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Ian Crawford *Editor*

Expanding Worldviews: Astrobiology, Big History and Cosmic Perspectives

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Expanding Worldviews: Astrobiology, Big History and Cosmic Perspectives

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Chapter 1
Introduction: Expanding Worldviews: Astrobiology, Big History and Cosmic Perspectives

Ian A. Crawford

> *The historical struggle, repeated now in ourselves, has always been to get a big enough picture; and we now stand at an exciting place: one world trying to figure out the others (Rolston 1986, p. 179)*[1]

> *The knowledge of humanity and nature, history and society, the knowledge that enlightens ethical and political choices and allows us to take our fate in our own hands, is not an illusion or failure of the past, but a goal for the future (Aerts et al. 1994, p. 11)*[2]

Astrobiology and 'big history' are both relatively new academic disciplines. Astrobiology is concerned with the evolution and prevalence of life in a cosmic context, while big history aims to integrate human history into the deeper evolutionary history of the Universe. Although there are differences in emphasis, and in the intellectual backgrounds of many of their practitioners, big history and astrobiology share much in common, especially their interdisciplinarity and the cosmic and evolutionary perspectives that they both engender. The interdisciplinary perspectives of both subjects have the potential to yield significant academic and scholarly benefits by helping to bridge the intellectual gulfs that have grown between academic disciplines and, perhaps especially, between C.P. Snow's (1959) "Two

[1]I am grateful to James Schwartz (2020) for reminding me of this quotation from Rolston.

[2]The context of this epigraph is a pushback by Aerts et al. (1994) against a 'post-modernist' doctrine, influential in some quarters, that any attempt to form a rational view of the cosmos and our place within it must necessarily amount to a meaningless, 'modernist', illusion. Rather, they argue that formulating a unified worldview, a key ideal of the Enlightenment, is essential if we are to avoid "a completely fragmented world, without any sense of direction and purpose." It is my hope that the chapters in this volume will, taken collectively, help to illustrate how the cosmic and evolutionary perspectives of astrobiology and big history may help in this endeavour.

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Cultures" of the sciences and the humanities. At the same time, the cosmic and evolutionary perspectives inherent in both disciplines may be expected to result in wider benefits to society, not least by enhancing public awareness of our place in the Universe and attendant environmental and socio-political corollaries.

In order to explore these relationships, and to investigate their wider societal implications, two meetings were organised a year apart on opposite sides of the planet. The first, *Expanding Worldviews: Astrobiology, Big History, and the Social and Intellectual Benefits of the Cosmic Perspective*, was held on 19 July 2018 at the Humanities Research Centre (HRC) of the Australian National University (ANU) in Canberra, while the second, *Expanding Worldviews: Astrobiology, Big History and Cosmic Perspectives*, was held on 19–20 September 2019 at Birkbeck College, University of London. Taken together, these two meetings provided a broad, if eclectic, overview of the interactions between big history and astrobiology, and their wider implications for society. Brief summaries have been given elsewhere (Crawford 2018, 2019), and this volume of Springer's *Astrophysics and Space Science Proceedings* now makes available formal, peer-reviewed, versions of seventeen of the papers presented at these meetings.

Earlier versions of five of these papers (specifically those by Elise Bohan, David Christian, Charley Lineweaver and Aditya Chopra, Mark Lupisella, and myself) were originally published in the *Journal of Big History*,[3] and I am grateful to the Editor, Dr. Lowell Gustafson, for permission to reproduce those articles, in whole or in part, in this collection. I thank the HRC at the ANU, and especially Professor Will Christie and Ms. Penny Brew, for financial and organisational support of the Canberra meeting, and for their hospitality during my stay as a Visiting Fellow in 2018. I am grateful to the Birkbeck Institute for the Humanities (BIH), the Birkbeck Centre for Legal Futures, and the UCL/Birkbeck Centre for Planetary Sciences for financial support of the London meeting, and to Ms. Lou Miller for help with the organization; I am grateful to Mukesh Bhatt for facilitating contacts with the BIH and the Birkbeck School of Law which resulted in funding for this meeting. Finally, I would like to thank Ramon Khanna for his support in publishing these proceedings, and to the editorial and production staff at Springer for their help in producing them.

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[3] https://jbh.journals.villanova.edu/issue/view/176. Accessed 6 Dec 2020.

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Chapter 2
"The Keen Longing for Unified, All-Embracing Knowledge": Big History, Cosmic Evolution, and New Research Agendas

David Christian

From my early youth I have had the strongest desire to understand or explain whatever I observed—that is, to group all facts under some general laws.
Charles Darwin (Autobiography)

We have inherited from our forefathers the keen longing for unified, all-embracing knowledge. The very name given to the highest institutions of learning reminds us, that from antiquity and throughout many centuries the universal aspect has been the only one to be given full credit.
Erwin Schrödinger (What is Life?)

Abstract This article offers an interpretation of recent attempts at the unification of knowledge. It argues that today's scholarly world is aberrant. It is splintered into distinct scholarly disciplines to such an extent that universities and research institutes have lost what Erwin Schrödinger called "the keen longing for unified, all-embracing knowledge." In contrast, most earlier human societies *have* valued the search for an underlying unity to human knowledge, a unity that was both conceptual and narrative, and often took the form of "origin stories". Unifying knowledge on the basis of modern science was also one of the central projects for

This chapter was originally published in the *Journal of Big History*, Vol. III(3), pp. 3–18, 2019; I am grateful to the Editor of JBH, Dr. Lowell Gustafson, for permission to reproduce that article here. It expands on and develops arguments presented earlier in Christian (2010, 2017a). I will use the labels "big history" and "cosmic evolution" to describe different approaches to the same unifying project. There is a rapidly growing literature; a start-up list might include: Chaisson (2001), Christian (2004, 2018), Stokes Brown (2012), Christian et al. (2014), Spier (2015), Rodrigue et al. (2015).

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the Enlightenment and for many nineteenth century thinkers. But at the beginning of the twentieth century, in every country in the world, knowledge was broken up into disciplines, to such an extent that most educators and researchers lost sight of the ancient hope of seeking an underlying unity to all knowledge. The essay describes the fragmentation of knowledge in the twentieth century and discusses reasons for that sea-change in the modern knowledge system. But it also argues that the period of extreme disciplinarity, in which the disciplines blocked the free flow of ideas between disciplines, may prove short-lived. The emerging transdisciplinary fields of "Big History" or "Cosmic Evolution" may herald a general scholarly return to a more balanced relationship between detailed research and the quest for large, unifying frameworks. This paper ends by speculating about how a return to the project of unifying knowledge may transform education, research agendas, and the institutions within which they take place. This chapter was originally published in the *Journal of Big History*, Vol. III(3), pp. 3–18 (2019).

1 Introduction

The epigraphs capture the central claim of this essay: that good education and research depend on a balance between detail and generality, between sharply-focused research, and the unifying intellectual frameworks that help us make sense of, and find meaning in, detailed research.

When Darwin wrote, the need for such a balance was well understood, and his own career offers a spectacular example of the extraordinary synergies that can be generated by connecting detailed research to deep, unifying ideas. Schrödinger wrote just after World War II, when scholars in most fields had abandoned the search for unifying ideas. His comment is a plea to re-establish a lost balance.

Today, we still live in an unbalanced scholarly world in which research normally means sharply focussed enquiry within the boundaries of particular disciplines. In such a world, research that tries to link ideas across many disciplines looks extreme, and (a bit like extreme sports) it can seem over-ambitious and unrealistic. But such projects seem extreme today only because of the emergence, early in the twentieth century, of structures that partitioned teaching and research between distinct scholarly disciplines. That change was so swift and so decisive that today few scholars show any interest in the unifying projects that were once the complement to all detailed research.

2 Coherent Worlds of Knowledge Before the Twentieth Century

So complete was the disappearance of the ancient quest for intellectual unity and harmony, that it can come as a shock to realize how important such unifying projects were for much of human intellectual history, and how recently they lost their centrality in most fields of scholarship.

Almost all human societies have constructed origin stories or creation myths: large, inter-linked collections of stories that summarize a community's best understanding of how things came to be as they are, by harmonizing many different types of knowledge.[1] Whether in small-scale societies with ancient oral traditions built up over many generations, or in societies with writing and institutionalized religious traditions, origin stories were powerful because they summed over a society's core understandings of reality. Origin stories shaped identities because they told you who you were, what you were part of, what roles you could play, and what roles you *should* play, so they usually structured how young people were educated.[2] As Marie-Louise von Franz (1995, Ch. 1) argues, creation myths "refer to the most basic problems of human life, for they are concerned with the ultimate meaning, not only of *our* existence, but of the existence of the whole cosmos." To take one random illustration, the thought world of Isaac Newton was framed from childhood to old age by the origin stories embedded within Christianity, and Newton's science flourished within these unifying stories. He thought of God as the "first cause", and once described the Universe as "the Sensorium of a Being incorporeal, living, and intelligent" (Westfall 1993, p. 259).[3]

It is important to avoid the common error of assuming that unifying projects must suppress diversity and dissidence. This was never true. Origin stories were always capacious enough to allow for disagreement. Isaac Newton, though a devout Christian, opposed the doctrine of the Trinity and was, technically (and discreetly) an "Arian", a denier of Christ's divinity (Westfall 1993). Similar tensions existed within all origin stories, and all religious and philosophical traditions. Indeed, as with modern scientific paradigms, it was the sharing of fundamental ideas that gave salience and significance to differences in interpretation, and sometimes made them worth fighting over. Modern descriptions of all "grand narratives" or unifying projects as necessarily monolithic and unchanging are simplistic caricatures.[4]

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[1] I have made this argument in Christian (2018). For an introduction to modern theories of "myth", and their relationship to modern thought and science, see Segal (2015).

[2] "In our creation myths we tell the world, or at least ourselves, who we are" (Leeming 2002, p. 36).

[3] Newton later abandoned the metaphor of a sensorium, but continued to believe that God was literally omnipresent in the Universe.

[4] That all myths evolve is the core argument of Leeming (2002); Tony Swain (1993) explores how indigenous Australian mythologies changed when faced with new, introduced origin stories, including those of Christianity.

As modern science emerged, it re-directed the quest for intellectual harmony and unity. The pioneers of modern science, and the major thinkers of the Enlightenment era, aspired to a new understanding of reality, and origin stories that would be based not on tradition, faith or authority, but on Reason and empirical research. "[W]e in effect propose a compleat system of the sciences," wrote David Hume (1739, Introduction) "built on a foundation almost entirely new, and the only one upon which they can stand with any security." Science, they believed, would set new standards for reliable knowledge, and release humanity from naïve trust in faith or authority. "Enlightenment," wrote Immanuel Kant (1794), "is man's release from his self-incurred tutelage [literally, *Unmündigkeit,* or "minority"]. . . [his] inability to make use of his understanding without direction from another. . . . *Sapere aude*! 'Have courage to use your own reason!'- that is the motto of enlightenment." Most Enlightenment thinkers were convinced that a better and more coherent understanding of reality would advance the progress of humanity as a whole (Pagden 2013, pp. 147 ff).

It is possible to identify two overlapping colours or qualities to the Enlightenment's unifying project, and it may be that the same two colours can be identified in all origin stories.[5] The first approach emphasises historical or narrative coherence, so it tends to take the form of stories or histories. It assembles diverse types of knowledge, like so many coloured tiles or pixels, into coherent accounts of how things came to be. Such narratives can be found at the heart of most religious traditions. The second approach can also yield large unifying narratives, but its primary emphasis is on conceptual unity, on the search for networks of ideas that are locked together tightly enough to provide a foundation for most of knowledge. Traditionally, this approach has shaped much theological, philosophical and mathematical thought, and today it can be found in unifying ideas such as General Relativity or Quantum Physics. The two approaches have always overlapped and reinforced each other. Thus, all the world religions contain large stories linked to logically rigorous foundational systems of ideas about how the Universe works.

The search for a science-based origin story flourished in Europe from the early eighteenth century. The search for conceptual unification drove the great intellectual systems of the nineteenth century, those of Hegel, Comte, Marx, Spencer and many others, though most of these systems also generated grand historical narratives. The emphasis on narrative unity shaped the natural histories of Buffon or the Universal histories of Voltaire, as well as nineteenth century universal histories, such as Alexander von Humboldt's multi-volume *Kosmos,* or Robert Chambers' *Vestiges of the Natural History of Creation,* which would have a profound influence on Charles Darwin (Spier 2008).[6] The deep desire to keep in touch with the underlying unity of life and the universe also drove much of the Romantic reaction against what

[5]In an important article on the emergence of big history, Eric Chaisson (2014) offers a similar, but not identical, distinction when talking of "two ways up the mountain."

[6]On Humboldt as a universal historian, see Spier (2015, pp. 18–21) and Wulf (2015).

they saw as the arid scientism and the extreme focus on detail of some scientific thought.

The quest for intellectual unity still flourished in the late nineteenth century, in both its conceptual and narrative forms. While James Clerk Maxwell showed that electricity and magnetism were different expressions of the same underlying force, the historian, Leopold von Ranke (often thought of as the primary exemplar of small-scaled historical research) warned against “the danger of losing sight of the universal, of the type of knowledge everyone desires. For history is not simply an academic subject: the knowledge of the history of mankind should be a common property of humanity . . .”.[7]

3 The Fragmented Knowledge World of the Twentieth Century

Early in the twentieth century, the unifying project vanished like a ghost at dawn. And it vanished so completely that, a century later, it is easy to forget how normal such projects once seemed. Two decades into the twentieth century, most scholarship and research was conducted within the well-policed borders of particular scholarly disciplines, and fewer and fewer scholars were willing or able to look for harmonizing concepts or stories that crossed multiple disciplines.[8] Those that tried, such as H.G. Wells (1920), were widely regarded as dilettantes, and had little impact on the academy. Suddenly, except in areas such as Physics, where unifying paradigm ideas such as General Relativity flourished, interdisciplinary research and scholarship began to seem extravagant, wasteful and unnecessary: a quaint intellectual hangover from an era in which scholars had not yet grasped their impossibility.

For most of the twentieth century, scholars and researchers inhabited an intellectual world whose borders were as well patrolled as those of modern nation states. An influential 1972 OECD report on interdisciplinarity noted the exclusivity and competitiveness of these new intellectual statelets. Each discipline, it argued, consisted of: “A specific body of teachable knowledge with its own background of education, training, procedures, methods and content areas,” and its own well-defined territories, interests, rituals and leaders, so that they often functioned like “autonomous fiefdoms” (Apostel et al. 1972, p. 9).

The idea of distinct scholarly disciplines is old, of course, as old as the first attempts to describe and certify specialist knowledge and skills. But in the narrower sense referred to here, “disciplines” emerged in the late nineteenth century, along with modern research universities (e.g., Turner 2017). German universities pioneered today’s combination of research and teaching within well-defined

[7]The Ranke quote is from “A Fragment from the 1860s” in Stern (1956, pp. 61–2).

[8]There are good introductory descriptions of the emergence of modern scholarly disciplines in Wittrock (2015) and Stichweh (2015).

discipline borders. But the model was soon copied elsewhere, and, in the early twentieth century it spread throughout the world.

> By the end of the nineteenth century a worldwide revolution in practice was beginning, ... The desire to emulate German universities led to the modern university in one country after another. Disciplines developed in association with licensing regulations or their de facto surrogates, and disciplinary organizations developed to define portions of academic turf. By 1910 the modern disciplines, and the modern research university, had been defined (Turner 2017, p. 18).

In many ways, the turn towards extreme disciplinarity was a success. The disciplines provided containers for research agendas that might otherwise have grown unmanageably. Within those safe spaces, research flourished throughout the twentieth century.

But the achievements came at a cost. Discipline-based research flourished, a bit like potted plants, because it was confined. Where thought threatened to sprawl unmanageably, the disciplines pruned over-reaching branches and root systems, creating the intellectual equivalent of a bonsai garden. As Fred Spier puts it: “In the real world, everything has remained connected with everything else. As a result of the ongoing ‘disciplinification’ of universities, however, this important insight, familiar enough to Alexander von Humboldt, was lost” (Spier 2008, p. 144). Modern education blinkered the educated, creating the world of mutually uncomprehending scholarly tribes that C.P. Snow lamented in his famous 1959 Rede lecture on “The Two Cultures” (Snow 1963). In 1963, Snow wrote (p. 60):

> Persons educated with the greatest intensity we know can no longer communicate with each other on the plane of their major intellectual concern. This is serious for our creative, intellectual and, above all, our normal life. It is leading us to interpret the past wrongly, to misjudge the present, and to deny our hopes of the future. It is making it difficult or impossible for us to take good action.

In such a world, as Martin Kemp (2009)[9] wrote: “a gulf of understanding has opened up by the time students enter university.”

The problem is not so much the existence of disciplines, as the fact that the disciplines have tended to block the free movement of ideas. In 1998, E.O. Wilson argued that the borders between disciplines were blocking fundamental research in many areas. The success of research *within* disciplines was creating more and more dead zones *between* disciplines, where new questions accumulated only to be ignored by discipline-based researchers, until they withered in an academic no-man’s land of extreme aridity (Fig. 2.1).

Here, each quadrant represents a distinct research world, with its own rules, its own criteria for good research, its own funding mechanisms, journals, and measures of prestige and success. But, he wrote, close to the borders between disciplines, “we find ourselves in an increasingly unstable and disorienting region. The ring closest to the intersection, where most real-world problems exist, is the one in which fundamental analysis is most needed” (Wilson 1998, p. 8). Though vibrant and productive

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[9]My thanks to Ian Crawford for this reference

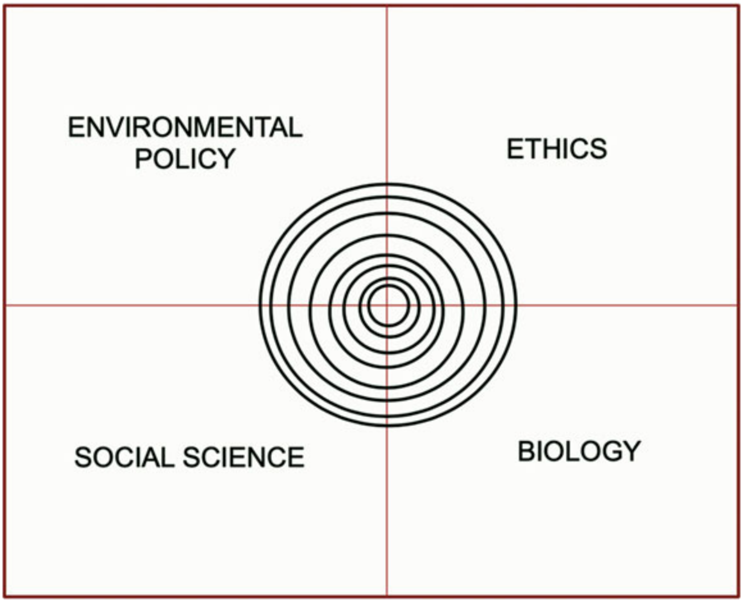

Fig. 2.1 Why consilience is difficult. Adapted from Wilson (1998, p. 8)

within their boundaries, the disciplines were creating intellectual dead zones at their borders. Insert into Wilson’s diagram other disciplines such as Anthropology, Neuroscience, History, and Primatology and you find, in the dead zone at their borders, the most fundamental question of all for the Humanities: what is it that defines our own species and explains why we are so unusual?

What explains this sudden fragmentation of knowledge that empowered and limited education and research for a century? Increasing government management of education and research, driven by the increased role of governments during the world wars, encouraged a focus on specific problems and a high degree of institutional compartmentalization. But two other powerful forces were also at work: the spectacular increase in new information in the nineteenth century, and scepticism about the failure of earlier attempts at intellectual unification.

Today, it is easy to forget how terrifying and destabilizing was the tsunami of new knowledge created by the earthquake of industrialization. In a famous passage in the *Communist Manifesto,* Marx and Engels wrote: “All fixed, fast-frozen relations, with their train of ancient and venerable prejudices and opinions, are swept away, all new-formed ones become antiquated before they can ossify. All that is solid melts into air, all that is holy is profaned,. . .” No universal systems or stories seemed robust enough to survive unscathed in a world of such intellectual turmoil, none of the ancient religious or philosophical systems, and not even the more modern systems of the great Enlightenment thinkers. The disciplines provided intellectual shelters from the hurricane of new knowledge.

The second reason for abandoning the unifying projects of the Enlightenment was that none of these projects really worked. The success of Newton's system was not matched in history or sociology or even in the sciences, and early in the twentieth century Einstein showed that even Newton's physics needed adjusting. Besides, the French Revolutionary Terror, and the bloody history of the nineteenth century undermined the Enlightenment's intellectual optimism, by showing that Reason, science and new types of knowledge could serve oppression as well as progress. Scepticism was magnified by the world wars of the early twentieth century and the rise of totalitarian systems sustained by science and claiming to be built on Reason. One of the most influential modern critiques of Enlightenment thought, Horkheimer and Adorno's (2002) *Dialectic of Enlightenment,* was written in the shadow of the Nazi death camps, which had put modern scientific knowledge to the most evil of ends.

In retrospect, most of the large nineteenth century systems and unifying stories do indeed look more like ideologies than science. That was because the science behind them was too thin to build robust intellectual systems, and had to be padded out with much speculative wadding. Though the nineteenth century did yield powerful unifying ideas, such as Darwin's theory of evolution, or Maxwell's unification of electricity and magnetism, there also appeared many pseudo-scientific systems of thought, such as phrenology, or Social Darwinism. These undermined the credibility of the Enlightenment project, and encouraged a turning away from unifying schema towards less ambitious scholarly agendas. The retreat from unifying projects was almost universal in the Humanities disciplines, which lacked the paradigm ideas that kept hopes of unification alive in the natural sciences. Historians reacted against the "scientific history" of Marx and his followers. And Anthropologists turned away from pseudo-scientific accounts of human progress, towards detailed studies of particular cultures. "In cleansing historical and cultural analysis of their nineteenth-century ideological baggage," write Shryock and Smail, "most of the high modern (and postmodern) versions of cultural anthropology and history turned their backs on the deep human past . . ." (Shryock and Smail 2011, p. 294).

But the structure of distinct disciplines inhibited the search for deep unifying ideas even in the natural sciences. In 1944, Erwin Schrödinger wrote:

> . . . the spread, both in width and depth, of the multifarious branches of knowledge during the last hundred odd years has confronted us with a queer dilemma. We feel clearly that we are only now beginning to acquire reliable material for welding together the sum total of all that is known into a whole; but, on the other hand, it has become next to impossible for a single mind fully to command more than a small specialized portion of it (Schrödinger 2000, p. 1).

4 Critiques of Hyper-Disciplinarity

As this passage suggests, there survived within the fragmented world of distinct scholarly disciplines a deep nostalgia for a lost world of intellectual cohesion. And it may be that the ideal of some sort of universalism survived better beyond the

Atlantic world. Marxist traditions in the Soviet Union and China preserved the ideal of universal knowledge, though in forms that were archaic and constricted by censorship; but survival of the ideal may help explain the profoundly inter-disciplinary ideas of Soviet astrobiologists such as Iosif Shklovksy, and geologists such as Vladimir Vernadsky, who pioneered the idea of a biosphere.[10] And small numbers of scholars in many different parts of the world continued to insist on the importance of transcending discipline boundaries and preserving a sense of the underlying unity of knowledge and research.[11]

In the early twentieth century, and particularly in the Atlantic world, nostalgia for some sort of intellectual coherence shaped much modern art, literature, philosophy and scholarship. Yeats' poem, "The Second Coming", captures that nostalgia and the terror of living in a world without intellectual unity or meaning.

> Turning and turning in the widening gyre,
> The falcon cannot hear the falconer;
> Things fall apart; the centre cannot hold;
> Mere anarchy is loosed upon the world,
> The blood-dimmed tide is loosed, and everywhere,
> The ceremony of innocence is drowned;
> The best lack all conviction, while the worst
> Are full of passionate intensity.

The yearning for a lost intellectual unity drove many scholarly attempts to cross disciplinary borders, but few made much headway because there was now little institutional support for genuinely transdisciplinary research, particularly in Europe and North America. Erwin Schrödinger wrote, forlornly:

> I can see no other escape from this dilemma (lest our true aim be lost for ever) than that some of us should venture to embark on a synthesis of facts and theories, albeit with second-hand and incomplete knowledge of some of them–and at the risk of making fools of ourselves (Schrödinger 2000, p. 1).

By the middle of the twentieth century, education, scholarship and research were so deeply embedded within the matrix of disciplines that even the most successful attempts at unification were no longer seen as unifying projects, but as attempts to travel between disciplines. It was the disciplines that now seemed fundamental rather than the networks of knowledge that linked them. Their borders seemed to map reality itself. As Wordsworth, a lifelong seeker of unity, wrote in *The Prelude* (Book 2):

> In weakness we create distinctions, then
> Deem that our puny boundaries are things
> Which we perceive, and not which we have made.

Attempts to unify knowledge were increasingly described as "interdisciplinary research". Interest in interdisciplinary research blossomed in the 1960s. The 1972 OECD report on interdisciplinarity that has already been mentioned argued that

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[10] On Soviet writing on big history, see Nazaretyan (2005). For Soviet pioneers of astrobiology, see Grinspoon (2016, pp. 301–26); see also Vernadsky (1998).

[11] A famous example is Jawaharlal Nehru, *Glimpses of World History*, a world history published in 1942 and written in prison.

scepticism about science arose from "specialised applications of knowledge, without a corresponding development of the synthesising framework which can illuminate their side-effects and long-term implications" (Apostel et al. 1972, p. 10). Interest in interdisciplinary research was also driven by new research areas, such as genetics or gender studies, that overflowed existing disciplinary boundaries.

There were also some spectacular examples of the synergies that could be released by interdisciplinary expeditions. Erwin Schrödinger's attempt to cross disciplines in his book, *What is Life?* provides a good example. Here was a physicist writing about a fundamental problem in biology. Schrödinger argued that life and reproduction must involve a sort of coding in large molecules, in which a small number of components could be arranged and re-arranged like letters in an alphabet. He suggested, therefore, that the chromosomes inside cell nuclei might each consist of what he called "an aperiodic crystal or solid" (Schrödinger 2000, pp. 60–62). That idea inspired a generation of biologists, including the discoverers of the structure of DNA. Indeed, Francis Crick, though originally a physicist, switched to biology and origin-of-life research after reading Schrödinger's book (Watson 1973, p. 23).

By the 1970s, there were increasing demands for more interdisciplinary research. The first major conclusion of the influential 1972 OECD report on interdisciplinarity was that: "Interdisciplinary teaching and research are the key innovation points in universities," in part because interdisciplinarity can "help the drift of science and research towards unity". But the report's second major conclusion was that the scholarly disciplines made the quest for unity extremely difficult. "Introducing this innovation comes up against enormous difficulties . . .", above all because of "The organization of universities into monodisciplinary Schools or 'Faculties' which jealously protect their branch of knowledge . . ." (Apostel et al. 1972, p. 12).

The mid twentieth century vogue for interdisciplinarity generated new university and research structures and spawned new composite disciplines, such as biochemistry or environmental science. And that is why, today, some forms of interdisciplinary research are familiar and well-funded. But the return to unifying projects was hesitant, partial and limited, and took several different forms. New typologies were constructed to describe different degrees of interdisciplinarity. The most widely used categories have been "Multidisciplinarity", "Interdisciplinarity" (in a non-generic sense) and "Transdisciplinarity" (Apostel et al. 1972, pp. 25–26).

"Multidisciplinarity" refers to a loose linking of disciplines, often around a common problem or research agenda, while the individual disciplines ". . . continue to speak as separate voices in encyclopedic alignment. Underlying assumptions are not examined and the status quo remains intact." "Interdisciplinarity" refers to a closer integration of disciplines that: "integrates separate data, methods, tools, concepts theories and perspectives in order to answer a question, solve a problem, or address a topic that is too broad or complex to be dealt with by one discipline. . . . in interdisciplinary fields a new body of knowledge emerges" (Klein 2005, pp. 1034–1035; see also Klein 2017).

