Astrobiology and Humanism

Astrobiology and Humanism:

Conversations on Science, Philosophy and Theology

By

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To:

Sarah Catherine Mary Dowling

Philosophy, as I shall understand the word, is something intermediate between theology and science. Like theology, it consists of speculations on matters as to which definite knowledge has, so far, been unascertainable; but like science it appeals to human reason rather than authority, whether that of tradition or that of revelation…But between theology and science there is a No Man's Land, exposed to attack from both sides; this No Man's Land is philosophy.

—Bertrand Russell:

"*History of Western Philosophy and its Connection with Political and Social Circumstances from the Earliest Times to the Present Day"*. 2nd Edition. George Allen & Unwin, London (1991), p. 13.

Contrary to the popular but inaccurate picture of science and theology being at loggerheads with each other, the fact of the matter is that there is a lively debate between the two disciplines, and many of the contributors to that debate are themselves scientists with a personal commitment to religion and a serious concern with theology.

—John Polkinghorne:

"Scientists as Theologians A comparison of the writings of Ian Barbour, Arthur Peacocke and John Polkinghorne". SPCK Publishing, London (1996), p. ix.

Then I discovered evolution. Suddenly—that is not too strong a word—I saw the world in a whole new light...I had experienced the Ionian enchantment...It means a belief in the unity of the sciences—a conviction far deeper than a mere working proposition, that the world is orderly and can be explained by a small number of natural laws. Its roots go back to Thales of Miletus, in Ionia, in the sixth century B.C.

—Edward Osborne Wilson:

"Consilience: The Unity of Knowledge". Alfred A. Knopf, New York (1998), p. 4.

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FOREWORD

> *The goal of maximizing human flourishing—life, health, happiness, freedom, knowledge, love, richness of experience—may be called humanism*.
> —Steven Pinker:
> "*Enlightenment Now: The case for reason, science, humanism and progress*". Penguin Books, London (2019).

Culture, especially intercultural communication, is a topic in which scientists, philosophers and theologians have much to learn. Since the times of ancient Greece, a certain antagonism between faith and reason has been inevitable, but understandable. The general problem of finding the appropriate contribution of science in the context of humanism is not an easy task. It has a most significant precedent attempt in the seminal Dublin lectures: *Nature and the Greeks and Science and Humanism* (Schrödinger, 1996). The Austrian Physics Nobel laureate underlined the difficulties for such a broad topic to be covered by single individuals, whether scientists, or humanists (Schrödinger, 1944):

> *We are only now beginning to acquire reliable material for welding together the sum total of all that is known into a whole; but, on the other hand, it has become next to impossible for a single mind fully to command more than a specialized portion of it. I can see no other escape from this dilemma (lest our true aim is lost for ever) than some of us should venture to embark on a synthesis of facts and theories, albeit with second hand and incomplete knowledge of some of them—and at the risk of making fools of ourselves.*

Accepting "*the risk of making fools of ourselves",* we humbly follow Schrödinger, our distinguished predecessor, in a preliminary effort to "*weld together the sum total of all that is known into a whole*". We discuss the frontiers of science of life in the universe (astrobiology) with the humanities, because the existence of life in the cosmos raises questions that are meaningful to humanists. One of the aspects of humanism is the role of knowledge in maximizing human flourishing. Our time in history cannot be better highlighted than by an appraisal of the progress of knowing our position in the universe, which illuminates science, especially astrobiology, and the humanities.

All aspects of life in the universe are among the most important conversations of our time. They involve, not only the frontiers of science, but they are relevant in a wider cultural context, in which ethics in intercultural communication is vital, and often sadly neglected, creating unnecessary confusion. Later on, we return repeatedly to ethics in science communication. But it is rewarding to notice that the question of ethics in the wider context of astrobiology, has been given its proper significant position in a cultural context—astrobioethics—a branch of astrobiology that studies the moral implications related to the presence of extra-terrestrial life (Cockell, 2008; Chon-Torres, 2018). In spite of the fact that ours is only a small book, a clear personal point of view has been expressed: *the horizons and frontiers of science are fundamental.* To make the work easier for our readership, we give full references to other views on science and humanism.

By the end of last century, long before the name "*astrobiology*" was introduced for the study of the origin, evolution, distribution and destiny of life in the universe, the universality of Darwinism had already been discussed during the memorable Cambridge Centennial Conference, which commemorated one hundred years after Charles Robert Darwin's passing away (Dawkins, 1983).

