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THE BEGINNING AND THE END

The Meaning of Life in a Cosmological Perspective

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Advance Praise for The Beginning and the End

“An outstandingly clear, comprehensive and systematic investigation of some of the deepest and most speculative questions of all time: How did the universe begin? How will it end? And what is the meaning of life in this cosmic evolution?”—**Francis Heylighen**, Director of the Global Brain Institute, research professor at the Vrije Universiteit Brussel.

“Cutting-edge science is starting to discover a ‘big picture’ in which humans have the potential to play a key role in the future evolution of life in the universe. If you want your mind to be expanded so that it takes in this wider perspective, Clément Vidal’s book is an absolute must read. His book is for everyone who wants to combine hard science with an understanding of the meaning and purpose of life.”—**John Stewart**, AUTHOR of *Evolution’s Arrow* and *The Evolutionary Manifesto*.

“This book is a magisterial work, a synthesis of systems theory, philosophy, cosmology, and life science. In a search for his own comprehensive and coherent worldview, Clément Vidal has come to some startling conclusions: evolution and simulation (and I would add, development) appear to operate at every scale within our universe, and can be used as a basis for a universal ethics. What’s more, this view yields some surprisingly specific suspicions about the nature and drives of advanced extraterrestrial intelligence: starivores. If we, stewards of Earth, are on the starivore development path, this insight alone will prove as revolutionary as Darwin’s nineteenth century elucidation of human evolution. It is exciting to see the many clues and arguments he presents, and to realize that Vidal’s hypothesis can be tested here and now. He also walks his talk, as he has founded with me a research community (Evo Devo Universe) to explore and critique these fascinating ideas. I invite you to join us there. His quest is our quest, to ask and answer our biggest questions with more truth, goodness, and beauty than ever before.”—**John Smart**, President, Acceleration Studies Foundation, Accelerating.org; Co-founder, EvoDevoUniverse.com

To every human, artificial, or extraterrestrial intelligence in this universe

Foreword by Steven J. Dick

We live in a universe expansive in space and time, the result of 13.8 billion years of cosmic evolution that has yielded ever more subtle and complex forms. On that planet we call Earth those forms include life and mind, mind that now turns its gaze back onto the universe itself. We contemplate the cosmos with awe and ask the question of questions: how widespread is life in the universe? The new science of astrobiology daily offers new insights into this question, including exoplanets galore, but as yet no answer to the riddle of life itself. Meanwhile, whether life is rare or common, the cosmic perspective is the unavoidable framework within which the history of our planet and the meaning of our lives must be explored. That perspective—the Master Narrative of the Universe, or Genesis for the Third Millennium, as it has also been called—is the framework adopted in this scintillating book full of new ideas. It is a framework I enthusiastically endorse.

But how to explore "The Meaning of Life in a Cosmological Perspective?" The mind reels, but Vidal argues that the search begins with a comprehensive and coherent worldview, a more robust version of the sometimes inconsistent worldviews we all hold whether we know it or not. The construction of worldviews and their influence on our thinking are deep philosophical problems, and the first part of the book discusses the nature of worldviews in detail. Not only does the author examine religious, scientific and philosophical worldviews, he also proposes criteria for evaluating which are best. This original and enlightening exercise results for him in a worldview that is fundamentally cosmological, though with philosophical, ethical, and religious implications. As the cosmologist G. F. R. Ellis has noted, philosophical choices necessarily underlie all cosmologies, and unexamined philosophical standpoints are still philosophical standpoints. Vidal, however, is not guilty of unexamined assumptions; he has systematically examined the possibilities, and his worldview places life and intelligence at the center of cosmology.

This evaluation of worldviews would be a significant contribution in itself, but Vidal is only getting started. In elaborating his worldview, and answering the basic questions about origins, life and mind, he takes up the entangled problems of fine-tuning and "free parameters" in the universe. These problems have been much discussed in the last few decades, as scientists and philosophers have asked why the free parameters of physics and cosmology (sometimes called "constants," though they may not be invariant) seem to be fine-tuned for life. Vidal evaluates the arguments and concludes that in order to answer the fine-tuning question we need to know how common "fecund universes" (those with life) really are. To this end he offers a "cosmic evolution equation" to estimate the probability of life existing in a multiverse—the space of all possible universes. Does fine-tuning really exist? If so is chemistry, life or intelligence being fine-tuned? Is God or the multiverse the answer? The author clarifies these and other questions, even if he cannot always provide the answers.

These questions lead Vidal to two bold hypotheses. First, in a parallel to Darwin's insight, he weighs the possibilities of cosmic natural selection (CNS) and cosmic artificial selection (CAS), arguing for an artificial cosmogenesis process, in which someone or something must be creating universes, or will in the future. He is not the first to pose such a startling scenario; in particular James Gardner has done so in his book *Biocosm: The New Scientific Theory of Evolution: Intelligent Life is the Architect of the Universe*. But Vidal argues the concept can be advanced with computer simulations, a kind of computational cosmology generating all possible worlds. Secondly, in the realm of observation rather than theoretical simulations, he hypothesizes the existence of starivores, civilizations feeding on the energy of their parent stars. Speculative though this may seem, he argues that some known binary star systems can be interpreted as living—proposing a "high-energy astrobiology."

These ideas are not for the faint of heart; Vidal cannot be accused of a failure of imagination, and everything here depends on the interpretation of observations—a venerable problem in the history and philosophy of science. Nonetheless, one is reminded of the young Soviet astrophysicist Nicolai Kardashev and his Type II civilizations, or the young American physicist Freeman Dyson, who proposed infrared shells around other stars, built by civilizations to capture energy.

At the center of the book is the primacy of life—individual and cosmic. The "core thesis" of the book is a philosophical speculation that the greatest outcome of science will be cosmogenesis in order to support life. In other words, the ultimate aim of science in the far future will be not just to study the universe, but also to create other universes. Perhaps other natural intelligences in the universe have already been doing so. In Vidal's view this artificial cosmogenesis holds promise to explain both the fine-tuning thesis and the ultimate meaning of life and intelligence in the universe. Looking forward, he believes studying the end of the universe helps us to also unravel its beginning—thus *The Beginning and the End* of the main title. In the end he elaborates a cosmological ethics where the ultimate good is the infinite continuation of the evolutionary process, resulting in life.

This is a highly unusual book, grounded in science and yet speculative, highly detailed and yet tackling the broadest possible questions, measured in its arguments but bold in its conception: in short, an exciting adventure reflecting the boldness and creativity of youth. But not unbridled boldness. As the author and others have emphasized, speculation is an integral part of science, more often going under the name of “hypothesis,” and Vidal makes a convincing case that in this volume his method is scientific and philosophical speculation rather than unchecked fictional speculation. Faced with the option of saying nothing about the great questions he undertakes, or carefully saying something, Vidal chooses the latter. We are the better for it.

Steven J. Dick
Baruch S. Blumberg NASA/Library
of Congress Chair in Astrobiology
Former NASA Chief Historian

Preface: Psychiatry and Cosmological Speculation

After high school, when I told my aunt I wanted to study philosophy at university, she looked at me sympathetically and said: “Have you considered consulting a psychiatrist? They can be very helpful, you know.” I was shocked. What did the philosophical pursuit to understand humanity and the cosmos have to do with psychic health? Maybe she had confused philosophy with psychology. Or maybe she thought that studying philosophy leads nowhere socially or professionally and that I was simply experiencing a temporary existential crisis. Seeing a psychiatrist would put me back on the right social track.

But maybe she was right after all. Maybe asking fundamental and philosophical questions *is* an illness. In that case I am proud to be ill. Even more, my hope is that it is highly contagious, and that you, my reader, will want to pursue even further the intellectual journey I will now share with you. But first, a word of caution.

I would like to warn my readers that this work contains cosmological speculations.[1] The speculations I discuss are cosmological because they stretch over billions of years and billions of light years. How can we legitimate such speculations? Part I constitutes one third of this work and is dedicated to a broad study of the philosophical method. I argue that a major aim of philosophy is to construct *comprehensive* and *coherent* worldviews. Constructing such worldviews requires one to answer big questions, such as: “Where do we come from? Where are we going? Are we alone in the universe?” Motivated by our existential need to answer such big questions, we naturally tend to speculate. But is such an endeavor in striking contradiction to the rigor of the scientific enterprise? Is it just fantasy?

Certainly not! Speculating does not mean being unscientific. On the contrary, it means identifying and relying on the most fundamental scientific theories and principles, and then extrapolating them. In my speculations, mostly contained in Part III, I have done my best to focus on the most robust and general scientific theories, such as principles of relativity theories, thermodynamics, systems theory, evolution, and theoretical computer science or logic.

[1] To make this warning explicit, my Ph.D. at the Vrije Universiteit Brussel (VUB) was defended with the subtitle “Cosmological Speculation and the Meaning of Life”, instead of “The Meaning of Life in a Cosmological Perspective”.

Of course, many speculations turn out to be wrong. As the multiple failures in the history of science show us, the risk that a speculative theory will be refuted is real. Indeed, cosmological speculations rely on and extrapolate from our current theories. Cosmological models in the next decades might refute speculations of our time, or lead to very different kinds of speculations. Speculating also means extrapolating the physical laws we can experiment with on Earth to extreme regimes of large energies, high densities, and huge scales in space and time. We need to be aware that such extrapolations are subject to strong uncertainties, for example because we do not yet have an established theory of quantum gravity.

Historian of cosmology Helge Kragh wrote in the introduction of his book *Higher Speculations: Grand Theories and Failed Revolutions in Physics and Cosmology* (2001, p. 2):

> Speculations have always been an integrated part of the physical sciences, sometimes hidden under the more palatable term 'hypotheses'. Indeed, fundamental physics without some element of speculation is hardly conceivable. All scientists agree that speculations have a legitimate place in the construction of scientific theories, but there is no agreement as to *how* speculative a theory may be and still be counted as scientific.

To evaluate how speculative a theory may be, we need to be clear on *why* we speculate. What is our aim when we speculate? I distinguish three kinds of speculations to navigate into their variety (Vidal 2012a):

1. **Scientific**: a speculation is scientific if we have strong reasons to think that future observations or experimentations will corroborate or refute it.
2. **Philosophical**: a speculation is philosophical if it extrapolates from scientific knowledge and philosophical principles to answer some fundamental philosophical problems.
3. **Fictional**: a speculation is fictional if it extends beyond scientific and philosophical speculations.

Fictional speculations are found in counterfactual history or science fiction books. Their main goal is entertain a reader, but their value for history as a discipline or the scientific enterprise is limited.

Scientific or philosophical speculations stem from our urge to complete logically our knowledge in areas where it has not yet been probed. Importantly, scientific and philosophical speculations have a clear aim, namely to solve scientific or philosophical problems.

Of course, the status of a speculation can change through time and even become normal science. For example, Giordano Bruno made the philosophical speculation that there were other solar systems in the universe. It was philosophical and not scientific because it was not clear at his time whether we would ever be able to develop telescopes and observational methods powerful enough to discover extrasolar planets. With technological progress, the speculation became scientific, because observational techniques evolved for checking such a claim empirically. Finally, the status of speculation disappeared altogether when we found the first exoplanets (Wolszczan and Frail 1992). Today, hunting and finding exoplanets is no longer speculation but part of normal astrobiological science. However, Bruno also accepted the common speculation that the universe is filled with a substance called "aether", a theory now considered obsolete.

So any speculation has to be taken with a grain of salt. In this book, I address problems that cannot be addressed without speculation. Facing the need to speculate, there are two options. Either we refuse to speculate and accept that we have nothing to say or to write, or we try to speculate as carefully as possible, making very clear the assumptions on which our speculations hinge. I have chosen the latter option, trying to review many different speculations, and refusing to overstate the conclusions. The hypotheses on which some of my core reasoning hinges are extracted and presented in the form of argumentative maps in Appendix II, and I hope they will facilitate rational and critical debate.

For readers familiar with my previous work, let me quickly outline how it connects with this book. Part I presents philosophical reflections on what philosophy is, and its method. It is a synthesis and expansion of several papers (Vidal 2007, 2008a, 2012b). Part II analyzes the origin of the universe: Chap. 5 is mainly based on (Vidal 2010a, 2012a) and Sect. 6.3 on (Vidal 2013). Part III is based on reflections about future cosmic evolution: Chap. 7 on (Vidal 2008b), Chap. 8 on (Vidal 2010a, 2012c, 2012a, 2012d), and Chap. 9 on (Vidal 2011). The good news is that the rest is new.

Brussels, January 2014

Acknowledgments

In the last few years, I have had the chance to interact with very inspiring, encouraging, and unconventional thinkers. First and foremost, I express my great appreciation for the atmosphere of free inquiry here at the Free University of Brussels (Vrije Universiteit Brussel, VUB). I know that previous generations have sustained tremendous efforts to maintain the ideals of the enlightenment.

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[2] http://evodevouniverse.com/wiki/EDU-Talk_subscription_form

[3] http://ecco.vub.ac.be/?q=node/114

I warmly thank John Smart for being such an amazing colleague and friend, for being the co-founder with me of the Evo Devo Universe community, for being a rare polymath, never short of amazing and stimulating ideas. I owe him inspiration on many aspects of this book, such as his contagious passion for astrobiology or the general evolutionary developmental view on the universe. I am also glad we identified together the Barrow scale of civilizational development (Sect. 9.2.2).

My immense gratitude goes to my Ph.D. supervisor Francis Heylighen for having been and still being an unfailing intellectual mentor. I am grateful that he trusted me to tackle big cosmological questions despite the fact that I had no formal background in theoretical physics. After one master in philosophy, another one in logic, and a third in cognitive sciences, I thought I had at last built up a solid intellectual background, but I was wrong. Learning in depth with Francis Heylighen about evolution, cybernetics, and complexity sciences led me to an intellectual rebirth. I felt almost angry to have learned such powerful yet simple concepts so late in my intellectual life. In particular, I hope the basics of cybernetics and systems theory will soon be taught early in schools.

I warmly thank my parents for offering me that slice of space-time-energy-complexity we call life, through their biological and cultural legacy. Very special thanks go to my father, for his immense support, patience, and trust.

Contents

Abstract

Where does it all come from? Where are we going? Are we alone in the universe? What is good and what is evil? The scientific narrative of cosmic evolution demands that we tackle such big questions with a cosmological perspective. I tackle the first question in Chaps. 4–6; the second in Chaps. 7 and 8; the third in Chap. 9; and the fourth in Chap. 10. But how do we start to answer such questions wisely? Doing so requires a methodological discipline that mixes philosophical and scientific approaches.

In Chap. 1, I elaborate the concept of *worldview*, which is defined by our answers to the big questions. I argue that we should aim at constructing *comprehensive* and *coherent* worldviews. In Chap. 2, I develop criteria and tests to assess the relative strengths and weaknesses of different worldviews. In Chap. 3, I apply those methodological insights to religious, scientific, and philosophical worldviews.

In Chap. 4, I identify seven fundamental challenges to any ultimate explanation of the origin of the universe: epistemological, metaphysical, thermodynamic, causal, infinity, free parameters, and fine-tuning. I then analyze the question of the origin of the universe upside down and ask: What are the origins of our cognitive need to find an explanation of this origin? I conclude that our explanations tend toward two cognitive attractors, the point and the cycle. In Chap. 5, I focus on the free parameters issue, namely that there are free parameters in the standard model of particle physics and in cosmological models, which in principle can be assigned any value. I analyze the issue within physical, mathematical, computational, and biological frameworks.

In Chap. 6, I analyze the fine-tuning issue in depth, i.e. the claim that those free parameters are further fine-tuned for the emergence of complexity. I debunk various physical, probabilistic, and logical fallacies associated with this issue, and I distinguish it from the closely related issues of free parameters, parameter sensitivity, metaphysics, anthropic principles, observational selection effects, teleology, and theology. I conclude that fine-tuning is a conjecture, and that to make progress we need to study how common our universe is compared to other possible universes. This study opens a research endeavor that I call *artificial cosmogenesis*. Inspired by Drake's equation in the search for extraterrestrial intelligence (SETI), I extend this equation to the *cosmic evolution equation*, in order to study the robustness of the emergence of complexity in our universe, and whether or to what

extent the universe is fine-tuned. I then review eight classical explanations of fine-tuning (skepticism, necessity, fecundity, god of the gaps, chance of the gaps, weak anthropic principle of the gaps, multiverse, and design) and show their shortcomings.

In Chap. 7, I show the importance of artificial cosmogenesis by extrapolating the future of scientific simulations. I analyze two other evolutionary explanations of fine-tuning in Chap. 8. More precisely, I show the limitations of cosmological natural selection (CNS) to motivate the broader scenario of cosmological artificial selection (CAS).