Finally, "Transdisciplinarity" takes us even closer to the unifying projects of the Enlightenment. Transdisciplinarity refers to an even closer integration of methods and insights from different disciplines that points towards "an over-arching synthesis that transcends the narrow scope of disciplinary worldviews" (Klein 2005, pp. 1034–1035). Julie Klein describes the most ambitious forms of transciplinarity as: "... the epistemological quest for systematic integration of knowledge" (Klein 2017, p. 29). In a world of disciplinary fiefdoms, transdisciplinarity, the most integrated form of interdisciplinary scholarship, made the least headway. It remains rare and poorly funded, and has had a limited impact on most of the Academy, despite the existence of some specially designed transdisciplinary institutions such as the Santa Fe Institute for Complexity studies.

5 The Re-emergence of Unifying Projects from the Late Twentieth Century

Despite all this, in the late twentieth century and early twenty first century there have been some promising signs of a return to the unifying projects of the past.

Transdisciplinary thought and research made most headway in the Natural Sciences, where they were buoyed by new paradigm ideas, including Big Bang Cosmology, the Standard Model of Particle Physics, Plate Tectonics and the modern Darwinian synthesis (see also Crawford 2019; this volume). Some scientists even began to dream of super-paradigms or "Grand Unified Theories" that would capture the fundamental rules by which our Universe was constructed. But the new paradigms also encouraged the quest for narrative coherence, because they were all historical in nature. They all described how the Universe, planet Earth, and life had evolved over vast periods of time. The Harvard astronomer, Harlow Shapley (who once described the splitting of knowledge between disciplines as "education-defeating"; Shapley 1963, p. 134), advocated for university curricula that: "would present the history of the universe and mankind as deduced from geology, cosmogony, paleontology, anthropology, comparative neurology, political history, and so on. ... wide integration is the essential key" (Shapley 1963, pp. 135–136). And he was as good as his word, teaching such courses at Harvard for several decades, before his successor, Carl Sagan, built from them a wildly popular television series, "Cosmos." Similar courses were taught in the Soviet Union by Iosif Shklovksy, in France by Hubert Reeves, and in Austria by Erich Jantsch (Chaisson 2014, p. 87).

In the late twentieth century, several scientists wrote synthetic works that combined conceptual and narrative coherence over large areas of knowledge. They included histories of the Earth by Preston Cloud, histories of the Universe by the astronomers George Field and Eric Chaisson, and the astrophysicists Erich Jantsch and Siegfried Kutter (Spier 2008, p. 144). In the 1990s, Eric Chaisson wrote a history of the Universe built around the central theme of increasing complexity, driven by increasingly dense flows of energy (Chaisson 2001). He called his unifying project "Cosmic Evolution", using a phrase first introduced in the late 1970s by George Field (see Field et al. 1978; Chaisson 2016). Fred Spier would later offer a theory of universal history that focussed on the emergence of "regimes" or semi-stable structures of many different kinds, an idea that had been partially prefigured in the work of Erich Jantsch (Spier 1996).

Scholars in the Humanities took longer to embark on serious transdisciplinary journeys, partly because the Humanities did not generate paradigm ideas as persuasive as those that emerged within the Natural Sciences. The unifying ideas that did emerge within disciplines such as Economics or Sociology or Archaeology were always contested, unlike some of the big ideas in the natural sciences, which were so widely accepted that they achieved the status of Kuhnian paradigms (Kuhn 1970). The "pre-paradigm" nature of most Humanities disciplines encouraged a focus on specifics, and a deep scepticism about attempts at intellectual unification, or the construction of "grand narratives".

Nevertheless, even in the Humanities disciplines, there were large, general problems, such as the rapidly increasing human impact on the biosphere, that encouraged some researchers to travel tentatively between disciplines (Klein 2011, p. 15). And the historical narratives emerging within the natural sciences encouraged some scholars to seek links between their own historical narratives and the large-scale narratives emerging within Cosmology, Geology and Palaeontology. Though most historians remained sceptical of the idea of universal history, fearing a return to the unsuccessful historical schema of the nineteenth century, some were attracted by the challenge of linking human history to the emerging histories of the biosphere, planet earth and the Universe as a whole. They were inspired, not only by the new unifying narratives being constructed within the natural sciences, but also by the fact that the science was so much richer and more rigorous than it had been in the nineteenth century. That encouraged hopes for unifying stories free of most of the non-scientific intellectual baggage of the less successful nineteenth century systems.

New dating methods also transformed the task of constructing universal histories. When H.G. Wells (1920) wrote a history of the Universe, he could offer no reliable absolute dates for any event before the first Greek Olympiad. All earlier events disappeared into a chronological fog. In the 1950s, new dating techniques were developed, based on the breakdown of radioactive materials. Radiometric dating allowed the construction of reliable chronologies reaching, eventually, to the origins of the Universe. These dates provided the chronological spine for a rigorous, science-based modern origin story.[12]

To scholars from the Humanities, unification meant, almost inevitably, *narrative* unification rather than the *conceptual* unification sought by scholars in the natural sciences. For scholars in the Humanities, the challenge was to link stories told in many different disciplines into a coherent universal account of the past. What larger plot lines could be seen, and what new themes and forms of coherence would emerge if you tried to weave together the stories told by cosmologists, astronomers, geologists, biochemists, palaeontologists, anthropologists and historians?

[12] A crucial work here was Colin Renfrew's (1973) classic study of the implications of radiometric dating for archaeology; see also Christian (2009).

My own experience of approaching these challenges as a historian may be fairly typical. When I first tried to teach a big history course embracing the whole of time, in 1989, I invited scholars from many different disciplines to lecture on the core ideas of their disciplines. My colleagues and I watched to see what would come out of the mix. What we got was a brilliant tour of modern paradigms alongside a rather loose account of human history. But the stories did not cohere, because lecturers spoke to the major themes of their disciplines, used the methods and jargon with which they were familiar, and had little time to build bridges *between* disciplines. I began to fear that big history courses would remain “interdisciplinary” in the most limited sense. They could not transcend the disciplines, and could, at best, serve up a sort of intellectual smorgasbord.

Over several years, though, broader plot-lines and a deeper coherence began to appear. It became apparent that one major narrative theme was the emergence of many forms of complexity, at many different scales, from galaxies to viruses to human civilizations. That theme raised deep questions about the creativity of the Universe as a whole, and about the relationship between complexity in the human world and complexity in the biosphere and the Universe as a whole. Watching unifying themes emerge over several years was a bit like watching a developing photograph in the chemical bath of a traditional photographic dark room. And the gradual appearance of unifying themes showed that the difficulties of seeking unified knowledge arose not from the intrinsic difficulties of the project, so much as from the habits of thought that dominated a world of distinct scholarly disciplines.

Since the late twentieth century, many scholars have taken up the challenge of constructing “big histories” or modern origin stories, and they have done so in many different parts of the world which suggests that there is an emerging “global conjuncture” around the idea of such projects (Rodrigue 2017). Today, there is a growing scholarly literature on big history, and big history courses are being taught in a number of universities, mostly in the USA, Australia and the Netherlands. Online courses in big history have also been developed for high schools, through the “Big History Project” (generously supported by Bill Gates) and, in 2018, through “Big History School” (supported by Macquarie University), which includes a Primary School curriculum in big history.[13]

6 New Transdisciplinary Projects and New Research Agendas

The final section of this essay is frankly speculative. If the changes described in the previous section are early signs of a scholarly return to more transdisciplinary research and thought, what impact will this have on the research landscape?

[13]These are available, respectively, at https://www.bighistoryproject.com/home and http://www.bighistoryschool.org/.

A world in which the unification of knowledge is taken seriously will be intellectually more balanced than today's world. The disciplines will survive, not just because of institutional inertia, but also because they serve many useful functions. And they will continue to shape research at smaller scales. But as transdisciplinary research becomes more important, the disciplines will have to become more sensitive to developments in neighbouring fields and in scholarship as a whole. Disciplinary boundaries will have to become more flexible, more permeable and more open to transformative changes.

To support, fund, and offer career paths to the increasing number of scholars drawn to transdisciplinary problems, new institutions will be needed to link disciplines and encourage more traffic between them. Amongst those most drawn to unifying projects, something of C.P. Snow's distinction between the cultures of the sciences and humanities will surely survive. But the differences will no longer arise from mutual incomprehension, but rather from sustained dialogue, in which some scholars will focus mainly on the narrative coherence between different fields, while others focus on the conceptual challenge of teasing out unifying paradigms.

A more unified knowledge world will transform school syllabi. But the changes need not be complex, and most of the existing infrastructure of education will remain in place. Most traditional disciplines will survive. But new, unifying disciplines will emerge, such as "Big History", which can help students see the underlying coherence of modern knowledge, and the many links between traditional disciplines. Such courses already exist, and they offer students the metaphorical equivalent of a journey to the top of the mountain, from where they can see more clearly what links different disciplines as well as what divides them. If such courses were to become standard components of school curricula throughout the world, they could provide students, as traditional origin stories once did, with a coherent vision that they could take with them into adult life.

In universities, too, teaching within existing disciplines will no longer create intellectual blinkers if students are also exposed to courses that help them see the unity beneath modern disciplines. Such courses are already being taught in many universities, and there already exist rich resources, both printed and electronic, to support their teaching.

A return to the unifying project of the Enlightenment may have its greatest impact in advanced research environments, which is where they have had the least impact so far. Today, scholars attracted by the challenges of transdisciplinary research struggle to gain recognition, to raise funding, and to find scholarly support. But a world that takes such projects more seriously will surely take more seriously the intellectual and institutional challenges faced by those researchers most interested in transdisciplinary research.

What will unifying research projects look like? We already have some answers because paradigm builders such as Darwin and Einstein have shown that there are deep, powerful unifying ideas waiting to be discovered by those who look for them. And there are areas of research where the need for unifying ideas is apparent to everyone, such as the challenge of linking Relativity Theory and Quantum Theory. Both theories work spectacularly well, yet one assumes a granular universe while the other does not. What are we missing? In the Humanities, the question that may drive unifying agendas most powerfully concerns the distinctiveness of our own species. What makes humans different, so different that our species is now dominating change in the biosphere?[14]

These large questions offer good models for unifying research in general, because to pursue them, scholars will have to link methods, insights, concepts, terminology and perspectives from different disciplines. Their task will be to translate between disciplines. Can you translate the concept of entropy, which does extraordinarily powerful work in the natural sciences, into the Humanities? Is the historian's "decline and fall" similar to the physicist's "entropy"? Is there enough common ground between the two concepts that, with some tweaking we may find ways of describing entropy that can inform research in the humanities? Much the same is true of concepts like information (do acoustic engineers, quantum theorists, geneticists and historians mean the same thing when they use the word?), or complexity, or energy.

The task is also to tweak how concepts are used at different scales, because many concepts work well at some scales and less well at others (e.g., Christian 2005). One of the most fundamental problems in contemporary science is how to make Quantum Physics work not just at the atomic scale but also at the cosmological scales of relativity? For the historian, concepts such as energy or information are too general to be helpful in most types of historical research, so the abstract concepts do not loom large in historical discussions, though specific forms of energy and information are woven into all historical narratives. Can we link these different levels of explanation, and will doing so prove illuminating? (Christian 2017b). The transdisciplinary challenge here is to check that the concepts used at different levels are aligned logically. That is a bit like assembling a conceptual ladder, all of whose rungs are part of the same system even though particular users may use a small part of the ladder. Or perhaps a better metaphor is a Mandelbrot set, in which each level seems very different from other levels despite some eerie similarities and despite the fact that all levels are generated by the same equation.

There are huge intellectual synergies awaiting scholars who can reformulate fundamental ideas so as to extend their reach and the amount of useful intellectual work they can do. Network theory is another field that promises huge synergies if its methods and ideas can be extended beyond their existing range. I have tried myself to use network theory to understand the accumulation of knowledge within and between different types of human communities (Christian 2004), and the Israeli historian, Irad Malkin, has shown how network theory can illuminate our understanding of ancient Greece (Malkin 2011).

[14] My own attempt at such ideas is the notion of "Collective Learning", which I have developed in *Maps of Time* (Christian 2004) and elsewhere. That idea is close to, and overlaps with many other attempts to tackle the same question; see Alex Mesoudi (2011) for a fine recent survey of the rich body of research surveying cultural change from a Darwinian perspective.

In addition to re-working and extending existing concepts, unifying research projects will surely generate new unifying concepts as well, ideas that can do useful work across large intellectual spaces. Many such ideas already exist. Eric Chaisson has explored the idea that the density of energy flows may provide one way of measuring and explaining different levels of complexity in a Universe in which the upper levels of complexity seem to have increased over time. Is this an idea that can help us make sense of phenomena as diverse as stars, solar systems, cellular life, ecosystems and human history? Fred Spier has argued for the usefulness of the idea of "regimes" in universal history. There have been many attempts to extend the concept of natural selection beyond the biological realm that first generated it, as a way of explaining increasing complexity through what Richard Dawkins describes as Universal Darwinism. In a famous essay called "Blind Variation and Selective Retention", Donald Campbell (1960) argued that, whatever the domain, evolution needs "a mechanism for introducing variation, a consistent selection process, and a mechanism for preserving and reproducing the selected variations." Do similar mechanisms explain emerging complexity in human cultures, or even in Cosmology, or in Quantum Physics, as some have argued? (Christian 2014). Whatever answers eventually emerge to such questions, these are rich and profound research agendas that will be very hard to pursue successfully until the world of scholarship returns once more to the unifying projects of the Enlightenment.

Unifying research agendas, requiring plenty of conceptual translation, will also emerge in response to complex, transdisciplinary problems. Environmental history offers a good model, as historians and climatologists and ecologists and scholars in many different fields have reached out towards each other to create what is now a vibrant and strategic transdisciplinary research field. Closely related, and driven by similar synergies, is the rapidly expanding field of "Anthropocene" studies. Understanding the planet-changing impacts of human activities in the twentieth century is a task that requires the sharing of insights and perspectives from historians, economists, climatologists, palaeontologists, biologists, geologists, and more.

These guesses about the research agendas and approaches of a world that takes seriously Schrödinger's "longing for unified, all-embracing knowledge" are all based on developments that are already apparent. Today's scholarly world may be slowly recovering the ancient balance between detailed and unifying knowledge. And doing that is increasingly urgent in a world that faces the colossal challenge of managing an entire planet, a challenge that cannot even be seen clearly through the narrow lenses of existing scholarly disciplines. The discipline-based scholarly world of the twentieth century generated such rich knowledge in so many fields that it should now be possible to return to the unifying projects of the Enlightenment, and tackle the new problems of the Anthropocene with a rigour and richness, and a global scholarly reach, that was unthinkable before the twenty first century.

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Chapter 3
From Planetary Dynamics to Global Trade and Human Genetics: A Big History Narrative

Lewis R. Dartnell

Abstract Big History is an academic enterprise engaged in combining many different fields within the sciences and humanities to provide a more complete, long time-frame perspective on human history. Such an interdisciplinary approach is particularly useful within education for providing teachers and students an interdisciplinary understanding of the causative processes behind major themes and trends of history. Presented here is a Big History narrative that explores the chains of cause and effect between intrinsic features of planet Earth and the course of global history from the early modern period. It traces the deep connections from the circulation dynamics of the Earth's atmosphere, to the trans-oceanic trade routes established during the Age of Exploration, and the pattern of European colonisation and empire-building in these earliest stages of globalisation that built our modern way of life, and finally to the genetic diversity of populations of people living across the Americas today. Along the way, it will also illustrate the links to seemingly-unrelated topics, such as why many industrial cities developed with an affluent, fashionable west-side contrasting against working-class slums in the East End, and why the Mason-Dixon line separating the Union and Confederate states in the American Civil War and the Great Wall of China both fundamentally follow ecological boundaries.

1 Introduction

Big History (Christian 1991), like astrobiology, is an inherently deeply interdisciplinary field of enquiry. It combines, for example, aspects of astrophysics, planetary sciences, geology, geography, evolutionary biology and anthropology to explore the

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ultra-*longue durée* of human history. It is 'Big' in many senses of the word: encompassing a broad diversity of related topics, operating across huge temporal scales and considering a global perspective, and dealing with profound, fundamental concepts. To consider these diverse factors in historical studies provides a richer and more complete understanding of why the past played out the way it did, and thus account for the state of the world we live in today, and inform us on the challenges and opportunities of the future.

Much of modern education is tightly compartmentalised; the class material prescribed by subject-focussed curricula without a great deal of discussion of common links or over-arching themes between different topics. History lessons are on a Monday, Geography on a Wednesday morning and Biology on Thursday, with minimal cross-fertilisation between departments, textbooks or coursework. This structurally-engendered discretisation of education today does not reflect the true interconnectedness of causative processes in science or history, and is in stark contrast to the wide-ranging interests and activity of the natural philosophers leading the Enlightenment and Scientific Revolution, and indeed to the way that much cutting-edge research is now being conducted in deliberately interdisciplinary teams.

Big History bridges across these divides between academic domains and so embraces a more all-encompassing narrative. Such a joined-up-thinking approach provides essential context and can deliver a much more representative and enriching perspective—an interdisciplinary gestalt—to education for both teachers and students.

What follows here is an example narrative within Big History. It traces the deep connections from the circulation dynamics of the Earth's atmosphere, to the trans-oceanic trade routes established during the Age of Exploration, and the pattern of European colonisation and empire-building in the earliest stages of globalisation that built our modern way of life, to the American Civil War, and finally to the genetic diversity of populations of people living across the Americas today. Along the way, it will also illustrate the links to seemingly-unrelated topics, such as why the Californian coast was so geostrategically critical for hundreds of years, or why many industrial cities developed with an affluent, fashionable west-side contrasting against working-class slums in the East End.

As an example of Big History, this tour therefore combines physics and planetary science, patterns persisting across centuries of early modern history, and human genetics. This account represents a more in-depth exploration and extension beyond the material covered in a chapter of the book *'ORIGINS: How the Earth Shaped Human History'* (Dartnell 2019). *ORIGINS* explores how different features of the planet we live on—from plate tectonics to the underlying geology and past climate change—have deeply affected the trends and themes of world history, and still influence current affairs and politics today. This is not to claim that human factors have not of course been crucial in our history, but to show that beneath these proximate drivers of human agency and cultural, social, economic and political factors there lay deeper strata of cause and effect that relate to planetary processes. All of the educational resources created alongside the published book are available at www.teachers.originsbook.com.

2 The Age of Exploration and Early Globalisation

The Age of Exploration, or the Age of Discovery, in European history (and the age of invasion and colonisation from the perspective of much of the rest of the world), began in the early fifteenth century. Navigators from the Iberian peninsula—the kingdoms that would become Portugal and Spain—ventured beyond the Mediterranean to discover the archipelagos of Madeira and the Azores, which served as stepping stones drawing sailors further out into the Atlantic ocean, and the coast of West Africa. Portuguese sailors were initially motivated by the search for the source of the gold being brought north across the Sahara by camel, and later in a determined effort to find the southern tip of Africa and thus a sea route to India and the riches of the spice trade.

After spending the best part of the century sending successive exploration missions progressively further down the western coastline of Africa, the Portuguese finally succeeded, with Vasco de Gama's 1497 expedition, in rounding the continent's southern tip and crossed the Indian Ocean, demonstrating the gateway for a maritime route between Europe and Asia. Christopher Columbus had in 1492 attempted to pioneer a western route to the Orient, but instead encountered the Americas and opened up a whole New World for exploitation by European powers. Where the Portuguese and Spanish had led the way, the Dutch, English and French were soon to follow, pursuing their own overseas ambitions in mercantilism, colonialism, and empire-building.

Within a generation, European sailors ventured across all the world's oceans and completed the first circumnavigation of the Earth. The trade routes they established spanned vast distances of ocean and knitted together the continents in a way that had previously never been seen—a revolution that heralded the birth of today's globalised economy.

All of this was made possible because mariners had begun to understand the global pattern of prevailing winds and ocean currents around the world, and how to link them together to plot reliable return routes across the seas (Paine 2013).

3 The Global Wind Machine

In simple terms, the global pattern of winds works like this. Sunlight warms the surface of the Earth around the equator, heating the low-lying air and evaporating a lot of water. This warm air rises and cools as it reaches higher altitudes. The moisture it holds condenses into clouds and falls as rain. This is why the tropical zone astride the equator is characterised by dense rainforests. At high altitude, the risen air mass diverges and splits to the north and south. Each of these arms travels around 3000 km before sinking back towards the ground again, at around 30° latitude—roughly one-third of the way between the equator and poles. Thus this solar-driven convection current creates two bands of 'subtropical highs' around 30° in the northern and southern hemispheres with the descending air, and leaves behind a region of low air pressure wrapped around the equator. The air descending back to the surface from high altitude is very dry, and cloudless, and so these two bands of subtropical highs are the major cause of deserts around the Earth: the Sahara, Arabian and Syrian deserts, and Mojave and Sonoran deserts in the northern hemisphere, and the Atacama, Kalahari and Australian desert in the southern hemisphere.

To complete this great convection current, the air must return to the equator from the subtropical highs at 30° north and south along the Earth's surface: what we know as winds. Thus, situated on either side of the equator are two immense atmospheric convection systems—the Hadley cells—like tubes wrapped around the planet, and rolling in opposite directions (Hadley 1735; Webster 2004).

The only other important factor for understanding the global pattern of winds is that while the atmosphere is undergoing this great vertical circulation, the entire planet is rotating. Because the Earth is a solid sphere, this means that the surface at the equator is moving faster than that at higher latitudes. So as the air returns from the subtropical highs towards the equator the ground beneath turns eastwards faster and faster. In essence, the winds blowing towards the equator get left behind by the rotating surface with the result that they are effectively deflected in a smoothly curving path towards the west. This is known as the Coriolis effect, and it influences anything moving over the surface of a rotating sphere.

Figure 3.1 shows the circulation systems in the planet's atmosphere on either side of the equator that create the global pattern of alternating bands of easterly and westerly winds blowing across the Earth's surface.

3.1 Trade Winds, Westerlies, and the Doldrums

Winds blowing in the Northern Hemisphere are deflected by the Coriolis effect to their right, and those in the Southern to their left. Thus between the latitude of 30° north and the equator the prevailing winds follow a curved path towards the southwest, and so by the nomenclature for winds are called northeasterlies. And the same is true in the Southern Hemisphere: the air returning north along the surface to the equator is again deflected towards the west to produce prevailing southeasterly winds. These easterlies are known as the trade winds, and as reliable winds blowing through the tropics they have been absolutely crucial for mariners. Thus, the zone of prevailing trade winds either side of the equator has the same underlying cause as the bands of tropical rainforests and subtropic deserts around the planet: the Hadley cells of atmospheric circulation.

The band where the returning northeasterly and southeasterly trade winds meet each other around the equator is termed the Intertropical Convergence Zone (ITCZ) by modern atmospheric scientists. But sailors know this region of the sea by a different name: the doldrums. This region of low-pressure air, characterised by light winds or periods of dead calm, can prove disastrous for ships as they wait for the winds to pick up again or an ocean current to carry them out. A ship could be

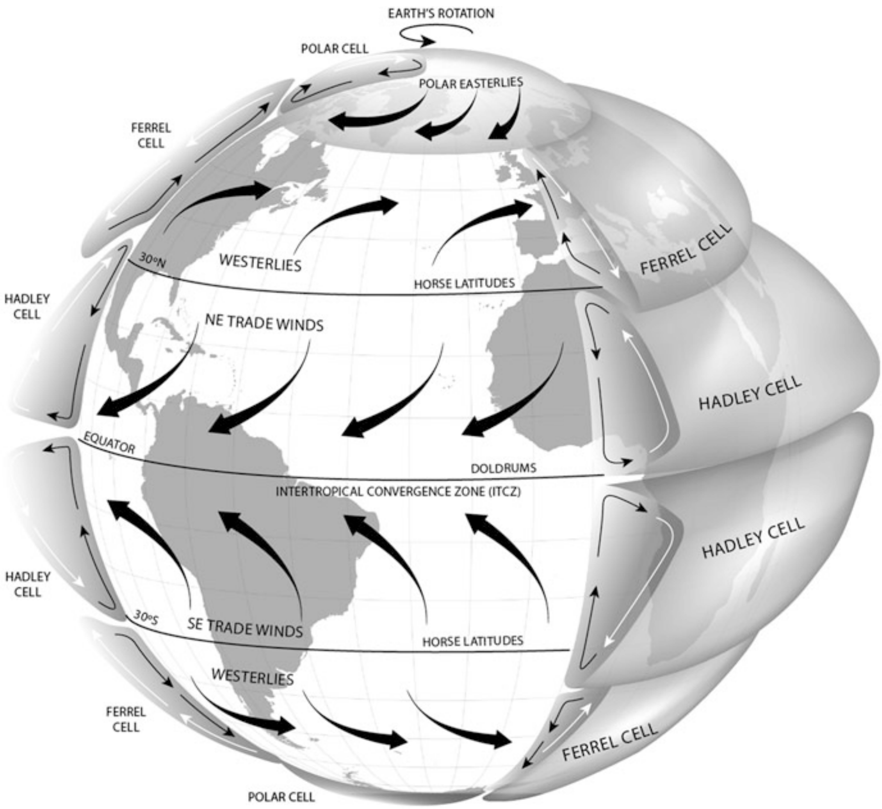

Fig. 3.1 The grand circulation currents in the Earth's atmosphere that create the global pattern of alternating bands of prevailing winds. (Figure designed by the author and drawn for *ORIGINS* by Matthew Broughton, based on Lutgens and Tarbuck 2000, and Wells 2012)

stuck becalmed in the doldrums for weeks, and in this equatorial region of hot and muggy climate it may mean not only a delay in delivering your cargo back to port but it can also spell death as onboard supplies of fresh water run out. The location of the ITCZ is determined by rising air warmed by the sun, and so it shifts north and south with the seasons. Furthermore, because land warms up more quickly than the ocean in summer, the ITCZ band is pulled further away from the equator by the continents. It therefore follows a decidedly sinuous, snakelike path around the waistline of the world. This makes the exact location and width of the ITCZ hard to predict, and increases the risk of sailors getting caught out in the doldrums.

Another pair of great convection cells in Earth's atmosphere are located beyond the Hadley cells, closer to the poles. At around 60° north and south the surface air, although cooler than at the equator, is still warm enough to rise into the atmosphere and drive another convection loop. Similarly with the Hadley cells, the surface winds blowing back towards the equator at the bottom of this loop are deflected to their right by the Coriolis effect, producing the band of winds called polar easterlies.

The third and final pair of grand circulation currents in the Earth's atmosphere are the two Ferrel cells, operating in the middle latitudes between 30° and 60°. Unlike the two already described, however, this Ferrel system is passive: it's not directly driven by its own rising warm air, but by the rolling of the Hadley and Polar cells it nestles between. It's analogous to a freewheeling gear being forced round by two powered cogs turning on either side of it. The descending arms of both the Ferrel and Hadley cells merge at around 30° north and south, forming two subtropical ridges of high pressure known as the 'horse latitudes'. These regions are also characterised by light, variable winds or calm conditions; and so, like the doldrums, sailors learned to be wary of them.

A crucial factor that enables long-range maritime trade routes—oceanic return-trips between the continents—is that because the Ferrel cell is driven by the Hadley and Polar cells on either side it turns in the opposite direction. The surface winds of the Ferrel cells blow not towards the equator but to the poles, and therefore the Coriolis effect deflects them in the opposite direction. The Ferrel cell provides a zone of westerly winds. Thus, the system of global atmospheric circulation provides two different latitude bands of surface winds blowing to the west—the trade winds of the Hadley cell and the polar easterlies—but if you want to sail back east again you can only do that within the realms of the two Ferrel cells and the westerly surface winds they produce. For example, Christopher Columbus complete his trans-Atlantic round-trip by following the trade winds from the Canary islands to landfall in the Bahamas 5 weeks later. To complete the return voyage he first needed to sail further north to encounter the band of westerlies that bore him back towards Europe.

