and new varieties of Geocentrism, accompanying the astrobiological enterprise from its exobiological start ("There is no astrobiology because there is no instance of confirmed extraterrestrial life"), recently rearticulated in the form of the rare Earth hypothesis (Ward & Brownlee, 2000). Against critics who view the astrobiological efforts as pure science fiction, Ćirković asserts that literary discourse presents a treasure-trove of potentially useful scientific hypotheses. There also has been much confusion about the issue of whether the theory of biological evolution conflicts with the idea of extra-terrestrial life, which it, of course, does not. Ćirković regards the astrobiological revolution in a wider context of the Enlightenment struggle for a completely rational world view, so extra-scientific resistance to this extension of the Copernican revolution has to be expected.

There has rightly been a good deal of attention on the search for *microbial* life. This could, however, present an anthropocentric bias, for in doing so we are implicitly assuming humans to be at the top of life in the universe. Susan Schneider observes that the current work in astrobiology, as diversified as it may be, does not draw from the intriguing discussions of superintelligence in the literature about artificial intelligence. Chapter 9 pieces these two domains together. On the one hand, Schneider identifies new directions for the postbiological intelligence approach in astrobiology. On the other hand, while the discussion of superintelligent artificial intelligence has mostly focused on the control problem, Schneider takes a step back and considers under which circumstances we could understand its computations, if at all. Anticipating ways to understand such sorts of intelligence may assist our efforts to control it. Schneider ends with discussing the social impact of encountering superintelligence, be it on Earth or discovered elsewhere.

Part III is about theological approaches. Ian G. Barbour (1997) sketched a very helpful typology of potential relations between science and religion,[2] distinguishing *conflict* cases (like creationism or a scientism blindly fighting any sort of religious interpretation of nature), an *independence* model (like Stephen J. Gould's NOMA or a complementarity approach), a *dialogue* stance or even an *integration* of aspects of one discipline (usually science) into the other (usually theology). All stances except for conflict of course mean respecting the other discipline's territory from the start.

In the media, many times only the conflict cases are reported and could hence invoke the impression of being dominant within academic communities as well. This is not the case. Although some sociological studies seem to enforce the conflict view, with titles such as "Leading scientists still reject God" (Larson & Witham, 1998) or "Eminent scientists reject the supernatural" (Stirrat & Cornwell, 2013), one should, however, note that the authors of the first study, for instance, chose as the title of the same study in the previous year "Scientists are still keeping the faith" (Larson & Witham, 1997). This is also the result of a very profound study conducted by Elaine Howard Ecklund (2010): even half of US top academics stick to some sort of religious faith, despite outward appearances. Of course, freedom of belief or non-belief is an important societal achievement, but it does not help that many still believe in the nineteenth-century myth that science and religion are at constant war with each other. The truth is that professional science in the nineteenth century often emancipated itself from the profession that previously only had the time to perform natural study, which was actually the clergy: the "scientific parson" was a well-established social stereotype, hence there have been some necessities of scientific distinction from theology (McGrath, 2003, p. 46), just because the two have often been very close together.

Andreas Losch asks, in chapter 10, what today's theology can contribute to the scientific question of "What is life?". He observes from the scientific beginnings a focus on the physical and chemical level of life and hence a potential bias. As the character of the dialogue between science and theology is, however, largely asymmetrical, theology can contribute more to the scientific setting than to science itself. First of all, scientists and theologians need to agree on some basic premises for dialogue, which actually means, as has been said, taking the other's contribution seriously. Elaborating on ideas from Michael Welker, Losch then argues that theology can prevent the sciences from developing false perspectives of theology and can correct mistakes and inconsistencies in scientific presentations of theological and religious issues. More constructively, it can also develop explorations of areas of knowledge common to both from multiple perspectives, and try to build small bridges at the boundaries of each side's areas of knowledge. It can remind science that completeness of knowledge has not yet been achieved and it can maybe serve in an auxiliary function for science, pointing out the existing gaps in the scientific account of the universe, and sometimes even propose a preliminary "filler". It may well be that theology one day has to retreat from the claim of a particular gap as it is closed by science. Yet until then, it leaves the floor open for new research.