In Chap. 9, I propose a new research field to search for advanced extraterrestrials: *high energy astrobiology*. After developing criteria to distinguish natural from artificial systems, I show that the nature of some peculiar binary star systems needs to be reassessed in view of thermodynamic, energetic, and civilizational development arguments that converge toward the idea that those systems are advanced extraterrestrials. Since the conjectured beings actively feed on stars, I call them *starivores*. The question of their artificiality remains open, but I propose concrete research proposals and a prize to further continue and motivate the scientific assessment of this hypothesis.

In Chap. 10, I explore foundations to build a cosmological ethics. I build on insights from thermodynamics, evolution, and developmental theories. Finally, I examine the idea of immortality with a cosmological perspective and conclude that *the ultimate good is the infinite continuation of the evolutionary process*. Appendix I is a summary of my position, and Appendix II provides argumentative maps of the entire thesis.

Introduction

The great philosophers have always been able to clear away the complexities and see simple distinctions—simple once they are stated, vastly difficult before. If we are to follow them we too must be childishly simple in our questions—and maturely wise in our replies.

(Adler and Doren 1972, p. 271)

Where does it all come from? It takes nothing less than a synthesis of modern science to answer this childish question. In a nutshell, modern science gives us the following story of our past. Everything started with a Big Bang, about 13.8 billion years ago (Planck Collaboration 2013). As the universe expanded and cooled down, atoms formed and stars clumped into galaxies and clusters of galaxies. On a tiny solid planet, around an average star, some special conditions allowed the self-organization of molecules, and the first cell was born. Life started. Later, vegetation used the radiation of the Sun and contributed to the creation of an atmosphere. Gradually, more and more complex organisms emerged, competed, and cooperated. Nowadays, human cities, societies, and technologies are growing rapidly.

That was our past. What about our future? Where are we going? Of course, we have—by definition—no data about the future. However, we do have physical scientific theories, which are temporally symmetrical, and it is thus legitimate to apply them not only to the past but also to the future.

Astrophysicists tell us that in about 5 billion years, our solar system will end, with our Sun turning into a red giant star, making Earth's surface much too hot for the continuation of life as we know it. The solution then appears to be easy: migration. However, even if our descendants do colonize other solar systems, all the stars in all the galaxies will ultimately die. Once stars have converted the available supply of hydrogen into heavier elements, new star formation will come to an end. In fact, the problem is even worse. It is calculated that even very massive objects such as black holes will evaporate (see e.g. Adams and Laughlin 1997). The second law of thermodynamics, one of the most robust laws of physics, states that the disorder or entropy of an isolated system can only increase. Eddington (1928) applied the law to the universe as a whole and concluded that our universe is doomed to perish in a *heat death*. Modern cosmology confirms that in the long-term future we will need to deal with a cosmic doom scenario such as heat death.

What do these insights about our past and future imply for the meaning of life, intelligence, and humans in the universe? Most people I talk to, both colleagues and friends, think it is too early to think about such a long-term issue as cosmic doom. I strongly disagree. If it is too early now, when are we to start worrying about the far future? When will be a good time to take responsibility?

Humans are insignificant in terms of the space they occupy in the universe. The Earth is ridiculously small compared to the universe. It is a tiny planet orbiting a common star, in a galaxy composed of billions of stars. And we can see billions of galaxies. Humans are also insignificant in terms of universal time. This is illustrated by Carl Sagan's (1977) cosmic calendar, in which the $\sim$14 billion year lifespan of the universe is compressed into one year. One second in that cosmic calendar corresponds to some 500 years in our Western calendar. Then, the first humans would appear on December 31, the very last day of the cosmic calendar, very late, at about 10.30 pm. Our spatiotemporal extension is thus ridiculously small seen from a cosmological perspective. To sum up, the fact that in a single, tiny cosmic pocket, life and intelligence very recently appeared seems an accident without any significance except that we are doomed to extinction.

Is this gloomy story true? Is it correct in all its aspects? Is it possible that it misses some important aspects of cosmic evolution? My aim is to show you that this story is wrong. Not so much in its scientific content, but in its conclusions and limited perspective. In this book, I will tell you a very different story, one in which intelligence and complexity are keys to unlock the universe's mysteries.

The questions of the beginning and the end of the universe are extremely difficult, because they require the utmost extrapolation of scientific models, whose results then become highly uncertain. Additionally, scientific models cannot directly answer such metaphysical questions as: Why is there something rather than nothing? Was there a beginning of the universe? Is our universe fine-tuned for life? What is the meaning and future of life in a cosmological perspective?

When dealing with such difficult questions, we have to acknowledge the limits of the scientific enterprise. For example, regarding the *ultimate origin*, there are observational limits to the early universe, i.e. data we will never get. Neither science nor philosophy will bring us certain answers, and this is an invitation to humility, honesty, and care when approaching those ultimate questions in cosmology (see e.g. Ellis 2007a, 1259; Vaas 2003, Sect. 7). This does not mean that science won't come up with an answer later. Scientific progress has often surprised us in the past, and there is no reason for it not to continue to do so.

Compared to those on the early universe, there are surprisingly few works on the *ultimate future* of the universe. Yet mysteries about our far future are as important and fascinating to explore as the ones about our past. Classic cosmic doom scenarios presuppose that intelligence is and will remain insignificant. But this seems to ignore past cosmic evolution, which shows an increase of complexity, from galaxies, solar systems, and life to mind, intelligence, society, science, and technology. What if intelligence could have a major impact on cosmic evolution? If we refuse to underestimate the increase of complexity, the matter of cosmic doom becomes much more exciting because it remains unsettled.

The human world may be small in comparison to cosmic space and time, but what about its increasing complexity? Mind, intelligence, science, technology, and culture *are* highly significant from a complexity point of view. There is even an acceleration in this rise of complexity (see e.g. Coren 1998; Livio 2000; Chaisson 2001). Could it be that mind, culture, science, and technology are not accidents in the universe? Could they have a profound and important cosmological meaning?

Our day-to-day lives may seem entirely disconnected from astrophysical or cosmological events. Yet we are in the cosmos. And future generations ultimately depend on the future of our universe. How will this acceleration and increasing complexity evolve in the far future? Where will it end? Will the universe end in cosmic doom? Or will our aspirations somehow win out in the long term? Is it possible for life and intelligence to survive forever? Can searching for—and maybe finding—advanced extraterrestrials bring us a better understanding of the increase of complexity in our universe? What is goodness in a cosmological perspective? Could an evolutionary ethic inspired by cosmic evolution help us in guiding our actions?

How can we hope to answer such difficult questions? If they cannot be fully answered in a scientific framework, should we switch to a religious approach? Religions do indeed offer creation myths and value systems, and thereby give practically and socially very valuable answers to those questions. But they often lack a self-critical and scientific basis. Could a philosophical approach answer those questions, with open, undogmatic, rational, and cautious answers? If so, how do we actually answer them in a philosophical and secular way? Is there a philosophical method for doing so?

I argue in this book that intelligence and complexity are essential components of our universe. My philosophical position is to remain rational, in agreement with science, yet to seek to go one step further than scientific inquiry, motivated by our childish curiosity and our need to answer the big questions.

I shall not attempt to write another comprehensive history of the universe. I assume that my reader is already well versed in cosmic evolution (if not, see e.g. Sagan 1985; Jantsch 1980; Turchin 1977; Christian 2004; Laszlo 1987; Chaisson 2001, 2006; Dick 2009a, 2012).

What follows is instead an exploration and analysis of three extreme or ultimate points of this story: the beginning, the end, and the meaning of increasing complexity. If on large scales all our sciences are reduced to cosmology, and if on small scales all our sciences can be reduced to particle physics, then how do we link the two? The sciences of evolution and complexity have the potential to bridge the gap between these two reductions to cosmology and particle physics. Evolution and complexity sciences are anti-reductionist by nature and seek to understand the emergence of new laws and of complexity transitions.

Inspired by the advice of Adler and Van Doren above, my ideal is to answer childishly simple questions in a mature and wise manner. These questions concern our ultimate origin, future, and values from a cosmological perspective. To answer the questions wisely, we shall inquire into many intricate theories and discussions, but our aim will always be to answer those simple questions. I plan to balance this apparently overweening ambition with an appeal to considered conclusions through a preliminary study of the philosophical method in Part I.

The organization of this book is simple. Part I deals with the philosophical method, Part II with the beginning of the universe, and Part III with intelligence in the far-future universe. By weaving insights in these three parts, we can find and refine a meaning of life in a cosmological perspective. Both the beginning and the end are extreme extrapolations, and it makes sense to treat them together, as we will face similar problems and solutions in exploring them.

What is philosophy? This work has a synthetic and speculative character. It is an attempt to answer some of the deepest philosophical questions by constructing a coherent and comprehensive worldview. In Part I, we inquire about the philosophical method, and show that there is an existential need to answer the big questions. In Chap. 1, we explore the richness and intricacy of philosophy as a discipline, through six dimensions, and I elaborate the concept of a worldview defined by our answers to the big questions. In Chap. 2, I develop criteria and tests to assess the relative strengths and weaknesses of different worldviews. In Chap. 3, I apply those methodological insights to religious, scientific, and philosophical worldviews. The first step toward answering the naive big questions is to reformulate them in a more sophisticated scientific and philosophical manner. This will be a significant aspect of Parts II and III.

Where does it all come from? In Part II, we examine in three steps the problem of the ultimate origin of the cosmos. Firstly, in Chap. 4, we deal with our *cognitive need* for origins. We ask: What is a cognitively satisfying answer to the question of the origin of the universe? In Chap. 5, we then focus on the existence of free parameters in physical and cosmological models. The problem is that such free parameters are not specified within our theories, yet all particle physics and cosmological models have them. We explore them with a variety of approaches: physical, mathematical, computational, and biological. These free parameters need to be inserted by hand into our models. But hand-insertion doesn't necessarily imply fine-tuning. We thus discuss, in Chap. 6, whether or not those free parameters are fine-tuned. More precisely, the fine-tuning of the universe is a highly confusing and controversial issue at the intersection of physics, philosophy, and theology. It is peppered with physical and probabilistic fallacies, mixed up with other issues (e.g. free parameters, parameter sensitivity, metaphysics, observation selection effects, anthropic principles, teleology, or theology), and seldom well defined. To clarify the debate, we first debunk various fine-tuning fallacies. We then ask: What is the fine-tuning for? Chemistry? Life? Intelligence? To clarify these different options, we introduce a Drake-like cosmic evolution equation, defining different cosmic outcomes we want to focus on. We then review classical and evolutionary explanations in view of our new framework. We conclude that to progress scientifically on the issue we need to explore the space of possible universes with the help of computer simulations. This involves simulating not only our universe but also other possible universes, within the nascent field of *artificial cosmogenesis*.

Where are we going? In Part III, Chap. 7, we explore the future of scientific simulations, and further substantiate the need to pursue artificial cosmogenesis. In Chap. 8, we discuss cosmological selection and develop a wide-ranging philosophical scenario, called *cosmological artificial selection* (CAS), which covers the origin and future of the universe with a role for intelligence. Surprisingly, CAS leads to the idea that by better understanding our ultimate future we will better understand our ultimate origin. The two may well be deeply intertwined.

There is great uncertainty regarding two main trends in cosmic evolution. The one trend is toward more disorder or entropy, the other toward more complexity. Which one will prevail in the long term? If the first prevails, it will be our end in the universe. But if the second trend prevails, there is hope to construct a meaning of life in harmony with the increase of complexity in cosmic evolution.

Are we alone in the universe? Predicting the long-term future of humanity, meaning its fate in thousands, millions, or billions of years, is a notoriously difficult task, often deemed impossible. But there is a workaround. The idea is to look at how other civilizations might have developed their complexity in the universe. In Chap. 9, we thus look for very advanced civilizations in the universe, and, to my great surprise and awe, my theoretical reasoning leads me to the conclusion that we might already have spotted very advanced extraterrestrials!

What is good and what is evil? What are the ultimate values for intelligent life? Here ultimate values are valid not only at all times, both past and future, but also in all places in the universe. In Chap. 10, we enquire about values derived from a cosmological perspective. We develop a cosmological ethics and apply the framework to the idea of immortality, which is a constant longing in human cultures. We survey five kinds of immortality and how they relate to the definition of the self. We argue that the ultimate good is the *infinite continuation of the evolutionary process*. We then discuss the possibility or impossibility of such cosmological immortality.

To facilitate navigation in this work, I have added two appendices. Appendix I is a straightforward summary of the worldview developed, presenting positions rather than arguments. In narrative terms, the summary is a spoiler for my thesis, so I leave it to the reader to decide whether or when to consult it. Appendix II provides two argumentative maps. The first map describes the core problems tackled in the book, and the second one summarizes the proposed solution. These two appendices will be of most benefit to professional academics familiar with the issues I tackle, but they may also help other readers who wish to take a bird's-eye view.

Academic research is always work in progress. So, at the end of each part or main chapter, I point to the most important and challenging *open questions* I came up with. I hope researchers will pursue them—with or without my collaboration.

For me, the achievement of this book is to put together pieces of a cosmic puzzle. Together, the pieces form a worldview that I confess to finding magnificent. My objective now is to share it with you. I hope to establish a deep, enduring, and yet evolving connection between intelligent life and the cosmos, which will give people a sense of the meaning of life, in harmony with cosmic evolution.

Part I
Overview of Worldviews

Following the development of modern science, scientists have taken over more and more issues from philosophers. For example, classic philosophical problems about the mind, time, space, or the cosmos are now investigated by scientific means. How should philosophers react to this? They may feel intruded upon, and react by taking refuge in issues science will never touch. Or they may be delighted by scientific progress on philosophical issues, since it contributes new ideas, arguments, and insights for our common quest to understand the world.

Philosophers thus often need to redefine the scope of philosophy and its relationship to science. They can also take the opportunity to embrace new scientific knowledge. Partly because science has taken over some formerly philosophical issues, modern philosophy has split into two main traditions, *analytic* and *continental*, with different drawbacks that we shall briefly examine.

Decades ago, Paul Ricoeur (1979) directed a survey of the main trends of philosophy. He distinguished three main trends:

(1) Philosophy as *Weltanschauung* (worldview),
(2) English and American analytic philosophy,
(3) Subjectivity and beyond.

Philosophy in trend (3) explores other forms of experience than objective knowledge. Philosophers who went this way include the young Hegel, Kierkegaard, the young Marx, and some disciples of phenomenology. This trend corresponds to *continental philosophy*. It is a stimulating intellectual approach but faces harsh criticism, most notably for its lack of methodology (see e.g., Shackel 2005).

By contrast, although analytic philosophy (2) brings precise methods of analysis and criticism into philosophy, it still lacks a general guideline or a unifying agenda. The use of logical methods is insufficient to constitute such an agenda. Analytic philosophy really needs to go beyond pure analysis; it also needs to be complemented with a synthetic dimension. Synthetic worldview construction, as we shall see, can fill this gap. Our philosophical position in this book will thus tend toward trend (1).

Still, distinguishing those three trends does not answer our question: *What is philosophy?* A fuzzy answer is that it is a quest to understand humankind and its world. For the most important questions, this enterprise overlaps with science and religion. Philosophy, science, and religion share this quest for understanding, and they can build more or less strong relationships to pursue it (see e.g., Russell et al. 1988). The result is that starting respectively from science, religion, or philosophy, we end up with different worldviews.

We shall argue that having a coherent and comprehensive worldview is the central aim of philosophy. But what, more precisely, is a worldview? How can we compare very different worldviews? Specifically, what are the respective strengths and weaknesses of scientific, religious, and philosophical worldviews?

To better grasp what philosophy is and to navigate its rich and complex landscape, I first introduce, in Chap. 1, six philosophical *dimensions* along with a *worldview agenda*. This agenda invites us to tackle big questions, and our answers to them define what our worldview is. Furthermore, to meaningfully and critically tackle the big questions, we must be able to compare different worldviews. For this we need a set of *criteria* and a battery of *tests*. We introduce such criteria and tests in Chap. 2, with the aim of easing the difficult task of comparing worldviews. We conclude our analysis of worldviews and criteria by showing that science and religion have *complementary* strengths and weaknesses (Chap. 3). By synthesizing them, we can hope to build more coherent and comprehensive philosophical or theological worldviews.

Thus Part I provides an ambitious yet considered philosophical framework to serve as a launch pad for our journey into the big cosmological issues: the beginning and the end, and the meaning of life.