3.2 Ocean Gyres and Currents

This system of alternating bands of winds between the equator and the poles also drives the grand patterns of surface currents in the world's oceans. These ocean currents have also been crucial for the establishment of global trade—because water is so much denser than air, even a gentle current can have a much greater effect on a sailing ship than the wind. The neighbouring zones of the easterly trade winds and the westerlies blow the surface water in opposite directions. This, coupled with the fact that the continents block the water from simply circling the world, and that water moving north or south across the globe also feels the Coriolis effect, creates great wheeling surface currents known as ocean gyres. There are five major gyres, in the North and South Atlantic, North and South Pacific, and in the Indian Ocean. These ocean gyres turn clockwise in the northern hemisphere, and anticlockwise in the southern, and like the direction of the wind bands they mirror each other over the equator.

The Canary Current coursing along the North African coast is the eastern arm of the North Atlantic gyre, and was well known to Phoenician and later Iberian sailors. The Gulf Stream, bearing warm waters from the Caribbean up to Northern Europe, forms the western arm of the same gyre. The Gulf Stream was discovered in 1513 when Spanish explorers sailing south along the coast of Florida realised they were being pushed backwards despite sailing with a strong wind. The commercial implications were immediately realised: heavily-laden galleons needed only slip into this wide, fast-flowing river within the ocean to be readily carried north and then round with the westerly winds back home (Winchester 2011). The Brazil Current, running along the east coast of South America, is the mirror-image counterpart of the Gulf Stream and carries ships south into the zone of the westerly winds which they then pick up for rounding Africa into the Indian Ocean.

The picture overall, therefore, is that in each hemisphere the atmosphere enveloping the planet is divided into three great circulation cells, like giant tubes wrapped around the world, each rolling in place and shifting north and south slightly with the seasons. These produce the major wind zones of the planet—easterly trade winds, westerlies and polar easterlies—which in turn drive the circulating ocean currents. The dominant pattern of winds around the Earth can therefore be explained with just three simple facts: the equator is hotter than the poles, warm air rises, and the world spins. (The seasonally-reversing system of monsoon winds is regionally important for the Indian ocean and south-east Asian archipelagos, but will not be discussed in greater depth here).

We are normally oblivious to this invisible churning of the planet's atmosphere high above our heads, but it can be discerned in a global view of the world. Fig. 3.2a shows an averaged view of the Earth (Kröger 2018) created from VIIRS weather satellite imaging data by taking the per-pixel median over the whole year of 2018. Snow and ice shows up clearly along mountain ranges like the Alps, Andes and Himalayas, as well as Siberia and Canada. Of most interest here are the regions of persistent cloud made starkly visible by this annual average. The relatively narrow equatorial band of rising air within the ICTZ is conspicuous across the Pacific and Atlantic oceans, as are the more nebulous cloudy regions over the Amazonian, central African and Indonesian rainforests. The trade winds are rendered visible as they blow this rainforest moisture off the western coasts. This is the rising arms of the Hadley convection cells made apparent by condensing water vapour in this averaged Earth view. Just as notable are the two bands where the planet's surface is clear, the manifest absence of clouds over the Sahara, Arabian, Kalahari and Australian deserts—marking the dry, descending arms of the Hadley cells around 30° north and south.

Another dataset makes clear how these systems of atmospheric circulation can be exploited by sailing ships taking defined routes between the bands of prevailing surface winds. We'll return in Sect. 4 to how these transoceanic trade routes were developed over the sixteenth and seventeenth centuries, but Fig. 3.2b shows a global picture for the early nineteenth century before steamships became dominant (Schmidt 2018). Each of the 950,000 points on this map represents the latitude and longitude coordinates of ships recorded in their logs, over the period 1784–1863. These numerous ships' logs entries, including wind, current and weather observations, were compiled by Captain Matthew F. Maury in the latter half of the nineteenth century, this collection then copied to microfilm in 1981, and digitised in the '90s as Deck 701 of the International Comprehensive Ocean-Atmosphere Data Set

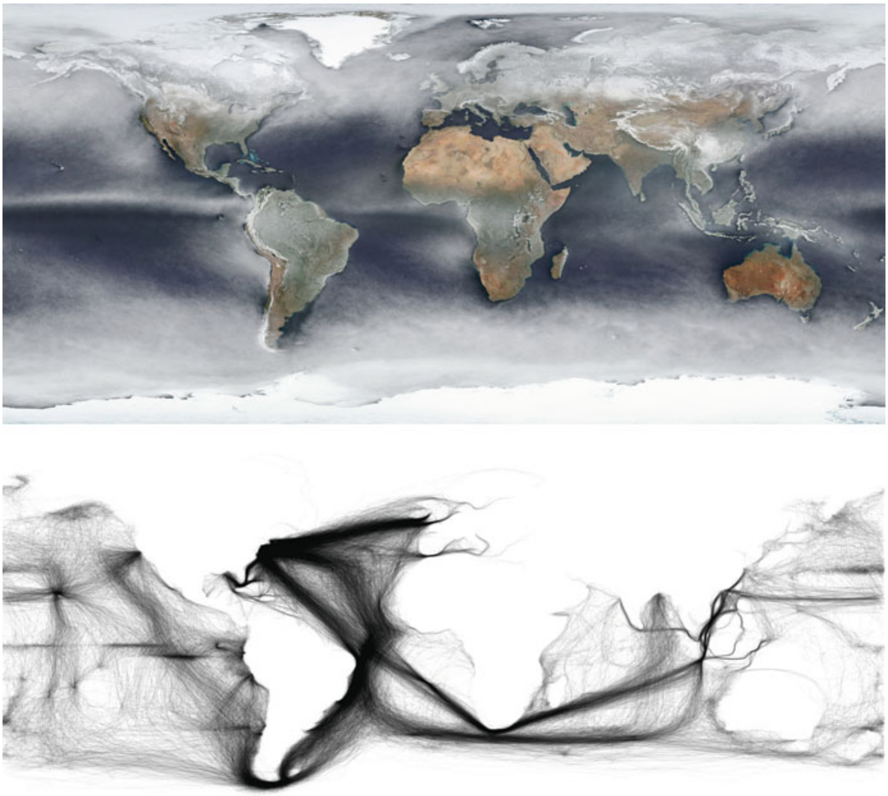

Fig. 3.2 (Top) The ‘Average Earth’ generated from a full year of satellite imagery. Persistent clouds along the equator, or their absence within the desert latitudes of 30° north and south, make visible the grand circulation currents within the Earth’s atmosphere. (Bottom) Maritime trade routes during the Age of Sail as revealed by ships’ positions recorded in captains’ logs. (‘Average Earth’ created by Kröger 2018, using VIIRS weather satellite imaging data. Ships’ logs map created by Schmidt 2018. Both reproduced with permission)

(ICOADS). This dataset is of US shipping (and so there is bias in the geographic spread of this dataset), but it nonetheless provides a clear demonstration of how the dense tracks of many ships reveal the global pattern of winds.

The outline of the continents are discernible in Fig. 3.2b from coastal shipping, and major ports like New Orleans, Portland, Callao, Liverpool, and Hong Kong are readily identifiable, as is the activity of whaling ships off the Alaskan coast. This plot clearly reveals the bustling route across the North Atlantic with the westerly winds, as well as ships heading down the West African coastline with the Canary current, or rounding Cape Horn between the Atlantic and Pacific (the Panama canal was not opened until 1914). The passage east to India can be seen taking a wide loop around the South Atlantic gyre, past Cape Town and then along the Brouwer route riding the Roaring Forties across the Indian Ocean; with the westward return route taking a much more northerly course with the trade winds. Traffic across the Indian ocean is funnelled through either the Sunda Strait between Java and Sumatra, or the Strait of Malacca to the north-west—the gateways into the East Indies and thus geostrategically critical chokepoints. Hawaii stands out in the mid-Pacific like a magnet governing field-lines of iron filings: shipping crossing to Japan and China with the trade winds, and returning again along a more northerly tract within the band of westerlies.

Also apparent are horizontal streaks running across the equatorial Pacific. Curiously, they don't seem to correspond to any particular port, island, or shipping route. In fact, these are the doldrums made visible—a trap for sailing ships, with the captains' logs recording many days spent becalmed in the unreliable winds of the ITCZ. The less prominent horizontal line much further south, off the western coast of Chile, relates to the Juan Fernández islands. This archipelago was a popular stop for British and American whaling ships (and incidentally was where Alexander Selkirk became marooned in 1704—the inspiration for Robinson Crusoe) after rounding Cape Horn. Even with chronometers for determining longitude, however, the islands were often difficult to find and so captains navigated to the correct latitude (easily calculated by sextant) and sailed along that parallel until they encountered the archipelago.

3.3 Prevailing Winds and Eastenders

Another enduring outcome of these wide bands of prevailing winds has been a clear east-west dichotomy in the development of cities across Britain and Northern Europe. For example, since the eighteenth century the disparity between the west and east halves of London has grown, with areas like Mayfair, Belgravia and Fitzrovia in the West developing as affluent, desirable places to live, characterised by spacious townhouses built around green squares, in stark contrast to the working-class slums of tenements and narrow streets in the East End of the city (Joyce 2003).

Northern Europe, which spearheaded the process of industrialisation, use of coal for domestic heating, and dense urbanisation, lies within the Ferrel cell of atmospheric circulation—the band of westerly prevailing winds—and so all of the smoke from factory stacks and household chimneys (and prior to the construction of underground sewer systems, the stench of effluence in the river as well) blew downwind towards the east. Those who could afford to do so lived in the west of the city and the working classes were left in the more polluted East End.

This argument linking the latitude and prevailing winds to social partitioning in industrialising cities may be slightly confounded in the case of London because the Thames also flows eastwards and thus the docklands and its workforce were located downstream where the river is wider. But this east-west pattern has been found in many other cities too. Heblich et al. (2016), for example, plotted the locations of industrial chimneys in 70 industrial English cities in 1880 and used an atmospheric dispersal model to map the spread of air pollution. They found that not only did the wind-blown pollution from smokestacks explain the deprivation of different neighbourhoods through the nineteenth century, but that these urban disparities persist today even though the smoke pollution has waned.

4 Transoceanic Trade Routes

The grand circulation cells in Earth's atmosphere and the bands of prevailing winds they generate were also critical to centuries of global development through the Age of Sail. As European navigators decoded the secrets of the planet's wind patterns and ocean currents they reached across the great expanses of the world's oceans, linked formerly unconnected regions of the planet, and began the process of globalisation (Paine 2013). The Age of Exploration was therefore not just a process of filling in the world map with strange new lands, but also of discovering invisible geographies. European sailors learned how to use the alternating bands of planetary winds and wheeling ocean currents like a great interlinked system of conveyor belts, to carry them where they wanted to go.

With their large, cannon-wielding ships and experience of building strong fortifications born of centuries of incessant warfare in Europe, the Portuguese rapidly asserted their dominance across the Indian Ocean and south-east Asian archipelagos. By 1520, the income from Portugal's control of the spice trade provided nearly 40% of the Crown's total revenue (Brotton 2013). Portugal had created a new kind of empire, made powerful and wealthy not through possession of large areas of territory but by the strategic control of sprawling oceanic trade networks on the other side of the world—an empire of water. The Spanish conquered the civilisations they encountered in the Americas and likewise grew rich on this plunder. The New World, and the new maritime routes to India and the Orient, offered Europeans access to a seemingly inexhaustible trove of territory and resources, wealth and power. And where the Spanish and Portuguese had led the way, the Dutch, British and French followed. The rivalry between these marine trading powers triggered colonial wars around the world as they attempted to eject each other from strategic ports and forts, and control chokepoints to dominate the critical sea passages.

The early exploration ships were slender-hulled and rigged for the greatest manoeuvrability around unknown coastlines, and in particular for beating into the wind. But these small caravels with triangular 'lateen' sails required large numbers of expert crew and had little stowage space for cargo alongside the necessary provisions. The ideal design for transoceanic trade, on the other hand, is a broad ship rigged with large square sails, which is much simpler to handle and so minimises the crew size whilst maximising the hold space for supplies and profit-making cargo. These square-rigged ships, exemplified by the Spanish galleons, catch a great deal of motive force but can only ever ride with the wind: beating against the breeze is virtually impossible (Rodger 2012). This meant that in contrast to the early years of exploration, the trade routes that came to establish the European imperial presences overseas were strongly dictated by the direction of the prevailing winds,

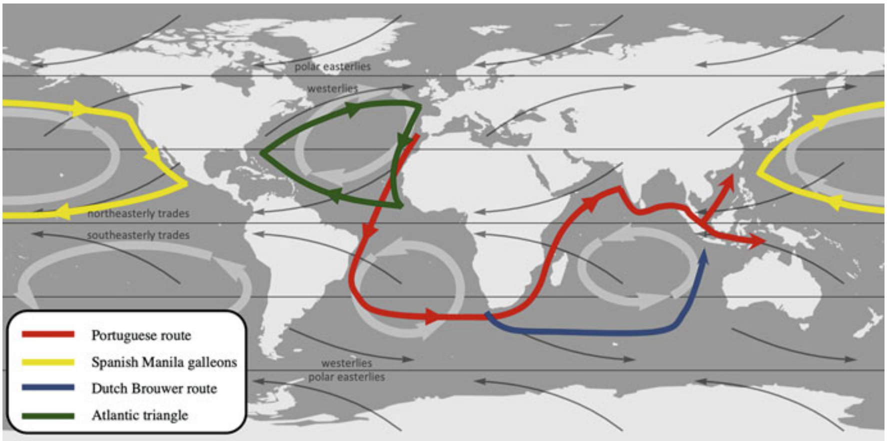

Fig. 3.3 The major European oceanic trade routes during the Age of Sail, navigating between different bands of prevailing winds and currents of the ocean gyres. (Figure created by the author using information from Jones et al. 2004; Bernstein 2009; Winchester 2011; Wells 2012)

and this had profound implications for patterns of colonisation and the subsequent history of our world. The three most important of these were the Manila Galleon Route, the Brouwer Route and the Atlantic Trade Triangle, depicted in Fig. 3.3.

4.1 Manila Galleon Route

While the Portuguese were establishing their trade empire in South East Asia, the Spanish were exploring their possessions in the Americas. By 1513 a Spanish explorer had trekked across the Panama isthmus and became the first European to set eyes on the ocean on the far side: *Mare Pacificum*—the Peaceful Sea (Brotton 2013). The Spanish began looking for their own westward maritime route to the Orient from the Americas. From Central America, ships can follow the trade winds across the Pacific to the Philippines and Spice Islands, or to trade with China. Realising that the pattern of winds in the Pacific replicates that of the Atlantic, Spanish navigators sailed north from the Philippines as far as the coast of Japan before picking up the band of westerlies (in the Ferrel circulation cell of the atmosphere) that carried them back across the Pacific (Bernstein 2009). This discovery enabled the Spanish to bridge the vast Pacific Ocean with regular round-trip shipping, the Manila Galleon Route. This ran between the colonies of New Spain in Acapulco, in present-day Mexico, and Manila in the Philippines for 250 years—from 1565 to 1815, ending with the Mexican War of Independence (Fish 2010).

The main cargo carried west across the Pacific on this route was silver. In the 1540s the Spanish discovered rich silver veins in Mexico, as well as the 'silver mountain' of Potosí high in the Andes (Bernstein 2009; Frankopan 2016; Paine

2013). Most of this silver was sailed up the South American coast on the Humboldt Current (the eastern arm of the South Pacific gyre) to the Panama Isthmus, carried across this narrow land bridge by packs of mules and then loaded onto ships bound for Spain. But about a fifth of the mined American silver was sent across the Pacific aboard Manila Galleons and in the Philippines it was traded for Chinese luxuries: silk, porcelain, incense, musk and spices (Bernstein 2009; Frankopan 2016; Paine 2013).

The westerly winds across the Pacific delivered the galleons to the coast of California, where they needed way stations to be resupplied after this long oceanic crossing and before setting off on the last leg of their journey south down the coast to Mexico. This is why California was so geopolitically significant—it's where the winds deliver you to after crossing the Pacific—and the names of the major cities of San Francisco, Los Angeles and San Diego still recall this Spanish influence today.

4.2 Brouwer Route

The maritime route to India pioneered by the Portuguese involved heading down the West African coastline with the Canary current, crossing the equator, and then using the South Atlantic gyre to carry ships across the band of southeasterly trade winds until they entered the zone of the westerlies. This then carried them past the southern tip of Africa and into the Indian Ocean and the realm of the seasonally-reversing monsoon winds. From the year after da Gama's triumphant return, the Portuguese began sending annual expeditions along this new sea route to India. The very first fleet that followed took such a wide loop through the South Atlantic to meet the necessary westerly winds that they encountered the eastern bulge of South America. Thus the reason that Brazil today speaks Portuguese but the rest of Latin America speaks Spanish is a colonial consequence of the wind patterns (Crowley 2016).

This mid-latitude band of westerly winds is the southern-hemisphere mirror image of the westerlies that the Spanish learnt to ride across the north Pacific from Japan to California on the Manila Galleon Route. The band of westerlies in the southern hemisphere, however, tend to blow far harder than their northern equivalent. After the break-up of the supercontinent Pangea over 200–150 million years ago (Frizon de Lamotte et al. 2015) the vagaries of continental drift have rearranged the Earth's face so that today two-thirds of the landmass—and mountain ranges which disrupt the flow of winds—lies in the northern hemisphere. The southern hemisphere of the planet, however, is dominated by open ocean, free of windbreaks. In particular, below about 40° only the bottom tip of South America and the two islands of New Zealand impede the uninterrupted rush of the westerly winds all the way around the world, and sailors came to call this zone the Roaring Forties. And if they dared to push even further south, risking fierce wind and waves, frigid climate and threat from icebergs, navigators could take advantage of the even stronger Furious Fifties or Shrieking Sixties.

It was a Dutch navigator who pioneered the use of the Roaring Forties as a short-cut from the Portuguese route around the Indian Ocean. In 1611, Captain Henrik Brouwer of the Dutch East India Company passed the Cape of Good Hope and instead of heading north-east towards India he turned south, deeper into the west-erlies. These carried him fully 7000 km east before he exited this fast-moving ocean freeway and turned north again towards Indonesia and the spice islands. The Brouwer Route, making use of the Roaring Forties, took less than half the time of the traditional passage—not least because it obviated the need to wait for the monsoon winds in the Indian Ocean.

The development of the new passage had a number of profound historical consequences. It was sailors taking the Brouwer Route who became the first Europeans to sight Australia, spurring further exploration and then colonisation. Furthermore, the Brouwer Route detouring south across the Indian Ocean meant that the Sunda Strait between Java and Sumatra became the crucial gateway into the East Indies, rather than the Strait of Malacca that the Portuguese had controlled. This caused a significant geostrategic shift, and the Dutch founded Batavia—present-day Jakarta—in 1619 as their operational centre in the region and to command this key strait. This zone of strong winds was also the reason behind the founding of Cape Town: the Dutch needed a resupply port for ships before the long final leg of their voyage to the East Indies. The Roaring Forties wind belt is therefore the reason why Afrikaans is spoken today in South Africa.

4.3 Atlantic Trade Triangle

Although it was spices that drove the early years of the Age of Exploration and the global oceanic trade carried by European ships, by the beginning of the eighteenth century new commodities had come to dominate demand. Crops indigenous to Africa and India had been transplanted to the New World and large amounts of coffee were now being produced in Brazil, sugar in the Caribbean, and cotton in North America (Bernstein 2009). The colonists' demand for labour needed to cultivate these commodities for the European markets led to another transcontinental trading system, which has arguably been the most significant for the shape of the world today.

In simple terms, the Atlantic Trade Triangle linked Europe, Africa and the Americas to serve Europe's insatiable hunger for cheap cotton, sugar, coffee and tobacco, at the expense of the inhuman suffering inflicted on the slaves exploited in the process. The Industrial Revolution, begun in Britain but soon spreading through Europe, saw the use of powered machinery to mass-produce wares like fabrics. This in turn drove a surge in demand for the raw materials needed for their manufacture, such as cotton fibres. Cotton is a tropical shrub that can't be grown in the European climate and so provided a large cash crop opportunity for plantations in the Americas. Due to the pattern of global winds, European ships bound for the

Americas must first sail down to the West African coast before they can catch the necessary trade winds for the trans-Atlantic crossing.

Ships sailed from Europe with industrially-manufactured goods such as textiles and weapons down to the western African coast. Here they were traded with local chiefs for slaves they had captured, who were then transported under brutal conditions across the Atlantic (along the ‘Middle Passage’ with the trade winds) to sell to plantation owners in Brazil, the Caribbean and North America. The capital raised by selling this human cargo was used by the captains to purchase the plant commodities grown on the plantations, the produce of the slaves’ labours. These raw materials were then sailed with the westerlies back to Europe for manufacturing, and so completing the loop (Jones et al. 2004). There were variations on the exact routes sailed and the wares transferred at each leg in overlapping circuits, as well as short hops shuttling goods along certain stretches of coastline (Bernstein 2009; Morris 2011), but this was the core of the Atlantic Trade Triangle that operated between the European homelands and their colonial territories from the late sixteenth to the early nineteenth centuries.

The shipping merchants sold their cargo for a profit at each stage of the triangle and so like an economic cog sat across the Atlantic, being blown round and round by atmospheric circulation, the system generated huge financial gains for its masters with each turn, but at an incalculable cost of suffering for the slaves involved. While the European nations began to use waterwheels and then steam engines to power their mills and factories, the enslaved human workforce overseas providing the raw materials was an equally important component of the machinery driving the economics of industrialisation.

5 Transatlantic Slavery and the US Today

The Spanish, and later English and French, slave traders crossed to their colonial possessions in the Caribbean islands and mainland central and north American, whereas Portugal transported captive labour to Brazil. While exact totals will never be known, overall the transatlantic slave trade forcibly transported over ten million people—and possibly as many as 12.5 million—from their homes in Africa to labour on plantations and mines in the Americas. The Transatlantic Slave Trade Database, hosted by Emory University (www.slavevoyages.org), reports data covering the years 1510–1870 of 9.98 million slaves embarked in African ports and 8.68 million arriving in the Americas. The discrepancy between these numbers itself exposes the abhorrent reality of this transatlantic trafficking of human life: over 1.3 million people died in transit under barbaric conditions aboard the slaver ships.

5.1 Atmospheric Dynamics and Transport Routes

Of the ~10 million total slave embarkations tracked on the Transatlantic Slave Trade Database, 3.5 million were shipped to Brazil, 5.1 million were transported to the Caribbean islands (over a million were taken to labour on the sugar plantations of Jamaica alone), and half a million to Spanish central America. Slaves transported to the North American mainland—what would become the US—represented only about 3.5% of the total trans-Atlantic trade.

There was also great variance in the regions of Africa that suffered most severely from their population being captured and sold to slavers. Before being loaded onto ships for the transatlantic crossing, African slaves were held in coastal forts, known as factories. These had mostly been established at the mouth of rivers as this offered the easiest way for moving captives from further inland. Over the duration of the transatlantic slave trade, most captives came from West Central Africa around the Congo river, with many also taken from Senegambia—the area between the Senegal and Gambia Rivers—and also the coastline around the Gulf of Guinea: the Bight of Biafra, Bight of Benin, and the Gold Coast. Figure 3.4a displays a schematic of the major transatlantic slave routes, with the ethnic group regions of Africa colour-coded for the number of slave exports (Nunn and Wantchekon 2011).

Although slaves captured in Africa could end up being trafficked anywhere in the Americas, there were nonetheless strong connections between the embarkation point and destination. Figure 3.4b plots data extracted from the Transatlantic Slave Trade Database to show where slaves arriving in Brazil, the Caribbean islands, and the North American mainland, had originally embarked in Africa. The majority of slaves sent to Brazil were from West Central Africa (57%), with a notable fraction from Southeast Africa (8%) that had been sailed around the Cape of Good Hope and across the South Atlantic, but only a minor input from Senegambia (3%). The Caribbean islands and mainland North America, on the other hand, both received about a fifth of their slaves from West Central Africa, but most of the slave labour arriving on the plantations of the North American mainland (24%) had set sail from Sierra Leone and Senegambia.

Whilst steamships or modern freighters can steer the most direct course to their target port, sailing ships are highly constrained by the global pattern of winds and the ocean gyres they create, and in particular prefer not to cross the equator and risk being becalmed in the doldrums. For example, the 'direct' distance (the Great Circle geodesic) from Senegambia to Pernambuco, the western tip of Brazil, is 3250 km, and from the mouth of the Congo river to Pernambuco is 5220 km. The Brazilian coast is significantly closer to Senegambia than the Congo, and yet received a much greater proportion of its imported slaves from West Central Africa. From West Central Africa a reliable sailing route follows the southeasterly trade winds and then around the south Atlantic gyre along the Brazilian coast to serve the coffee plantations. Whereas from Senegambia and the coastline of the Guinean Gulf, all situated north of the equator, ships can ride with the northeasterly trade winds and ocean current to the sugar plantations of the Caribbean islands, the cotton plantations

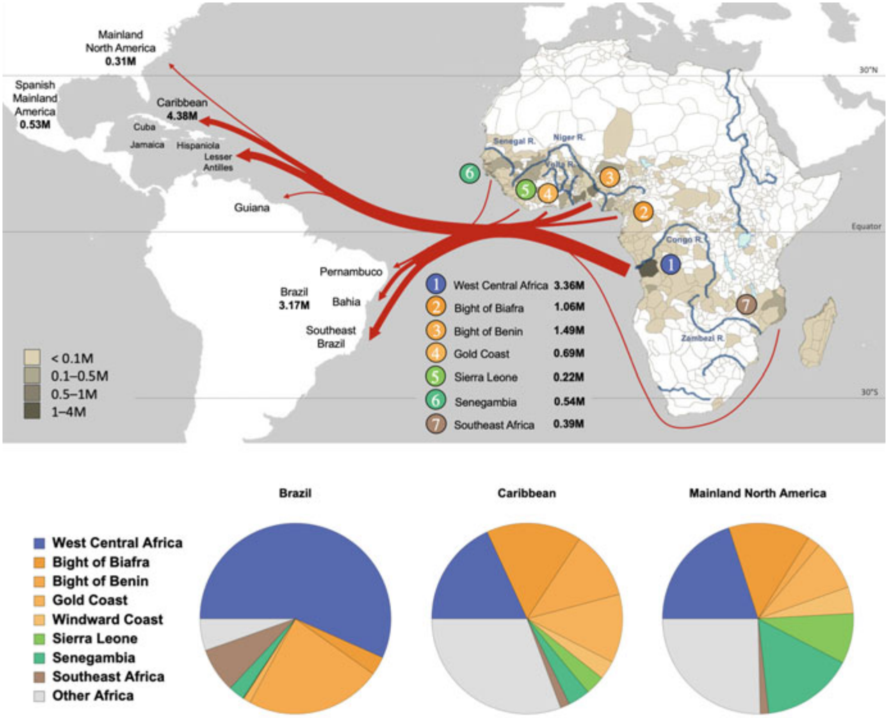

Fig. 3.4 The Transatlantic Slave Trade. (**a**) Top map shows number of millions of people captured into slavery in different regions of Africa (colour-coding). Captives were moved to coastal factories, often along rivers, before being loaded onto ships for the transatlantic crossing (red arrows). Numbers in millions disembarked at major colonial destinations in the Americas also shown. (**b**) Bottom diagram shows the pattern of winds and currents for the transatlantic passage created strong associations between particular loading and disembarkation locations. Pie charts show where slaves arriving in Brazil, the Caribbean islands, and the North American mainland where originally embarked in Africa. (Figure created by the author using data extracted from The Transatlantic Slave Trade Database, publicly-available river data, and overlaid with colour-coded Africa map from Nunn and Wantchekon 2011, reproduced with permission)

of Alabama and Carolina, or further to the tobacco plantations of Virginia. Thus it is environmental causes, ultimately rooted in the circulation dynamics of Earth's atmosphere, that defined two partially distinct slave-trading systems: North America and Brazil (Domingues da Silva 2008).