We shall endeavour to illustrate that Darwinism is conceivably the most influential scientific contribution of all time, as we have maintained in our earlier book (Chela-Flores, 2011). Consequently, it is timely to bring the attention of our readers to the major intellectual contribution of the great scientist from Shrewsbury (Darwin, 1859). In this context, a "Second Genesis" is a suggestive term introduced by Christopher McKay to denote the presence of independent lines of evolution—the emergence of life in places other than on Earth (McKay, 2001, Chela-Flores, 2009). Darwinism is expected to govern all evolutionary processes, on Earth and elsewhere (Dawkins, 2017).

There are difficulties that Darwinism has inherited since the time of the publication of "*The origin of species"*. In order to avoid misunderstandings, we have encouraged a constructive dialogue of faith and reason on questions raised by the evolution of life on Earth, as rationalized by Darwin. The dialogue between faith and reason has perennially been a source of controversy. In the following pages we rationalize disagreements that are solely due to ignoring the horizons and frontiers of science: The question of faith is entirely in the domain of the humanities, a fact that is

often ignored, rendering Darwin's profound, rationalization of natural history difficult to understand appropriately.

We give an advice to our readers. First, you may choose, either to read through the text to appreciate the compatibility of science and humanism, or preferably you may proceed directly to Appendix 1, where life in the universe is surveyed with helpful audio-visual means. Second, since we are restricting ourselves to a book of a reasonable size, the section of *Short biographies* in Appendix 6 is intended to be a complement of the main text. Third, sometimes we have referred the readers to a helpful selection of relevant images in "The Author Photo and Video Archives" (Chela-Flores, 2019a).

Finally, a word on the use of the phrase "Divine Action". We chose to capitalize both words, following the 1950 Literature Nobel laureate Bertrand Russell. We adopt the same respectful style that Lord Russell used for "Divine Mind". This is one way in philosophical considerations to appropriately convey veneration of the main topics that are involved in religious traditions (Russell, 1991).

PREFACE

Your serpent of Egypt is bred now of your mud
by the operation of your sun.
—Lepidus addressing Mark Antony:
Shakespeare, W. *Mr. William Shakespeare's Comedies, Histories & Tragedies.* In: Shakespeare Complete Works. W. J. Craig (ed.), London OUP. The Oxford Standard Authors edition was reprinted in 1969, pp. 977-1011.

An understandable non-scientific explanation of the origin of life can be traced back to various sources in the humanities. One of them is to be found in William Shakespeare's *Antony and Cleopatra,* from which the citation has been taken. In addition, a biblical account of the origin of life is contained in the first book of Genesis. Closer to our time, the collaboration of Walt Disney, a pioneer of the animation industry and the conductor Leopold Stokowski based their account of the origin of life on the ballet music *The Rite of Spring* of Igor Stravinsky. Their work on the origin and evolution of life on Earth was inserted in a larger project, the full motion picture *Fantasia* (Disney, 1940).

One of the author's objectives, being an active professional scientist, who is at the same time a believer, is to attempt to encourage a constructive dialogue between believers and non-believers. We aim to illustrate that this dialogue is especially relevant in a modern approach on questions of the origin, evolution, distribution and destiny of life on Earth. Such discussions are particularly relevant in the contemporary world, where globalization has brought different cultures and religions closer to each other. To avoid misunderstandings the careful, ethical role of scientists within the boundaries of their influence is more urgent than in the past. Galileo Galilei clearly defined the frontiers of science, which are generally accepted. This remarkable Italian scientist and humanist was at the University of Padua. Later on, he moved to Florence under the protection of the Medici family at the time of Cosimo II (1590 – 1621).

On the other hand, a scientific explanation of the origin of life has been widely discussed in the tradition that started with Galileo's insistence on experimental verification. During the last decade of the 20th century and at the beginning of the present one, several meetings were enjoyed in the city

of Trieste. They have particularly influenced this book. The Trieste series of conferences were suggested and began with the support of the Pakistani Nobel laureate in Physics Abdus Salam (cf., Appendix A2). The astrobiology pioneer, Cyril Andrew Ponnamperuma initially directed the conferences. These events brought together a large group of scientists. Discussions on astrobiology were, strictly speaking, centred on scientific topics. They preserved the rigor that is required by current research standards. Exceptionally, and most fortunately, a small group of humanists were invited to these meetings, in order to encourage pondering on topics that are of special concern in different sectors of culture.