One example of how such a contribution could look is presented in chapter 11. Most modern philosophy and especially molecular biology have typically looked at nature through mechanistic glasses. Alexander Maßmann, however, wants to set aside the inherited Cartesian dualism that isolates mind from matter and, with the help of philosophers Evan Thomson and Hans Jonas, attempts at regrinding our lenses to see more clearly physical self-organization as the external dimension of cognition, and cognition as the internal aspect of self-organization. He also enters into dialogue with Kant, stressing that only if the regulative idea of teleology is corroborated by a cogent connection to the phenomenal world can it appropriately define the referent of the discipline of biology. Maßmann combines the mechanist events of genetic mutation and natural selection with the teleological autopoiesis of the organism. Towards the end of his chapter, he shifts to more proper theological interpretation of what he has presented, developing a theology of creation which understands creation in systemic and in evolutionary terms, elaborating on the potential role of the Holy Spirit in autopoietic organization.

Chapter 12 by Ted Peters aligns with Maßmann's underlying idea and claims that *where there's life there's intelligence*. He provides a comprehensive scale of intelligence that includes simple single-celled organisms in continuity with the highest level of intelligence we know, viz. *Homo sapiens*. Elaborating on seven distinct traits of intelligence he demonstrates a spectrum within the single category of intelligent life, hoping to steer astrobiological eyes to see what might

surprise us. Hence what happens at the human level is in continuity with all levels of life in our biological evolution. According to Peters, an organism is intelligent when it possesses interiority, intentionality, communication, adaption and finally mental activity, including problem-solving, self-reflection and theory of mind, and judgment. In his account of intelligence, Peters leaves consciousness, values and free will aside. He also discusses three potential holes in his argument's boat.

Juan Pablo Marrufo del Toro, SJ, zooms out of this particular focus and reinstates the great picture of life in the universe from a theological point of view. Chapter 13 takes science utterly seriously and hence starts with a recapitulation of the contemporary scientific findings. It then turns to theology proper, which discusses the implications of the potential existence of extra-terrestrial intelligent life for the Christian dogma of incarnation, which relates God deeply to creation. Would this mean for the theologian that he could conceive of multiple incarnations? Marrufo del Toro subscribes to Niels Henrik Gregersen's idea of "deep incarnation", which means that the presence of the Logos reaches not only humanity but every tissue of biological existence with its growth and decay, entailing "deep crucifixion" and "deep resurrection" as well. The search for extra-terrestrial intelligence has begun, so theology should be prepared to answer such questions.

What really drives the search for exoplanets and extra-terrestrial life is the central question of chapter 14. Taede Smedes is convinced it is actually the hope of finding *intelligent* (and self-conscious) extra-terrestrial life, so somebody more or less like us. Smedes, however, expresses some scepticism about this approach, as it reduces *otherness* to *sameness*. Following Wittgenstein's remark "If a lion could speak, we could not understand him", he emphasises the otherness of potential aliens inhabiting another ecological niche and reflects on the possible incommensurability between potential aliens and human beings, a position he calls "apophatic astrobiology". As with regard to the possible religious beliefs of aliens, he argues that if god concepts supervene on the cognitive functioning of human beings, then perhaps religion is limited to humans only. If intelligent extraterrestrial beings lack religion and god concepts altogether, this would obviously raise interesting theological questions for e.g. Christian theology.

The reader is welcome to regard chapter 14 in some sense as a critical counterpart to chapter 13. As previously mentioned, reasonable speculation and sound critique both need to be trained, and so this book will end after a summarizing conclusion with a sceptic's afterword. There are many more objections I can imagine: isn't the theological focus on Christian traditions witness of a bias? Why don't we learn more about the historical perspectives of interactions? Every book has its limitations, and in this book we set the focus mostly on contemporary interactions in the Western hemisphere. It can only be a beginning. "Astrotheology" has just

been started to be re-developed (see the editorial of the collection of articles in the journal *Zygon*, Losch, 2016a). Who knows, maybe one day we will indeed find extra-terrestrial life? If not on Mars, maybe somewhere else in the solar system – or beyond. I hope this book will have helped us to be prepared.

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Notes

1 The paragraphs are partially taken from Catling, 2013, pp. 96–7, and from Carol Cleland's *The Quest for a Universal Theory of Life: Searching for Life as We Don't Know it*, see http://rintintin.colorado.edu/~vancecd/phil150/Cleland.pdf.

2 The drawback of Barbour's approach is to have left philosophy as a discipline of its own out of the picture, which is needed in almost any attempt of fruitful interaction bridging science and religion (Losch, 2011). This is one of the reasons why philosophy plays a crucial part in this book.

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