5.2 *American Civil War*

The Atlantic slave trade was banned by the British in 1807, but smuggling continued to North America until the abolition of slavery after the conclusion of the American

Civil War in 1865. The Mason-Dixon line was originally surveyed in the 1760s to resolve a border dispute between Pennsylvania, Maryland, Delaware, and West Virginia, but later came to denote the division between the Union and Confederate States. The climate of the southern states enabled them to grow cotton and tobacco as cash crops, and thus their economic system became dependent on plantations and slave labour. Whereas the economies of the more northerly, cooler, Yankee states were based on agriculture of staple cereal crops and industrial manufacture. Thus, although the Mason-Dixon line marked the cultural boundary between the southern slave states and northern free states, it ultimately represents an environmental distinction between warmer and cooler climates and modes of agriculture. (Similarly, the Great Wall of China follows an ecological boundary, between wetter latitudes capable of supporting agriculture and thus agrarian civilisation, and the dry steppes to the north suitable only for nomadic pastoralists: 'barbarian' raiders like the Scythians, Xiongnu or Mongols) (Fernandez-Armesto 2002).

5.3 Population Genetics Today

Even after the Confederacy lost the Civil War and slavery was abolished across the southern states, there was no sudden change in the demographics or indeed in the economic focus of this region. The former slaves continued to work on the same cotton plantations, but now they were sharecropping as freedmen. However, the economic fortunes of the Deep South began to slump with falling cotton prices followed by the infestation of the boll weevil in the 1920s. Several million African-Americans migrated from rural areas in the southern states to the major industrial cities of the north- eastern and midwestern United States, especially after the Great Depression of the 1930s.

Since the abolition of slavery, therefore, there has been a lot of population movement within the Americas as well as interbreeding and genetic admixture. Slave traders and owners kept few records, but DNA studies have begun shining light on family ancestry and how this regime of forced migration from different regions of Africa has shaped the genetic structure of modern populations across the Americas.

For example, a recent research programme led by Gouveia et al. (2020) sequenced the genes of over 6000 individuals with African ancestry across the Americas. They found that West African ancestry is the most prevalent in African-Caribbeans and US African-Americans today, whereas African-Americans in south-eastern Brazil show a high degree of ancestry from south/east Africa. This is believed to be due to the fact that after the British abolished the slave trade in 1807 and the Royal Navy closed the slave transport routes in the North Atlantic, Portuguese traders came to rely on slaves captured in southeast Africa for their Brazilian plantations. This south/east African ancestry in modern Brazilians could also be differentiated into two different sources of gene flow through Africa, from the western and eastern Bantu populations. These distinct populations descend from two streams of migrations that expanded out of the Nigeria-Cameroon region over 5000–2000 years ago to cover much of sub-Saharan Africa (Bostoen 2018)—Bantu farmers who displaced the previous hunter-gatherer populations. These DNA markers, therefore, track the ancient expansion of farmers across Africa, and then the forced migration of people to southeast Brazil in the holds of slaver ships (with a much smaller flow going to the Caribbean or North America).

Gouveia et al.'s analysis also indicates that African ancestry has become far more homogeneously distributed in the American gene pool than is found in the native populations in Africa. This greater admixture is due to the fact that plantation owners often deliberately sourced slaves who spoke different language and therefore were from different geographic origins, so as to minimise the risk of organised uprisings—as well as the far greater levels of mobility and intermarrying within America over the last 150 years than across the long stretch of western Africa.

So although the ancestral roots of African-Americans today reveal the signature of both planetary factors (wind patterns favouring particular sailing routes) and historical geopolitical influences (such as the abolition of slavery by the British in 1807 forcing Brazil to rely on slaves brought across the south Atlantic), there has been a much greater degree of subsequent genetic admixture in America than in Africa (Gouveia et al. 2020).

6 Summary

Big History is an academic enterprise committed to combining many different fields within the sciences and humanities to produce a broadly-encompassing, long-term perspective on the human past, present and potential futures. Such an approach holds great promise within education for providing teachers and students an interdisciplinary understanding of the causative processes behind major trends and themes of history.

The Big History narrative offered here explored the chains of cause and effect from the fundamental modes of circulation in Earth's atmosphere, to the long-range maritime trade routes established during the Age of Exploration that harnessed knowledge of the global system of prevailing winds and oceanic currents, to the pattern of European colonisation, exploitation and empire-building in these earliest stages of globalisation that built our modern way of life, and finally to the genetic diversity of populations of people living across the Americas today. The surprising connections were also drawn to seemingly-unrelated topics, such as why many industrial cities developed with an affluent, fashionable west-side contrasting against working-class slums in the East End, and why the Mason-Dixon line separating the Union and Confederate states in the American Civil War and the Great Wall of China both fundamentally follow ecological boundaries.

This has been just one illustrative example, but hopefully serves to demonstrate how fundamental features of the planet have profoundly influenced centuries of modern history and the shaping of the world we live in today.

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Chapter 4
How Big History Could Change the World for the Better

Elise Bohan

Abstract Big History is ideally positioned to act as a major driver of social change through the promotion of a rigorous and accessible scientific origin story. This origin story appeals to our species' universal predilection for storytelling and unifies key scientific theories across disciplines within a single, coherent narrative. Below, I identify two interrelated problems that Big History can help combat: suboptimal cultural knowledge priorities, and scientific illiteracy. I then explore how Big History can be part of the solution, with reference to my own experience teaching Big History in Australia. I argue that if taught globally and promoted as a core part of the assumed knowledge of every culture, Big History could help facilitate a much-needed shift towards a more enlightened, rational, scientifically literate, and future conscious society. This chapter was originally published in the *Journal of Big History*, Vol. III(3), pp. 37–45 (2019).

1 Introduction

Contemplating the role of Big History in the social sphere is a crucial and ongoing task for big historians and one that must, at this early stage in the evolution of this academic culture, make reference to subjective opinions and anecdotal experiences. I hope this paper, and the others that appear in this collection, helps to start a conversation in the Big History community about our ongoing research, teaching and social outreach objectives. While Big History is unlikely to be a panacea for the world's ills, this paper is an argument for why we should think *big* when it comes to what we can achieve as teachers and researchers of this modern, scientific origin

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story. We should not underestimate the potential for a cultural shift in modern knowledge priorities to have major impacts down the line, perhaps even extending to our species' odds of ongoing survival.

2 Knowledge Priorities and Scientific Literacy

Our knowledge priorities in the Western world are currently skewed far too heavily towards things that don't matter much in terms of ongoing human and planetary survival, like sport, celebrity gossip, TV shows, and the theatre of partisan politics. Meanwhile, far more important issues, like existential risks, policy and funding priorities, and the promotion of scientific literacy, are massively underweighted. Most existential risks are not strongly politically prioritised and we still overwhelmingly favour short-term thinking and problem solving in the political arena (Bostrom 2002, 2013; Todd 2017).

Outside of professions where scientific literacy is essential, nobody bats an eyelid if you say that you hated science in school, or if you admit that you can't explain foundational scientific concepts and terms like the laws of thermodynamics, or natural selection. On the contrary, people are likely to nod in vigorous agreement and bond with you over the fact that they also find science hard and boring (Pew Research Center 2013). But if you've never heard of Kim Kardashian, Shakespeare, Harry Potter, or Donald Trump, many people in the Western world would be flabbergasted to hear you admit it. These are names that everybody *just knows*. You don't have to know a great deal about the characters in question, but keeping a few factoids up your sleeve allows you to signal that you are an informed participant in modern Western culture and it reassures others that you have a basic sense of what's going on in the world.

In contrast to the emphasis that we place on celebrity culture and human drama, few people seem to need reassuring at dinner parties, or in the office tea room, that you can explain terms like matter, or DNA, or that you know the difference between viruses and bacteria. C. P. Snow made a similar point over 50 years ago when he expressed consternation over the divide between the two intellectual cultures of the sciences and humanities. Of many humanities scholars, he noted:

> They give a pitying chuckle at the news of scientists who have never read a major work of English literature. They dismiss them as ignorant specialists. Yet their own ignorance and their own specialisation is just as startling. A good many times I have been present at gatherings of people who, by the standards of the traditional culture, are thought highly educated and who have with considerable gusto been expressing their incredulity at the illiteracy of scientists. Once or twice I have been provoked and have asked the company how many of them could describe the Second Law of Thermodynamics. The response was cold: it was also negative. Yet I was asking something which is about the scientific equivalent of *Have you read a work of Shakespeare's?*
>
> I now believe that if I had asked an even simpler question—such as, What do you mean by mass, or acceleration, which is the scientific equivalent of saying, *Can you read?*—not more than one in ten of the highly educated would have felt that I was speaking the same

> language. So the great edifice of modern physics goes up, and the majority of the cleverest people in the western world have about as much insight into it as their neolithic ancestors would have had (Snow 1959).

Snow's concerns about disciplinary siloisation and scientific illiteracy are as relevant today as they were in the 1950s. In a world where science and technology are major drivers of rapid economic growth and social change, it is more important than ever that the voting populace is informed about basic scientific concepts and that we are aware of how physical laws and phenomena have shaped the world around us, from the climate and ecology, to human nature itself. We don't need everyone to become scientists, but we should seek to bridge the growing chasm between how scientists and laypeople view the world, particularly with regards to how they reason and make decisions.

The greater the chasm between the knowledge of scientists and tech leaders, and that of the general public, the more likely our society is to fracture into tribes that speak past each other—right at a key historical moment when we need to unite in order to confront challenges on a global scale. Unfortunately, a knowledge chasm between scientists and the public already exists in the West. According to a recent Pew survey, 50% of Americans believe that climate change is mostly due to human activity, compared with 86% of scientists. 59% of Americans believe that a growing world population will be a major world problem, compared with 82% of scientists. 37% of Americans believe that it is safe to eat genetically modified foods, compared with 88% of scientists, while 65% of Americans believe humans have evolved over time compared with 98% of scientists (Pew 2015). In another representative survey of 1000 Americans, 80% of respondents stated that they supported mandatory labels on food containing DNA (Department of Agricultural Economics 2015). That's a lot of labels!

It is important that our broader set of cultural values includes at least as much respect for evidence and objective inquiry as it does for sporting heroes and celebrities. It is not magic, myth or mysticism that will help us build a sustainable future, combat the worst effects of climate change, deflect asteroid collisions, send rockets to Mars, or safely develop human level artificial intelligence, or superintelligence. If the majority of citizens don't learn to think beyond the immediate needs of their communities and countries, our governments will not have the necessary political impetus to plan ahead and work collaboratively to solve global problems like climate change, or develop strategies to cushion the blows and upheavals that could be wrought by widespread automation (Ford 2009; Pistono 2012; Yang 2013).

Although Western governments have recently begun to fetishise STEM education and publicly emphasise its importance in the modern knowledge economy, there is a major roadblock standing in the way of the successful global spread of scientific literacy. Science is *hard* and human brains are not optimally wired to think about huge numbers and temporal and physical scales, or phenomena that are invisible to the naked eye. Given a choice between a human story with human actors, or a story involving microbes gallivanting around on our skin and in our guts, we will gravitate to the human story.

To get a majority of humans to value science and take a basic interest in its foundations, we must show how it frames their lives, explains their hardwired biases, emotions, motivations and predilections. We must demonstrate how this knowledge can help them make smarter decisions and think more insightfully about the future in this age of accelerating techno-social evolution. Telling the world to wake up and embrace the STEM revolution because the robots are coming for their jobs is a band-aid solution and a scare tactic. Our social priorities need to extend far beyond trying to make sure as many people as possible remain employable in the age of automation.

A respect and reverence for evidence, reason and empiricism, and an understanding of the biases and limitations that are encoded in human cognition and preferences will place us on higher ground when it comes to making collective decisions and defending ourselves against the modern onslaught of novel and emerging risks. I suggest here that the key to the *cultural* promotion of the Enlightenment values of reason, empiricism and the pursuit of rigorous scientific knowledge, is to bring science back to the human level and promote it through a unified narrative like Big History, which places life, the universe and everything into a comprehensible framework and renders scientific concepts and phenomena more digestible.

3 The Awkward Idea of Ranking Knowledge

Some kinds of knowledge are more important and more useful than others and we should value them higher in our societies and education systems. Claims like this tend to worry people in the humanities who think that hordes of beady-eyed STEM imperialists are coming to wipe art and literature and all things ‘humanities’ off the face of the planet. They needn’t worry. Short of enslaving and oppressing the entire human race, you couldn’t expunge art from human societies no matter how hard you tried. People will still write, blog, make videos and design impressive new things even if nobody pays them and even if nobody does humanities degrees. The arts are safe—indeed, they are flourishing in the information age, as there are more avenues than ever to create and share content. Humanities majors like literature are probably not very safe, but that’s a separate issue from the survival of the arts themselves, and a subject for another paper.

The point here is that every choice to teach X, is a choice not to teach Y. We don’t seem to have a good grasp of this when we talk about educational priorities. If I suggest that teaching Shakespeare to twenty-first century teenagers might not be the *best* use of their time, English teachers and Shakespeare enthusiasts may get very fired up and passionately explain how wonderful Shakespeare is, how much his work enriched their lives, and how outrageous it is to suggest that literature and the arts are not important. They seem to miss the word *best* and assume I’m claiming that Shakespeare is garbage and has no value whatsoever (which I’m not).

The point is that for every hour of a school day that you teach a class of teenagers about Shakespeare, that's an hour that you're not teaching them millions of other things. If, as a society, we decide to teach Shakespeare in schools, we should be very confident in our belief that this subject is of equal or greater importance than all those other possibilities. We have finite time and finite brain capacity to dedicate to the study or an enormous and ever-expanding body of material. We can't know a lot about everything and we have to make hard choices and rank some things as higher cultural knowledge priorities than others.

But what could possibly be more important than for most human beings to understand on a deep evolutionary level where we come from, how we have evolved, what kinds of cognitive biases we are still saddled with, and how we fit into a larger evolutionary framework of physical, chemical, biological, cultural and technological evolution? It should be a universal cultural expectation that human general knowledge includes a knowledge of the age of the universe and the Earth, how stars and planets formed, continental drift, natural and sexual selection, the laws of thermodynamics, and how profoundly non-human actors like asteroids, pathogens and ice ages have shaped the course of planetary and biological evolution. This macro-evolutionary history gives us the context to comprehend how and why humans have become a major driver of planetary evolution and accelerating change in the past 250 years (Crutzen and Stoermer 2000; Steffen et al. 2015; Zalasiewicz et al. 2011). Understanding how we've got to now sets us up to think more robustly about where we're going, how much influence we have over our actions, and how we can mobilise to try and shape the future for the better.

Now, back to Shakespeare. Of the many possible arguments defending the proposition that exposure to Shakespeare is extremely important, I think the best would state that his work deftly captures universal human traits and shows in dramatic form how social and environmental pressures can drive human beings to regicide, existential despair, or the contemplation of suicide. It's all there: competition, jealousy, love, death, vaulting ambition—human nature in a nutshell. There's just one problem; the evolutionary underpinnings of these facets of human nature are not explained in the texts, as they were not yet understood. Perhaps a discussion of evolution could be brought into the lessons to great effect? But why explore texts written in old English that many teenagers will find boring and inaccessible when there are millions of other works of art and literature that deal with the same themes? Every choice to teach X is a choice not to teach Y.

Now let's push the argument about knowledge priorities into more extreme territory with a hypothetical. If every work by Shakespeare and all knowledge of him evaporated overnight, would we have more wars? More cruel and ignorant societies? Would all the power go out? Would there be chaos? I happen to love Shakespeare's work, but my life would not be measurably worse if all traces of it were vaporised tomorrow. If all traces of the internet, electricity, or modern medicine were vaporised, or if we wound scientific knowledge back to its state in the Middle Ages, my life (and yours) would all be dramatically, qualitatively worse.

A world where nobody knows anything about Shakespeare, Harry Potter, or Kim Kardashian is not dangerous. The loss of these memes poses no obstacle to long-term human flourishing. But a world where nobody understands evolution, or basic scientific concepts, and where many people distrust scientific findings, is very dangerous. Scientific ignorance and distrust can literally up humanity's existential risk ante. It matters for the whole of humanity that people continue to vaccinate their children. It matters that there is continued political support for research and development in areas that could lead to cures for diseases and extend the human life and health spans. It matters that we don't elect loose cannon leaders who may be more likely to consider a nuclear first-strike. It matters that we have effective global policies in place to that enable us to mobilise immediately in the event of a pandemic.

I argue that in the Western world, our hierarchy of assumed knowledge and values needs to be stripped away and rewritten with science forming a key part of the new foundations. Cultivating a basic knowledge of how evolution works, and how the universe and the world evolved, is *more* important than many of the things we spend much longer learning, thinking and gossiping about. Such a project will take generations, but significant gains could be made in a single generation if we collectively decide to rank some forms of knowledge and memes higher than others.

4 Why Big History Should Be a Key Knowledge Priority

A scientific origin story like Big History can help the global community make sense of the novel phenomena of the modern world, imparting a general knowledge of evolutionary history that places humanity within a 13.8 billion-year cosmic continuum (Christian 2005, 2017; Christian et al. 2014). This origin story can also promote an epistemology that emphasises reason, science and empiricism, over magic, myth and mysticism. If a large-scale cultural shift could be effected in knowledge priorities, and if humans learned to think more scientifically and prioritise issues on a global scale, the world could be a safer and more cohesive place. Such a shift might even make the difference between human survival and extinction.

Teaching Big History at Macquarie University in Sydney revealed to me how powerful this origin story could be if it were universally taught to children and adults around the world. Macquarie University is the major global hub of Big History and is home to the Big History Institute, which is headed by the founding big historian, Professor David Christian. David was my PhD supervisor, and I taught alongside him for two semesters on Macquarie's flagship first year Big History Course MHIS115: An Introduction to Big History in 2016 and 2017.[1]

For the most part, my Big History classes at Macquarie University were made up of humanities majors, who often told me they hated science in school. At the start of the course, most of them couldn't explain natural selection to me if their lives

[1]This course is now called MHIS1015: A Big History of the Universe to the Present. See course outline here: https://coursehandbook.mq.edu.au/2020/units/MHIS1015.

depended on it. The majority also couldn't explain the difference between a scientific theory and a hypothesis and many of the students throughout the course continually asked, "but isn't evolution just a theory?"

These were smart, educated university students who had no idea how old the Earth or the universe is, how it got here, how organisms are related, or how the struggle for existence works. I also came out of high school not knowing any of that—I don't know how, but it's an alarmingly common story in Australia. When teaching Big History to a cohort of mostly humanities majors, I often wondered: how can we truly call them *humanities* majors if they don't know anything about the evolutionary history of humans?

Understanding natural and sexual selection, and the selection pressures that have shaped our brains, our physiology and motivations can help us to understand families, bonding, love, competition, war, reciprocal altruism, adultery, virtue signaling, gossip, humble bragging and Twitter mobs—the stuff that our lives are made of. These things do not appear out of thin air and nor does racism, nationalism, or any other form of tribal behaviour. The same goes for civilisations, technologies, and everything else created by humans or studied in human history.

In Big History, we aim to bridge the two cultures divide, bringing the sciences and the humanities in closer communion (Snow 1959; Wilson 2013). We do not do this tokenistically, but for the sake of rendering important knowledge about the world more accessible (Christian 2017). It is helpful to harness robust scientific knowledge and use it as a starting point to explore questions of meaning, purpose, ethics and values, which have traditionally been the bread and butter of the humanities. This merging of the two cultures appears to give students a more robust framework to start thinking, not just about what life is and how it evolved, but about how to live well in the Anthropocene—a time when things are changing very fast.

Although my experiences are anecdotal, I believe that Big History is an ideal educational tool to impart scientific knowledge globally, because the delivery method of an origin story appeals to the universal human predilection for storytelling (Corballis 2009; Gottschall 2012; Gottschall and Wilson 2005). Most people will never become scientists or experts in particular fields of science. But most people have a deep hunger to find meaning in the world and to orient their lives within a broader framework of existence (Wilson 2013). Big History satisfies the enduring human drives for storytelling, myth making and meaning, but it helps modern humans make sense of the world with reference to the theories and findings of modern science. It is also "the product of a globalized world" and "the first origin story for all humans" (Christian 2017). We need a global worldview like Big History, as it can help humans across continents and cultures find common ground and learn to view each other as kin.

5 What Do We Teach in Big History?

The first year undergraduate Big History course at Macquarie University is open to students from all faculties and disciplines. The cohort is large—usually between 150–300 students. The course spans 13 weeks and the students are taken on an epic journey from the big bang to the present and the future.

The course is rapid fire, to be sure, but students are introduced to:

- The big bang and the evolution of the early universe
- Stellar and planetary evolution
- Gravity
- The laws of thermodynamics
- Plate tectonics and continental drift
- The origins of life, biological evolution and natural selection
- Hominid and human evolution
- The rise of collective learning and the accelerating pace of cultural and technological evolution in the Palaeolithic, Neolithic and modern eras
- The rise of a single world system of communication and trade
- The Industrial Revolution
- The Anthropocene and the future

Instead of teaching about each topic in isolation, Big History tutors illustrate how all of these phenomena fit together in a larger sequence of billions of years of evolution. They remind students how fleeting and recent all of human life and history is in the larger scheme of space and time and introduce them to the core bodies of evidence that support the leading scientific theories on which Big History is built. Tutors also draw students' attention to knowledge gaps on important questions like when, where and how life originated on Earth, and encourage them to critically evaluate the robustness of the bodies of evidence they encounter.

When I taught Big History at Macquarie, we also primed students to start thinking about the future of human, planetary and cosmic evolution. How did humans muster the power to start shaping the future of terrestrial evolution? Are we wise enough to wield the powerful new technologies we have invented? What will become of our planet and the universe long term? And how can our choices today affect how the lives of future generations will unfold? (Christian 2005; Christian et al. 2014).

By the end of a 13-week Big History course, it's remarkable how many students wrote in their feedback forms that their worldview had changed. This feedback was heartening, in no small part because these students vote and influence market trends with their consumer behaviour. Many of them will eventually have children and they will have to make choices about what to teach the next generation. Just imagine what a difference it could make to their lives and to society if they didn't start this intellectual awakening in their twenties, but had the tools and frameworks to think about the big picture of evolution and humanity from the get-go.

Of course, I can't make concrete claims about how much knowledge big history students retain after completing a tertiary big history unit. The lack of data on the social impacts and benefits of Big History courses is conspicuous—though it is worth pointing out that the discipline is young and has not had the social cachet to attract the interest of education researches until recently. Nevertheless, similarly encouraging preliminary feedback has been reported by Joseph Voros (2018), who teaches Big History at Swinburne University of Technology in Melbourne, Australia. In addition, the Italian education researchers Adalberto Codetta Raiteiri et al. (2018) have flagged Big History as a knowledge framework that could play an important role in helping young people develop as global citizens who will be capable of responding to the unique challenges of the twenty-first century.

Seconding the thoughts of the researchers above, I can't help thinking that as long as students of Big History carry away with them some of the gist of the story, some sense of the scale of history, and some feeling that change is an evolutionary constant, they're better off than they were before and more likely to pick up new scientific ideas and keep assimilating them into a larger worldview in the future.

6 Concluding Remarks

We currently devote a huge proportion of the human-headspace pie to entertaining memes focused on human dramas. There is nothing objectionable about the fact that humans love stories and gravitate to gossip and drama. But it is problematic that we are *so* enamored with human drama that we allocate little time or headspace to the contemplation of anything else.

I have argued in this paper that it should be a universal cultural expectation that human general knowledge includes a knowledge of the age of the universe and the Earth, how stars and planets formed, continental drift, natural and sexual selection, the laws of thermodynamics, and how profoundly non-human actors like asteroids, pathogens and ice ages have shaped the course of planetary and biological evolution. Among other things, this cosmic evolutionary narrative gives us the context to comprehend how and why humans have become a major driver of planetary evolution and accelerating change in the past 250 years (Crutzen and Stoermer 2000; Steffen et al. 2015; Zalasiewicz et al. 2011). Understanding how we've got to now sets us up to think more robustly about where we're going.

If there is only one thing the next generation of students walks away from high school knowing, the evolutionary worldview conveyed through Big History would be my choice over any other single subject area. Whatever a person chooses to do from there, it's relevant, not just in work, but in family life, relationships, future planning and self-understanding. Big History is a modern, scientific map of reality that renders key scientific concepts and theories accessible to all. If taught globally, Big History could serve as a much-needed torch against ignorance, superstition and tribal thinking—or to use Carl Sagan's (1996) turn of phrase, act as "a candle in the dark".

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Chapter 5
Expanding World Views: Can SETI Expand Its Own Horizons and that of Big History Too?

Michael A. Garrett

To understand the Universe, you must know about atoms—about the forces that bind them, the contours of space and time, the birth and death of stars, the dance of galaxies, the secrets of black holes. But that is not enough. These ideas cannot explain everything. They can explain the light of stars, but not the lights that shine from planet Earth. To understand these lights, you must know about life. About minds. (Stephen Hawking: speaking at the launch of the Breakthrough Listen Initiative).

Abstract The Search for Extraterrestrial Intelligence (SETI) is a research activity that started in the late 1950s, predating the arrival of "Big History" and "Astrobiology" by several decades. Many elements first developed as part of the original SETI narrative are now incorporated in both of these emergent fields. However, SETI still offers the widest possible perspective, since the topic naturally leads us to consider not only the future development of our own society but also the forward trajectories (and past histories) of many other intelligent extraterrestrial forms. In this paper, I present a provocative view of Big History, its rapid convergent focus on our own planet and society, its over-simplified and incomplete view of events in cosmic history, and its limited appreciation of how poorly we understand some aspects of the physical world. Astrophysicists are also not spared—in particular those who wish to understand the nature of the universe in "splendid isolation", only looking outwards and upwards. SETI can help re-expand all of our horizons but the discovery of extraterrestrial intelligence may also require its own practitioners to abandon preconceptions of what constitutes intelligent, sentient, thinking minds.

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1 Introduction

For untold millennia, humankind has looked up at the sky and marvelled at the vastness and beauty of the cosmos. Countless generations have tried to understand their place in the centre of these immensities while contemplating the meaning of life and their own individual mortality. The scientific method has revealed the inner workings of the universe, and yet there are some fundamental questions that remain unanswered. One of these is: Are we alone?

Over the last few 100 years, astronomers have learned a great deal about the universe and our place in it. Major astronomical discoveries have been made, and almost without exception these lend weight to the idea that life may be widespread in the universe. Most recently, Kunimoto and Matthews (2020) performed a statistical analysis of data collected by the Kepler space observatory, arguing that in our own Galaxy alone, there are more that six billion Earth-sized planets located in the so-called "habitable zone", orbiting Sun-like (G-type) stars. The evidence from our own planet's geological record demonstrates that simple life arose here very rapidly, evolving in ways that enabled life to survive and indeed prosper under quite diverse physical conditions. Exactly when life emerged on Earth is a key input to Bayesian based analyses of this topic—if we accept depleted ^{13}C in zircon mineral samples as the first evidence of life around 4.1 Gyr ago, then an objective analysis suggests that microbial life is likely to be common elsewhere in the Galaxy (Kipping 2020). Whether it is reasonable to extrapolate from a sample of one is disputed—but historically, astronomers often do—the Copernican principle (also called the principle of mediocrity) is embraced rather strongly in our field, leading to a view in which life, and quite possibly intelligent life, is common.