The horizons and frontiers of science and humanism are outlined in this work under the influence of two outstanding personalities: Saint John Paul and Cardinal Carlo Maria Martini. They were responsible for significant advances in the dialogue of faith and reason. St. John Paul interacted fruitfully with scientists, including Salam (cf., Book II, Chapter 9). Martini changed the perspective of the dialogue between science and theology with the creation of the Chair of Non-believers. These meetings took place in Milan, Italy (cf., Book I, Chapter 1). A further influence on a different aspect of humanism was the author's participation in the UNESCO Chair of Philosophy, when it had been assigned to the Venezuelan philosopher Ernesto Mayz Vallenilla (cf., Fig. I.1).

Earlier writings in English, Italian and Spanish were incorporated into the present work (Chela-Flores, 1998a, b, 1999, 2019).

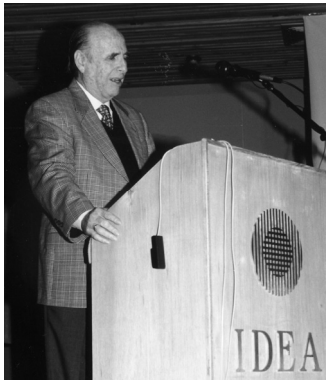

Figure I.1. The Venezuelan philosopher Ernesto Mayz Vallenilla lecturing at the ICTP Iberoamerican Advanced School of Astrobiology, IDEA, Caracas, 1999, (cf., also Fig. 4.1).

INTRODUCTION

SCIENTISTS AND BELIEVERS

We will consider with our readers, believers and non-believers, the main issues that astrobiologists share with philosophers and theologians. We will bring to their attention the need for ethics in science communication, putting special emphasis on astrobioethics.

Our conversations are centred on the science of astrobiology with a language that is not that of the specialized scientist. Our main concern is an introduction of the implications of questions that have been raised by the origin and evolution of life on Earth, and possibly elsewhere.

There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone cycling according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.
—Charles Darwin:
"*The origin of species by means of natural selection or the preservation of favoured races in the struggle for life*". London, John Murray (1859).

1. Science communication at the frontiers of philosophy and theology

It is remarkable that Albert Einstein, probably one of the most influential scientists, should maintain that *"cosmic religious feeling is the strangest and noblest incitement to scientific research* (Einstein, 1949). The German scientist appreciated that there was an overlap on two sectors of culture that are sometimes seen as being in conflict. We should keep in mind the following question:

Is there a need for a change in the way science is communicated to the general public, keeping in mind its overlap with philosophy and theology?

It is unwise to shift aside topics in the humanities that may be especially relevant to a constructive dialogue. Science is only a single sector of culture, but we shall focus on two additional ones, namely philosophy and theology, the need for which was pointed out by Russell (1991, cf., the quotation at the beginning of our book).

2. The group of believers will eventually reach over 5 billion people

With the extraordinary progress in science and technology, there has also been the emergence of specialized groups dedicated to providing information on world trends. The Pew Research Center is one of them. They foresee a remarkable change in another cultural sector, namely that of the humanities (including religion). This is especially evident concerning the dichotomy of believers and non-believers. The group of believers will reach over 5 billion people by 2050, in a world population that will exceed 9 billion inhabitants (Pew Research Center, 2015). At present there are almost four billion believers amongst the world population, who would understand the point of view of Dante, a believer,

whose profound and inspiring faith was expressed unambiguously in his "Divine Comedy" over 700 years ago (cf., Paradise).

There are two issues to ponder upon. First, to understand cultural differences is essential in science communication, when we keep in mind speakers of other cultural sectors, if we are to respect their identities. This is typically the case of the dialogue of faith and reason. Normally, problems in communication appear in groups of individuals from different religious, social, ethnic and educational backgrounds. However, in the context of our book we focus our attention exclusively on scientists and humanists.

Second, there is the question of taking ethics into account. Numerous harmful effects of forgetting ethical substance have led to unfortunate misunderstandings both between scientists and humanists, as well as between believers and non-believers. In due course, we shall attempt to define the appropriate level in our conversations on these matters. The present book discusses faith and reason in some detail, beyond our earlier writings (Chela-Flores, 2005). In the past these arguments were also given attention in the multiple influential publications of Rev. Sir John Polkinghorne (1996).