Part II
The Beginning of the Universe

Modern science can successfully connect physical and chemical evolution with biological and cultural evolution (e.g., Chaisson 2001; De Duve 1995). Thus, it seems reasonable to assume that science is an effective method to understand cosmic evolution. The problem of harmony in the universe has thus shifted to its beginning: How did it all start? Why did the universe start with these initial conditions, parameters, and laws, and not others? Was the initial universe fine-tuned for the emergence of life and intelligence?

The belief in God allowed western thinkers to understand why the "Laws of Nature" are as they are and not otherwise. Scientific activity ultimately consisted of discovering the Laws of Nature set up by God. However, now that many scientists no longer believe in God, they lack an explanation of the origin of the laws of nature (Davies 1998).

Nicholas Rescher (1985, p. 230) summarized alternative ways to answer the question of why nature's system of laws is as it is:

1. The question is illegitimate (rejectionism).
2. The question is legitimate, but inherently unsolvable (mystificationism).
3. The question is legitimate and solvable. But the resolution lies in the fact that there just is no explanation. The world's law structure is in the final analysis reasonless. The laws just are as they are; that is all there is to it. And this brute fact eliminates any need for explanation (arationalism).
4. The question is legitimate and solvable, and a satisfactory explanation indeed exists. But it resides in an explanatory principle that is itself outside the range of (normal) laws—as it must be to avoid vitiating circularity (transcendentalism).

Rejectionism (1) will not make science and rationality progress. Although I am aware that (1) is a common philosophical position, I am committed to answer childishly simple first-order questions. I do not want to dismiss those questions too quickly as meaningless. *Mystificationism* (2) does not make science and rationality progress either. Only if it could be proven that the question is indeed unsolvable would it be an impressive result, similar to negative results in mathematical logic, like the proof of the impossibility of constructing the quadrature of the circle. *Arationalism* (3) is equivalent to saying that all explanations will fail. Without arguments to support this view, we cannot take it seriously. *Transcendentalism* (4) invites an external and most likely supernatural explanation, which is not something we presuppose in this book. Rescher mentions a fifth option, the position of rationalism. It states that the question is legitimate and solvable, and the resolution lies in the fact that there is an explanation, yet to be defined and found.

Where does it all come from? Before attempting to answer this question, we ask, in Chap. 4: Where will a satisfying solution to “Where does it all come from?” come from? The answer is … from our brain! This is why I conduct a cognitive and philosophical study to understand our cognitive expectations for any explanation of the origin of the universe. Of course, answers to the origins also very much depend on our available scientific theories. But exploring and better understanding how our cognition functions in this ultimate quest will help us to unveil our biases and preferences in selecting explanatory models. Specifically, I argue in Chap. 4 that there are two cognitive attractors that we use to explain the beginning of the universe, the *point* and the *cycle*. Building scientific models is a process involving two equally important items, an external system to be understood, and an observer who constructs a model of that system. By better understanding the structure and functioning of the observer–model relationship, we have better chances to avoid biases and confusions between reality and our models.

In Chap. 5, I focus on a common feature of all cosmological models: they bring in free parameters that are not specified by the model. Can we reduce their numbers? How can we bind them? Which strategy should we use? I shall examine physical, mathematical, computational, and biological approaches, bringing different perspectives on this fundamental problem. This multiple analysis will prevent us from falling into any kind of reductionism. Moreover, an understanding of free parameters is a necessary step toward making sense of the fine-tuning debate.

In Chap. 6, we shall see that some free parameters also have puzzling properties. If we vary them even slightly, no complexity as we know it in our universe emerges. Our cosmological models display parameter sensitivity. This suggests that our universe is somehow very special. These arguments are known as *fine-tuning* arguments and are widely debated in science, philosophy, and theology. Unfortunately, they are often confused with other related issues. Many researchers, including leading scientists, commit and repeat fine-tuning fallacies. I clarify and untangle those issues, which are necessary steps for the new research discipline of *Artificial Cosmogenesis*, a scientifically promising and concrete way to study the emergence of complexity and the fine-tuning issue.

Part III
Our Future in the Universe

The laws of the universe have engineered their own comprehension
(Davies 1999, p. 146)

We are now entering the third part of our journey. Our challenge is to answer the age-old questions "Where are we going?" Chaps. 7–10) and "What is good and what is evil?" (Chap. 10). As usual, we ask these questions in a cosmological context with a maximal scope in space and time. So we are concerned about where we are going in the extremely far future. The most extreme point is the "last" point, which leads us naturally to the field of *eschatology*. The word comes from the Greek *eskhatos* (last), and *logos* (doctrine or theory). The word "eschatology" introduces a bias similar to the word "ultimate." We saw that the latter comes from *ultimare*, which means to "come to an end," while the former is the doctrine of last things. Taken literally, those words a *priori* rule out cyclical views of the universe, where there is no past or future end point.

Our discussion of cognitive attractors to understand the origin (Chap. 4) also applies to the future. Let us give brief hints of why it is the case. What are our cognitive attractors for the future? What do we expect? In the optimistic case, civilizations long for a kind of immortality (see Chap. 10). It can take the form of a point (e.g., heaven) or a cycle (e.g., with reincarnation cycles). We find the idea of multiple reincarnation or resurrection not only in Eastern philosophies, but also in contemporary Christian theology (see e.g., Hick 1976; Steinhart 2008). From a physical perspective, as we shall see below, the attractor point can be a cosmic doom scenario, where everything is stabilized to a uniform and lifeless state. Many cosmological models are cyclical, such as Tolman's (1934), the phoenix universe (Dicke and Peebles 1979), the famous chaotic inflation scenario (Linde 1990), Smolin's (1992) cosmological natural selection, or Penrose's (2011) recent conformal cyclical cosmology. We also mentioned in Chap. 4 the model of continuous creation of Hoyle and Narlikar, which is associated with a line rather than a point or a cycle. There are also cosmological models that include a role for intelligent life, which we shall examine in more detail in Chap. 8. As with the origin, there are psychological difficulties over accepting a cyclic future. But this is a problem only if one holds a point-like metaphysics that requires an ultimate beginning or end.

Importantly, different eschatologies focus on different "ends." Do we mean the end of a human life? Of humanity? or of all things? Not surprisingly, we focus here on the end of all things, since we want to avoid anthropocentrism or species-centrism. Inspired by Freitas (1979, Sect. 22.4.4), I distinguish four kinds of eschatology: *eternalistic, historical, naturalistic*, and *physical*.

Eternalistic eschatologies see time as an endless cycle of eternal recurrence. We already discussed eternal return (Sect. 4.3.4) and its many associated difficulties. For the stoics of ancient Greece and for Indian thinkers, time moves in cycles. Buddhists and Hindus believe in cycles of creations and destruction.

Historical eschatologies are grounded in linear time. Western traditions such as Christianity, Judaism, or Islam believe in a beginning and an end of time. Even the title of this book, *The Beginning and the End*, shows this Western bias. In Plato's *Republic*, death is accompanied by a judgment, where the immortal soul is rewarded or punished before choosing the condition of its next existence. The nature of this new existence is a topic in theology.

Naturalistic eschatologies emphasize harmony with nature. Goodness is seen as unity with nature, while wrongness is seen as alienation from nature. Interestingly, the main concern is to be in harmony with nature here and now, and not the prospect of a far future state after death. This is illustrated in Taoism, where there is virtually no interest in the beginning or the end of the universe (Ward 2002, p. 235).

Eschatology has most often been discussed within religious doctrines. But this need not be. Milan Ćirković (2003) wrote a review of *scientific* approaches to this topic, *physical eschatology*, gathering more than 200 references. Still, if we consider from a symmetry argument that past and future studies should have equal importance in treatment, there are surprisingly few studies about the far future universe compared with studies of the early universe. Ćirković argued that physical eschatology is a part of science:

> Since the laws of physics do not distinguish between past and future (with minor and poorly understood exceptions in the field of particle physics), we do not have a *prima facie* reason for preferring "classical" cosmology to physical eschatology in the theoretical domain.

It is correct that most physical laws are reversible in time with the notable exception of thermodynamics. The reconciliation of classical, relativistic, and quantum theories with thermodynamics is a major challenge in contemporary physics. It gives rise to thorny issues such as the arrow of time. Inspired by a science fiction novel by Gregory Benford (1978), Freitas proposed that an advanced civilization would focus on a "thermodynamic eschatology" striving to halt or reverse entropic processes in this universe. However, it is not necessarily the best strategy to fight frontally against such a widely confirmed physical law as the second law. It leads to the dream of a perpetual motion machines (Ord-Hume 1977). On the contrary, it was by accepting the laws of conservation of energy that engineers were able to design more and more efficient engines and machines.

Thanks to modern theoretical physics and astrophysics, many of the questions regarding the ultimate fate of the universe are thus now quantitatively addressed within the field of physical eschatology. What will happen to the Earth and the Sun in the far future? The story developed by modern science is a gloomy one. In about 5 billion years, our solar system will meet its end, with our Sun turning into a red giant star, making the surface of Earth much too hot for the continuation of life as we know it. The solution then appears to be easy: migration. But even if life were to colonize other solar systems, there will be a creeping death of all stars in galaxies. Once stars have converted the available supply of hydrogen into heavier elements, new star formation will come to an end in the galaxy. In fact, the problem is worse. It is estimated that even very massive objects such as black holes will evaporate in about 10^{98} years (Adams and Laughlin 1997).

Generally, the main lesson of physical eschatology is that in the long term the universe will evolve irreversibly toward a state of maximum entropy, or *heat death*. This is a consequence of the second law of thermodynamics, one of the most general laws of physics. It was first applied to the universe as a whole by Hermann von Helmholtz in 1854. Since this heat death discovery, a pessimistic worldview has spread that sees the existence of humanity as purposeless and accidental in the universe (e.g., B. Russell 1923; S. Weinberg 1993b). The fatalism of this worldview can lead people to lose their sense of the meaning of life.

Modern cosmology shows that there are some other models of the end of the universe (such as Big Bounce, Big Rip, Big Crunch: for an up-to-date review see Vaas 2006). The point is that none of them allows the possibility of the indefinite continuation of life as we know it. If any of the cosmic doom scenario is correct, it implies that the indefinite continuation of life is impossible in this universe. What is the point of living in a universe doomed to annihilation? Ultimately, why should we try to solve the mundane challenges of our daily lives and societies if we cannot even imagine a promising future for life in the universe? If we recognize this fundamental issue, then we should certainly do something to avoid it, and thus try to change the future of the universe.

On the other hand, there is an apparent paradox caused by this increase of entropy and the accelerating *increase of complexity* in the universe (e.g., Livio 2000; Chaisson 2001; Morowitz 2002; Kurzweil 2005). Chaisson (2001) showed with a thermodynamic analysis that this paradox can be resolved. It is the *expansion of the universe itself* that allows a decrease of entropy *locally*, while there remains an increase in entropy *globally*. But which of the two trends will turn out to be dominant in the long term remains unsettled.

In short, are we ultimately going toward rising entropy or rising complexity? A few authors have proposed some speculative solutions, but we shall see that they are insufficient because none of them presently allows the infinite continuation of intelligent life. I shall argue instead that intelligent civilization in the far future could make a new universe (Chap. 8). Although this may sound like a proposition from a science fiction story, I shall consider it within a philosophical agenda, by addressing objections seriously and replying carefully to them, and by comparing the idea to alternatives.

What are the limits of this complexity increase? The best way to test ideas regarding the future of complexity increase is to search for *advanced* extraterrestrial intelligence (ETI, see Chap. 9). For example, if we speculate that ETI might play snooker with stars, we should see much more star collisions, and stars moving on unpredictable trajectories. This is not the case, so we probably are not missing out on cosmic snooker games. Philosophically, the search for extraterrestrials is also a topic of fundamental importance. Are we alone in the universe? If you want to know who you are as a human being, you must compare yourself to or interact with others. The same holds for humanity as a whole. If we want to understand our place in the universe, there is no better option than to search for other life forms, in the hope of finding them and comparing ourselves to them.

It is easy to predict that as humanity becomes more and more connected and ever more in harmony as a globalized entity, the question “Who am I in the universe?” will only become more pressing. I chose to title Part III “*Our future in the universe*” and not “*The future of the universe*” because we are immersed in the universe and implicated in it. We are not merely spectators, we are actors in the great show of cosmic evolution. And to act in the universe, we need values and ethics. This is why Chap. 10 is key to this part.

We should note that the proposition of involving intelligent life in the fate of the universe is at odds with traditional science. In the characteristic worldview of modern science, it is often suggested that the emergence of intelligence was an accident in a universe that is completely indifferent to human concerns, goals, and values (e.g., S. Weinberg 1993b; Stenger 2007). I challenge both this proposition and another one that is commonly associated with it, namely that intelligent civilization cannot have a significant influence on cosmic evolution. A recurring objection to the importance of this topic is that it is too far away to be worthy of consideration. If this is your opinion, I invite you to ponder a thought experiment about global warming and universal cooling.

Imagine you are at a classy cocktail party, and you meet the rich CEO of a coal-fired power station. You strike up a conversation:

– What do you think about global warming?
– It’s not my job to think about it.
– There’s wide agreement that coal burning largely contributes to global warming.
– So what?
– I’m wondering how you can be morally comfortable about the major impact of your industry on the planet. Don’t you care?
– Not at all. Global warming isn’t my problem, it’s for future generations. I focus on providing energy to people, and incidentally making money.
– But who’s going to tackle the problem if each generation reasons like you?

What would be your opinion of this CEO? At the very least, you'd think that he's not highly morally developed because he doesn't care about future generations. I have the same impression when friends or colleagues quickly dismiss cosmic doom scenarios as "not their problem" because they are too far in the future. The fact that so many people on Earth care about global warming is a truly extraordinary shift of mindset. It means we have extended our worldviews to future generations and to planet Earth as a whole. As we extend our worldview further, why should we stop there, with a sphere of compassion limited to the size of our tiny planet? I predict that future generations will increasingly care not only about global warming but also about the heat death of the universe, which is actually a universal cooling, or indeed about any cosmic doom scenario that could threaten the survival of life in the universe.

What is good and what is evil? I address this issue in Chap. 10. What lessons can we learn from our cosmological worldview? What does this cosmological perspective imply for our actions and values here and now? What is our purpose in the universe? What are the ultimate goals or results that intelligence is seeking in the universe? What is the meaning of life in this cosmological perspective? At first sight, evolutionary reasoning tells us that survival is the ultimate value. But survival of what? And for how long? Can we aim as high as immortality? If so, which kind of immortality can we long for?

Guessing the future is a notoriously perilous enterprise. Part III will thus be more speculative. In Chap. 8, we explore a philosophical extension of Lee Smolin's cosmological natural selection (CNS), which is itself already often regarded as speculative. In Chap. 9, I shall explore heuristics to search for ETI, and even argue that we may well already have found ETI much more advanced than us.

Speculating on those issues can easily lead us too far. For this reason, we need to have clear ideas on why we speculate. As I wrote in the preface, I distinguish three kinds of speculations to navigate into their variety (Vidal 2012a):

1. **Scientific**: a speculation is scientific, if we have strong reasons to think that future observations or experimentations will corroborate or refute it.
2. **Philosophical**: a speculation is philosophical, if it extrapolates from scientific knowledge and philosophical principles to answer some fundamental philosophical problems.
3. **Fictional**: a speculation is fictional, if it extends beyond scientific and philosophical speculations.

Let us outline how we shall tackle those numerous issues:

Chapter 7 explores the future of scientific simulations, and the implications for our understanding of the universe. As Paul Davies wrote above, through cosmic evolution and the emergence of humans and science, "the laws of the universe have engineered their own comprehension." This self-awareness is dazzling. Where will this trend find a limit? We further develop and motivate the already mentioned extension of Artificial Life to *Artificial Cosmogenesis*.

Chapter 8 presents two kinds of cosmological selection. First, *cosmological natural selection* (CNS) is a remarkable theory applying ideas from evolutionary biology in cosmology. Second, *cosmological artificial selection* is a philosophical scenario extending CNS with a philosophical agenda. I discuss the history of both and formulate critical objections. Through the CAS scenario, we shall see surprising links between the study of the origin and our possible future in the universe.

Chapter 9 addresses the big question: *Are we alone in the universe?* In Chap. 6, we unveiled the real difficulties behind the fine-tuning issue, namely, that we only know one universe, ours. To progress, we concluded that we must study *other* possible universes. In a similar fashion, we know in detail only one instance of the development of higher complexity: life on Earth. If we want to understand the general future of complexity in the universe, it would be invaluable to find *other* cosmic intelligences. The discipline of *astrobiology* promises to fill this gap, and we shall lay the foundations for the more specific subdiscipline of *high energy astrobiology*. I propose a testable hypothesis to detect the existence of very advanced civilizations and suggest that we may already have observed them. Since they actively feed on stars, I call them *starivores*.