We see a more cautious approach from other disciplines, in particular biology. By viewing the emergence of life as a random process, some biologists estimate the probability of life, and especially intelligent life as tiny, even compared to the billions upon billions of locations in the universe where the physical conditions might be right for it to arise (e.g. Cobb 2016). However, without a full understanding of how life actually originates (the murky transition between chemistry and biology), this also seems like a rather naïve standpoint. Probably the answer lies somewhere in between these two extremes. In the meantime, progress takes the form of two possible directions—either we sit and wait for biologists to generate a complete theory of life that culminates in a lab-based abiogenesis or we start searching for evidence for life outside of the Earth's biosphere now.

The Search for Extraterrestrial Intelligence (SETI) is a distributed research endeavour that carefully analyses astronomical data, looking for the tell-tale signatures of advanced technical civilisations located in our Galaxy and beyond (see Wright et al. 2019 for a recent review of the state of the profession). A wide variety of so-called "techno-signatures" are being searched for across the electro-magnetic spectrum, as recent advances in astronomical instrumentation have made us sensitive, for the first time, to anomalies in data associated with energy-intensive civilisations modifying their environments on planetary, stellar or galactic scales. Good

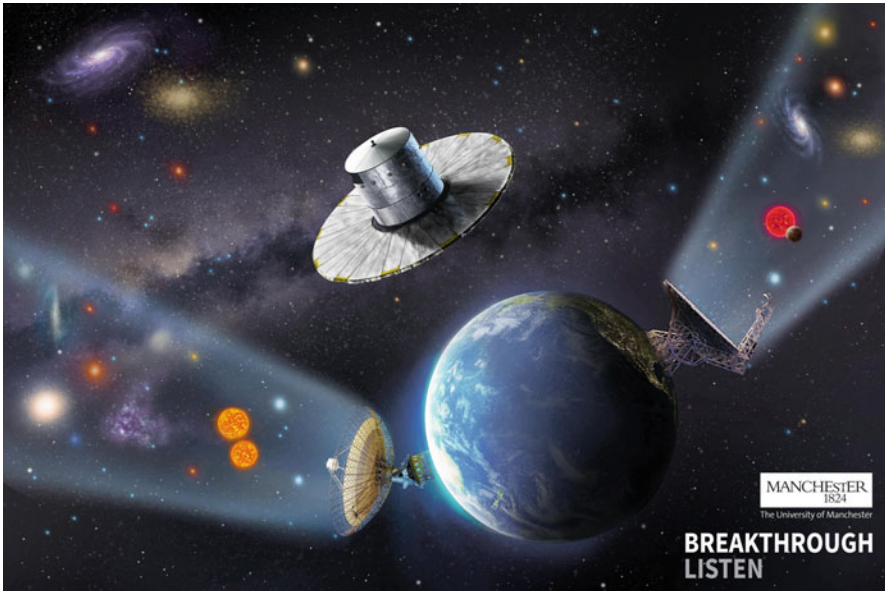

Fig. 5.1 Breakthrough Listen is placing the tightest limits yet on the prevalence of extraterrestrial civilisations, aided by data from the Gaia mission (Wlodarczyk-Sroka et al. 2020). Artwork courtesy of Danielle Futselaar

examples include surveys that seek to detect waste heat (via excessive infrared emission) or extraterrestrial communication systems (via narrow-band radio signals). A renaissance in the field has recently taken place, partly inspired by the recent establishment of the privately funded Breakthrough Listen Initiative (Worden et al. 2017). The first systematic SETI surveys for artificially generated, narrow-band radio signals are now underway, and a million-star survey using the MeerKAT radio telescope in South Africa is planned to commence next year. Recently, a re-analysis of the Breakthrough Listen radio data (Wlodarczyk-Sroka et al. 2020) that also utilises stellar distances measured by the Gaia mission (see Fig. 5.1), was able to place the tightest limits yet on the prevalence of high-duty-cycle extraterrestrial transmitters within 0.1–10 kpc (300–30,000 light years).

In parallel with these exciting developments, there is an enormous resurgence of interest in the topic of SETI world-wide. Young scientists are particularly attracted to the field, and the progress being made is also seen in the number and quality of SETI-related publications now appearing in well-established astronomical journals. With this dramatic blossoming of SETI related research, NASA itself has re-entered the field having recently organised a community workshop on the topic (Gelino et al. 2018).

2 Big History and SETI

The term "Big History" (hereafter BH) is attributed to Christian (1991) but many others have contributed to the topic. The idea is to attempt to describe the history of humankind within the context of a much bigger origins story that borrows heavily from the wide perspectives provided by cosmologists, astrophysicists, geologists, biologists, archaeologists, anthropologists etc. While there are many good textbooks on the topic (e.g. Spier 2010), the vast majority of students will first encounter the subject via online initiatives such as the Big History Project[1] (hereafter BHP). Funded by Bill Gates, BHP provides a stimulating course that freely provides high quality web-based resources to teachers and students alike. Themes in Big History include the importance of "Goldilocks conditions" (Spier 1996) and "thresholds of increasing complexity" (Christian 2008). These thresholds of increasing complexity are often used to sub-divide the topic into a number of easily digestible teaching modules (see Fig. 5.2).

2.1 Big History: A Critique

The idea of providing a history course to high-school and university students that presents a much larger "Big Picture" view of history compared to traditional approaches is of course a good one. However, there are some aspects of the BHP courses that are troublesome in my view. In particular, the use of thresholds of complexity is rather artificial, and leads to some crucial aspects of cosmic evolution being rather neglected. In particular, the jump between threshold 3 (New Chemical Elements) and threshold 4 (Earth & The Solar System) represents a whopping 8+ Gyr of cosmic history! The result is that some very important and thematic phases in the evolution of the universe often get passed over—in particular:

- "Cosmic Dawn"—around 0.1–1 Gyr after the big bang at the end of the "dark ages" when the universe re-ionises with the emergence of large-scale structure in the form of the first stars, galaxies and proto galaxy clusters,
- "Cosmic Noon"—around 2–3 Gyr after the big bang where rapid galaxy evolution fuelled by mergers and gas accretion results in a significant peak in the cosmic star formation rate during which the vast majority of stars are formed and the metallicity of the universe begins to greatly increase. This period also sees the coeval growth of black holes which manifest themselves via spectacular Active Galactic Nuclei (AGN) that can outshine their galactic hosts, and
- The creation of our own Galaxy—with the bulge and halo forming first, followed by the disk in a process that was largely complete about 8 Gyr after the big bang.

[1] See https://www.bighistoryproject.com/home.

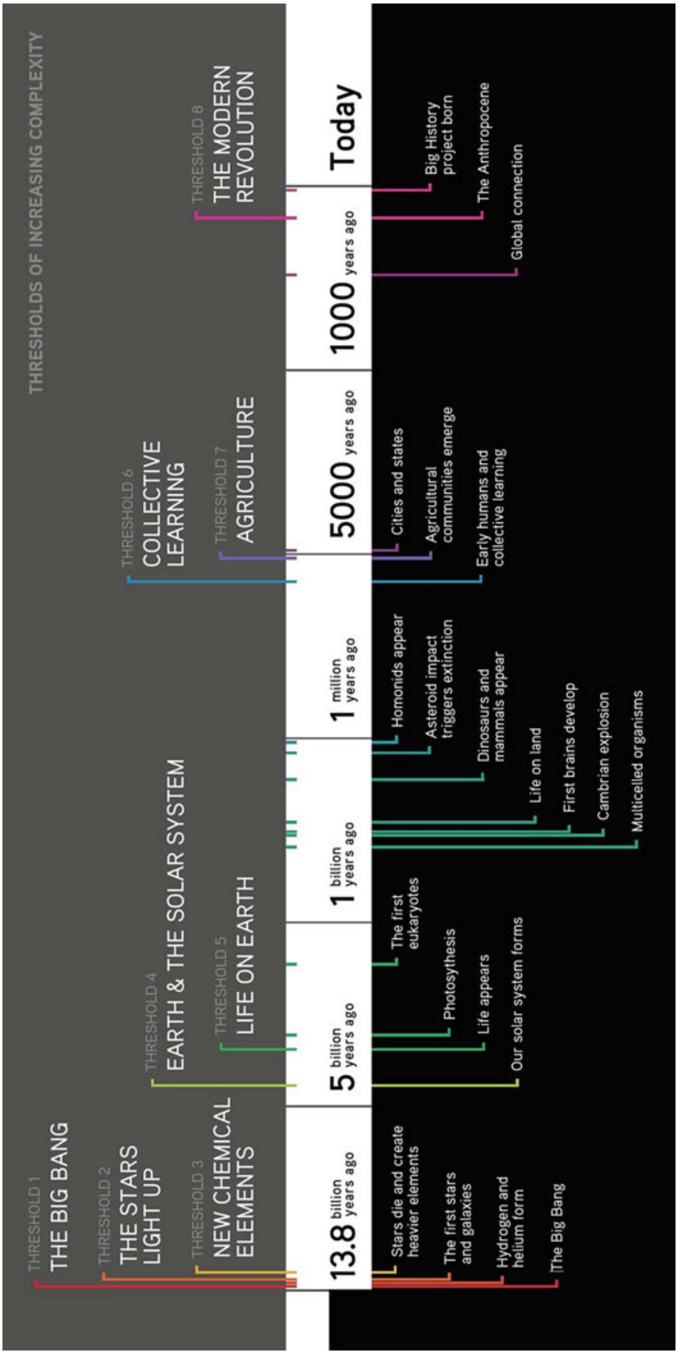

Fig. 5.2 The Big History Project proposes that history can be split up into thresholds of increasing complexity. (Image courtesy of the BHP teachers blog)

Having by-passed these important events, the focus of BH becomes entirely Earth-bound (see Fig. 5.2—"Threshold 4") introducing the formation of our own solar system in the outskirts of the Milky Way about 5 Gyr ago. It therefore neglects to consider that countless other stellar systems have been forming planets (including rocky terrestrial ones) in our own and other galaxies for most of cosmic time (so for at least the last ten billion years). Beyond this particular "threshold of complexity", the remaining BH narrative (see Fig. 5.2 thresholds 5–8) concentrates on the emergence and evolution of life on Earth, and the late emergence of human civilisation (sometimes considered to be commensurate with the first evidence for agrarian communities, around 10–20 thousand years ago). To my mind, the thresholds of increasing complexity that BH identifies, seems to correlate not only with advancing cosmic time but with increasing introspection.

SETI takes a much broader view point, considering the possibility that life might be wide-spread throughout the universe, and that intelligent life, including advanced technical civilisations, may have developed not only on our own planet but on the countless others that have formed over the last 10 billion years of cosmic history. In that sense, SETI introduces a narrative that puts the "Big" back into an increasingly myopic "Big History". However, SETI also requires us to consider the lifetime of such technical civilisations—if they are all very short-lived (e.g. <1000 years), the chances of them overlapping in both space and time becomes small (Drake 1961). For this reason, the longevity of a technical civilisation is a topic that is keenly considered by SETI researchers, with our own society serving as an example of what we might expect from others, or at least some others. In this sense, the future development of human civilisation becomes a key discussion point for SETI studies. Related to this, is the realisation that there is a lot of cosmic future still to come, even in our own Solar System that has at least another 5 Gyr of interesting evolution to look forward to—who knows what surprises there will be as the Sun begins to warm the outer regions of our own planetary system.

While there is surely considerable benefit of exposing students to many of the topics covered in BH courses in terms of providing a well-rounded education, there remains the question of whether BH as a discipline itself provides any real added intellectual value. So far as I can see, the leading practitioners of BH have not made many unique contributions to our understanding of how human society will evolve over the coming years. It seems that domain specific studies by expert scientists bringing real depth and understanding to these issues do much better in this regard (e.g., Rees 2018).

Another shortcoming of BH is that the need to provide a very simplified (and, as we've seen earlier, incomplete) version of events, that can lead to a prescriptive narrative that ignores the fact that there are actually many aspects of the scientific world that we do not fully comprehend. A non-exhaustive list of some major topics for which our knowledge is sparse or totally lacking include:

- What is the nature of dark matter and dark energy—the primary components that dominate the energy budget of the universe, together with normal matter (see Fig. 5.3),

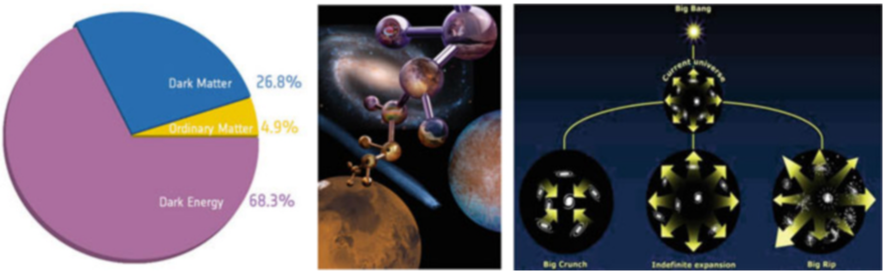

Fig. 5.3 A few examples of things we understand rather poorly—Left: The nature of dark energy and dark matter (presented here as "the pizza that no one ordered", image courtesy of ESA); Centre: Abiogenesis and the potential role of panspermia (image courtesy NASA); and Right: The ultimate fate of the universe (image courtesy of NASA). On-line version in colour

- Understanding inflation—the epoch just after the big bang in which the universe is required to experience a momentary phase of exponential expansion,
- What is the ultimate fate of the Universe—'big freeze' *versus* 'big crunch' *versus* 'big rip'?
- How does life arise? (abiogenesis),
- Is there life beyond Earth (in the Solar System, other stellar systems etc.)?
- Panspermia—can life propagate between planets in the same stellar system or even between the stars?
- Is there intelligent, conscious life beyond the Earth?
- Could we be living in a simulated multiverse in which physics and in particular quantum mechanics are the tools that generate levels of detail that currently equate to our own sense of reality and individual consciousness?

In the context of BH it is interesting to ask whether it matters that we do not know about these things in great detail. For example, is humankind's view of itself or of its future development greatly influenced by a deep knowledge of such things? The answer is almost certainly yes. For example, a steady-state theory of the universe would essentially guarantee that rare events (e.g. the emergence of intelligent life elsewhere) will always happen given sufficient time. On a more practical level, if we knew the answer to all, or even just a reasonable subset, of the questions listed above, we would probably be in a much better position to tackle some of the current challenges facing our own technical civilisation e.g. climate change, mass pandemics, energy production, general sustainability etc.

In any case, SETI can certainly help to widen BH's rather limited horizons. The idea that there may be other intelligent forms of consciousness 'out there' challenges us with a huge range of intriguing and curious questions. What will they look like? In what kind of environment have they evolved? Are they biological, machines or something else? Are they religious? Do they play football (soccer)? What kind of morals and ethics do they subscribe to? Do they create and enjoy music? What political ideologies do they subscribe to? Do they wage war against each other? Do they recognise the concept of love? What challenges did they overcome through the ages? How long do they live for? What do they eat? How do they reproduce? What has been their shared history? What can they teach us about mathematics, science, art and culture? There are so many questions to ask, and depending on the type of consciousness we encounter, some will be more relevant than others! What is quite clear is that any advanced technical civilisation will bring its own "Big History" to the table, and it promises to expand our minds in all sorts of different directions and unpredictable ways.

2.2 *SETI and Astronomy*

Astrophysicists also have something to learn from SETI in my view—the very fact that intelligent life exists on this planet, and increasingly modifies its local environment, is something that should not be ignored as an irrelevant consideration. My experience is that there is still a substantial number of astronomers that wish to understand the nature of the universe in "splendid isolation"—only looking outwards and upwards, ignoring the fact that the presence of an intelligent, technical civilisation on our own planet (and potentially others) is surely telling us something rather profound about the nature of the universe we live in. This conservative approach sometimes leads to a blind application of physics that is almost designed from the outset to always exclude any non-natural explanation that might lead us to conclude that the imprint of energy-intensive civilisations might be found in astronomical data. A good example of how the community can over-react to a more expansive approach is the reception Bialy and Loeb (2018) received when they suggested that the non-Keplerian dynamics of the interstellar asteroid 'Oumuamua were consistent with it being a large artificial light sail (see Tingay 2015 for a discussion). My own view is that we should be encouraging such expansive thinking, provided it is backed up by good scientific evidence. In the words of the novelist Thomas Hardy, "While much is too strange to be believed, nothing is too strange to have happened" (see Taylor 1979) (Fig. 5.4).

3 SETI Success: Thinking Out of the Box

This wider perspective that SETI demands, attracts contributions from many other disciplines. There are two reasons for this—first of all people from all walks of life are just extremely interested in the question of whether intelligent life exists elsewhere and what it will be like. And secondly, people coming from many other different areas of study (e.g. theology, music, linguistics, language and literature, medicine, economics, ethics, law, anthropology, AI, sociology, philosophy, technology, media studies, design, film, art, dance, sport, popular culture etc.) understand that the discovery of another intelligent and thinking species could have a major impact on their own subjects.

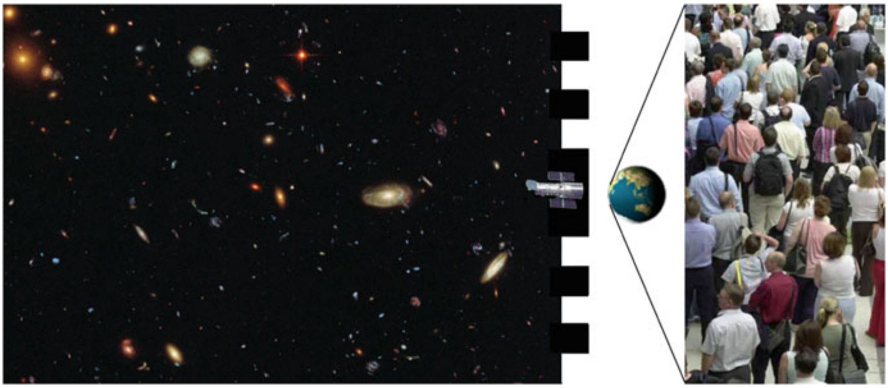

Fig. 5.4 Astronomers often view the universe in "splendid isolation"—only looking outwards and upwards—the interface with the living world around is often largely ignored (Image left is the Hubble Ultra Deep Field courtesy of NASA/ESA). On-line version in colour

As a result, SETI meetings often attract people from a wide range of different backgrounds, in addition to a hard core of scientists and technology developers. The variety of contributors is probably best represented by the SETI sessions organised annually at the International Astronautical Congress (IAC), in addition to meetings of the International Academy of Astronautics (IAA) SETI Permanent Committee.[2] For those most engaged in the technical search, this variety of input can be a bit overwhelming at first but I personally find it highly stimulating, exercising our capacity to be open to all sorts of new ideas and critical thinking. The opinions of all of humankind are important to SETI—currently the scientific world cannot answer the question of whether we are alone—not even in our own Solar System—there is simply no consensus on this topic, so in my view, all opinions are valid, irrespective of where they originate from. In this sense, everyone has a legitimate and important contribution to make on this topic—at least for the moment. This is really important because one of the challenges facing SETI is our ability to recognise the presence of intelligence, especially if it comes in a form with which we are completely unfamiliar.

We already have been given some indications that the shape intelligence might take could be quite different from our preconceptions. When SETI searches began in the early 1960s, our focus was on the detection of technical civilisations very much like our own. At the same time, it was also appreciated that even on our own planet, our species did not have a monopoly on intelligence, e.g. dolphins and other marine mammals. In the last few decades, we have all observed the advances made in artificial intelligence (AI) and robotics, suggesting that intelligence and perhaps even consciousness itself might be embodied within non-biological entities (e.g. Kurzweil 1990; Bostrom 2015). These technologies, coupled with other advances such as

[2] https://iaaseti.org/en/.

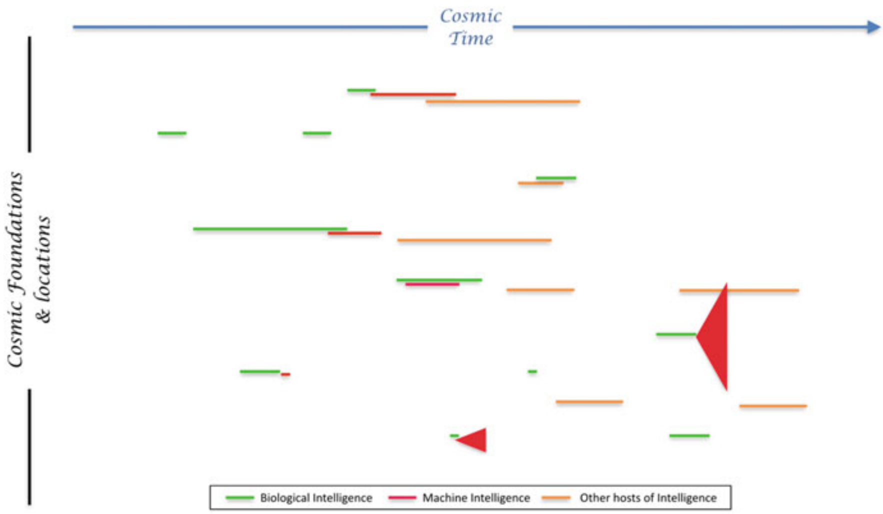

Fig. 5.5 A generic model in which intelligence arises at a range of times (horizontal axis) and location (vertical axis). Biological intelligence (green) may always be coupled with machine intelligence (red). Other potential hosts of intelligence that are uncoupled to biological intelligence are also presented (orange). Different forms of intelligence can overlap in time and location. Some forms of intelligence will expand out to occupy a range of locations (see triangular wedges). Occasionally some forms of intelligence (or their signatures) will overlap. A subset of possible examples is shown

nanotechnology, 3D-printing, advances in material sciences, molecular engineering, etc. can be very powerful in creating (for example) a microscopic intelligence that can reproduce itself easily and expand its presence well beyond our own solar system. As AI begins to play a major role in our own SETI searches (Zhang et al. 2018), the scenario of "our machines, detecting their machines" becomes increasingly more likely.

We can also reasonably ask whether there might be other non-biological ways of hosting intelligence, that we, as yet, have no knowledge of. We've only just begun to appreciate the role intelligent machines may play in our own future but there could be other non-biological hosts of intelligence that we (or they) have still to create or encounter. If Sagan (1980) was correct, and "we are a way for the cosmos to know itself", then it would be surprising if there were not other ways, other hosts of intelligence with the same ultimate driver. Some SETI scientists are uncomfortable with such broad thinking—the need to be "mainstream" in a field that already has its detractors (often other astronomers) can sometimes force us into an intellectual corner.

The main ideas are presented in a generic form in Fig. 5.5. Building on the enormous potential of our cosmic foundations (the big bang, the emergence of large-scale structure and stellar nuclear synthesis), there is an enormous potential for a wide range of different phenomena to arise, including conscious, intelligent forms. If our own example is typical, biological hosts of intelligence may be coupled with the rise of intelligent machines. Other non-biological hosts might exist independently of biological or machine intelligence. In the scenario depicted in Fig. 5.5, both biological and (unrelated) non-biological intelligence can arise at different times in the same location or (less likely) at the same time in the same location. Hosts of intelligence can also expand out from one location to settle many others (e.g. space faring societies). In these ways, intelligent hosts can have knowledge of each other, when they (or indeed their propagating signatures) overlap in space and time.

4 Conclusions

The wide perspective that is inherent in SETI research has much to offer the topic of BH. The idea that there may be many other forms of intelligence in our own Galaxy and beyond, encourages a much broader BH narrative that avoids an otherwise rapid descent towards a singular focus on our own planet and the development of one particular species on it. The idea of thresholds of increasing complexity seems to correlate not just with increasing cosmic time but also with increasing introspection. The incomplete nature of many online BH courses in terms of cosmic evolution should be addressed, in addition to the prescriptive way in which some aspects of the topic are taught. There are many aspects of the physical world that are completely opaque to us—we should not pretend otherwise. SETI opens our minds to consider some of these issues. At the very least we are intrigued about what shape these other forms of intelligence might take: will they reinforce our current thinking about ourselves and the universe, or will they bring a perspective that is totally disruptive, overturning some of the ideas and concepts we hold most firmly?

Astronomers can also benefit from a less blinkered view of the universe, and SETI researchers themselves must be prepared to think expansively, challenge our own preconceptions and open our mind to all possibilities, even if that means moving a bit further away from our own particular comfort zone. The idea that intelligence can also exist in non-biological hosts (including those that we have no familiarity or affinity with) is proposed as an example of the need to be prepared for the unexpected. In the words of the fictional character Fox Mulder, “the truth is out there”.

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Chapter 6
The Summons of a Silent Universe: The Relationship Between Existential Risk and Cosmic Silence

Thomas Moynihan

> *Two things fill the mind with ever new and increasing admiration and reverence, the more often and more steadily one reflects on them:* the starry heavens above me *and* the moral law within me. *[...] The first view of a countless multitude of worlds annihilates, as it were, my importance as an* animal creature*, which after it has been for a short time provided with vital force [must] give back to the planet (a mere speck in the universe) the matter from which it came. The second, on the contrary, infinitely raises my worth as an* intelligence *[driven by a] purposeful vocation that determines my existence because of this [moral] law. (Kant 1997, p. 113)*

Abstract This chapter aims to clarify and elucidate the conceptual relationship between two extremely important philosophical and practical issues: that of existential risk and the Fermi Paradox. It does so by assessing their conjoint development across time. To begin with, the chapter assess and recounts the ways in which the Fermi question has inspired and encouraged thinking on extinction threats in the past 70 years. Once this has been established, the chapter pulls back to a wider historical backdrop: revealing how both topics emerged from the wider drama of modern inquiry and the revelations of the scientific worldview. In this way, it aims to show how central both issues truly are to 'modernity,' here considered as an ongoing process and a philosophical project: a project concerned with the self-assertion of human justice and value in the face of an otherwise silent and sterile cosmos.

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1 Introduction

This chapter studies how, across the modern epoch, it was studying the starry heavens above that summoned us to a better understanding of the moral law within. In short, it explores how, across the history of thought, it was that coming to an awareness of the seeming silence of outer space has also provoked a better sense of the potential preciousness and precariousness of the human species on Earth.

Existential risk has, in the past two decades or so, become the target of a fast-growing field of academic study (Bostrom 2002; Bostrom and Cirkovic 2008; Ord 2020). An existential risk, as defined by Swedish philosopher Nick Bostrom (2002), is the threat of 'an adverse outcome [that] would either annihilate Earth-originating intelligent life or permanently and drastically curtail its potential.' Note that this definition shifts the focus from the aetiology or factual specification of the disaster towards its moral badness. By creating a structured framework within which to think about these threats, the work of Bostrom and many others has made the topic of mitigating extinction threats a serious and action-focused field of study. By some accounts, protecting humanity's longterm future potential is swiftly becoming *the* most important arena of research (Wiblin 2017).

In tandem, Fermi's Paradox has also attracted building academic attention in the past few decades (e.g., Brin 1983; Cirkovic 2009, 2018; Sandberg et al. 2018; Forgan 2019). Briefly, Fermi's Paradox is the conflict between our theoretical expectation of a high probability of intelligent life elsewhere in the universe and the lifeless and inactive universe that we actually observe. Ever since it gained the attention of scientists and philosophers, the so-called paradox of the cosmic 'Great Silence' has generated plenty of rich and valuable thinking on the potential challenges and obstructions that may prevent inorganic matter from blossoming into spacefaring civilizations.