Specialization in science, which is undeniably necessary for good research, has its roots deep in historical times. Plato in his book "Republic" [Republic, 373bc – 374bd] argues that each member of the State is more competent in some field than in others. In an ideal society best results would be achieved if each person dedicates his time to a single activity. The prosperous State is the one in which individuals carry out their duties where they are most gifted. What has happened since Plato's time is that science communication has gone beyond what he dictated: more than one specialization is needed.

3. Endless forms most beautiful and most wonderful are evolving

We shall focus on Darwin’s hint that life on Earth had simple beginnings (cf., the quotation at the beginning of this chapter for understanding our own paraphrasing of the title of the section). We intend to communicate what we know about “simple beginnings”. Such scientific undertaking is a major objective of the science of astrobiology. In agreement with Bertrand Russell, we begin with the assumption that besides science, not only philosophy is a sector of our cultural patrimony, but we should also

include natural theology that is inevitably, and inexorably, another relevant domain of a non-fragmented culture. Such fractionation occurs by the already mentioned excessive, although comprehensible "Platonic" specialization that today inevitably hides the evident and the genuine frontiers of science. Together philosophy and theology define robust limits beyond the horizons of science, which frequently remain hidden, due to scientific communication that often lacks ethical substance.

At the beginning of my scientific career I did not suspect that I would have had personal contact with so many illustrious people, whose influence has been reflected in this book. First of all, there was a fruitful contact with the Pakistani physicist Salam over an extended period of time in the city of Trieste (cf., Book II, Chapter 2). He was a scientist and a believer, who attempted with perseverance to bring harmony between his faith and research in the origin of the sub-nuclear forces–the subject that led to his Nobel Prize in Physics. We have followed his ideas both in science and science communication. He was an early pioneer in what later was to be called astrobiology, as well as in his participation in the dialogue between faith and reason.

As mentioned earlier, Salam conceived and supported the early stages of the series of seven Trieste conferences. More than five hundred leading scientists attended these events. During the time of the Trieste meetings, the study of chemical evolution and the origin of life gradually evolved into what is now astrobiology. Amongst the scientists that attended the Trieste meetings we had the good fortune to welcome many pioneers of astrobiology, from whom we have learnt and deepened our understanding. They included, the author's three co-directors Cyril Ponnamperuma, Francois Raulin and Tobias Owen. Amongst others. we should underline the names of Stanley Miller, Frank Drake, Sidney Fox, John Oro, André Brack and William Schopf.

From the point of view of humanism, we will also appeal to several intercultural meetings between scientists and humanists. First of all, in a Vatican event emphasis was put on the frontier of science and religion (Russell et al, 1998). Of special relevance was the interpretation of Darwin's Theory of Evolution as a transcendental, seminal and original contribution in the life sciences (Ayala, 1998, Chela-Flores, 1998a). There was general agreement among the participants that Darwinism is not in conflict with a constructive dialogue between believers and non-believers.

These topics were discussed in the Vatican Observatory, in collaboration with the Center for Theology and the Natural Sciences in Berkeley, California. We were extremely fortunate to have as a co-participant Saint John Paul II, who together with some of us was also promoting Darwin's ideas (John Paul II, 1998).

4. Endless forms most wonderful may evolve elsewhere

Going beyond Darwin's quotation, if a Second Genesis were to be discovered elsewhere in the Universe, its scientific implications would evidently be profound. To achieve this fundamental step forward in our scientific insights, we require the wise use of new methods that are been employed in the exploration of the Solar System. The most significant implication of these enquiries would be to begin having access to a second biochemistry. This knowledge would allow us to perform comparative molecular biology. Success would also provide better understanding of terrestrial biology, as well as allowing us to make better conjectures in the definition of suitable fingerprints of life. Such biomarkers are necessary for investigating whether there exists the possibility of habitability, not only in our Solar System, but also in the numerous planets around stars in our own galaxy. Many of these new worlds, also known as "exoplanets", were discovered with a space telescope, the NASA Kepler mission that was focused on the constellation of Cygnus. It was launched in 2009 and was retired in October 2018, because it had run out of fuel. In that decade the NASA astronomers had discovered some 2,600 planets with an additional 3000 awaiting confirmation.