Chapter 10 brings us back down to Earth with cosmological wisdom. I explore foundations for ethics on a cosmological scale, a *cosmological ethics*. I build on thermodynamic, evolutionary, and developmental values and argue that the ultimate good is the infinite continuation of the evolutionary process. I apply the framework to a ubiquitous longing of humanity: the will to immortality. I survey five kinds of immortality and their relation to the definition and development of the self.

Let me sum up. Chapter 7 emphasizes the importance of scientific simulations for understanding our universe. Chapter 8 presents two kinds of cosmological selection and introduces CAS, a philosophical scenario linking the beginning and the end of the universe and offering a meaning for life and intelligence in the universe. Chapter 9 is about understanding who we are in the universe, by searching for and perhaps finding extraterrestrials far more advanced than us. Chapter 10 concludes Part III with an outline of basic principles for a system of universal cosmological ethics, illustrated with five different kinds of immortality.

Conclusion

Science cannot solve the ultimate mystery of nature.
And that is because, in the last analysis,
we ourselves are part of nature and therefore
part of the mystery that we are trying to solve.

Max Planck (1932)

It is time to take a big picture perspective on our intellectual adventure.

In Part I, I built scaffolding for answering our childishly simple big questions. Adults usually fail to answer such deeply philosophical questions. This is for a very good reason: answering the big philosophical questions demands both philosophical care and scientific expertise.

The elucidation of the nature of philosophy and its method is a delicate and arduous endeavor because throughout its history philosophy has cultivated more or less strong ties with art, religion, and science. As a result of this mixing with other disciplines, and because the scientific enterprise is becoming increasingly interdisciplinary, I have focused on developing the concept of a *worldview*, which holds promise for a meaningful integration of human knowledge.

We saw in Chap. 1 that we all both have and need a worldview, even if it is only implicit. To make it explicit requires introspection and philosophizing, but the gain in perspective is priceless. To do so is to look at how we look at the world. I have argued in favor of the tradition of philosophical systems that strive to build *coherent* and *comprehensive* worldviews.

Philosophy is a rich domain constituted by six dimensions, each concerned with different kinds of questions. The *descriptive*, *normative*, and *practical* dimensions try to answer what is, what is good and bad, and how to act in the world. The practice of the *dialectical* dimension consists in stating and reconstructing issues and a variety of positions toward them. It is essential in order to avoid forming premature doctrines and sinking into dogmatism. The *critical* dimension of philosophy is valued both in continental and analytical philosophy. It is an intellectual acid that can attack any proposition. Finally, the *synthetic* dimension is the climax of philosophizing, the one aiming at coherent and comprehensive worldviews, but also its most demanding dimension. To handle it successfully, one must master and juggle all of the other five dimensions.

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Furthermore, given that we all develop different worldviews depending on our culture, education, or psychology, in Chap. 2 I tackled the question of how to compare worldviews. Recognizing six philosophical dimensions and making the worldview agenda explicit were the first steps. I then developed in detail nine criteria to compare worldviews, classified in three broad categories: objective criteria (*objective consistency*, *scientificity*, *scope*), subjective criteria (*subjective consistency*, *personal utility*, *emotionality*), and intersubjective criteria (*intersubjective consistency*, *collective utility*, *narrativity*). From the criteria and the agenda, I derived worldview assessment tests (the *is-ought*, *ought-act*, and *is-act* first-order tests; the *critical* and *dialectical* second-order tests; the *mixed-questions* and *synthetic* third-order tests; and the *we-I*, *we-it*, and *it-I* tests).

I see the six dimensions, the worldview agenda, the nine criteria, and the seven tests as metaphilosophical apparatus to understand, improve, compare, and constructively criticize different religious, scientific, or philosophical worldviews. I outlined in Chap. 3 the major strengths and weaknesses of those three kinds of worldviews, and argued that the way to synthesize them is to build comprehensive theological or philosophical worldviews.

As William James noted, an important outcome of philosophical activity is to give birth to new scientific disciplines. The almost Oedipal stage of a scientist saying that philosophy is dead, that he doesn't need it, is actually a sure sign that the scientific field can sustain itself. Philosophy has done its job, and the umbilical cord can indeed be cut. The second stage of scientific maturity is the realization that killing philosophy, like killing one's parent, was finally not such a good idea, at least if we want to remain creative, to question the foundations of science and tackle the deepest mysteries of nature.

With hindsight, I proposed giving birth to two new research fields. The first regards the exploration of possible universes, which has so far chiefly been a metaphysical recreation. I defined the field of *artificial cosmogenesis* (Sect. 6.3 and Chap. 7) in order to study possible universes scientifically. The second regards the search for advanced extraterrestrials. Here too, the field is usually very speculative and actually most often explored not by philosophers or scientists but by science fiction authors. With the starivore hypothesis (Chap. 9) and the more general field of *high energy astrobiology*, I showed that existing knowledge in astrophysics demands a reassessment from an astrobiological viewpoint.

In Part II, I focused on the origin of the universe. I first outlined seven fundamental challenges underlying the quest for ultimate explanations: *epistemological*, *metaphysical*, *thermodynamic*, *causal*, *infinity*, *free parameters*, and *fine-tuning*. I conducted a detailed study on the last two only: free parameters in Chap. 5 and the fine-tuning conjecture in Chap. 6. Of course, the awareness of the five other challenges was in the background and helpful in clarifying analyses and conclusions throughout this book.

In Chap. 4, I applied the concept of the origin to itself, and asked what are the origins of the origin? In other words, what do we cognitively expect to be a satisfying answer to the ultimate origin of the universe? I argued that our explanations fall into two kinds of cognitive attractors: the point explanation and the cycle explanation.

An analogy from dynamical systems theory clearly shows that these correspond to the simplest attractors: the fixed point (0-dimensional) and the limit cycle (1-dimensional). We have no reason to exclude *n*-dimensional attractors or strange attractors (noninteger-dimensional) whose nature are fractal. Admittedly, it becomes challenging for our brains to think about the origin in such terms.

The major thesis of Chap.5 was that free parameters in particle physics models will be reduced to free parameters in a cosmological model. It is a fundamental issue in physics and cosmology to reduce or explain those remaining free parameters. I analyzed the issue with physical, mathematical, computational, and biological backgrounds. But are those free parameters further fine-tuned for life or complexity?

To answer this much debated fine-tuning issue, I started by reviewing the probabilistic, logical, and physical fallacies that surround it. Then I distinguished the issue from seven other closely related issues: *free parameters*, *parameter sensitivity*, *metaphysical issues*, *anthropic principles*, *observational selection effects*, *teleology*, and *theology*.

I introduced the *cosmic evolution equation* as a central conceptual tool to study how *robust* our universe is when it comes to the emergence of complexity and to what extent it is *fine-tuned* compared to other possible universes. The fine-tuning issue can then be formulated as: "Are fecund universes rare or common in the space of possible universes?" The straightforward way to answer such a difficult question is to explore the space of possible universes, through *artificial cosmogenesis*. Although it would be extremely ambitious and computationally intensive, in Chap. 7 I gave more arguments to show why artificial cosmogenesis is a natural outcome of future scientific activity. Since comparing our universe to other possible ones has just gotten under way, I concluded that the fine-tuning of our universe can at most be a conjecture.

Studying the fine-tuning conjecture is one thing, explaining it is another. I showed the shortcomings of eight classical explanations: *skepticism*, *necessity*, *fecundity*, *god of the gaps*, *chance of the gaps*, *weak anthropic principle of the gaps*, *multiverse*, and *design*. This left two additional explanations inspired by evolutionary theory: *cosmological natural selection* (CNS) and *cosmological artificial selection* (CAS), which I discussed and critically analyzed in detail in Chap. 8.

I started by reviewing the history of cosmological natural selection and formulated objections to it. To remedy these objections, I introduced cosmological artificial selection and reviewed its generally unknown history. This evolutionary scenario is my core thesis, a philosophical speculation aimed at explaining the fine-tuning issue and the meaning of life and intelligence in the far future universe.

Such an ambitious thesis naturally triggers many objections, and I formulated and addressed eight of them. I then summarized four different roads leading to CAS and further substantiated this scenario by showing that because it is so broad, it has limited alternatives. Furthermore, I showed that the nine other alternatives encounter problems and difficulties.

Once the development of intelligence is seen as a central feature of our universe, we can address the issue Max Planck evokes in the quote above. We need to take into consideration ourselves and intelligence in general if we want to solve the "ultimate mystery of nature". However, according to CAS, the greatest outcome of the scientific enterprise is not an almost spiritual quest to find the key to the mysteries of nature, but actually a more practical activity: to make universes in order to avoid cosmic doom.

CAS finally invites us to focus more on the future of the universe than on its past. Indeed, we will probably never know what happened at the big bang or "before" it. But thinking about the far future leads to increasing understanding of the beginning. This led us to the architect point of viewv: *The more we are in a position to make a new universe, the more we shall understand our own universe*.

We saw that assessing the robustness of the emergence of life and intelligence in the universe is a central issue. I showed how it can be tackled with extensive runs of computer simulations. However, there is a shortcut, which is to search for extraterrestrials—the natural "re-runs" of the tape of life.

In Chap. 9, I thus focused on the search for *advanced* extraterrestrials. Why advanced? Because it would be much more informative, insightful, and disruptive to find extraterrestrials 2 billion years older, rather than finding an extraterrestrial bacterium. On the historical side, I clarified the fundamental importance of astrobiology, whose outcome will lead to major scientific worldview changes. On the methodological side, I first debunked many implicit and limiting assumptions in past and current searches and then summarized and compiled criteria for artificiality.

When I started to think about extraterrestrials, it was as an intellectual challenge, trying to explore how CAS could help. This started without scientific pretension, but to my surprise such extreme speculations quickly turned into a scientific hypothesis, the possible existence of *starivores*, civilizations feeding actively on stars. The hypothesis is now ready for rigorous empirical and scientific assessment. You may recall the open questions section at the end of Chap. 9, my concrete scientific research proposals and the associated High Energy Astrobiology prize. I am looking forward to congratulating the winner of the prize.

Even proving that the hypothesis is wrong, which of course is also worthy of the prize, speculating about advanced extraterrestrials gives a unique cosmological perspective on humanity and its role in the universe. In the meantime, what about us and our values?

Finally, in Chap. 10, I outlined foundations for a cosmological ethics. I focused on very general ethical principles, as far as possible applicable to all living things. I thus critically outlined thermodynamic, evolutionary, cybernetic, and developmental values. As an application of the cosmological ethical framework, I discussed in detail five conceptions of immortality, from the personal *spiritual* and *individual* immortalities to the transpersonal *creative*, *evolutionary*, and *cosmological* immortalities. I argued that the ultimate good is the *infinite continuation of the evolutionary process*.

Our time is unique. Humans are connecting both via and with more and more networked and pervasive computers, creating a new level of planetary intelligence best conceptualized as a global brain. We are also on the brink of confirming the existence of extraterrestrial life, via astrobiology or high energy astrobiology, which would refute *biocentrism* or *intellicentrism*.

This event will change our worldviews forever, and thanks to the cosmological perspective developed in Part III, we are ready. But the scenario of cosmological artificial selection also prepares us to be ready for the eventual refutation of *univercentrism*, the belief that our universe is somehow central and unique. This would defeat the very last bastion of anthropocentrism.

Is it a tragedy that we shall probably die before witnessing such major and magnificent evolutionary or worldview transitions? No, because if we become wise enough to endorse a cosmological ethics and grow toward a will to cosmological immortality, we are also ready to die as individuals.

All in all, what is the meaning of *your* life in a cosmological perspective? Of course, it was not the purpose of this book to tell you what the direction of your personal life should take. Becoming a doctor, a dancer, or a high energy astrobiologist remains your own choice. Yet you might want to better harmonize your life with the whole of cosmic evolution. This practical shift remains to be worked out, but at least we have set some theoretical foundations. In a nutshell, here is the meaning of life in a cosmological perspective: It is to replicate at the grandest scale, through an intimate connection of intelligence with the universe.

Instead of seeing the cosmos as hostile to life and intelligence, I would like to end with a short poem, *Cosmosis*, conveying a vision of cosmic evolution as a love story; a love story between the cosmos and its precious intelligence:

To begin, love is ego.
Then opening to alter ego,
now growing to Earth.

Yet, only from the osmosis
Between wisdom and the cosmos
ends love in an infinite cosmosis.

Appendix I
A Cosmic Evolutionary Worldview: Short Answers to the Big Questions

Introduction[1]

Across the centuries, humanity has been wondering about its existence and its place in the universe. Human beings employed insights from myths, religions, art, philosophy, and science to make sense of the world around them.

However, in the current era of accelerating scientific, cultural, and social developments, all the old certainties are put into question. The resulting confusion and fragmentation often lead to pessimism and uncertainty, and a need for psychological guidance in the form of a clear and reliable system of thought.

This need makes it important to search for a *coherent* and *comprehensive* worldview by finding new answers to the big questions associated with this quest for understanding. Answering them explicitly is traditionally a task that has fallen to philosophy, and often took the form of comprehensive and coherent systematic philosophical treatises. The great philosophical systems are of this sort. Regrettably, this trend seems to have fallen out of fashion, since most of today's philosophy is busy with second-order problems (Adler 1965).

In contrast to most contemporary philosophical practice, below are tentative and provisional responses to first-order philosophical questions. The answers to these questions together determine a worldview, i.e. a comprehensive philosophical system, a coherent vision of the whole. A worldview gives meaning to our life, and helps us to understand the world around us.

Each worldview question would need at least a book to answer it properly. Moreover, the most appropriate way to answer them is with a systematic philosophical system (e.g. Bunge 1974; Rescher 1992). I do not have that objective here. Instead, I provide below very short responses as *positions*, *not arguments.* I give some main references to the works that influenced me, where the curious reader will be able to find many detailed arguments. Before I start, it is worth recalling the many advantages of explicitly stating one's philosophical position.

[1] Eventual updates to this "philosophical identity card" can be found at: http://www.evodevouniverse.com/wiki/A_Cosmic_Evolutionary_Worldview:_Short_Responses_to_the_Big_Questions.

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First, these short responses will obviously let the reader grasp my position quickly. The position is stated transparently and straightforwardly, using a minimum of technical concepts.

Secondly, the task of answering those questions is a daring effort. I balance this *great ambition* with *great caution* in answers I provide. They are non-dogmatic, provisional, revisable, and sometimes falsifiable. The responses proposed here are mixed philosophical and scientific conjectures to make sense of the world. Accordingly, some of them are speculative. They are of course not definitive. In such a short format, I also do less than justice to the pros and cons of alternative positions (the dialectical dimension of philosophy). This doesn't mean that I'm unaware of them. Still, if you think I've missed either something important or a position clearly better than the ones presented here, please contact me. Like any good philosopher and scientist, I very much value and warmly welcome criticism and any further reflection you might have reading this text.

Thirdly, this transparency in responding to basic questions allows *efficient debate and communication*. Many debates and disagreements get lost in details, without touching the heart of issues at stake. This practice of answering first-order questions can save an enormous amount of time in confusing debates, because enduring disagreements always end up in disagreements about such fundamental questions. I invite you to do the same exercise before reading what follows, and simply answer the worldview questions for yourself. Feel free to use the following space to outline your main worldview answers. Good luck!

Make Your Worldview Explicit!

(g) Where do we start from?

(a) What is? *Ontology* (model of being)

(b) Where does it all come from? *Explanation* (model of the past)

(c) Where are we going? *Prediction* (model of the future)

(d) What is good and what is evil? *Axiology* (theory of values)

(e) How should we act? *Praxeology* (theory of actions)

(f) What is true and what is false? *Epistemology* (theory of knowledge)

My Worldview Made Explicit

(g) Where do we start from?

Before proposing responses to those big worldview questions, here are some preliminary considerations, laying bare how I start this enterprise. The (meta)philosophical framework and method are mainly inspired by the works of Adler (1965, 1993), Rescher (1985, 2001, 2006), and Bahm (1979).

If I had to choose a philosophical stream, I would say I am mostly influenced by *systems philosophy* (esp. Laszlo 1972b; Heylighen 2000b, 2010b on which this text is based). To summarize it in one sentence, its "data come from the empirical sciences; its problems from the history of philosophy; and its concepts from modern systems research" (Laszlo 1972a, p. 12). We may add to *systems theory* an interdisciplinary *problem solving* approach and *evolutionary developmental theory*, applied on many scales (Vidal 2008a).