The two topics are natural bed fellows. This is demonstrated, most plainly, by the fact that many authors that write on one topic have also published on the other. However, the connection goes much deeper. The present chapter assesses just how deep. After establishing how the two ideas have facilitated and furthered each other's development across the past half-century or so, we will draw back across the history of Western thought and show just how intimately intertwined these themes are and how essential to the conceptual kernel and driving thrust of modernity they are. Because, even if they were both only explicitly articulated comparatively very recently (i.e., in the past half century or so), the twin themes—of the sterility of space and the precarity of humanity's project—have been implicit for much longer as identifiable intellectual currents. Moreover, though they were not yet explicitly articulated, they can be demonstrated to have exerted a tacit yet continuous and consistent effect on the development of modern thought. In this way, they are revealed to be master ideas: something like 'attractors' in the landscape of intellectual discovery. By revealing the convergent centrality of these twin themes to the modern epoch, this chapter hopes to show just how important they are. These are not fringe topics for astronomers and physicists, they should hit straight at the heart of all serious philosophical and ethical thinking in the twenty-first century.

2 Existential Risk and Fermi's Paradox, Historical Bed Fellows: 1950 to Present

2.1 1980 to the Present

Existential risk focuses on how *morally bad* the extinction or permanent curtailment of the potential of Earth-originating intelligence would be. The question of cosmic silence rests upon how confident we might be that comparable intelligences exist elsewhere in the cosmos. Together, they link the moral law with the starry heavens: the judgement of the former is at least in some way related to the judgement on the latter. The connection should be plain.

In Bostrom's original (2002) paper on existential risk, he lists the Fermi Paradox as an informative context for thinking about such risks. Given that, by definition, we cannot reason from past experience of existential risks, it is noted that 'indirect methods' of assessing the probability are especially informative (Bostrom and Cirkovic 2008, p. 123). These are ways of assessing likelihood of existential disaster by taking into consideration 'general features of the world in which we live.' Bostrom lists the Fermi Paradox as one such indirect method. It is rallied as an informative supporting consideration for his general argument that we should start thinking seriously and analytically about such risks and prioritise their mitigation. As part of this, Bostrom (2002) references the American economist Robin Hanson's notion of the Great Filter. Hanson (1998) had argued that the sterility of outer space implies that something stops inorganic matter from evolving into spacefaring civilizations. Some 'step' (or multiple steps) on the way from the former to the latter must be incredibly improbable. But *when* is this 'Great Filter'? Is it behind us or waiting in our future? Perhaps it is behind, and abiogenesis—or perhaps the evolution of multicellularity—is massively improbable. This, however, would mean that the discovery of basic life elsewhere (whether extinct or alive) would be bad news. It would revise upward our credence that the major challenge lies ahead. The more advanced the life is, and closer to our own complexity, the worse the news is.[1]

Both Bostrom and Hanson were inspired by John Leslie, a Canadian philosopher whose 1996 book *The End of the World* was arguably the first book-length treatment of the topic of human extinction to bring the rigors and clarity of analytic philosophy to the topic. Indeed, it is hard to over-stress the importance of Leslie's book in inspiring and influencing current thinking on the topic of existential risk. In that book, Leslie devotes a section to 'Fermi's Question' in the chapter entitled 'Judging the Risks.' Leslie carves the topic at the joints: either we resolve the question by saying intelligence evolves extremely rarely, or we say that it evolves commonly but reliably destroys itself 'after developing technological civilizations.' Either way, the topic remains relevant to our estimation of existential risk: the 'self-destruction' answer effects our judgement of the *likelihood* of extinction; whilst the 'rarity'

[1]The filter metaphor has a longer history: Sebastian von Hoerner (1975, p. 706) remarked that survival and extinction across the astrosociological landscape is a 'process of repeated filtering.'

answer effects our judgement of the *severity* of our extinction. On the latter (i.e., the question of severity), Leslie writes:

> It is little use arguing that we need to treat the intelligence-carrying planet on which we find ourselves as fairly typical until we get evidence to the contrary—for if there were instead only a single intelligence-carrying planet in the universe, where else could we intelligent beings find ourselves? Very possibly, almost all galaxies will remain permanently lifeless. Quite conceivably the entire universe would for ever remain empty of intelligent beings if humans became extinct.

He reaches the following conclusion:

> In view of all this we have a strong duty not to risk the extinction of the human race, and above all not to risk it for utterly trivial benefits. As soon as it became fairly clear that CFCs were efficient at destroying stratospheric ozone, their use for spraying deodorants into armpits ought to have been banned outright and worldwide. (Leslie 1996, pp. 137–139)

For Bostrom's part, he appears to endorse a 'rarity' answer to Fermi's question. He writes that 'what we know about our evolutionary past is consistent with the hypothesis that the Great Filter is behind us' (2002). Not only would this mean our extinction would be bad because we are 'rare' as a matter of brute fact (in the trivial sense that all species are rare and unique), but primarily because if we are the only intelligent species then we, uniquely, have the opportunity to effect an enormous amount of morally consequential change upon the cosmos at large. If it is the case that most of the galaxy is inorganic, inactive, sterile, and unoccupied, then it is not doing anything particularly worthwhile—where 'worthwhile' is here intended in the sense of hosting normatively worthwhile forms of life, consciousness, and well-being. But, given that these expanses of unoccupied matter and energy *could* host normatively worthwhile systems, we can thus see this as a massive opportunity to effect hugely meaningful change on the moral landscape of the accessible cosmos (Cirkovic 2002; Bostrom 2005).

Thus, if humanity survives the oncoming challenges and manages to spread throughout the galaxy it could effectuate a kind of 'waking up' of our local cosmos (Kurzweil 2005): an awakening of a sterile firmament to the richness of consciousness and moral agency. And, again, if we are currently the only intelligent species, then we are the only beings that can implement this enormously consequential transition. The stakes in our survival, therefore, are large. Such reasoning lies behind arguments to make existential risk mitigation our 'chief goal,' here and now. In other words, a genuinely astronomical amount of future value could be riding on our survival here and now. In a similar vein, the late philosopher Derek Parfit (2017, p. 437) recently wrote the following:

> If we are the only rational beings in the Universe, as some recent evidence suggests, it matters even more whether we shall have descendants or successors during the billions of years in which that would be possible. Some of our successors might live lives and create worlds that, though failing to justify past suffering, would have given us all, including those who suffered most, reasons to be glad that the Universe exists.

Such 'uniqueness' arguments have become more prominent since the late 1970s and early 1980s (Hart 1975; Jones 1976; Shklovsky 1977; Tipler 1980). Indicative of this, the great Soviet astrophysicist Iosif Shklovsky shifted, in 1977, from believing the universe is replete with intelligent life toward believing we are entirely alone. By the time his pathbreaking book *Universe, Life, Mind* [*Вселенная, жизнь, разум*] went to its fifth edition, he had entirely shifted from great optimism concerning contact toward great confidence in our loneliness. Around the same time, Michael D. Papagiannis (1978, p. 277) wrote that '[t]he euphoric optimism of the sixties and the early seventies that communication with extraterrestrial civilizations seemed quite possible [...] is being slowly replaced in the last couple of years [...] by a pessimistic acceptance that we might be the only technological civilization in the entire Galaxy.' Part of the reason for this was growing acceptance that interstellar travel and galactic colonisation was at least physically feasible (where previously this was often dismissed as impossible) and, moreover, could be completed at surprisingly short intervals (Hart 1975; Tipler 1980, 1981). This shift in thinking intensified the problem of cosmic silence. Indeed, it took place during the period when the question of cosmic silence first came to be referred to *as* a 'paradox' (Stephenson 1977; Gray 2015), and during which it first began generating a significant number of scientific papers and inspiring compendia of the competing solutions (Brin 1983).[2]

2.2 1950 to 1980

Prior to this, the question of absence of evidence of extraterrestrials was approached in a slightly different manner (due to general optimism regarding contact and pessimism regarding interstellar travel), but it nonetheless remained very relevant to the development of ways of thinking about extinction risks and cosmic challenges to humanity during the period of 1950 through 1980. For even if you approach the issue with the earlier confidence that intelligence has evolved comparatively often, then you have to assess why exactly it is that it doesn't succeed in becoming obviously visible to us. As above, this immediately impinges upon our judgement of the risks and obstacles that might face our own civilization in the near or far future. As Sagan (1979) wrote:

> The existence of a single message from space will show that it is possible to live through technological adolescence: the civilization transmitting the message, after all, has survived.

He added that such transmissions might give us useful clues and 'detailed prescriptions for the avoidance of technological disaster, for a passage through adolescence to maturity' that 'lead [to] stability and longevity' (Sagan 1979). Such questions had always surrounded the question since it was first articulated in 1950; from the beginning, 'self-destruction' lent itself as a plausible and alluring answer to

[2]Note that Leslie quotes Brin as his predominant source for the Fermi Paradox in *The End of the World*.

cosmic silence. Indeed, as we shall see, it was, at least in part, the posing of Fermi's question that prompted the first rigorous thinking on the potential inventions and technologies that could trigger an existential catastrophe (i.e., in the sense of mapping a space of plausible future pitfalls and as-yet-undiscovered inventions that extended beyond the dual-use technologies—such as, most obviously, nuclear power—which were already discovered and extant at the time).

Famously, Fermi posed his question '*Where is everybody*?' at a lunch on the site of the Manhattan Project in 1950. He was joined by Emil Konopinski, Edward Teller, and Herbert York. Memory of this event has been fortuitously archived by E.M. Jones (1985). The gist of the question appears to have been: why has Earth not already been invaded by ETI? York recalled that Fermi himself concluded that either interstellar flight is impossible or, if it is, 'technological civilization doesn't last long enough for it to happen' (Jones 1985, p. 10).

Ten years later, Project Ozma failed to return any ready evidence of a populated galaxy (Dick 1998, pp. 208–209). The question was soon asked: does something stop ET from progressing enough to have visited us? Against a backdrop of escalating Cold War tensions and Teller-Ulam tests, 'the bomb' leant itself readily as an explanation. Indeed, in 1961, German-American astronomer Sebastian von Hoerner published a paper assessing the matter in detail. He proposed that we do not receive messages from extraterrestrials because of the relatively brief 'longevity of the technical state of mind'; and, amongst the factors truncating this longevity for extraterrestrial civilizations, he listed the invention of technologies that lead 'to [their] total destruction' (von Hoerner 1961, p. 1839).

Across the Iron Curtain, Iosif Shklovsky quickly became interested in the matter. The 1962 first edition of his *Universe, Life, Intelligence* was the 'founding stone of SETI research in the USSR' (Gindilis and Gurvits 2019). Aside from the standard 'self-destruction as the result of thermonuclear holocaust' (Shklovsky 1965), he soon added 'overproduction of information' and 'a crisis precipitated by the creation of artificial intelligence' to the list of plausible explanations for the lack of signatures of intelligence. Inspired by Kardashev (1964) and Dyson's (1960) pathbreaking work on astroengineering, Shklovsky intensified the problem: it's not just that we don't receive direct messages or find nearby evidence of previous colonization waves within the Milky Way, we don't see traces of *any* intentional activity or largescale architecture in the entire observable universe.

Putting aside the shaky assumptions that underwrite issues of messaging or colonisation, this stronger version of the question (which can be traced to Dyson, Kardashev and Shklovsky's work during the 1960s) can be put thusly: if there were any 'supercivilizations,' anywhere in the universe, we would presumably see the effects of their industry. All it would take was for one galaxy to be 'industrialised' or 'domesticated' by a host civilization (Kardashev 1984), and this would surely be quite readily visible to us. (The larger the effect, the more visible it should be.) Already, Dyson (1966) had stated that 'there is nothing so big nor so crazy that one out of a million technological societies may not feel itself drive to do, provided it is physically possible.' 'They just need determination and time,' von Hoerner (1975) later added: and the travelling-time of light 'between galaxies' is 'millions of years';

yet we see 'not a single sign of life, among the billions of stars in our own galaxy, among the billions of other galaxies visible in our telescopes?' It is not as crazy as it first seems to ask the question '*why don't we see any galaxies in the shape of Platonic solids*?' (Cirkovic 2018, pp. 133–137). Yet we see no such 'cosmic miracle', as Shklovsky (1965) adroitly pointed out: 'for me, the greatest miracle will be that there are no cosmic miracles [космических чудес].' Indeed, it was precisely the lack of 'cosmic miracles' that forced Shklovsky to later convert to a 'uniqueness' position in the late 1970s. Kardashev (1971) expressed the issue as such:

> There is a high probability that civilization is a universal phenomenon, and yet there are no currently observed signs of cosmic activity of intelligent creatures.

Taking up Shklovsky's and von Hoerner's lead, and glossing the resulting problem as the 'law of impermanence of civilizations,' the brilliant Polish philosopher and science fiction author Stanisław Lem soon added some other colourful options to the mix as contender explanations for the low 'psychozoic density'.[3] During the mid-1960s, he pointed to 'hedonistic and consumerist' tendencies in contemporary terrestrial culture, and suggested that many civilizations might effectively give up an interest in external reality: seceding into their own artificial entertainment-simulations, rather than pursuing the hardships of outward exploration and investigation of nature (Lem 2010, pp. 52, 205–206). Shklovsky (1965, p. 12) himself had hinted that such intense cultural insularity would be, from the outside, indistinguishable from extinction and degeneration. Sebastian von Hoerner (1975) expanded his previous speculations on the longevity of civilizations, and the existential 'crises' they face, and concluded that the civilizations that don't destroy themselves—because they pursue regimented stability and preventative coordination instead of exploratory inquiry and open-ended freedom—will instead face 'irreversible stagnation.' (Compare with Bostrom's (2006) theses on 'singleton societies'). In von Hoerner's estimation (1975), these stagnancy scenarios, in distinction from self-destruction scenarios, could be classified as 'the crisis to end all crises,' in the sense that they are a permanent end of history: a point beyond which no further danger, nor development, takes place.

Similar theses took a prominent place at the first Anglo-Soviet CETI conference in 1971, where they were chiefly championed by American scientists John R. Platt and Günther Stent (Sagan 1971, pp. 153–160). Stent proclaimed that it was a law of progress that intelligence's improvements of its material conditions—in creating ease, comfort, and convenience—remove the very factors and stressors that drive and promote the persistence of intelligence. Technological civilization is thus 'self-limiting.' He ventured this was astrosociologically universal: civilizations thus reach a 'steady state' of comfort and harmony with nature. Platt claimed that perhaps all civilizations turn inward, toward something like 'Zen Buddhism,' and lose interest in

[3]He also gave the issue the beautiful name of the '*silentium universi*'. Perhaps too erudite, it hasn't caught on.

the outside world. Hence, the lack of signals. Related theories of a tendency toward 'insularity' and 'stability'—with varying shades of optimism and pessimism—were proposed by Drake (1976) and Papagiannis (1984).

This work, starting from von Hoerner's (1961) paper and expanding through the ensuing work of Shklovsky and others, is recognisable as some of the first thinking on 'existential risk' in its full sense: i.e., serious thinking on the range of pitfalls (with a stress on 'internal' or 'endogenous' factors) that might limit the longevity of technological civilization, afflict its long-term stability, and obstruct the realisation of its potential.

3 The Tsiolkovsky-Teilhard-Fermi-Viewing-Hart Question?

Of course, others had reached the question prior to Fermi. It is well known that Konstantin Tsiolkovsky arrived at a similar question in the 1930s (Lytkin et al. 1995). Tsiolkovsky reasoned that, if it is possible our future descendants may travel across space, then it becomes a conundrum as to why other species have not already visited Earth. In 1933, Tsiolkovsky wrote that people deny 'intelligent [extraterrestrial] beings' because 'if they existed, they would have visited the Earth.' But what has not thus far been recorded is that the Jesuit palaeontologist and futurist, Pierre Teilhard de Chardin, also independently reached the same question in 1945. Speaking at the French Embassy in Beijing in 1945, Teilhard (1964, pp. 126–127) delivered a lecture entitled 'Life and the Planets.' Near the talk's close, he declared:

> if journeying between celestial bodies were practicable, it is hard to see why we ourselves have not already been invaded. . .[4]

In this sense, we should update Webb's (2002, p. 22) proposal for naming the 'Fermi Paradox' the 'Tsiolkovsky-Fermi-Viewing-Hart paradox': it should really be the 'Tsiolkovsky-Teilhard-Fermi-Viewing-Hart Paradox.'

Notably, however, both Teilhard and Tsiolkovsky's proposed solutions to their own question were thoroughly optimistic. Teilhard thought that intelligence collapses inward, into ever denser internal complexity and reflexivity, as opposed to expanding outward. Taking a cue from the centralization and concentration of nervous systems across evolution, he was certain that 'mind' implodes rather than explodes, reaching a kind of critical density that he called the 'Point Omega'. This would essentially be a state of complete spiritualization and transcendence over the

[4] As far back as Fontenelle's 1686 *Conversations on the Plurality of Worlds*, a similar argument is canvassed regarding the inhabitants of the Moon. On the plausibility of 'flight' between the Moon and Earth, one interlocutor remarks that it is not possible because if it was 'the Inhabitants of the Moon would have been with us before now, if that were likely'. The other conversant replies that it took 'six thousand years' for Europeans to invade the New World (Fontenelle 1688, p. 68). Thanks to Ian Crawford for pointing out this precursor.

material world, he theorised. So, Teilhard implied that the galaxy may be dotted with inward-looking hyper-spiritualized worlds—each on the way to attaining Omega-status—essentially isolated from one another in a state of extremely deep meditation. He noted that attaining such a state may look 'outwardly akin to death' (Teilhard de Chardin 1964, p. 127). In this, he prefigures later 'insularity' hypotheses of Shklovsky and others, as well as Smart's (2012) recent 'transcension hypothesis' explanation for the Fermi question.

Tsiolkovsky's own explanation prefigured Ball's (1973) 'Zoo Hypothesis', in that he proposed that the universe is already full of life, but it is just so advanced that it has not revealed itself to us yet—given humanity's state of immaturity on Earth.

> Humanity is just as far in its development from more perfect [extraterrestrial] beings as the lower [terrestrial] animals are from human beings. [. . .] Can we have intelligent intercourse with dogs and monkeys? So the higher beings remain powerless to communicate with us.

When we have grown up enough, the 'higher beings' will reveal themselves Tsiolkovsky (1992, p. 183) assured.

Despite their optimism, both authors were nonetheless sensitive, in their own ways, to the risks technological intelligence might face within the universe. Even from his early days, writing during his service in the closing years of World War 1, Teilhard taxonomized various risks that could obstruct a planet reaching the critical density for spiritual enlightenment: 'in cold or conflagration, in intestine struggles or in slumbering happiness' (1978, p. 190). Tsiolkovsky (1921) wrote a long document—entitled 'Planetary Disasters'—compiling and assessing probabilities and severities for a wide range of astrophysical disasters that could wipe out all life on Earth, from comets to colliding suns. Though Tsiolkovsky was concerned enough about the planetary disasters that could wipe out humanity, he was optimistic in general about the prevalence and recurrence of life within the universe. Tsiolkovsky reasoned that the universe was so spatiotemporally vast that all possible intellectual achievements and successes will be (and have been) realised.

This was indicative of a worldview that was dominant, from Russia to Western Europe, prior to this point. It is one of the reasons why the question of cosmic silence, and conjoint awareness of existential risk, only truly began developing after Tsiolkovsky and Teilhard. People could not care about these topics until relatively recently because, for the vast majority of human history, people weren't aware that the universe is *not* maximally populated with value and value-structures. In other words, there was a strong *a priori* belief that the universe is already as good as colonised: i.e., is maximally habitable and inhabited. Maximal populousness was, more often than not, taken as a given. This meant that question of observable evidence for such 'psychozoic density' was not posed, and, more importantly, the potential moral severity of our extinction could not be grasped. Though the change was gradual and uneven, it is the case that—throughout the past few centuries—there has been a steady shift from existential nonchalance to existential insecurity when it comes to our sense of our position within the cosmos. In other words, it was discovering the sterility of the skies above that lead us to acknowledge our precariousness on Earth and, latterly, has summoned us to the notion that our preciousness may well rest in our capacity to effect a genuinely astronomical amount of change on the aggregate amount of value within an otherwise silent and sterile universe. We are the spark that might wake up the entire firmament from its current state of inorganic slumber, rendering its phase transition into a vast system of moral richness.

Let us turn to the story of how we came to realise that the universe we live in is *not already* maximally populated with value. Recounting this story, in its brief lineaments, will reveal how central the topics of existential risk and of cosmic silence are to the historical process of 'modernity.'

4 A Populated Cosmos and Existential Nonchalance: Prehistory to 1950

4.1 Plenitude and the Conservation of Value

Across history of Western thinking, a default way of thinking about the world is that it is maximally full of value independently of what we do. Note that 'full' here is meant not comparatively, but absolutely. Nature is as full of value as it possibly can be—it is *perfectly* full. Hence, the notion is compatible with both optimist or pessimist sentiments. Moreover, in a strict sense, it does not come with normative judgement at all. It is strictly neutral because it forecloses comparison. All it expresses is an equilibrium—a balance sheet—between the amount of value that *can* be realised and the amount of value that *will* be.

This idea, which might seem strange to our contemporary minds, rests in one of the most prevalent presumptions of Western philosophy: the Principle of Plenitude. The Principle states the following: *'All things equal, nature is as full of all possible things as it can be.'* This can be stated in the reverse. Nowhere in nature is there a 'gap,' where something could be, but simply never is for no good reason. There are no wasted opportunities in nature. From Arthur Lovejoy onward, various intellectual historians have tracked the persistence of this idea from the Ancient Greeks down to the late Enlightenment (Lovejoy 1936; Knuuttila 1981).

Even if not always explicitly or openly articulated or endorsed, it was almost universally assumed throughout the Ancient world. This is because there was no way of showing that it *was* an optional supposition. This is because the ability to define possibility based on logical coherence alone (i.e., as a lack of a contradiction) did not exist until the latter Middle Ages. In lieu of this, the most common definitions of possibility rested on measuring the frequency of realisation or manifestation within time. Possibility was 'that which sometimes exists' (demarcated against necessity as 'that which always exists' and impossibility as 'that which never exists'). Clearly, this definition entails some form of the Principle of Plenitude: everything possible happens *some time or other*. Note that this means that, independently of our actions, the aggregate amount of moral value realised within the universe will shake out the same way—regardless of what we do and how badly we misstep.

Moreover, the belief that there can be no wasted opportunities in nature also led to a conviction that there can be no permanent, or irreversible, destructions or extinctions. Because this would leave behind a permanent gap, where something could be, but never is again. And this applied as much to natural kinds as to moral values (hence, linking back to the thesis that the world is maximally full of value independently of our actions).

This scenario leads to various *false friends* when it comes to Ancient authors describing events that we might now want to recognise as existential catastrophes. (I borrow the term from linguistics where it refers to misleading words that look and sound identical in different languages but actually mean very different things.) Take for example, Plato (2008, pp. 9–10), who wrote in the third century BC of 'periodic destructions at long intervals of the surface of the Earth by massive conflagrations.' This appears to assent to the possibility of human extinction as a potential tragedy, but this is misleading: he nested such world-cleansing disasters within a cycle of perpetual returns and rebirths. '[T]he human race,' he wrote, 'has often been destroyed in various ways—as it will be in the future too.' This might be a tragedy each time it happens, but it is not an existential catastrophe, because it is not the loss of the entire human future (because each time the human race eventually returns on Earth).

But what if humans don't return upon Earth or Earth itself wears down? In this case, there is still no tragedy, because humans will simply exist or recur elsewhere. In 100 AD, the Roman philosopher Lucretius (2007, Bk.2, ll. 1130–1174 and Bk.6, ll. 565–569) warned against celibacy 'lest the human race should perish'—thus seemingly entertaining the possibility of human extinction—and he also theorised that our planet itself would eventually become geriatric and die. However, this still could not be an existential catastrophe, because Lucretius was sure that everything—from species to entire worlds—would be made and remade, again and again, throughout the churning infinitudes of the cosmos. Convinced nothing could eternally be lost within nature (because this would leave an eternally wasted opportunity), he was certain that 'nothing in creation is the only one': there can thus be no final instance of any natural kind, nothing can truly die out. Indeed, was certain that there must be 'races of men' elsewhere, on other planets (Lucretius 2007, Bk.2, ll. 1077–1080). So, if our planet dissolves, it matters little.

Within this worldview, whatever is lost will return—here or elsewhere. As already hinted, aside from denying the ontological reality of permanent extinction, this has epistemic and ethical consequences too. For one, discovery is just remembering the past. Moreover, maximizing moral value is just returning to elder maxima. Aristotle (1984, pp. 2005 & 1698) said it clearly:

> . . .probably each art and each science has often been developed as far as possible and has again perished—indeed, on an infinite number of occasions.

What is the practical upshot of this for action and conduct?

> We should therefore make the best of what has been already discovered, and try to supply defects.

Almost a millennia later, during the Middle Ages, the thirteenth-century philosopher Siger of Brabant (1964, pp. 92–93) made the same Aristotelian claim:

> . . . the same species [. . .] return in a cycle; and so also opinions and laws and religions and all other things [. . .] although because of the antiquity there is no memory of the cycle of these.

Given all this, it is the case that value is conserved through its destructions (and useful knowledge through intervals of forgetfulness) because it always returns, elsewhere and elsewhen. In other words, *value is indestructible*. There was no minimizing or maximizing the total amount of it.

Moreover, within the wider Ptolemaic cosmological outlook of Medieval Christendom, there was no distinction between ethics and physics. As another extension of plenitude-derived thinking, within the celestial hierarchy, every region of the universe is peopled by some degree of spiritual value (highest in the outermost sphere of heaven) or spiritual disvalue (most intense in the innermost kernel of hell), with each of the intermediary 'spheres' being populated by angels of varying ranks and orders. Though the degree of value or disvalue was graded, the idea of a region of the cosmos *totally unpeopled* by any value-structure or degree of normative activity was unthinkable. This, then, was as far from the idea of cosmic silence and sterility as you could get. Indeed, with the wailing of the damned (Matthew 13: 42) and the singing of the heavenly retinue (Job 38: 7), the cosmos was *positively noisy*.

4.2 The Indestructibility of Value within a Maximally Populous Cosmos

After the birth of modern science, and the beginnings of the Copernican Revolution, the sheer size of space—and our unexceptional position within it—began to truly dawn on natural philosophers. Though, of course, speculations on extraterrestrials go back to Lucretius and far beyond (Crowe 1986), it was after the Copernican Revolution that the plurality of worlds really took hold.

However, despite this, the Principle of Plenitude (i.e., assuredness that nature does not waste any opportunity for realising value) continued and stubbornly persisted. Instead, it simply morphed into the *a priori* assumption that none of these other worlds could be *wasted real estate*. Because unoccupied planets seem morally unjustifiable (what a waste of space!), people presumed that they were physically impossible. From the 1600s onward, many scientists and naturalists announced that they were sure that the other planets simply must be populated with beings ethically equivalent to ourselves. Thus, again, there could be no existential risk: because humanity, or at least human-like beings, exist everywhere. Our planet may be destroyed, but we can rest assured that there are many others exactly like it.

Echoing Lucretius's earlier thoughts on the prevalence of 'men' throughout the cosmos, Dutch polymath Christiaan Huygens (1698) announced that all planets harbour rational and bipedal beings like ourselves. Though they may be radically different from us (he considered the potentiality for crustacean sophonts), he was certain that they would share the same values and also study 'Astronomy,' 'Geometry,' 'Arithmetick,' 'Writing' and 'Musick.' Each one is, to all intents and purposes, the 'functional equivalent of humans' (Sagan 1995).

And others had already made comments on how this populousness impinges on how we should weight the severity of a planetary disaster. Henry More explicitly announced in 1632 that the destruction of populous planets remains nothing other than a triviality in the grand scheme of things. He wrote:

> Long ago there Earths have been / Peopled with men and beast before this Earth / And after this shall others be again / And other beasts and other humane birth. (1646, pp. 18–20).