In another context, biomarkers could be inferred from comparative biochemistry. For instance, chirality is a property existing in left- and right-handed structural forms, both at the microscopic, as well as in the macroscopic scale. In biochemistry the molecules of life have this chiral property. Indeed, on Earth protein amino acids and other biomolecules have chiral symmetry. If the emergence of life were discovered elsewhere, in which biomolecules had different symmetries, we would have biomarkers independent of the evolution of life on Earth.

In our contribution to the 1996 meeting in the Vatican Observatory, we suggested the possibility that within the Solar System—on Europa the Jovian Galilean Moon—life could evolve. Such a phenomenon would raise multiple questions in the humanities, both in the philosophical realm, as well as in natural theology. In the present volume we return to that contribution. In fact, in the following 20 years after the Vatican meeting,

the hypothesis of life on Europa has been gradually strengthening. At the present time it is almost compulsive. All the data gathered by the NASA Galileo mission (1995-2003) has added some missing stepping-stones in establishing a solid hypothesis that will be tested in the late 2020s, or early 2030s by a European Space Agency, (ESA) mission to the Jovian system, the JUpiter ICy moons Explorer (JUICE) (Grasset et al., 2013). In addition, there will also be a NASA mission dedicated to that Jovian moon, sometimes informally called the *Europa Clipper*, but now it has formally adopted this name. It is planned for launch in the 2020s, arriving in the Jupiter system after a journey of several years. Consequently, a question that is forced upon us is the following:

How many experiments are possible with the instruments that have already been selected for the JUICE Mission?

Since the arrival of the Galileo Mission in the vicinity of Jupiter in 1995-1996, all of the research with our collaborators has been dedicated to the search for fingerprints of life (Horvath et al., 1997, Gowen et al., 2011, Crawford et al., 2013). These attempts are compatible with feasible and readily available instrumentation (Chela-Flores et al, 2015). The technological progress of the major space agencies (USA, Japan, Russia, The People's Republic of China and India) raises the possibility that a constructive dialogue between science and humanism will be greatly encouraged by research in astrobiology. Some examples have been discussed in the Iberoamerican School of Astrobiology in Caracas, 1999, in the Trieste conferences of Chemical Evolution and the Origin of Life and in the series "Cellular Origin and Life in Extreme Habitats and Astrobiology" (Chela-Flores et al., 2000, 2001, 2008b).

Multiple collaborations with the Israeli microbiologist Joseph Seckbach of the Hebrew University of Jerusalem have significantly influenced the work reported in this volume (Chela-Flores and Seckbach, 2008). Books III and IV are based on publications that began with the participation in the meeting of the Templeton Foundation at the University of Harvard (Barrow et al., 2008), where a fascinating question was raised in the frontier of science, philosophy and theology (Chela-Flores, 2005; 2008a):

Is the cosmos biocentric and fit for the presence of life?

At the Templeton meeting, the subjects of biochemistry and fine-tuning were approached by numerous interdisciplinary groups of scientists and humanists, including experts in physics, chemistry, biology, biochemistry,

earth sciences, medicine, biomedical engineering, philosophy, theology and history of science.

5. Humanism from the point of view of believers and non-believers

It has often been said that the dialogue between faith and reason should be stimulated. We insist that such dialogue not only should be stimulated, but that they should be significant inter-cultural activities amongst scientists, philosophers, theologians and, especially with the general public. These initiatives ought to be considered from the point of view of dialogues between believers and non-believers, rather than at the level of interreligious discussions. Yet, scientists themselves are not always in agreement (Seckbach and Gordon, 2008).

Science, philosophy and theology are largely non-overlapping. We focus on the scientific sector, mainly on the science of astrobiology, for it is one of the few instances where there is a meaningful overlap between questions on science and religion. We attempt to address some of the main problems arising from interpreting different cultural sectors by appealing to illustrations drawn from astrobiology. Special care has been taken in communicating science, while addressing believers and non-believers.

The influential writer Augustine of Hippo discusses the biblical interpretation in his seminal book "The City of God" (Augustine, 1984). He focuses on Jerusalem, as a city hosting three religions. He thinks about Jerusalem as an eternal city. From his influential point of view, he firstly comments that Jerusalem was the city where King David established Hebraism after its conquest. Following the established tradition in those early days, the "City of David" became his personal property, (Samuel, 5: 9). Much later, Caliph Abd al-Malik erected the first major Islamic building in 691 AD. Al-Quds (Jerusalem) has also become a Holy City for another monotheistic religion that is rooted in the sanctity of previous traditions (Armstrong, 1996, p. 236).