(i) The worldview agenda

I start with the philosophical agenda described in Chap. 1.

(ii) The metaphilosophical criteria

Once the questions are asked, we obviously need to answer them and use standards to evaluate their strengths and weaknesses. In Chap. 2, I developed nine criteria and a battery of tests to compare and assess different worldviews. Which criteria do I value most?

The aim in Chap. 2 was descriptive. As to how I use the criteria prescriptively to answer the agenda of the worldview questions, here I use above all *objective criteria* (*objective consistency*, *scientificity*, and *scope*) to construct a coherent and comprehensive cosmological worldview. In this cosmic evolutionary worldview, the *scope in level depth* is maximally wide in time and space, concerning the whole universe. As objective criteria are maximally satisfied, I turn to *subjective* and *intersubjective* criteria to make the worldview successfully applicable in the conduct of a good life and in the organization of a good society. The pursuit of a good life and a good society is then harmonized with cosmic evolution.

(a) What is?

As a preliminary remark, I am generally skeptical about reductionist ontological statements. Reality is complex, evolving, and multi-layered, and different ontologies are more or less appropriate to analyze and solve different problems. Dooyeweerd's (1953) fifteen aspects, although static rather than dynamic, offer an example of a non-reductionist ontology.

My ontological commitment goes toward systems theory, which aims to offer a universal language for sciences (e.g. von Bertalanffy 1968; Boulding 1956). It is also very fruitful for philosophizing (e.g. Laszlo 1972a). It is best combined with evolutionary reasoning, which gives rise to an evolutionary-systemic approach (Heylighen 2000b).

I choose an ontology of actions and agents, i.e. elementary processes and relations, not independent, static pieces of matter (in the spirit of Whitehead (1930), Lazslo (1972a), Jantzch (1980), etc.). Out of their interactions, organization emerges. Through evolutionary processes, these systems become more complex and adaptive, and start to exhibit cognition or intelligence, i.e. the ability to make informed choices.

(b) Where does it all come from?

Modern science explains—at least in part—the harmony within nature, connecting physical, chemical, biological, and technological evolution (e.g. Chaisson 2001; De Duve 1995). Regarding the origin of the universe, although Big Bang models are a success of modern cosmology, the initial conditions remain mysteriously fine-tuned (e.g. Leslie 1989, 1998; Rees 1999; Davies 2008). In Chap. 6, I concluded that fine-tuning is hard to prove and that it is at most a conjecture. Whatever possible explanation we favor, we need to cope with difficult metaphysical choices (Vidal 2012a). The scenario of cosmological artificial selection (CAS) developed in Chap. 8 connects the origin and future of the universe with a role for intelligent life (Vidal 2008b, 2010a, 2012a).

(c) Where are we going?

Modern science has shown that there are two trends at play in cosmic evolution. First, there is a tendency to produce *more order*, with the emergence of ever more complex systems, from galaxies, stars, and planets to plants, humans, and our technological society (Chaisson 2001; Kurzweil 2005; Morowitz 2002; Livio 2000). Secondly, the second law of thermodynamics applied to the universe as a whole implies that in the far future the universe will change irreversibly toward a state of *maximum disorder*, or heat death (e.g. Adams and Laughlin 1997). The outcome of these two opposite trends remains unsettled.

The discovery of the heat death led to the spread of a pessimistic worldview that sees the existence of humanity as purposeless and accidental in the universe (Russell 1923; Weinberg 1993b). With Darwin (1887b, p. 70), I estimate that “it is an intolerable thought that he [man] and all other sentient beings are doomed to complete annihilation after such long-continued slow progress”.

Hopefully, the first trend will prove to be more promising. The process of ongoing complexification and adaptation can reasonably be extrapolated into the future. This allows us to predict that in the medium term, conflict and friction within human society will diminish, cooperation will expand to the planetary level, and individual and collective intelligence will be spectacularly enhanced.

Generally, more advanced biological organisms build more and more sophisticated representations of their surroundings (Russell 1995). The research field of *artificial cosmogenesis* pushes this trend to its limit, to the point where intelligent life constructs a model of the whole universe. This modeling capacity can be used to understand not only our own universe, but also other possible universes (see Sect. 6.3). The radical proposal of cosmological artificial selection

(CAS) developed in Chap. 8 is that in order to avoid the effect of the second law of thermodynamics, those toy universes could become a blueprint for a new universe (Vidal 2008b, 2010a, 2012, 2012a).

This scenario is a mixed scientific and philosophical speculation. It is philosophical because it involves a role for intelligent life, and so the success of CAS depends on our conscious choices for the future of cosmic evolution. It thus requires an axiological dimension, proper to philosophy, which we explored in Chap. 10.

CAS has also a scientific aspect, since its general perspective gives rise to far-reaching consequences and implications regarding the search for advanced extraterrestrials. To confirm or disconfirm the existence of the starivores I introduced in Chap. 9, we must approach the question scientifically within the field of *high energy astrobiology*.

(d) What is good and what is evil?

The inner drive or implicit value governing all life is fitness, i.e. survival, growth, development, and reproduction. From a human perspective, this fundamental value includes a sustainable quality of life, well-being, or happiness. Evolutionary, developmental, thermodynamic, psychological, and cybernetic theories allow us to derive a number of more concrete objectives from this overarching value, i.e. properties that are necessary for long-term well-being. These include openness, diversity, intelligence, knowledge, cooperation, freedom, personal control, health, and a coherent and comprehensive worldview.

In the longer term, fitness implies increasing adaptiveness and evolvability beyond human society as we know it. Actions that promote these values with the least friction possible are intrinsically good, and actions that suppress them are bad.

As our psychology grows in higher stages of development, we make sure our values do not conflict with higher evolutionary systems. Not only do I try to improve my happiness, but my happiness becomes more and more tightly linked with my family, my country, society, humanity, the planet, and the cosmos. Ultimately I should act from awareness of and compassion with such a hierarchy, combining the values of my own life with the sustainability of larger and larger evolutionary systems.

At heart, humans have a will to immortality (e.g. Turchin 1990; Lifton and Olson 2004). In my worldview, this takes the form of an endless, infinite cosmic evolution. The metaphysical and speculative part of cosmological artificial selection translates this will to immortality into an infinite process of evolution sustained by intelligence making offspring universes (Vidal 2008b, 2010a; 2012; esp. Vidal 2012a).

(e) How should we act?

To maximize the achievement of these values in real life, we need to overcome a variety of problems and obstacles. Cognitive sciences, cybernetics, and complex systems science suggest various tools and strategies to tackle complex problems, and to stimulate self-organization so as to be as efficient as possible. These methods include feedback control, anticipation, hierarchical decomposition, heuristic search, stigmergic coordination, extended mind, and memetic engineering.

At the level of society, these methods define a strategy for effective governance, for the maximization of collective intelligence and the minimization of friction and conflict.

There is a trend in cosmic evolution to do ever more with less energy, space, and time (Smart 2009). Using less energy and fewer resources to achieve more is also at the heart of productivity principles. On the personal productivity side, The Getting Things Done method combines high productivity with low stress (Allen 2001; Heylighen and Vidal 2008).

(f) What is true and what is false?

This is a second-order question concerning knowledge about knowledge. Also, the domains of epistemology and ontology are closely related. We can divide this question into the following two questions (Heylighen 2000b, p. 15):

- What is knowledge? This question defines the domain of epistemology.

Science can be seen as a natural outcome of the more general evolutionary pressure to gain more and more accurate knowledge (Campbell 1974). Knowledge is the existence in a system of a model that allows that system to make predictions, i.e. to anticipate processes in its environment. Thus, the system gains control over its environment. Such a model is a construction, not an objective reflection of outside reality (Turchin 1993; Heylighen 1997a).

- What is truth?

There are no absolute truths. The truth of a theory is merely its power to produce predictions that are confirmed by observations (Turchin 1993). The scientific enterprise is one of conjectures and refutations (Popper 1962), and there is a natural selection of ideas and theories that give more power, i.e. prediction and control (Campbell 1974).

Ultimately, what is the meaning of the phenomenon of science in this pragmatic, constructive, and evolutionary epistemology? It is not the search for an ideal "truth" but the pragmatic goal of acquiring knowledge. In the scenario of CAS, it is to build a model of our actual and other possible universes that could become, with some variation, a blueprint for a future universe, thereby escaping predictions of cosmic doom.

Appendix II
Argumentative Maps

This appendix presents the logical structure of the main arguments presented in this book. The core problems of our concern are mapped in the first map called the current reality tree (CRT, Figs. A.5, A.6, A.7, A.8, A.9, A.10, A.11) and the proposed solution in the second map, called the future reality tree (FRT, Figs. A.12, A.13, A.14, A.15, A.16, A.17, A.18). To facilitate readability, I first present a collapsed version of both the CRT (Figs. A.1, A.2) and the FRT (Figs. A.3, A.4).[2]

This approach provides an *externalization of reasoning* so that arguments can be clearly visualized. This brings many benefits, such as:

- Allowing the reader to grasp the logic of the argumentation quickly and clearly.
- Presenting an alternative structure of the content of the book. The table of contents and the abstract tend to present a rhetorical and less logical structure.
- Allowing the possibility of a constructive discussion of assumptions and deductions. For example, a critic can say "the core problem is not P but Q"; or "I disagree that hypothesis X leads to Y, you need implicit hypothesis Z, ..." or "hypothesis W is wrong because ..."; or "there is another solution to your problem, which is ..." etc.

However, it should be clear that reading the maps cannot replace reading the book. Only the core reasoning is mapped, often in a simplified way. The maps also represent what I consider the core issues and proposed solutions, with no ambition toward comprehensiveness. Many more arguments are developed and discussed in the text. You as a reader can distill many other insights from the text. I am not claiming that these trees should be considered as my dogmatic position. I am in principle open to other interpretations and emphases. Those who have worked with argumentative maps know too well that drawing them is above all a basis for continuous improvement.

To draw the maps I used some of the insights of Eliyahu Goldratt's theory of constraints (TOC) and its "thinking process" (see Goldratt and Cox 1984; Goldratt

[2] A poster presentation of these maps is available at: http: //student.vub.ac.be/~clvidal/writings/Vidal-PhD-Poster-Maps.pdf.

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Institute 2001; Scheinkopf 1999). The TOC is a well proven management technique widely used in finance, distribution, project management, people management, strategy, sales, and marketing. I see it and use it as part of a generic problem solving toolbox, where causes and effects are mapped transparently. In this TOC framework, three fundamental questions are employed to tackle a problem:

1. What to change?

A core problem is identified, leading to *undesirable effects*, and mapped in a "current reality tree" (CRT).

2. To what to change?

A solution is proposed and mapped in a "future reality tree" (FRT), which leads to *desirable effects*.

3. How to cause the change?

A plan is developed to change from the CRT to the FRT. This third step involves drawing a transition tree. Such trees are important for practical problems, but in the more theoretical context of this book, I did not map one.

To tackle the problem in practice, six important questions should be addressed, constituting "six layers of resistance to change". These questions can be used to trigger discussions (Goldratt Institute 2001, p. 6):

1. Has the right problem been identified?
2. Is this solution leading us in the right direction?
3. Will the solution really solve the problems?
4. What could go wrong with the solution? Are there any negative side-effects?
5. Is this solution implementable?
6. Are we all really up to this?

The following pages map the core problems (CRT) and my core arguments and thesis (FRT). I recommend consulting the maps in their original expandable, collapsible, and zoomable format thanks to the free Flying Logic reader software and the maps.[3]

[3] http://flyinglogic.com/download/ for the software as well as http://student.vub.ac.be/~clvidal/writings/Vidal-CRT-PhD.logic and http://student.vub.ac.be/~clvidal/writings/Vidal-FRT-PhD.logic for the CRT and FRT maps.