Planets may come and go, but the species that inhabit them remain permanent, returning through an eternal cycle. A few decades later, the French writer Bernard Fontenelle scaled this up to entire Solar Systems, pronouncing that stars and the planets they nurture must all eventually die. But as 'some ancient Stars [...] disappear, other new ones are born in their places, and that Defect in Nature must be so repair'd, and no Species can totally perish' (Fontenelle 1688, pp. 151–156). In More's earlier words, nothing can be destroyed in nature, because across '[t]he infinite number of these Worlds' all will be 'conserve[d] to infinity' (More 1646, p. 27).

Indeed, such a view even allows a teleological justification of destruction (at any scale, up to and beyond the planetary). More claimed that these destructions have a purpose because they make the way for new productions later on. That is, by assuming equilibrium between destructions and rebirths across time (which is a form of the Principle of Plenitude), you can teleologically *justify* any destruction (of value or species) as part of an eternal cycle and undying balance. During early modernity, assumptions about the prevalence of humanoids actively, and explicitly, stymied any sense of the severity of an astrophysical disaster. Indeed, More (1646, p. 27) reasoned that even the destruction of our planet—its reduction into 'ashes'—would in fact have a teleological justification. If not for such intervals of rest and renewal, living nature would 'grow stark and drie as aged tree,/Unless by wise-preventing Destinie/She were at certain periods of years/Reduced back unto her Infancie.'

4.3 Cosmic Nonchalance and Returning Humanoids

This way of thinking persisted well into the 1700s. Early in the century, the otherwise forwards-thinking French diplomat Benoît de Maillet (1968, pp. 175–178) wrote that 'we can estimate how many years [our planet] has been inhabited, and how long a time it may still have inhabitants.' He calculated around

50,000 years, based on observable physical processes. But this was where the evidence-based science ended. He then assured his readers that this finite window of habitability need not worry us:

> But whatever may be the fate of the Earth and of its inhabitants, there are reasons to believe that in the great multitude of globes contained in space or in that infinite void there will always be other terrestrial globes beside which are inhabited by as many generations of men and animals.

In 1755, Immanuel Kant announced that 'we ought not lament the perishing of a [populated] world as a real loss of Nature' (Kant 1900, p. 150). Again, this is because the Principle of Plenitude—and the resulting assumption that the universe is maximally habitable and inhabited—assures that such catastrophes don't even slightly diminish the total amount of value in the universe. Because the civilized planets that are lost will be made up for by the evolution of morally equivalent beings elsewhere or elsewhen. Indeed, other natural philosophers were certain that, should humanity be wiped out on Earth, we (or beings functionally and morphologically equivalent) would simply *eventually re-emerge*.

Just over a decade after this, Denis Diderot was asked if he thought humanity could go extinct at a salon at Baron d'Holbach's house in central Paris. He replied 'yes,' but assured his friends that *Homo sapiens* (which had only just been nomenclated as such by Linnaeus) would return after many aeons of evolution retracing its ponderous steps from protozoa to primate:

> At first, [there will appear] I don't know what; and then another; and then, after several hundreds of millions of years of I-don't-know-whats, the biped animal who goes by the name of Man! (Diderot 1955–1970, pp. 94–96)

All of the above statements, of maximal habitability and of recurrent humanoids, lead from a background assumption of the Principle of Plenitude. Plenitude allows one to accommodate natural disaster at any scale (from the planetary to the stellar), whist stripping these disasters of all moral severity, because total value remains conserved and indestructible regardless. Put differently, extremely high *a priori* confidence in the omniprevalence of humanoids—as an almost entirely uninspected and uncritiqued assumption—led to a sense of *cosmic nonchalance* throughout the early centuries of the modern period. Let cosmic nonchalance refer to the assumption that humanity's extinction would only ever be a local or temporary affair—and thus, in the grand scheme, a morally trivial affair—given the fact that the cosmos is both *full* of humanoids and *recurrently* creates more of them.

Similar motifs and assumptions persist until today (though as we are about to see, they have stopped being the 'only game in town,' conceptually speaking). For example, a century after Kant and Diderot, the nineteenth-century Danish physicist Hans Christian Ørsted (1852, pp. 53–74) announced that he was confident that '[t]he same fundamental idea of the globe and of man must be repeated in each [solar system], though borne out under different conditions.' But the degrees of freedom that these 'different conditions' were thought to allow remained very small: Ørsted was certain that not only the same values of rationality and morality, but also even of aesthetics, must be convergently shared by every civilized world across sidereal space. During the same decade, Auguste Comte compromised his own principles of positivism by supposing that the Earth had somehow intelligently organised itself so as to ensure the evolution and arrival of mankind. Our planet exerted its 'physico-chemical activity so as to improve the astronomical order by changing its principal coefficients':

> Our planet may be supposed to have rendered its orbit less eccentric, and thereby more habitable, by planning a long series of explosions, analogous to those from which, according to the best hypotheses, comets proceed. Judiciously reproduced, similar shocks may have rendered the inclination of the Earth's axis better adapted to the future wants of [humanity].

Even though Comte intended this just-so story of habitability as a kind of fable or myth, it still irked his friend John Stuart Mill to remark that teleological flights of fantasy such as this made his late philosophy 'trash' (Mill 1965, pp. 17–18). Indeed, Comte admitted that he simply could not imagine a future for our planet without the continued existence of the 'Great Being who consecrates it' (i.e., humanity).

The notion continued into the twentieth-century, particularly in the form of the re-evolution of humanoids on Earth. In 1928, echoing Julian Huxley and J.B.S. Haldane, the influential Canadian palaeontologist William Diller Matthew said that the human species will soon take control of its own evolution.

> [But, if] before man has learned to guard and guide his own destiny, some irretrievable catastrophe, some universally fatal disease, some unforeseen enemy, should wipe out and destroy the whole human race then indeed the evolutionary clock would be set back some millions of years.

Betraying a strong confidence in the re-evolution of human-level intelligence, Matthew confided that, in the case of human extinction, 'in far distant ages to come the future destiny of the world might be committed into the hands of some super-intelligent dog or bear or glorified weasel.' And if the mammals don't make it to the planet-consecrating status of Comtean humanoids, Matthew (1928, p. 234) ventured that 'the lizards might rebuild the Age of Reptiles, evolving into progressively higher intelligent animals.'[5]

Scientists were still making confident claims about returning and recurrent humanoids in the 1960s and 1970s. For example, in 1966, a book on exobiology assuages that even the most 'pessimistic possibility,' of the 'extinction of man,' is tampered in its severity by the fact 'that within a few tens of millions of years some new intelligent species would evolve' (MacGowan and Ordway 1966, p. 248). In 1973, the Estonian astrophysicist Ernst Öpik (1973, p. 122) wrote of our chances of finding a 'planet of the apes' elsewhere in the Milky Way. He was writing this 5 years after the seminal film implied that apes would take up the civilizational reigns on Earth should we nuke ourselves. Suitably enough, the planetary scientist Charles Lineweaver (2009) has recently pointed out this persistent assumption of recurring

[5]Interestingly, Matthew (1921) had already contradicted such wildly orthogenetic thinking, with a proto-astrobiological article published in Science, in which he insisted we should be wary of thinking that evolution in other worlds 'must needs [...] culminate in the existence of intelligent life, still less of civilization.'

humanoids and adroitly given it a name: the '*Planet of the Apes Hypothesis,*' which he defines as the misleading idea that there is some 'intelligence niche' for human-like brains that will repeatedly be filled by evolution, here or elsewhere in the cosmos. But, as we are about to find out, Lineweaver is not the first to criticise this notion. Ever since the later Enlightenment, there has been a growing notion—very gradual at first, but nonetheless consistent and continuous—to the effect that we can't just *take it for granted* that we live in a cosmos fully populated by brethren minds. In tandem with this awareness, there was also a growing sense that we ought to take our position and our decisions seriously (e.g., Crawford 2018): that our existence and survival potentially matters and that our extinction would not be a matter for nonchalance or complacency.

5 The Precarity of Value in an Increasingly Inhospitable Cosmos: 1750 to Present

5.1 Waking Up to the Question of Habitability and the Planetary Specificity of Humankind

In 1770, Paul-Henri Thiry, Baron d'Holbach, wrote his highly influential materialist system of natural philosophy, *The System of Nature*. Possibly reacting to the 'planet of apes hypothesis' of his friend, Denis Diderot (as explored above), d'Holbach definitively declared the opposing view—announcing that *Homo sapiens* is a specific and contingent production of our fragile and changeable globe.

Writing that it is utterly wrong for man 'to conjecture that it is for himself alone [that] the universe was formed,' he claimed that 'man is a production formed in the course of time, who is peculiar to the globe he inhabits.' As such, 'if this globe by any revolution should happen to shift its position'—or 'by any accident [. . .] should become displaced'—then *Homo sapiens* would be 'obliged to disappear.' And from this supposition on the planetary specificity of humanity, he arrives at the following conjecture:

> Thus, every thing seems to authorise the conjecture, that the human species is a production peculiar to our sphere [and appears] to contradict the ideas of those, who are willing to conjecture that the other planets, like our own, are inhabited by beings resembling ourselves. (d'Holbach 1770, pp. 80–85)

Baron d'Holbach appears to be one of the first to have said this in such an explicit manner. Indeed, only a few decades later, in 1800, the brilliant French palaeontologist Georges Cuvier (who provided undeniable evidential proof for the permanent extinction of species) stressed that each organism has highly specific 'conditions of existence.' He conceived of this an intimate relation between the organism and its environment: the way in which every morphological feature of the animal is functionally coordinated to live in a specific milieu. Rather than taking the existence of species for granted, as many prior naturalists had tended to do, he stressed that organic existence (i.e., survival) *requires* specific and contingent conditions. This concept is the birth of all later ideas on habitability.

Indeed, before this new stress on the conditions of habitability, the question of habitability (as the search for *specific regions* where life or certain types of life can exist) was simply unavailable and invisible. Again, this is why the universe was simply considered maximally habitable and inhabited. It required early ecological thinkers to realise that organic existence requires conditions, that are not universal, in order for the question of habitability or non-habitability to come into view.

In tandem with this, the eighteenth-century saw the birth of the geological sciences, which created a new awareness of the spatial and temporal precedence of the abiogenic and inorganic domains of nature. Scientists began realising that complex life was not always a fixture on our planet in the past, and so they also began inferring that it might not be a fixture elsewhere in space. Indeed, in 1793, Cuvier's teacher, the German naturalist Carl Friedrich Kielmeyer was already hinting towards this. He announced that the part of nature that we call 'living nature' stands apart from the 'skies' of outer space. And, even though it may seem small in comparison, when you measure 'masses, volumes, and distances,' this region of living nature (called the 'biosphere' a century later by Eduard Suess (1875)) seems to outweigh the cosmic background in terms of sheer complexity:

> Here, one could say, that in the small space that is created by the surface of the earth and its relationship to the sun, there are gathered seven million different species (after a very moderate estimate); each multiplied (according to the lowest possible estimate) into 10,000 individuals, and every individual composed of a slew of different organs, whose number [...] often reaches the 1000s and 10,000s. (Kielmeyer 1793, pp. 3–4)

Here we get the beginnings of the sense that the existence of complex biology should not be taken for granted, within a cosmic context, and, more so, that there might be something uniquely valuable about the biosphere in comparison to the void expanses of space (here, perhaps for the first time, measured in terms of physical complexity).

5.2 Two Copernican Turns

By the mid-1800s, philosophers were synthesizing these insights into a new sense of the position of humanity in relation to the wider cosmos. Here are the words of the German philosopher, F.W.J. Schelling, from 1843:

> As it was naïve for an earlier age of man to believe that the entire universe was constructed for the good and benefit of man, it is no less naïve for our later time, to which a larger view of the cosmos is available, to go on presuming that humanoid beings are found everywhere and are the ultimate purpose. (Schelling 1856–1861, p. 312)

Here we see the lineaments of what are, in fact, *two Copernican turns*. One decentered humanity by spreading it all through space, and the other—far more radical—decentering revealed that *Homo sapiens* is not any teleological inevitability nor inexorable recurrence throughout the cosmos.

Indeed, the old sore of intellectual history—that the Copernican revolution was instantly a blow to human self-esteem—is partially inaccurate. The revolution initiated by Copernicus, Kepler, Brahe, and Galileo in the 1500s and 1600s was not *instantly* the fatal wound to human self-perception that many have implied it was. Because, prior to the dismantling of background assumptions such as the Principle of Plenitude and its notions of maximal habitability and indestructible value, the revelation of a plurality of worlds could only amount to the extension of humanoid life throughout the newly-discovered vastness of interstellar space.

Initially, during the 1600s and early 1700s, Copernicanism implied only our planet's *unexceptionality* within the cosmos. Which could well be read—as indeed it invariably was—as the universalisation of humanity and human values. Only much later, during the latter decades of the 1700s, did Copernicanism acquire the additional implication that the cosmos was *unresponsive and indifferent* to our values and wishes. This was expressed in the growing sense of the sterility and silence of outer space, in comparison to the fragile complexity of our biosphere, and the sense that present-day humans may be specific to our planet and its contingent 'conditions of existence.' So, two historical flavours and phases of Copernicanism: first, Copernican as unexceptionality; and, second, Copernicanism as unresponsivity.

Baron d'Holbach (1770, pp. 85–89) represents the second flavour of Copernicanism when he concludes his speculations on the prevalence of humanoids thusly:

> Suns encrust themselves, and are extinguished; planets perish and disperse themselves in the vast plains of air; [. . .] and man, an infinitely small portion of the globe, which is itself but an imperceptible point in the immensity of space, vainly believes it is for himself this universe is made; foolishly imagines he ought to be the confident of Nature; confidently flatters himself he is eternal: and calls himself King of the Universe!!!

Indeed, though his confidence in returning humanoids elsewhere prevents him from fully realising the importance of his words, Diderot (2017, Bk v. p. 641) himself made similar statements:

> One thing especially always to bear in mind is that if one banishes man or the thinking and contemplative being from the surface of the Earth, this deeply moving and sublime spectacle of nature becomes a sad and silent scene. The universe stops speaking; silence and night take hold. Everything changes into a vast solitude where unobserved phenomena occur as though veiled or muffled. [. . .] Is there a better point in the infinite space from which we could start to construct the immense lines that we are proposing to extend to all other points?

5.3 Bringing Home the Lessons of Modernity

In criticising the assumption that the universe was made with us and our values in mind, Baron d'Holbach (1770, p. 85) wrote that he was inveighing against the belief that '*whatever is, is right.*' This is but another formulation of plenitude: existence is maximally full of value because everything that exists is exhaustively valuable. It is precisely such assumption that he wants to detonate. Accordingly, d'Holbach was articulating the lessons of Copernicanism-as-unresponsivity. We cannot assume, *ahead of evidence*, that the universe accords with what we would find most valuable; we cannot assume, *ahead of searching,* that the cosmos is maximally populated with rational beings and systems of value.

This is one of the master themes of modernity: that values are precepts that rational beings actively elect to follow and promote, rather than features of the independent world that are passively obeyed or inherited. In other words, our values are dependent upon our own self-election of them. Or, in other words, they would not subsist or persist as independent features of nature beyond this. In other words, the upholding of our values is entirely our own responsibility. We cannot assume that value is indestructible, or conserved through its destructions, simply because we find such a view flattering and comforting. Nor can we simply assume that humanoid life is omniprevalent, ahead of any attempts to search for evidence. We cannot just assume that, should terrestrial humanity go extinct, nature would continue to uphold what we find valuable (whether this be through the recurrent re-evolution of humanoid life or advanced civilization, here or elsewhere). Taking this into account, suddenly the consequences of our actions begin to matter a lot more: insofar as the amount of aggregate value is conjointly revealed to—at least to some degree—depend on our actions and is not constant or conserved independently of them.

One philosopher who was particularly instrumental in this shift was Immanuel Kant. In the above, we saw him professing to a naïve form of cosmic nonchalance: saying that we should regard planetary disasters with 'complacency.' But as he matured, he realised that exactly these type of statements are problematic, because they project our psychological values onto objective nature in its vastness and independence (we might *want* the real estate of the cosmos to be fully occupied and utilised, but this doesn't mean that we should presume that it *is*). Hence, why, in his later work, Kant came to the realisation that upholding human values is a uniquely human responsibility, and no matter how vast and unresponsive the 'starry heavens' seem to be, we must act to uphold and promote the 'moral law within'—because there are no guarantees that anyone else will (Kant 1997). Indeed, although Kant remained confident that other rational beings exist elsewhere in the cosmos, he ceased remarking that this means we can be 'complacent' with our own fate on Earth. After all, it would be very rash to imply that the probable existence of responsible and rational beings elsewhere licenses us to act irresponsibly and irrationally with our own fate down here. (Indeed, this would be a breach of Kant's famous categorical imperative.)

Moreover, with the recognition that outer space may not be maximally full of civilization and rational values comes the recognition that our destiny may be to fill these spaces if they really are void and barren. Certainly, after critiquing the assumption that 'humanoid beings are found everywhere and are the ultimate purpose,' F.W.J. Schelling (1856–1861, pp. 389–390) implied that in our journey to break 'free from the fetters of the concrete' we must spread beyond the Earth. '[O]ur home is in heaven, that is, precisely the universe,' he announced rhapsodically.

This is the summons of the silent universe, the connection between the material vastness of the starry heavens and the compelling stakes of the moral law: the realisation not only that the fate of ethical intelligence may rest entirely upon us but also the realisation that, because of this, we may well have the chance to be the spark that wakes up the rest of the firmament to the richness of life and worthwhile consciousness. A lot rests upon us getting things right, then, here and now.

5.4 Outgrowing Cosmic Nonchalance

Such sentiment only built as the nineteenth-century rolled into the twentieth. In 1928, advances in astronomy allowed the cosmologist Sir James Jeans (1928, pp. 85–86) to conclude that:

> On any scheme of cosmogony, life must be limited to an exceedingly small corner of the universe [. . .] We look out and see a universe consisting primarily of matter which is transforming itself into radiation [. . .] In rare instances, special accidents may produce bodies such as our earth, formed of a special cool ash which no longer produces radiation, and here life may be possible. But it does not at present look as though Nature had designed the universe primarily for life; the normal star and normal nebula have nothing to do with life except making it impossible. Life is the end of a chain of by-products; it seems to be the accident, and torrential deluges of life-destroying radiation the essential.

One long-running reason for thinking otherwise was the notion of the eternity of the universe. Since the mid-1800s, this was the natural bedfellow of theories of cosmozoa or panspermia, whose proponents (such as Gustav Fechner (1873) or William Thierry Preyer (1875)) often made claims that organic matter was coterminous and coeval with inorganic matter within the cosmos: in the sense that both had *always* existed. Eternity gives you enough time to not worry about the emergence of entirely novel things or the permanent disappearance of old things, because you can hold secure in the notion that, within eternity, everything possible has already happened and will happen again. As with Plenitude, this insulates life and value in the cosmos from any risk of destruction or minimization: it is constant and conserved. The famous mid-twentieth-century proponent of steady state and eternalist cosmology, Fred Hoyle, was unsurprisingly also fond of panspermia theses. However, with growing support for Lemaître's Big Bang theory, some noted that '[i]nfinite time is *not* at our disposal in estimating life's capacities'; or, in other words, the cosmos is not eternal but, rather, is a 'moment in the afterglow from a great explosion whose fires are dying' (Eiseley 1953). These words were written by the best-selling American anthropologist Loren Eiseley. In his best-selling 1957 book, *The Immense Journey*, he wrote the following, poetic lines:

> Lights come and go in the night sky. Men, troubled at last by the things they build, may toss in their sleep and dream bad dreams, or lie awake while the meteors whisper greenly overhead. But nowhere in all space or on a thousand worlds will there be men to share our loneliness. There may be wisdom; there may be power; somewhere across space great instruments, handled by strange, manipulative organs, may stare vainly at our floating cloud wrack, their owners yearning as we yearn. Nevertheless, in the nature of life and in the principles of evolution we have had our answer. Of men elsewhere, and beyond, there will be none forever.

'Today, as never before, the sky is menacing,' Eiseley wrote: 'Things seen indifferently last century by the wandering lamp-lighter now trouble a generation that has grown up to the wail of air-raid sirens and the ominous expectation that the roof may fall at any moment.' Interestingly, he instantly relates this to the Fermi paradox, in much the same formulation that Enrico Fermi originally asked it:

> Since we now talk, write, and dream endlessly of space rockets, it is no surprise that this thinking yields the obverse of the coin: that the rocket or its equivalent may have come first to us from somewhere "outside". As a youth, I may as well confess, I waited expectantly for it to happen. So deep is the conviction that there must be life out there beyond the dark, one thinks that if they are more advanced than ourselves they may come across space at any moment, perhaps in our generation. Later, contemplating the infinity of time, one wonders if perchance their messages came long ago, hurtling into the swamp muck of the steaming coal forests, the bright projectile clambered over by hissing reptiles, and the delicate instruments running mindlessly down with no report.

Following this, he reasons:

> Surely, in the infinite wastes of time, in the lapse of suns and wane of systems, the passage, if it were possible, would have been achieved. But the bright projectile has not been found and now, in sobering middle age, I have long since ceased to look. Moreover, the present theory of the expanding universe has made time, as we know it, no longer infinite. If the entire universe was created in a single explosive instant a few billion years ago, there has no been a sufficient period for all things to occur even behind the star shoals of the outer galaxies. In the light of this fact it is now just conceivable that there may be nowhere in space a mind superior to our own.

Whether or not Eiseley reached this conundrum independently, or heard the reports of the Fermi luncheon, we cannot know. It was only 7 years afterwards. (Regardless, perhaps we should update the Tsiolkovsky-Teilhard-Fermi-Viewing-Hart problem to the Tsiolkovsky-Teilhard-Fermi-Eiseley-Viewing-Hart problem?) Thereafter, in the same essay, Eiseley repudiates the 'astrotheology' (as he called it) of his biologist predecessors: who saw in the fossil record of the Earth a prophetic narrative, converging upon the evolution of *Homo sapiens*, and exporting this same surging evolutionary ascent across the galaxy. He writes:

> Man could not be proved preordained or predestined from the beginning simply because he showed certain affinities to Paleozoic vertebrates. Instead, he was merely one of many descendants of the early vertebrate line. A moose or a mongoose would have had equally good reason to contend that as a modern vertebrate he has been "prefigured from the beginning", and that the universe has been organised with him in mind.

For him, the conclusion—in terms of practical, ethical lesson—is clear:

> In a universe whose size is beyond human imagining, where our world floats like a dust mote in the void of night, men have grown inconceivably lonely. [...] As the only thinking mammals on the planet—perhaps the only thinking animals in the entire sidereal universe—the burden of consciousness has grown heavy upon us. (Eiseley 1957, pp. 143–162)

By 1964 (the same year that Penzias and Wilson discovered evidence for the past temporal finitude of the universe), the prominent evolutionary biologist George Gaylord Simpson made similar comments in his incendiary paper 'On the Non-Prevalence of Humanoids' (Simpson 1964). Simply *assuming* that our universe is teeming with humanoids, ahead of evidence and argument, was no longer feasible. Moreover, after the failures of early SETI to return this evidence, people started making the conclusion that we ought not be rash with our decisions on Earth.

In a 1964 lecture, in which he mistakenly attributes the Fermi paradox to Edward Teller, Fred Hoyle (1964, p. 46) averred that civilization on Earth will not get any retries.[6] We ought to act with due care, he advised (Hoyle 1964, p. 64). Three years later, the American anthropologist William W. Howells—arriving at the same question—wrote the following:

> But what about the chances of men coming into existence again, not elsewhere, but on this very planet? Supposing, in a moment of idiot progress, we really killed ourselves off. Would *Homo* rise again?

After studying the tree of life for candidates for taking up the helm, he concludes:

> [. . .] our hopes for repetition are not good, so we had better stay the hand that drops the bomb. (Howells 1967, pp. 353–354)

As explored above, this was precisely the period during which Fermi's question started to really gain serious attention and momentum amongst the scientific community. Given its intensification (in the shift in focus from messaging to astroengineering heralded by Dyson and Kardashev) and the complete lack of 'cosmic miracles,' Iosif Shklovsky soon reached the conclusion that we may well be cosmically unique. And, again, he noted the 'burdens' that this puts upon us. Here are Shklovsky's stirring words on the matter, from the fifth revised edition of his *Universe, Life, Mind*, published in 1980:

> our loneliness in the Universe [is] of great moral and ethical significance for humanity. The value of our technological and especially humanistic achievements is growing immeasurably. The knowledge that we are, as it were, the "vanguard" of matter—if not in all of the universe but a giant part of it—should be a powerful stimulus for the creative activity of each individual and all humanity. The responsibility of mankind is growing to an enormous extent in connection with the exclusivity of the tasks facing it. The inadmissibility of regressive social institutions, senseless and barbaric wars, and self-destructive [potential] is becoming extremely clear. [. . .] The firm awareness that no one will give us "useful instructions", on how to master space nor what strategy our unique civilization ought to follow, ought to foster a sense of responsibility for the actions of individuals and all of humanity. The choice should be made by ourselves alone. There is no doubt that the dialectical return to a very curious version of the geocentric (or, rather, anthropocentric) outlook raises the old problem of man's place in the Universe in a new way. (Shklovsky 1980, pp. 350–351)

Seen in this way, the stakes are potentially very large. And it doesn't matter if we are actually alone or not, because, now that we have learnt that it is at least an open question, we must consider it an option and act accordingly. In other words, we must act *as if* we were alone, and recognise all the 'burdens' that this places upon us. A far

[6]The passage relating to the Los Alamos question runs as follows: 'I do not know whether Edward Teller was correctly quoted when he was reported to have said, "If there is anybody up there, why haven't we heard from them?"' This shows that the question was percolating through the wider scientific community.

cry from the pre-modern worldview, and its prevalent assumption of the indestructibility of value, here is a solemn acceptance that value can not only be destroyed or augmented within the physical cosmos, but it can potentially be wiped out entirely. But, by the same token, we realise that humanity may just be in a position to effect the totally astronomical amount of consequential change that would be the 'cosmic awakening' heralded by spreading consciousness throughout the Hubble volume. If this really is physically feasible, as contemporary experts claim it may be (e.g., Crawford 1990; Lingam and Loeb 2020; Armstrong Sandberg 2013), then the stakes truly are astronomical.

6 Conclusion

The question of the recurrence and prevalence of humanoids, and sophonts and technological civilizations in general, remains an open one. We do not know the answer; there is no scientific consensus. However, given the moral severity of our extinction if we are alone, then just a nonzero chance of our cosmic loneliness should alert us to act responsibly and deter us from nonchalance and cosmic complacency. Even staunch proponents of the convergent inevitability of something like the human intellect profess that 'it is far more prudent to assume that we are unique, and to act accordingly' (Conway Morris 2003). If we fail here, others elsewhere or elsewhen may succeed, but taking into account the great lesson of modernity—that we cannot simply assume that nature aligns with values—we cannot simply rely on this vague hope. The lesson of modernity is that we cannot let our values (our admiration for teleology, for example) bias or contaminate our judgements regarding objective nature. Two great realisations flowing from this lesson were that the cosmos is not independently full of value and, thus, that our extinction might well matter in some unique degree.

As demonstrated, there has, since the 1950s, been an entwined relationship between the growth of discourse surrounding what later came to be known as 'existential risk' and the growth of discourse surrounding what eventually came to be known as 'Fermi's paradox'. Each has facilitated and furthered the development and articulation of the other. As Toby Ord (2020, p. 310) recently wrote, on the relationship between existential risk, the Fermi question, and the future of humanity:

> One way of understanding cosmic significance in consequentialist terms is to note that the more rare intelligence is, the larger the part of the universe that will be lifeless unless we survive and do something about it—the larger the difference *we* can make.