In the context of the Eternal City, Augustine anticipates our contemporary discussions by well over a millennium and a half. The Saint points out a clear separation between alternative interpretations of the Holy Books. The Augustinian interpretation is always a source of spiritual values. The alternative interpretation of the Holy Books could be as a substitute of scientific matters, but Augustine recommends his readers to accept the first interpretation (XVII; 4):

> *"Now in my opinion it is certainly a complete mistake to support that no narrative of events of this type of literature (i.e., the Bible) has any significance beyond the purely historical record; but it is equally rash to maintain that every single statement in those books is a complex of allegorical meanings."*

In his "Confessions" (Augustine, 1961, Book VI; 4), he returns to the same argument impressed by the wise counselling of Ambrose:

> *"I was glad too that at last I had been shown how to interpret the ancient Scriptures of the law and the prophets in a different light from that which had previously made them seem absurd, when I used to criticize your saints for holding beliefs which they had never really held at all."*

These views agree with the great majority of contemporary thinkers, including the author (cf., Book III, Chapter 4, for additional comments on such surprising early insights on faith and reason). From the perspective of another religious tradition, the Italian Rabbi Giuseppe Laras points out that (Laras, 1999):

> *"The Torah is not a book of science, but it points out some basic principles".*

From yet another tradition, the distinguished Pakistani physicist Salam, a believer, comments on the relevance of the interreligious dialogues as follows (Salam, 1996):

> *"Allied with the wonder of God's creation, all explanations we have found are based on symmetry concepts".*

We can also recall the work of Galileo Galilei, a great scientist in the modern sense of the word. With his transcendental contributions he set frontiers to the scientific method. A thousand years after Augustine, Galileo limited his research to only theories that could be refutable either by experiments, or by repeatable observations. Today all scientists accept this limitation, this horizon, to our research.

We have a clear illustration in the study of sub-nuclear matter, which is accessible to ever increasing precise measurements by means of the Great Hadron Accelerator in CERN, Geneva. As we have underlined earlier, Augustine, Galileo, and most contemporary scientists, including the author, feel that evidence for scientific matters should never be searched beyond the frontiers of science.

In this context, a conservative strategy would be to understand that passages in the Scripture may describe features of the natural world, but also to admit that where this description disagreed with a reasonably established scientific explanation, an alternative to the literal meaning in the Scripture passage should be an inspiring source of dialogue (McMullin, 2013).

In the Council of Trent (1545–63), there was a remarkable self-reform and clarification of doctrines. From that event until today, there has been a significant development concerning the manner in which the biblical texts should be interpreted, and whether they can be said to be in conflict with scientific data (Coyne, 2013). Not far from the time-honoured Augustine contributions, these more recent assertions underline a kind of ecumenism that gives believers valuable insights beyond the literal interpretation of the Holy Books.

6. Motivation for writing this book

Our fascination with the life sciences began in the late 1970s after accepting a position in science administration in Simon Bolivar University, Caracas. This had an unexpected advantage, since it required discussion and evaluation of research in biology. Being trained as a theoretical physicist, the transition from physics to biology was not trivial, but somehow the administration duties helped. Fortunately, a long professional career has the advantage of meeting outstanding scientists and humanists, who shared a common goal: to understand the emergence of life on Earth and, most likely, elsewhere in the cosmos. Such an opportunity has encouraged us to provide the readers of this book with an introduction to the profound question already raised by Darwin early during his career while he was at Down House, Shrewsbury:

What are our origins?

Darwin understood that his time was not ripe for a complete answer to this deep question. In June 1837 he opened the second of his transmutation notebooks, known as the “B Notebook”, which had the name “Zoonomia” written on its cover, a title that had first been used by Erasmus Darwin, his grandfather, where attempts had been made to outline the laws of life and health. Charles sketched roughly a single tree of life with a trunk symbolizing a common ancestor of all living organisms on Earth, with roots (i.e., life’s beginnings) buried deep in the past. The scientist from Shrewsbury viewed as “excessively complicated” the problem of the

origin of life itself, thinking about it as something that happened once somewhere long before the Silurian times (Desmond and Moore, 1991). Early the following year in his Notebook C, he explicitly mentioned, "spontaneous generation is not improbable" (Keynes, 1998).