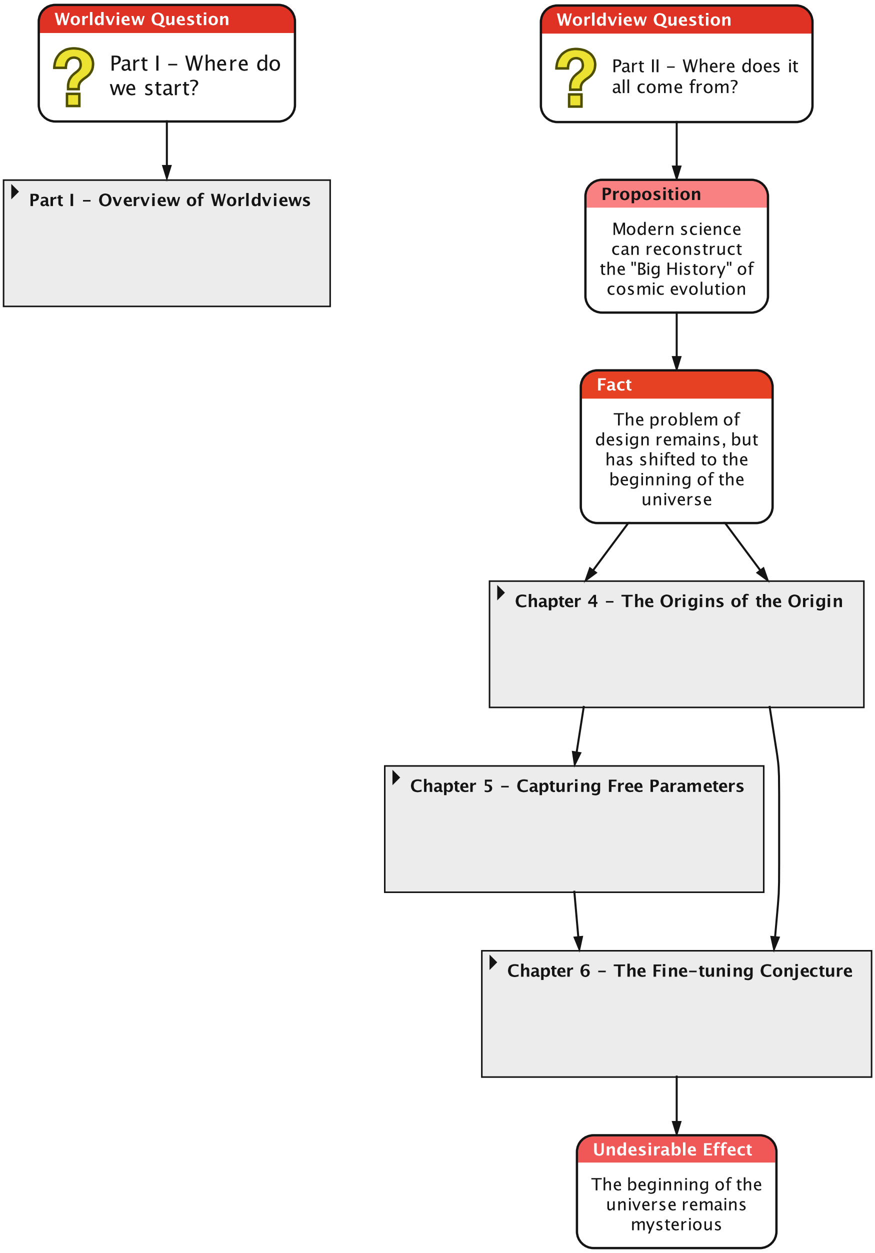


Fig. A.1 CRT for Part I and II, collapsed versions

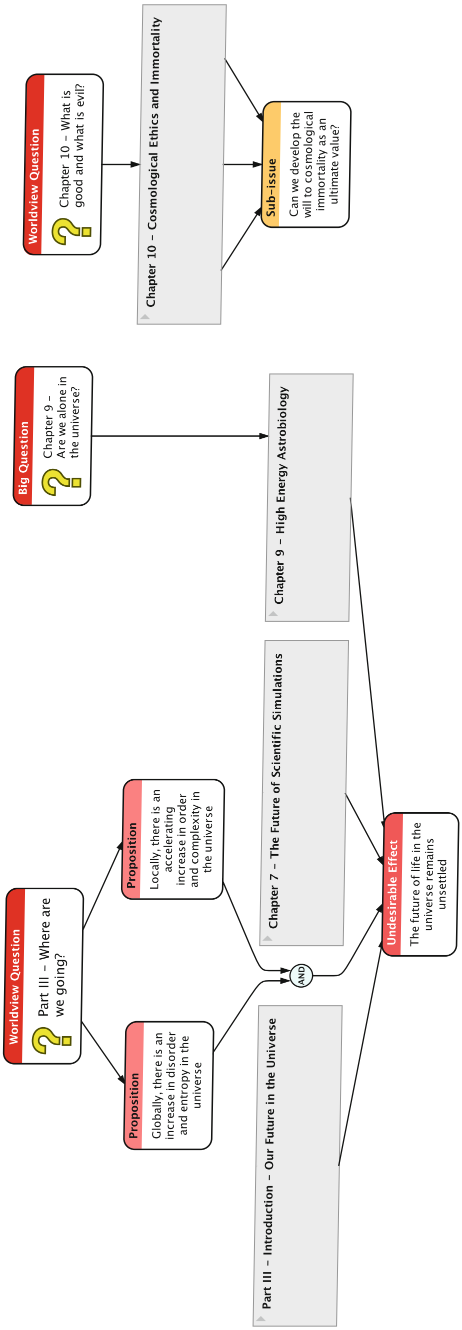


Fig. A.2 CRT for Part III, collapsed versions

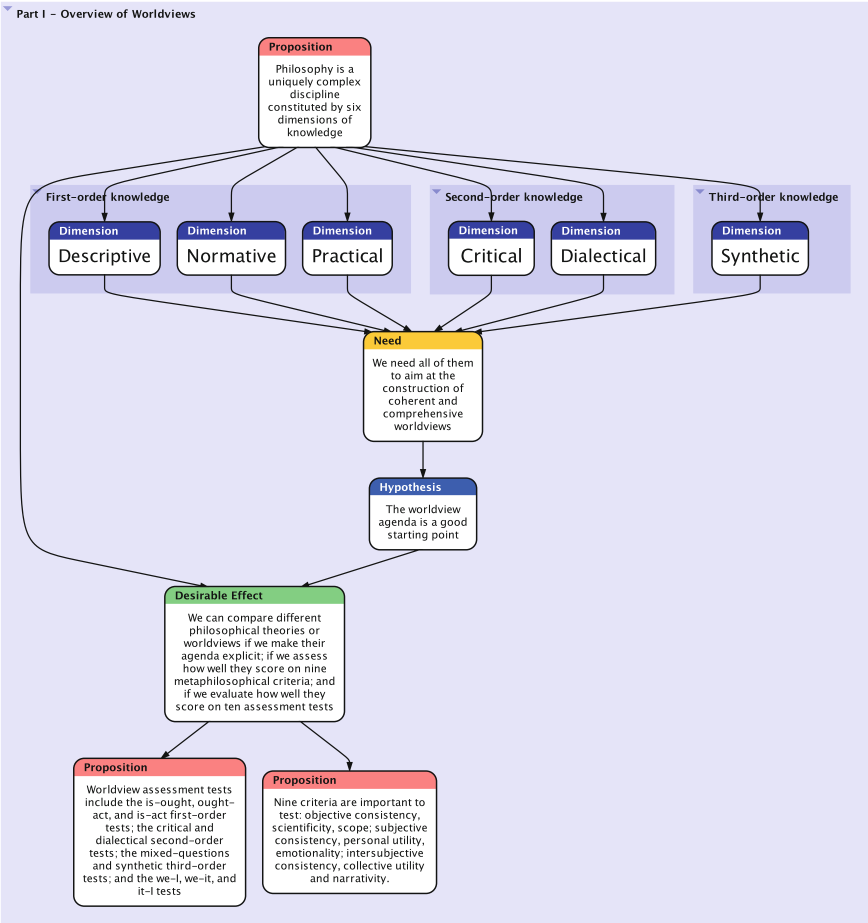


Fig. A.3 FRT of Part I, expanded

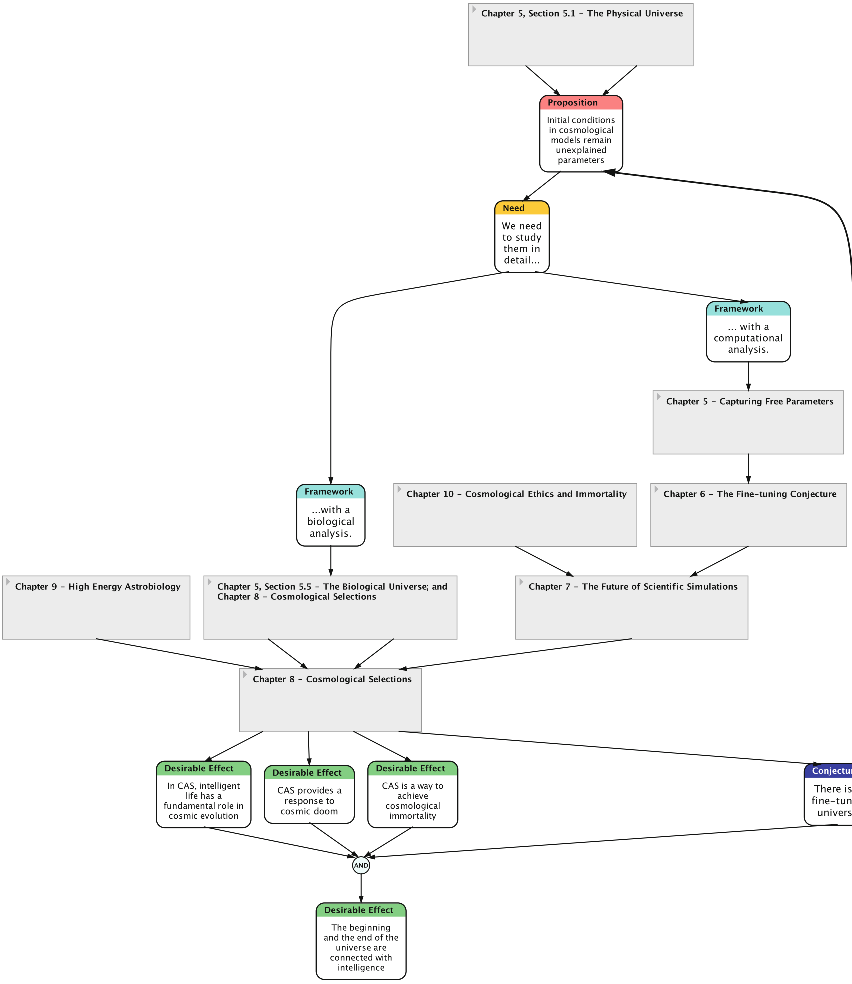


Fig. A.4 FRT of Part II and III, collapsed

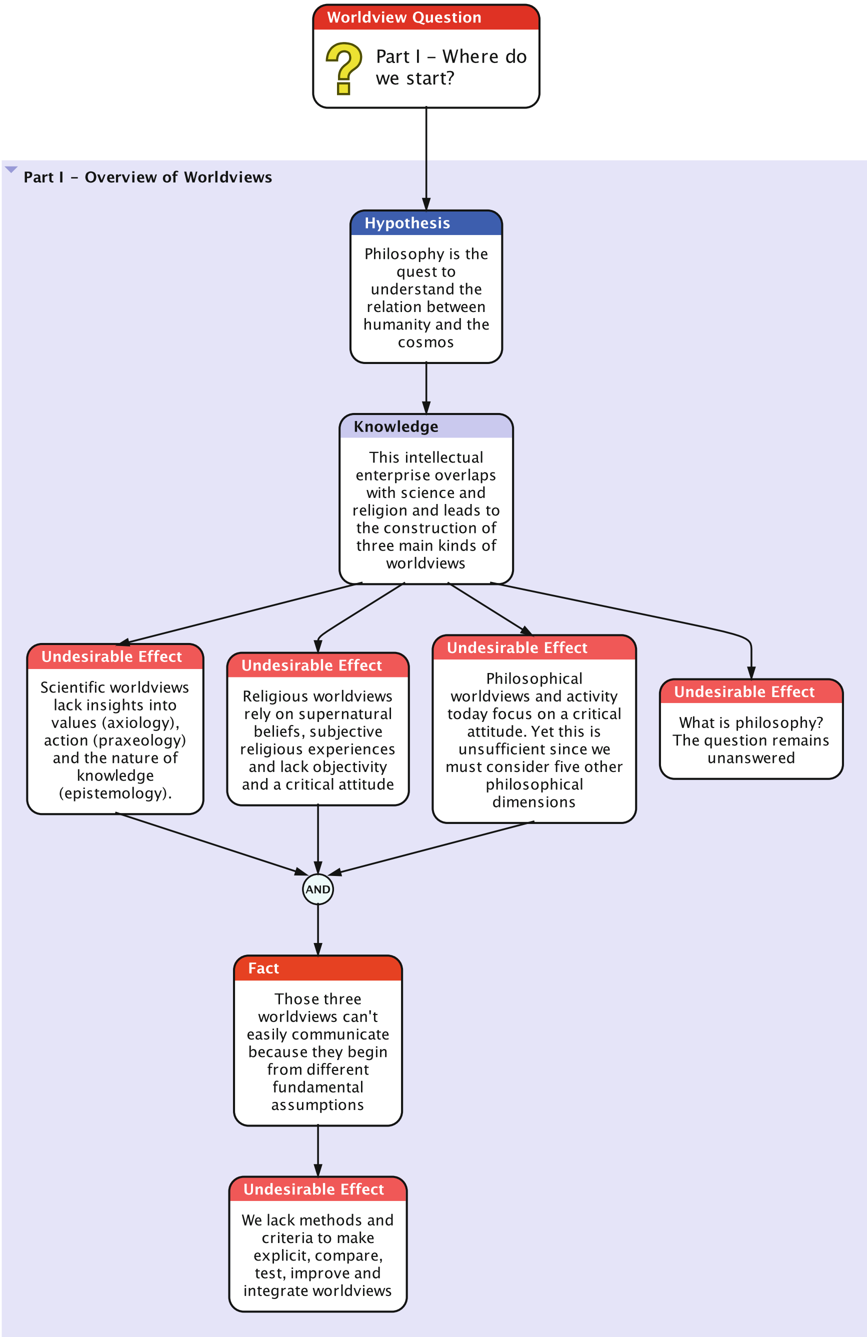


Fig. A.5 CRT of Part I, expanded

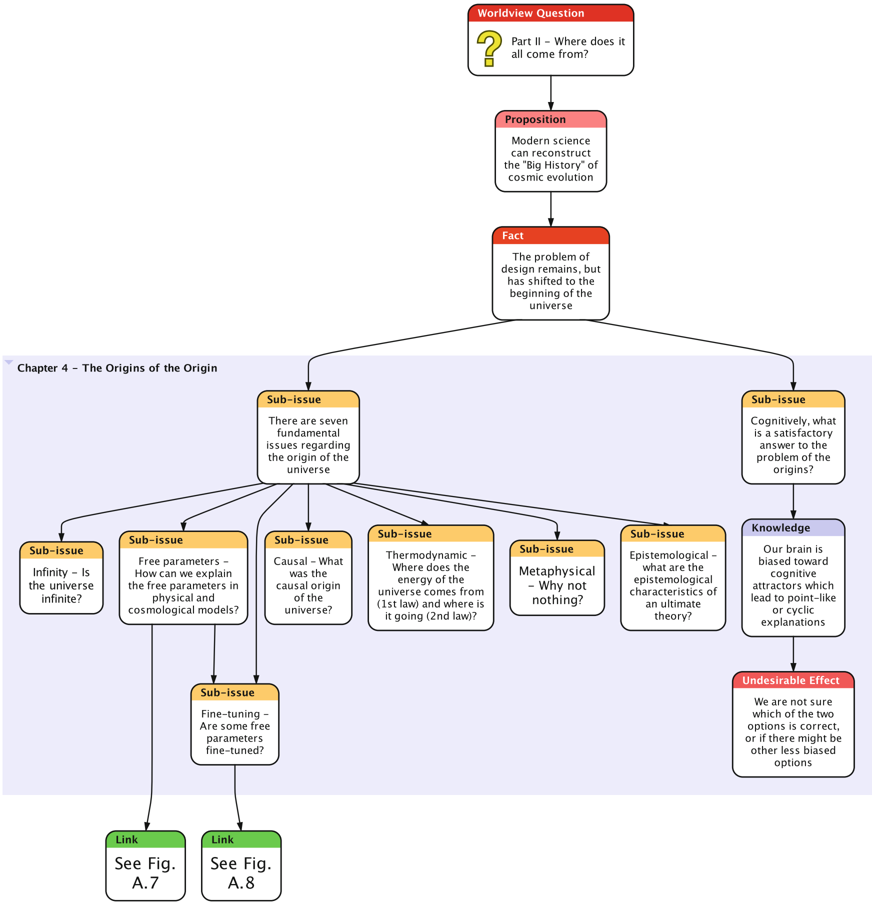


Fig. A.6 CRT of Part II, Chap. 4

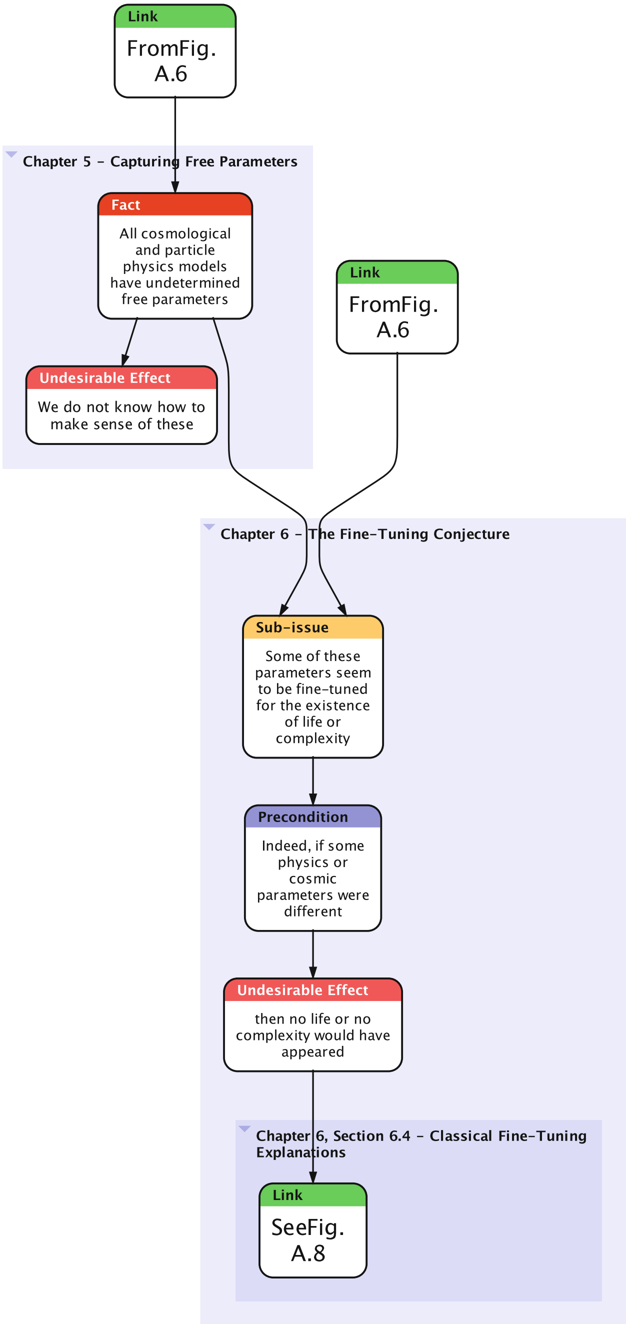


Fig. A.7 CRT of Part II, Chaps. 5 and 6

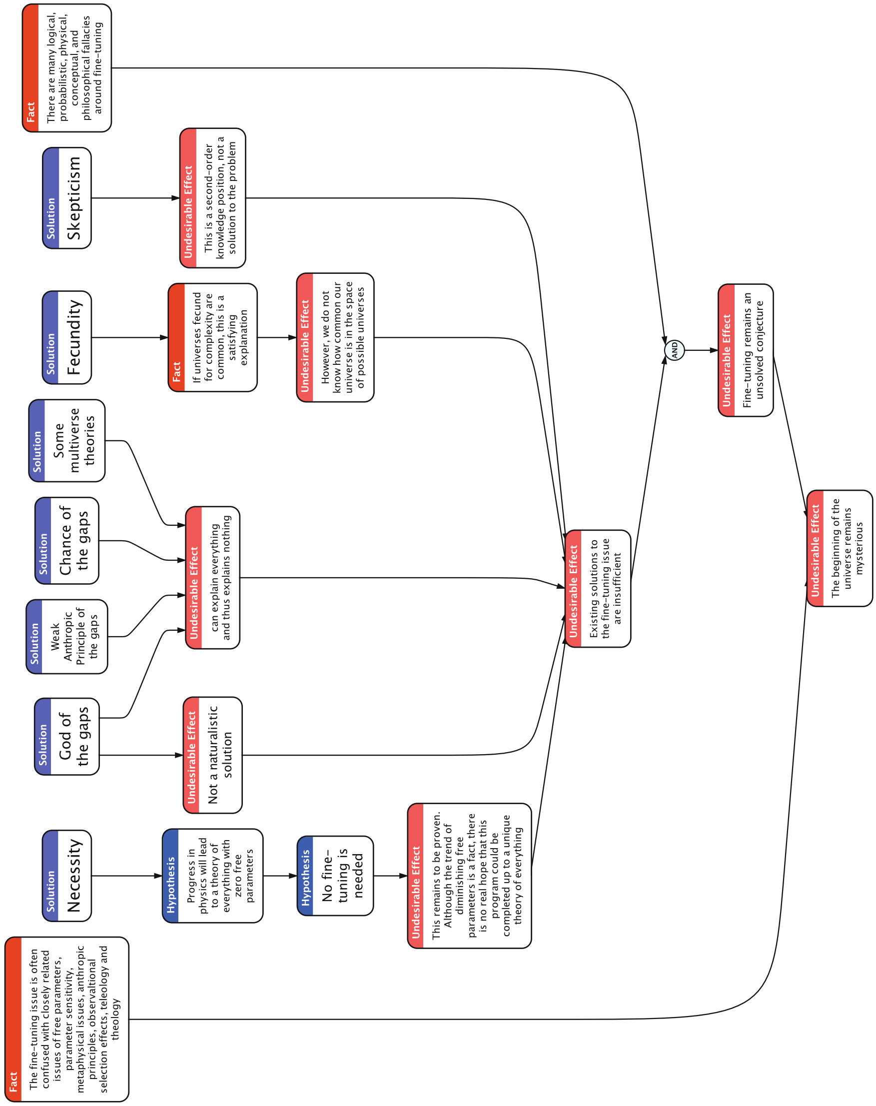


Fig. A.8 Detail of Fig. A.7, showing that classical fine-tuning explanations are unsatisfactory