To provide a terminology that can be easily shared with the non-specialist, we shall extend an analogy that first appeared in the Down House naturalist's B-Notebook, where the trunk of a single "tree of life" represents the evolution of life on Earth. We shall refer not to the study of a single tree of life, which is the main concern of biology, but rather we shall refer to the central problem of astrobiology, where the terrestrial tree of life is a single example that induces us to search for a multitude of potential evolutionary lines elsewhere, so that instead we should be searching for a "forest of life". A single tree represents life on Earth.

Our search for a Second Genesis, or even for a forest of life, will put an emphasis on the difference between rationalizing life's origins in purely scientific terms or according to the holy traditions. The significance of the first book of the Torah (Genesis) does not provide an explanation of how life could evolve on other worlds as a natural cosmic biological event. If it is an explanation that event is needed it should be searched in astrobiology (Irwin and Schulz-Macush, 2010).

Without abandoning appropriate science communication, we have appealed to various forms of modern culture, including art, music, aesthetics and high-level science fiction. In addition, we can learn from experiences of people, who can help us to visualize the scientific horizons more clearly. In this context, there is a fortunate reference to the Torah (Davies, 1998), when vegetation was created, it may be thought of as a "fifth miracle", after the four previous ones, creation of universe, light, the firmament and dry land. Astrobiology itself is a "miracle" of modern science, which is thoroughly based on the most rigorous scientific traditions that began with Galileo Galilei.

7. Acknowledgments

For my education in the humanities, I wish to acknowledge the kind invitation of the Venezuelan philosopher, the late Professor Ernesto Mayz Vallenilla (1925-2015), to deliver a set of lectures within the UNESCO Chair of Philosophy. I also thank the outstanding Italian humanist and unforgettable religious leader, His Eminence the late Cardinal Carlo María Martini, for his invitation to the talks on "Horizons and Limits of

Science". The complete cycle of all the Chairs of non-Believers, including the one in which the author participated, are published by the Carlo Maria Martini Foundation as part of the first volume of his complete works (Martini, 2015).

I would also like to acknowledge the opportunities that helped me to deepen my studies of astrobiology, especially all the directors of the UNESCO Abdus Salam International Centre for Theoretical Physics, especially its Founding Director Abdus Salam, who shared my enthusiasm for astrobiology (Salam, 1991, Chela-Flores, 1991) and had the far-reaching vision to initiate the Trieste conferences on Chemical Evolution and the Origin of Life

I am grateful to Director Miguel Angel Virasoro for supporting my participation in many specialized meetings of astrobiology, especially the timely San Juan Capistrano meeting convened less than a year after the *Galileo* orbiter became the first man-made satellite of Jupiter (Chela-Flores, 1996a and Horvath et al., 1997). He also encouraged participation in other USA and European meetings: San Diego (1997a, 1998c), Pasadena (1997b) and the Bioastronomy meetings in Capri and Hawaii (Chela-Flores, 1996b, 1999a). Besides, throughout his Directorship Virasoro continued supporting at the Trieste Campus all the activities related to astrobiology that Abdus Salam had begun in 1992.

Secondly, I acknowledge the help of Director Katepalli Srinivasan for supporting the author's participation in the meeting of the Templeton Foundation: "Fitness of the Cosmos for Life" at the University of Harvard, Boston, USA (Chela-Flores, 2008a). Professor Srinivasan also supported the Trieste Astrobiology Series. He had the initiative to honour Stanley Miller during the seventh Trieste Conference, which was dedicated to the 50th Anniversary of the publication of the first paper on the emergence of amino acids in pre-biotic conditions.

Professor Fernando Quevedo was Director of the ICTP at the time of writing the present volume. He encouraged our participation in a series of five General Meetings of the European Geophysics Union (EGU). His kind invitation in 2014 to continue as a Visiting Scientist of the Abdus Salam ICTP was very timely. It came after having completed full-time administrative duties at the UNESCO Centre, uninterruptedly during the period from 1 August 1990 till 31 July 2014.

The privileged position of being a researcher, with no administrative duties, was one of the major factors for the completion of a series of papers (Chela-Flores et al., 2015, 2017, 2018b), and chapters in books (2018a, 2019b). Finally, since 2014 the position of Visiting Scientist at the Abdus Salam ICTP has allowed sufficient time for the initiation, preparation and completion of "Astrobiology and Humanism".

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