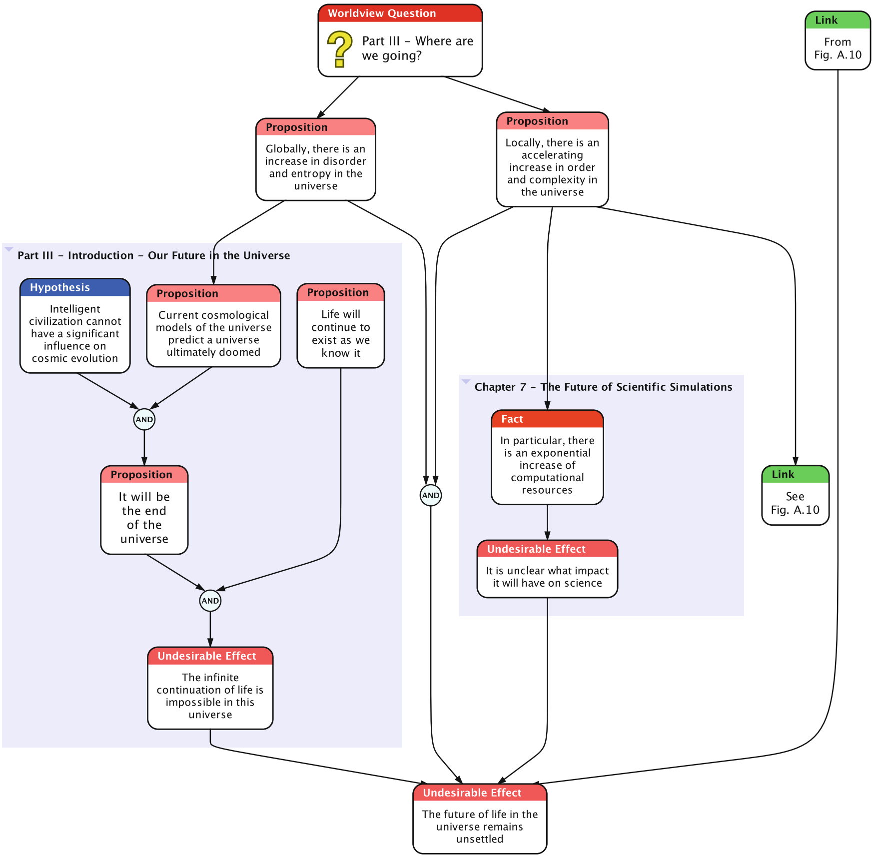


Fig. A.9 CRT of Part III, introduction and Chap. 7

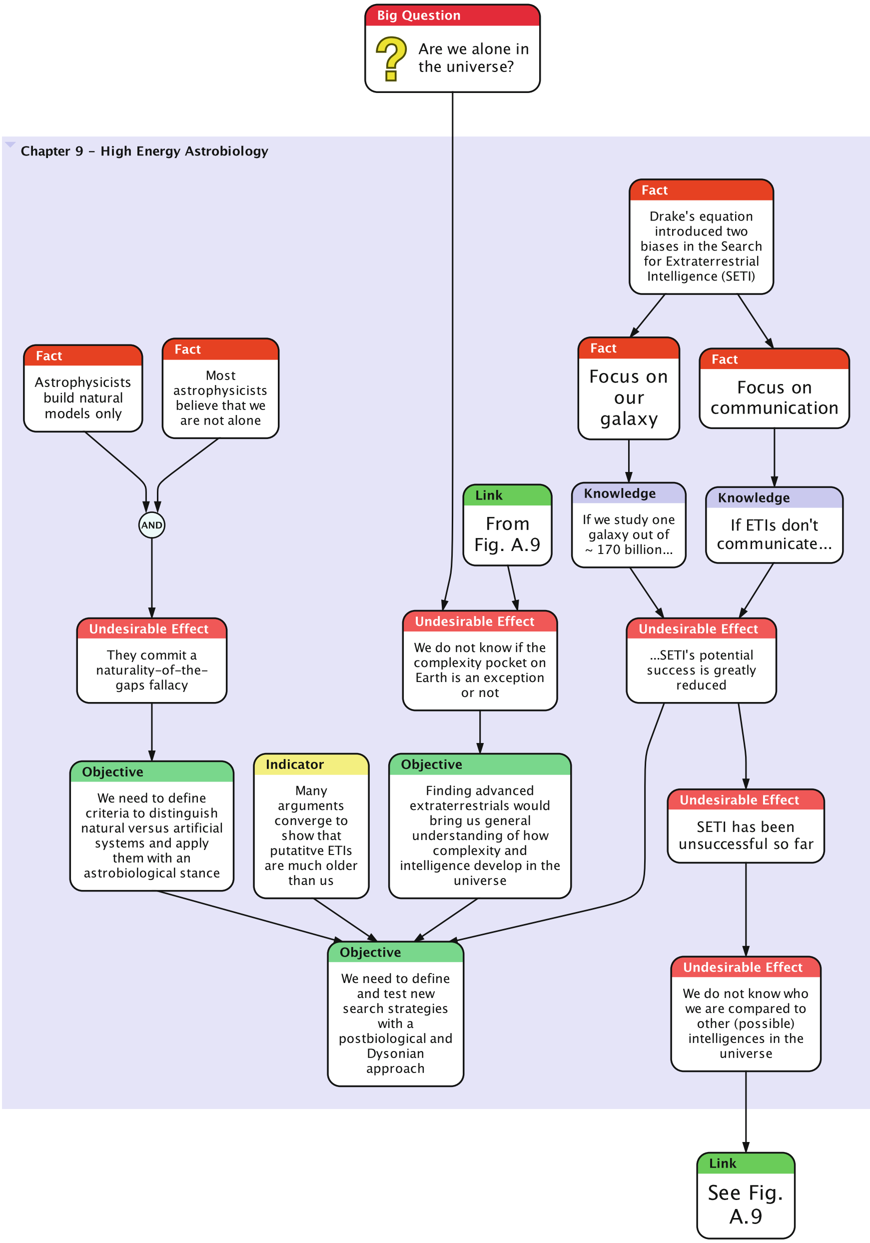


Fig. A.10 CRT of Chap. 9

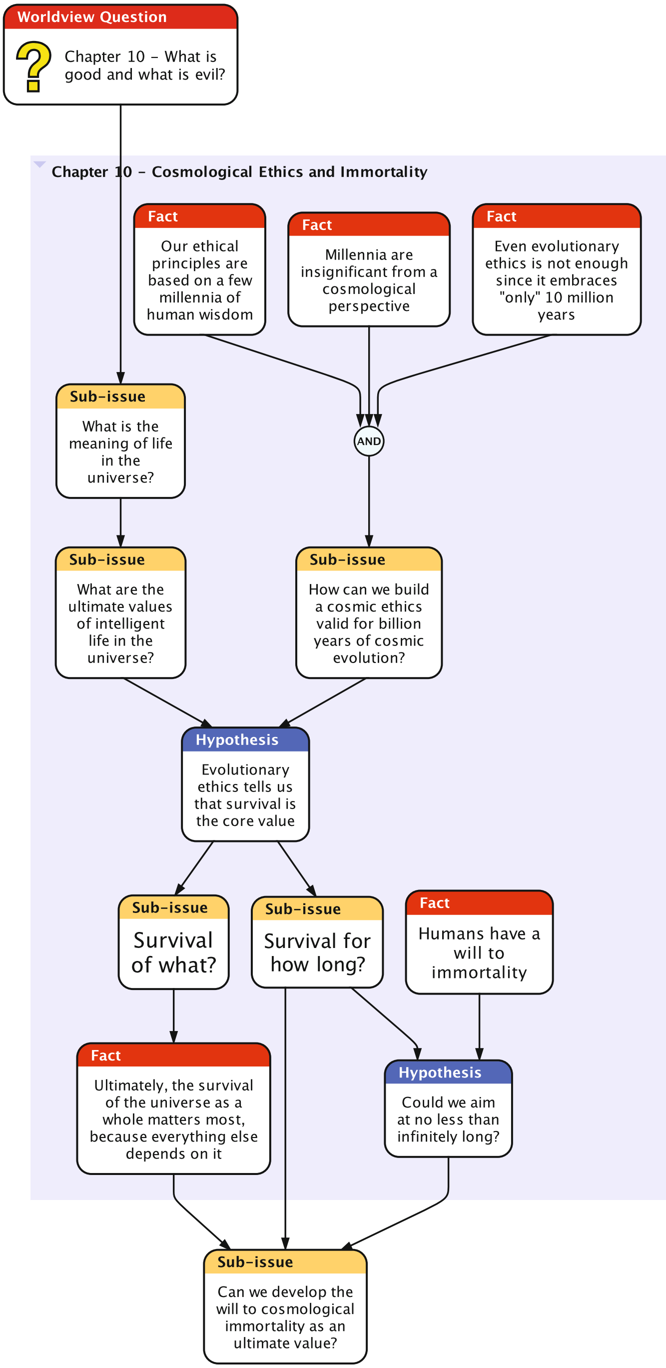


Fig. A.11 CRT of Chap. 10

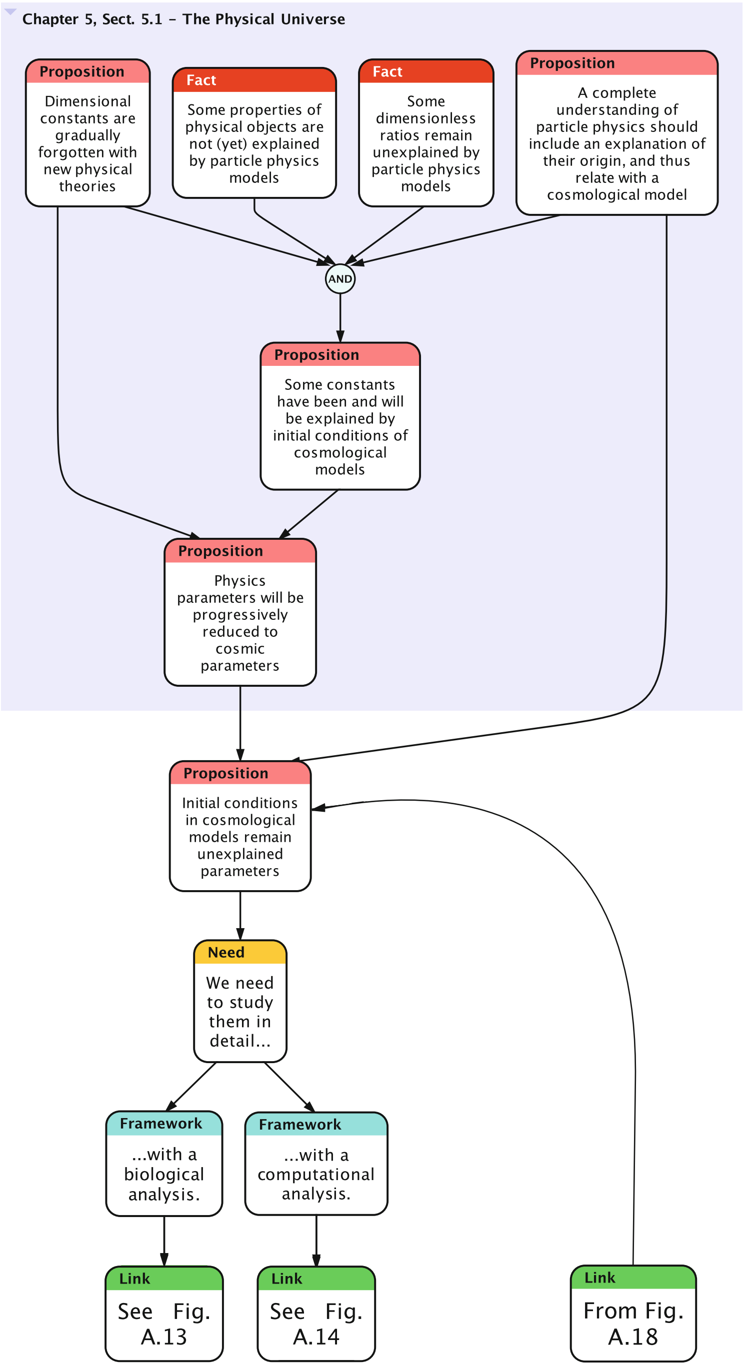


Fig. A.12 FRT of Chap. 5, Sect. 5.1

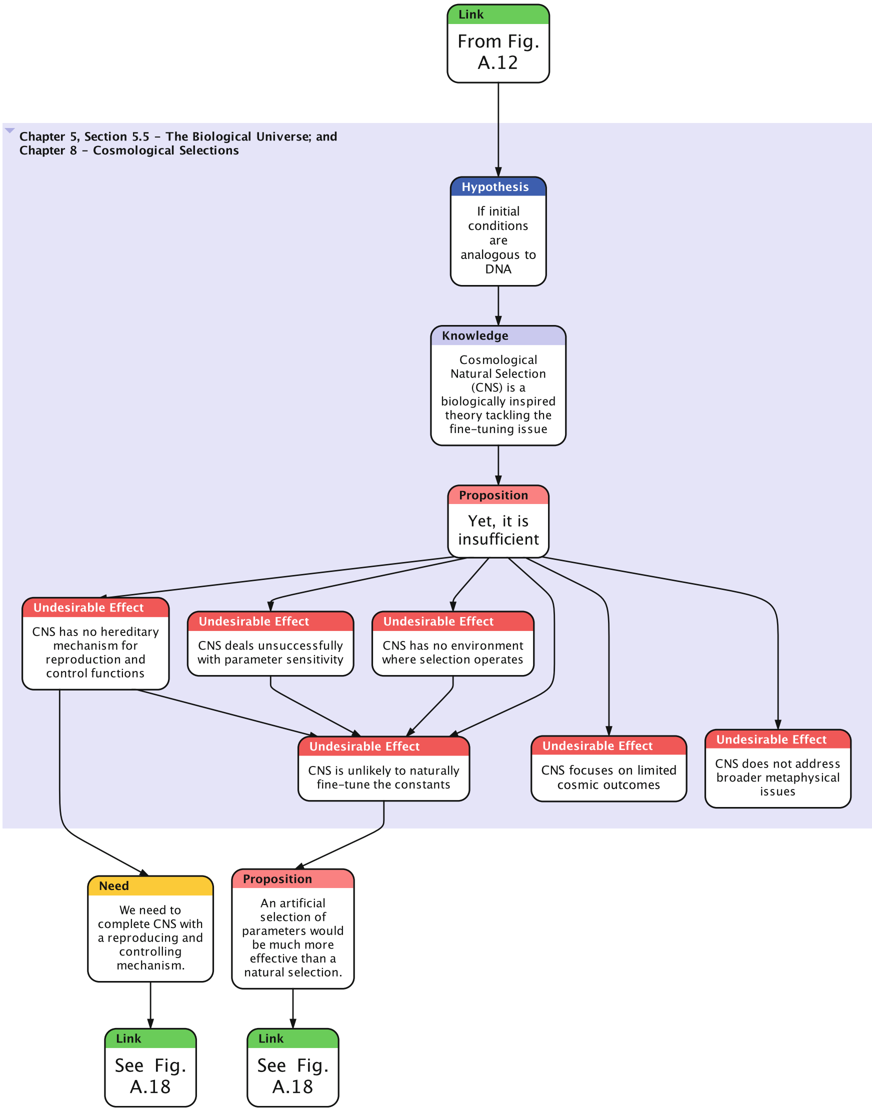
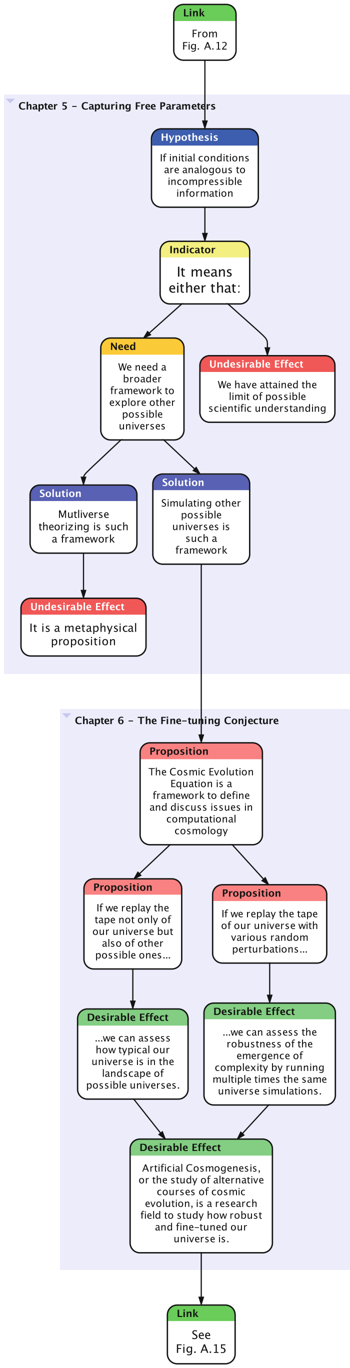


Fig. A.13 FRT of Chap. 5, Sect. 5.5 and Chap. 8

Fig. A.14 FRT of Chaps. 5 and 6



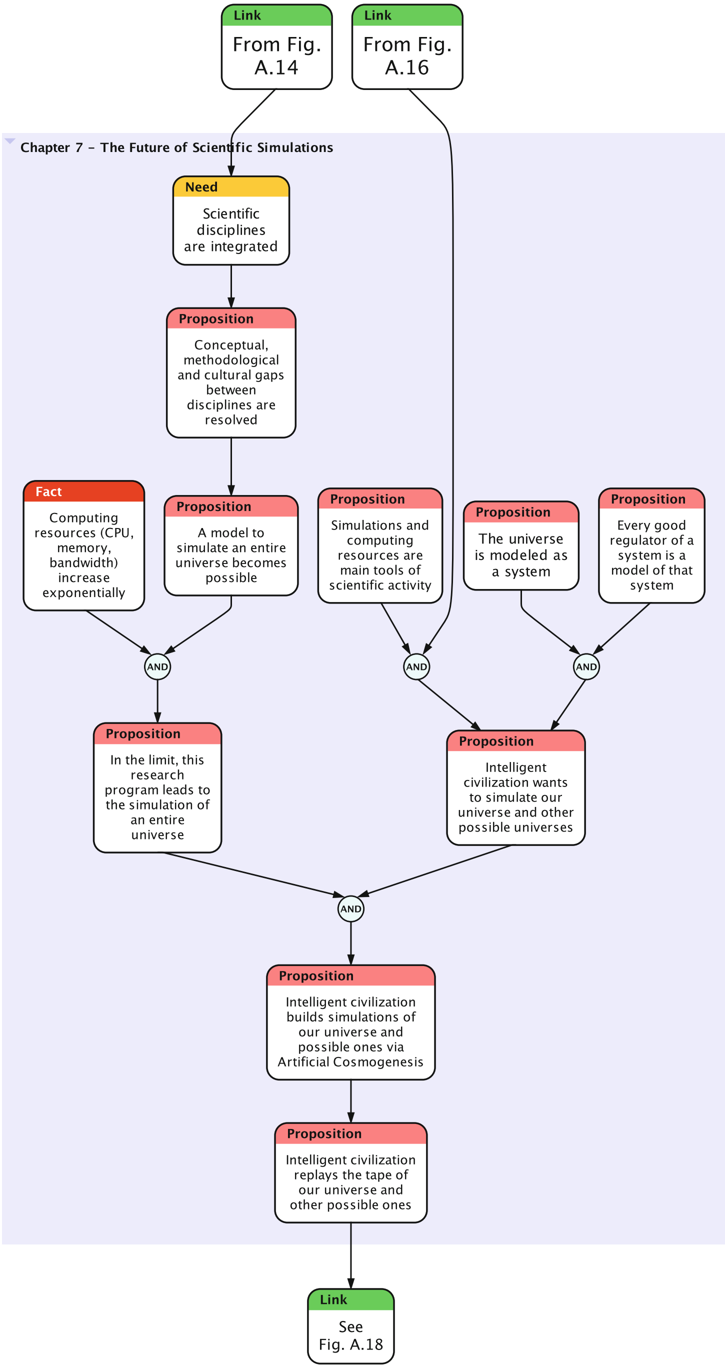


Fig. A.15 FRT of Chap. 7

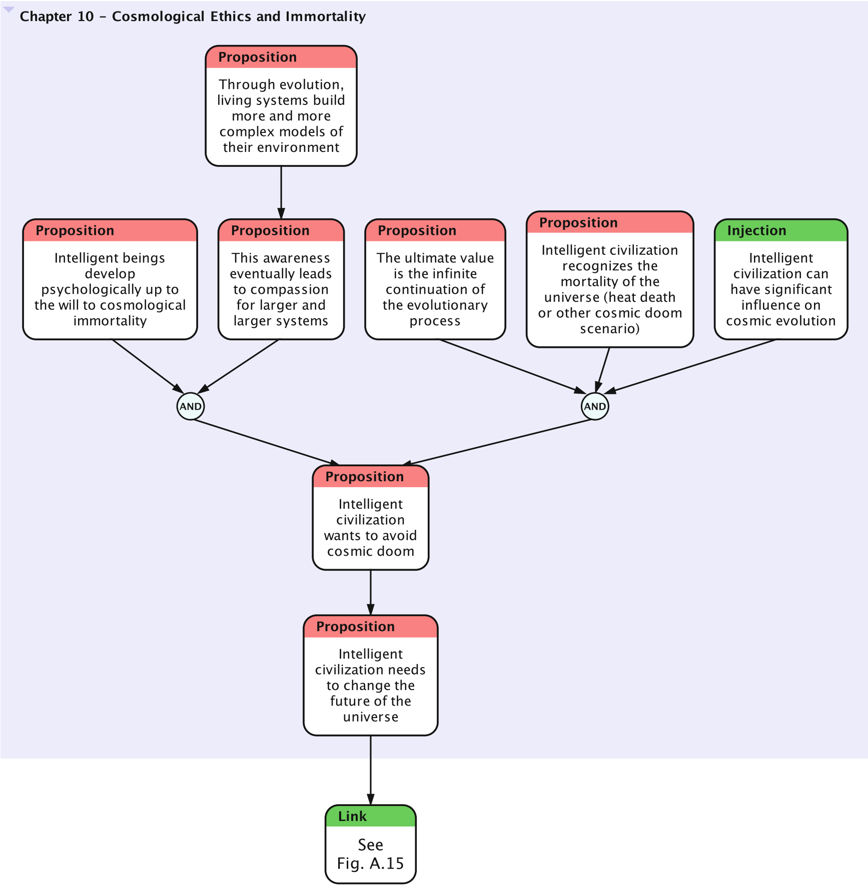


Fig. A.16 FRT of Chap. 10

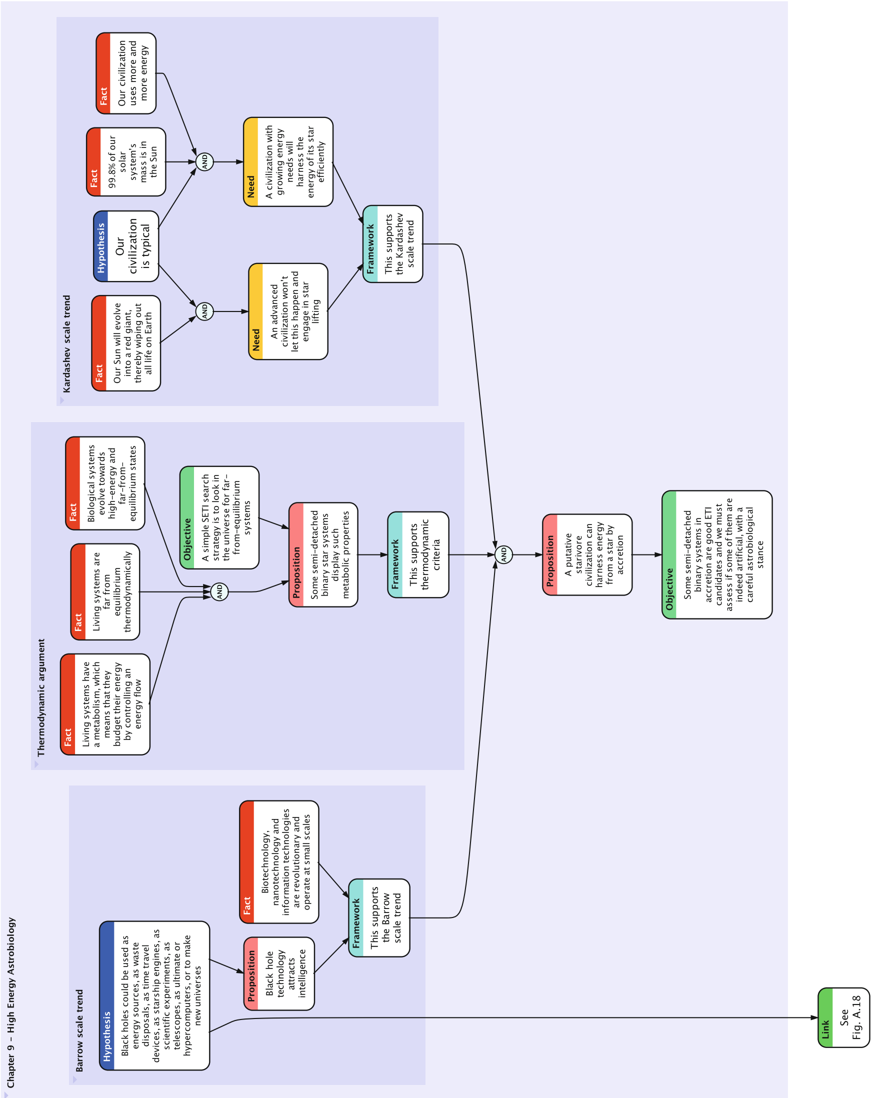


Fig. A.17 FRT of Chap. 9

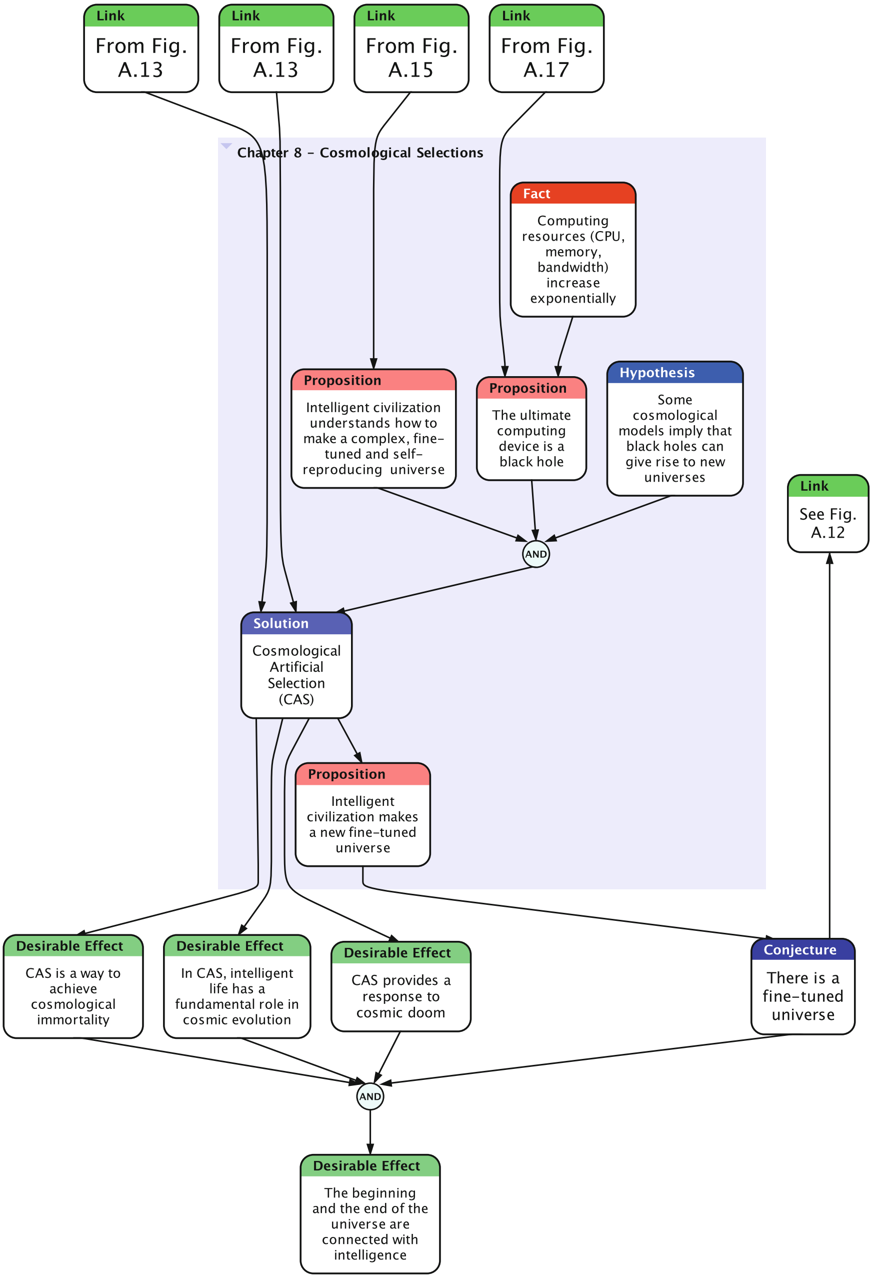


Fig. A.18 FRT of Chap. 8

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Clément Vidal

THE BEGINNING AND THE END

In this fascinating journey to the edge of science, Vidal takes on big philosophical questions: Does our universe have a beginning and an end, or is it cyclic? Are we alone in the universe? What is the role of intelligent life, if any, in cosmic evolution? Grounded in science and committed to philosophical rigor, this book presents an evolutionary worldview where the rise of intelligent life is not an accident, but may well be the key to unlocking the universe's deepest mysteries. Vidal shows how the fine-tuning controversy can be advanced with computer simulations. He also explores whether natural or artificial selection could hold on a cosmic scale. In perhaps his boldest hypothesis, he argues that signs of advanced extraterrestrial civilizations are already present in our astrophysical data. His conclusions invite us to see the meaning of life, evolution, and intelligence from a novel cosmological perspective that should stir debate for years to come.

"An outstandingly clear, comprehensive and systematic investigation of some of the deepest and most speculative questions of all times." Francis Heylighen, Director of the Global Brain Institute, research professor at the Free University of Brussels (VUB)

Dr. Clément Vidal is a philosopher with a background in logic and cognitive sciences. He is co-director of the ‚Evo Devo Universe' community and founder of the ‚High Energy Astrobiology' prize. To satisfy his intellectual curiosity when facing the big questions, he brings together many areas of knowledge such as cosmology, physics, astrobiology, complexity science, evolutionary theory, and philosophy of science.

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