But, as this chapter has also demonstrated, this intertwinement goes much further back into history and is essential to the development of the modern epoch itself. The silence of the skies and the precariousness of our human project remain two of the most important lessons of modernity: even if they were only explicitly articulated very recently (in the 1980s, for the Fermi paradox; in the 2000s, for existential risk), they have exerted an implicit force on the development of modern thinking for much longer. Their centrality, and importance, to the entire modern project—of the self-assertion of human justice in the face of an uncaring nature—cannot be understated.

In short, it was only upon discovering the silence of the skies above that we came to realise our precariousness down below; and it was only upon realising that intelligence might be astronomically precarious that we truly began to realise that it might be astronomically precious. Only very recently have we started to genuinely think of ways of acting accordingly. As Eiseley remarked back in 1957, the burden of consciousness grows heavy upon us. But this is nothing other than us answering the summons of a (seemingly) silent universe.

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Chapter 7
The Visibility of Big History

Stephen Baxter

Abstract In the sense of SETI (the Search for Extraterrestrial Intelligence), how visible is Big History? For how long have we been visible to sensitive instruments looking from afar? Our radio emissions over the last century or so could have been detected with human-class radio telescopes across light years. Perhaps advanced exoplanet telescopes could see present-day industrial products in the atmosphere, and maybe observed earlier perturbations such as caused by farming, or even forest clearances in the deeper past. If so, we may have been visible for thousands of years, and therefore potentially witnessed by external observers across thousands of light years. In a cosmic context our Big History may already be big in space as well as time. It is striking, however, that we ourselves have failed so far to detect traces of intelligence beyond the Earth. This may betray a fundamental misunderstanding on our part of the nature and distribution of life and mind on the universe—indeed of our own future—and so a misunderstanding of our own place in the Biggest History of all.

1 Introduction

The purpose of this chapter is to explore the cosmic visibility of the Big History of human society in the present, past and, tentatively, the future.

Big History has some philosophical relationships with the endeavour known as SETI, the scientific Search for Extraterrestrial Intelligence. Both seek to explore the wider frameworks which shape human history, or are shaped by it—in the case of SETI, the framework that is life in the universe as a whole, of which we are a part.

It is striking, given the theoretically possible interstellar visibility of civilisations even no more technically advanced than our own, that SETI has continued to deliver null results ever since the first experiments in the 1960s (Cocconi and Morrison

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1959). A recent expression of this was an announcement in June 2019 by the Breakthrough Listen project (Price et al. 2020) of a scan of over 1700 stars within 160 light years by the Green Bank and Parkes radio telescopes, with searches for 'technosignatures' from transmission or propulsion technologies. Specifically, there were searches for narrow-band radio signals, for lasers used for communication or propulsion, and a machine-learning scan for other unexplained astrophysical phenomena—with null results.

This of course is an expression of the Fermi Paradox (Cirkovic 2018): Where is everybody? Arguments based on the principle of mediocrity would indicate that we as a technological species should not be unique, but if they exist, why don't we see them? Surely the resolution of the Paradox, however it turns out, will tell us something profound about ourselves and our place in the universe. And this in turn must have profound implications for our own Big History.

The two basic possible resolutions of the Fermi Paradox, either we are alone in the universe or we are not, both underpin the significance of our own Big History. If we are alone, ours is the *only* Big History in the cosmos. And even if 'they' exist, given the lack of contact, our 'SETI visibility' is crucial, for at present it is our only link to the wider Big History of the universal story. Indeed if they are observing us, then we are *already* part of a Bigger History of which we understand little or nothing. If 'they' have been observing our Big History, however, by what means, and how long for?

2 Visibility: The Observers

2.1 Remote Observers

Since the birth in 1960 of the modern mainstream SETI programme, the idea of watchers among the stars has become a familiar trope: ETI (extraterrestrial intelligence) may be observing us as we seek to observe them, or even communicate with them. And we may speculate that advanced civilisations might achieve a great deal with such searches and observations. In general, ETI and its technology is not expected to be godlike, but we can assume that it can do at least all *we* could do, with unlimited budgets, foreseeable technologies and understood physical limits such as lightspeed. ETI may have observed us very deeply and may understand us very well indeed.

How might we be observed from the stars? Recently Mullan and Haqq-Misra (2019) gave an overview of the observability of life and civilisation on Earth, given current and foreseeable human technology devoted to the study of exoplanets (Seager et al. 2019). Remote ETI observers could, potentially, detect spectroscopic biosignatures as evidence of life on Earth. Detectable evidence of the presence of an intelligent species might include: radio signals, either leakage or intentional messages; our civilisation's impact on Earth's atmosphere; and technosignatures, such as the night side glow of Earth.

The most familiar of these evidence types are electromagnetic emissions. The modern mainstream SETI programme, the search for electromagnetic signals from extraterrestrial sources, came about almost as a technological accident. In the late 1950s physicists Giuseppe Cocconi and Philip Morrison (1959) noted that the large radio telescopes such as Jodrell Bank (80 m diameter) then coming online, happened to be capable of acting as transmitters and receivers of radio signals in exchanges spanning light years—and, even in 1959, there was sufficient power for a 200 m diameter dish to send a signal with the power to stand out against the galactic radio noise background. There seemed no reason why such beams should not exist already, coming 'from any suitable star within some tens of light years… Few will deny the profound importance, practical and philosophical, which the detection of interstellar communications would have… The probability of success is difficult to estimate, but if we never search, the chance of success is zero.'

This suggestion, that we should effectively look for cultures similar to our own, may seem parochial in a sense. But possibly our best initial models of the behaviours of ETI, given no direct evidence at all, remain those based on the assumption that *they do as we do*, if on different scales. Thus our best hope is to look for worlds and civilisations like our own, or extrapolated from our own—while combing the evidence for other anomalies. The initial SETI paradigm did make sense.

With no rapid detection of purposeful alien signals, however—and, as above, drawing on analogies with our own behaviour—attention turned to the possibility of detecting their 'leakage' radiation, analogous to that produced by our own civilisation from perhaps 1950: powerful radio-frequency signals from radar installations, TV and radio broadcasts, etc. (Sullivan et al. 1978). With the coming of narrow-band signalling and the delivery of signals through cables and fibres, in more recent decades Earth has in fact become 'quieter' in this regard, and there is some discussion about the detectability of such radiation with current or near-future instruments (e.g., Forgan and Nichol 2011). But still there is a bubble of powerful, structured 'leakage' radiation spreading out into space. So, given a lightspeed limit, we are at present visible as a technological species *through direct evidence* out to perhaps 70 ly, and there has been time for such signals to be picked up and responded to from stars within ~35 light-years.

In addition to these efforts to detect technologies directly, however, as Mullan et al. note, distant observers may seek indirect evidence of humanity's technological progress—such as from our impacts on our planet's atmosphere.

We ourselves are developing capabilities for studying the atmospheres of exoplanets remotely (see e.g., Lockley 2015, and references therein). The study of albedo spectra could yield day length, temperature, and a modelling of such features as cloud cover. As for evidence of intelligence, advanced instruments could potentially detect industrial pollutants. For example, some pollutants in the Earth's atmosphere have significant absorption features in the spectral range covered by the James Webb Space Telescope (Lin et al. 2014). The most easily detected anthropogenically produced chlorofluorocarbons (CFCs) could be detected or constrained at ~10 times the current terrestrial level by the JWST with less than 2 days' integration time.

If so, as discussed in the next section, ETI watchers among the stars could have been observing the evolution of our planet over extended periods of time—and could have deduced our own existence from evidence of our activities. But it is also possible that we have been observed closer at hand.

2.2 Close Observers

It is generally assumed that ETI observers of humanity will be remote—watching us from other star systems, as in the classic SETI paradigm. But this is not necessarily true. We ourselves have sent probes to inspect the planets from close range. So perhaps alien observers might send probes for close inspections of us.

An interesting test case of what an alien probe might make of modern-day Earth was an experiment run in December 1990 by Carl Sagan and others (Sagan et al. 1993) when the Galileo space probe, *en route* to Jupiter, made a flyby of the Earth (for trajectory boost purposes). The craft's instruments were trained on the Earth, and Sagan's team tried to interpret the data as if received from an unknown world.

Much of the interpretation teased from the Galileo data confirmed the ground truth. Earth had huge oceans with sheets of frozen material, presumed to be water given the temperature range and the presence of water in the atmosphere. Disequilibria in atmospheric gases were the strongest sign of life from a distance, including plentiful oxygen, and methane, a trace presence which, without renewal, should have been depleted in a decade. With an imaging resolution of ~1 km, Galileo's cameras showed no signs of intelligence-designed structures on the surface. Powerful, structured radio signals were the only sign of intelligence 'visible' to Galileo. Indeed, as the authors remarked, aside from the radio signals, "most of the evidence [of life on Earth] uncovered by Galileo would have been discovered by a similar flyby spacecraft as long ago as about two billion years" (Sagan et al. 1993).

This is a cautious reminder of the possible capabilities and limitations of such a remote probe's-eye view. However we should not underestimate the potential capabilities of probes derived from advanced technologies.

The idea of ETI using smart space probes as a specific means of monitoring us in fact dates back to Bracewell (1960), a proposal made at the time of the beginning of the 'conventional' SETI enterprise. Bracewell imagined a culture sending out many minimal-cost probes equipped with artificial intelligence at least at the human level. Even if the target system turned out to be uninhabited a probe could wait, for perhaps very long periods, for life to evolve or a target culture to develop.

Bracewell's argument was developed further over the years; a recent review was given by Gertz (2016). Tipler (1980) pointed out that the use of self-replicating von Neumann machines (von Neumann 1966) as the probes could reduce the costs of such a programme drastically—the originating culture need only bear the costs of sending out the first probe, and allow descendants to seed the Galaxy. A further purpose of such a probe could be to respond to the emergence of an advanced civilisation on Earth, and perhaps even make contact, as suggested by Bracewell himself (1960). The basic advantage of this approach lies in the possibility of rapid dialogue with a local probe, compared to an exchange of electromagnetic signals which might take decades.

One valuable treasure to be offered by contact with such a probe might be access to records of our own Big History. While our own SETI search is a mere 60 years old, the probe could have come here long ago. There are worlds billions of years older than ours—indeed the peak rate of rocky planet formation in the universe has been estimated as 6–8 billion years ago (Cirkovic 2018, p. xiv), so long before the formation of Earth. Perhaps such a probe might share detailed, *directly collected* data on our own past, of a quality beyond the reach of our own reconstructions from traces of evidence surviving to the present day, in geology, archaeology and palaeontology.

However, even remote observers could have been witnesses to humanity's deep past.

3 Visibility: Our Past and How ETI Sees Us

ETI astronomers may have maintained a continuous telescopic scrutiny of our Earth over many millennia—and perhaps much longer; the signature of oxygen in our air, an attention-grabbing sign of life, may have been visible remotely for two billion years.

If so we should assume they understand the background evolution of Earth systems at least as well as we do, such as the astronomical cycling of Earth's orbital parameters which in recent megayears has been forcing periodic ice ages. And, as noted above, they could surely recognise intelligence-induced divergences from the background pattern, as we ourselves have discovered in recent decades with the analysis of anthropogenic greenhouse gases (Ruddiman 2005). But how deep into our past have we been creating signals recognisably of intelligent origin?

As one early estimate, tentative evidence (Lewis and Maslin 2018) indicates that the first human control of fire may have been as far back as 1–1.9 mya, when *Homo erectus* was dominant. Fire may have been used to cook food and make it easier to eat, to flush out game—even, on a longer term, to adjust vegetative cover, with the promotion of grasslands. Fire is a natural phenomenon on the Earth (indeed Earth is the only planet on which fire is possible), but perhaps a remote observer might have recognised new patterns of fire on the planet, with the scattered sparks of camp fires as opposed to the more random lightning strikes and forest fires. This is only a tentative suggestion; the further back we go in time the more uncertainty of visibility there must be. But the control of fire seems to be *in principle* the earliest possible astronomically detectable signal of our ancestors' intelligent manipulation of the environment. And, if so, we may *in principle* be visible across a million light years, far beyond the bounds of the Galaxy.

Considerably more significant, and visible, impacts on the environment were inflicted after the emergence of anatomically modern humans some 300 kya[1] (Reich 2018, p. 28) with their increasingly complex societies and cumulative culture of invention and learning. From around 50 kya onwards humans carried out the slaughter of the megafauna (Lewis and Maslin 2018, p. 104ff), in which, over tens of thousands of years, 1–10 million humans destroyed a billion large animals. The more expert human hunters became, the more significant and rapid the percentage losses; 18% of Africa's megafauna was lost from 200 kya, while over 70% was lost in the Americas after the eruption of humans into those continents from ~5 kya (Harari 2011, Ch. 4). Further, consequential large-scale reconstructions of ecosystems were inflicted, for example the disappearance of the 'mammoth steppe' in Eurasia, which was replaced by a forested landscape with significantly less diversity. This may be an early example of a 'progress trap' for humanity, in which a growing expertise in the exploitation of a resource leads to the destruction of that resource.

A significant, and potentially remotely visible, consequence of this may have been the 'Younger Dryas' climate episode 12.8 kya (Lewis and Maslin 2018, p. 111), in which a drop in atmospheric methane—possibly due to the loss of the methane-producing megafauna—induced a brief return to glacial conditions.

Much less controversial human impacts in the historic greenhouse-gas signatures arose from the development of farming from some 7 kya (Lewis and Maslin 2018, p. 115ff). In a kind of cultural positive feedback, the accidental domestication of favoured plants and animals led to selection and rapid evolution, and an increased food supply that encouraged the growth of populations. This cultural development (or progress trap) is believed to have occurred at least fourteen times independently, across Eurasia and the Americas. Human numbers began to grow precipitately, from perhaps five million 11,000 years ago, reaching two or three hundred million by 0 AD (Lewis and Maslin 2018, Ch. 4).

The climatic impact of this is clearly seen in the greenhouse gas record. In terms of carbon dioxide, at 7 kya the concentration was at a 'natural' level of some 260 ppm (parts per million)—natural in terms of the relevant cycles of astronomical forcing. This concentration was actually declining as another epoch of glaciation approached. But by 1700 AD, after the injection of carbon dioxide from farming, and with the addition of methane from paddy farming in China and other sources, that decline, long reversed, had reached 280 ppm. There had been push-backs, such as the 'Orbis spike' dip at around 1500 AD, thought to have been caused by the Columbian Exchange, with the subsequent dramatic collapse of human populations in the Americas, and the reforestation of much of the continents. After 1700 AD and the Industrial Revolution the rate of rise itself rose dramatically, from some 0.3 ppm per century to about 60 ppm per century. And since about 1960, the 'Great Acceleration' rise has been some 150 ppm per century (Lewis and Maslin 2018, p. 143).

This dramatic rise reflects, of course, a rise in human population driven by the agricultural and industrial revolutions. In hunter-gatherer times human populations

[1]kya: thousand years ago.

grew by a factor of some 10^{-4}/year, with a doubling time of ~7000 y. Farming delivered a growth factor of some 1% per year, doubled to 2% a year after the Industrial Revolution. Could remote watchers correctly interpret our modern-day carbon dioxide spike?

Over its life span, the surface temperature of Earth has varied drastically, and so have levels of greenhouse gases. But it is the pacing of such phenomena that might help distant observers distinguish human-induced changes from rare but natural events. One such is the Eocene thermal maximum of some 56 Mya (Zalasiewicz 2008, p. 136ff). Here a rapid discharge of methane, perhaps from clathrates, led to a build-up of carbon dioxide, some 124 ppm over 10,000 years. After a peak temperature rise of 5°–10°, a recovery over 100–250,000 years followed. This bears some comparison to our own human-induced changes, but our post-Industrial Revolution greenhouse-gas concentration rise has been larger and considerably faster.

On the other hand, our 'spike' is not remotely as savage as that most dramatic of climate interventions, the impact that ended the Cretaceous some 66 Mya. In that event, with, essentially, the whole world ablaze, a carbon dioxide rise of six *thousand* ppm may have occurred in the first days, lingering at 2300 ppm even twenty thousand years later (Beerling et al. 2002).

This is not to say that a dramatic enough industrial accident could not be the cause of such an event. In the *Doctor Who s*erial 'Earthshock' (Marter 1983) a very large but out of control space freighter is diverted from the twenty-sixth century back through 66 m years, and its crash causes the Chicxulub event. The detonation, equivalent to some 10^{24}–10^{26} J, could have been caused by the detonation of some 10 m tonnes of matter-antimatter fuel. Equivalently a simple impact with a 'worldship' the mass of a comet core could have worked just as well—or, worse yet, some devastating interplanetary war in our future (Crawford and Baxter 2015).

In either case it may be that the modern-day growth rate in our emission signatures, somewhere between the Eocene maximum and the Chicxulub spike, may itself be a function of growth rates of population and energy usage typical of young civilisations like ours, and so recognisable from afar as the sign of intelligence. And it is these growth rates that may enable us, tentatively, to predict our own visibility into the further future—and therefore to extrapolate the potential visibility of ETI to us in the present day.

4 Visibility: Our Future and Why We Don't See Them

As noted above, possibly our best source of theoretical observables of ETI is based on extrapolations of our own behaviour, now, in the past, and in the future: now, in terms of for example the Earth's nightside glow; in the past for example in terms of analogies of anthropogenic climate change—and, when it comes to more advanced ETI, in our future too. How then do we anticipate our own future, given our past? And what SETI-style observables might be predicted?

4.1 The Kardashev Scale

Over the last few decades the *Kardashev scale* (Kardashev 1964), which categorises capabilities of technological civilisations by their energy requirements, has emerged as a useful organising principle in discussions of hypothetical futures for humanity, as well as debates about the possible nature and capabilities of ETI in the present.

In 1964 the Soviet astronomer N. Kardashev, seeking estimates of the power needed by a culture to send a SETI signal capable of being detected on modern Earth, defined three classes of technological society:

- Type I (or K-I)—a civilisation exploiting all the energy from its star intercepted by a planet—for Sun-Earth, characterised by a power level of ~2×10^{17} W
- Type II (or K-II)—a civilisation exploiting the total energy output from its star, for example using a Dyson sphere—for the Solar System, ~4×10^{26} W
- Type III (or K-III)—a civilisation exploiting the entire energy output of its Galaxy of ~10^{11} stars—for our Galaxy, ~4×10^{37} W.

(Note that with time Type I has been subtly redefined from Kardashev's original definition, which he gave as the Earth's present technological level.) Some extensions to the scale have been proposed based on other measures of value, for example information usage. But since it takes energy to process any information however efficiently, such scales are interrelated.

Against the background of his own rapidly growing civilisation of the 1960s, Kardashev estimated the times that might be taken to reach the various type stages—and they were surprisingly short. Starting from an estimated ~4×10^{12} W in 1964, and growth levels of 1% pa (with a doubling time of 70 years), Kardashev calculated that we would reach K-I (planetary) in a mere millennium (~1087 y), K-II (stellar) in ~3200 y, and K-III (galactic) in ~5800 y. (There is an obvious logical flaw in the K-III estimate, given that the Galaxy is some 120,000 ly across; with lightspeed limits its extent could not be explored in 5800 y—see the discussion of the 'light cage limit' below.)

For the purposes of the present discussion, how would the visibility of the Earth change if we grew and approached these stages?

4.2 Transition from Modern to K-I (Planetary)

As our terrestrial culture advances, it is possible that very large-scale modifications to the planet, perhaps through 'geoengineering', the management of planetary systems to mitigate the climate crisis, might actually be visible remotely. These might include a rapid sequestration of greenhouse gases from the air, or large-scale land management resulting in, for example, reforestation in geometrically neat patches—or huge mirrors suspended in orbit to deflect sunlight.

More fundamental signatures of technology might be changes to the planet's albedo and infra-red output. Mullan and Haqq-Misra (2019) pointed out that an emerging K-I civilisation using a large fraction of the incident stellar energy, and/or energy from some independent power source, could alter its planetary spectrum in the mid-infrared due to additional waste heat. Currently some 30% of the sunlight incident on Earth is reflected away; the other 70%, having passed through the Earth's systems, eventually radiates away as waste heat. But human power usage at present is some 30 TW (International Energy Authority 2019), negligible compared to the total solar insolation at the top of the atmosphere of ~175,000 TW. (Geothermal energy is also negligible compared to the insolation.) If very large artificial energy sources such as fusion reactors were deployed on Earth, perhaps the waste heat output would rise significantly. This could be detected remotely if the total heat radiated away were significantly greater than the incoming insolation.

Alternatively, if all of the insolation were harnessed, if the planet were coated with solar energy capture panels with very little reflection, its albedo (currently ~30%) might approach the Moon's (~14%). But a very heavily industrialised planet—like Coruscant, capital of an interstellar empire in the *Star Wars* franchise—with the inhabitants relying totally on artificial power, might be *highly* reflective, and with a very high waste heat output: a monumental night glow.

The nature of such modified worlds might be hinted at, then, simply from their albedos and waste heat signatures. We have yet to detect any such modification, though our studies of exoplanets are still in their infancy.

But what of the further future?

4.3 Transition from K-I (Planetary) to K-II (Stellar)

Over the decades, and even before Kardashev, space advocates have tried to predict, or shape, our future expansion into space. The result has been engineering visions showing, in principle, how energy at Kardashev's next level might be captured and exploited. But these visions, often based on exponential-growth models, extrapolated from the present, have a tendency to predict reaching the K-II stage, that is a significant exploitation of the Solar System's resources, on a timescale of mere millennia—just as in Kardashev's preliminary calculation. For example, in the 1970s Gerard K. O'Neill (O'Neill 1976) at Princeton and co-workers delivered the most detailed prospectus yet on the human settlement of space, and why, in O'Neill's thinking, it is necessary for our future—a prospectus and argument that is still influential, indeed is revisited, today (e.g., Gunn and Soilleux 2019).

O'Neill predicted that by tapping the flow of energy from the Sun, and with raw materials initially taken from the Moon or the asteroids, a very rapid expansion of industry and population in space could be achieved. O'Neill was suspicious of 'static' societies, but was also aware of the danger of the rapid depletion of resources through growth, and suggested a bootstrapping expansion of space colonies modelled with a 'modest' growth rate: 'about a tenth as large as our present explosive increase would be sufficient to make the difference between stasis and change' (p. 247). The growth rate chosen was ~0.2% pa—a doubling time of ~350 y. The measure of expansion was a growth in living space for humanity based on the construction of swarms of space habitats.

But even on that 'modest' basis the asteroids—which O'Neill claimed would enable the construction of living surfaces 3000 times that of Earth (p. 9)—would be consumed in ~4000 years. Further out, the outer planet moons with combined mass ~10,000 times the asteroids would be consumed after 8600 y, and even the outer planets, a thousand times more, after 12,000 y.

Such predictions continue to be made, such as by Zubrin (2019), with order-of-magnitude similar outcomes. In such models exponential growths are extremely rapid in the closing stages. It is striking that in O'Neill's model all the planetary masses, including Jupiter, would have to be dismantled for raw materials in the final 3–4000 years.

There have been push-backs against such visions. History shows us that the fate of expansive cultures which hit their resource limits is often not pretty; see Diamond (2005) for well-documented historic examples. Elvis and Milligan (2019) have suggested imposing a purposeful end to exponential growth well within the limits of accessible Solar System resources. They proposed a one-eighth rule, with one-eighth of the System's resources free to consume, but the rest of the System—seven-eighths—left as 'wilderness.' This would be three doubling times before the emergency of terminal exhaustion, so would give time for deliberation, but late enough in the process for the growth rate's consequences to be clear, and debatable.

What of the visibility of a civilisation approaching K-II status?

The transformation of the Solar System itself could be very visible. In the later stages of a culture's evolution to full K-II capabilities we might expect the development of very large structures in space, capturing more and more of the Sun's light. As such structures pass between an observer's telescope and the Sun, anomalous light dips might be observed, not explicable by the presence of planets or other simple naturalistic explanations. No such objects have yet been definitively observed around other stars by the exoplanet astronomers, though 'Tabby's Star' (Meng et al. 2017) was briefly a candidate.

In a SETI context, Zubrin (1996) has analysed the detectability of various classes of (hypothetical) starships, of the kind that might be constructed by a sub-K-II star-faring civilisation, with foreseeable technology. Certainly, the energies required for interstellar travel ought to be within the means of a K-II culture. A 1000 tonne craft travelling at 10% lightspeed would require 4.5×10^{20} J of kinetic energy—equivalent to fractions of a second of the culture's total power budget.

Such ships would be very visible indeed, even to remote observers. For example, Zubrin showed that an antimatter-drive starship capable of interstellar journeys of ~decades could be detectable even with amateur astronomical equipment at ~11 y,[2] by the Palomar 200-in. telescope at ~20 ly, by more powerful ground-based

[2] ly: light-year.

instruments more remotely, and by the Hubble at ~300 ly. Such a drive would be distinguishable from a star by the lack of hydrogen lines in its spectrum. No such technologies have yet been observed.

Perhaps the ultimate K-II artefact, now known as the ‘Dyson sphere’, was proposed by Freeman Dyson (1960). Dyson estimated it would take only ~800 y of the Sun’s output to disassemble Jupiter (based on its binding energy), and to assemble a shell of radius ~1 AU and perhaps 2–3 m thick, the purpose being to trap all the Sun’s radiant energy and to maximise living area. Dyson would later refine his proposal to suggest a spherical swarm of habitats rather than a simple solid sphere. Dyson suggested looking for such objects, extended, with the power output of the Sun, but radiating waste heat in the far infra-red, at effective temperature 200–300 K. These are big targets astronomically. At 4 light-years, such a sphere would subtend a similar angle to an asteroid ~500 km across at 1 AU. Several such searches have since been made (e.g., Carrigan 2009; Mullan and Haqq-Misra 2019), but no such technologies have been observed.

In summary there is, at present at least, no evidence for post-O’Neill, post-K-I industrialisations to be found among the nearby stars.

4.4 Transition from K-II (Stellar) to K-III (Galactic)

Suppose we do achieve K-II status. As a first step towards a further maturity as a K-III galactic-scale culture, could we continue to drive a colonising wave of the O’Neill kind beyond the confines of the Solar System? And might ETI have made the same transition?

In 1975 von Hoerner published a very influential paper on this subject. The argument was revisited by Mullan and Haqq-Misra (2019) with much the same result. Humanity’s growth was modelled in terms of a sphere of interstellar exploitation whose volume grows exponentially (and in fact von Hoerner noted that at the time of his writing human population growth was believed to be *more* than exponential). Von Hoerner asked, could our growing numbers be absorbed, in principle, by interstellar expansion? His conclusion, based on simple mathematics, was that they could not.

Consider a colonised volume V with radius R, in light years. If the colonisation volume is growing exponentially at annual rate k (so that if the growth is 2% per annum, $k = 0.02$), then its radius must also be growing at an exponential rate, and the rate of that expansion is actually a speed (distance divided by time), its size given by kR/3. So the wavefront expands at a speed proportional to the radius—a speed which must reach a limit at the speed of light, c. From the formula, this occurs at a maximum distance $R = 3c/k$.

Von Hoerner suggested a growth factor of 2% pa; the bubble would be expanding at light speed when $R \sim 150$ ly. Such a bubble might contain 57,000 stars (given modern estimates of stellar density of 4×10^{-3} stars per cubic light year, see Mullan and Haqq-Misra (2019)), and if 20% of planets are in the stars’ habitable zones there may be ~11,000 colonisable targets. (Von Hoerner reached similar numbers with 1970s data.) However, this limit would be reached in a mere ~460 y.

This has become known as the 'light cage limit' (Baxter 2002; McInnes 2002): the limit beyond which it seems clear that even interstellar colonisation could not 'soak up' a population expanding at historic rates. In practice such a colonisation wave would presumably collapse in on itself through resource depletion—or there could be war over resources either internally within bubbles, or as one expanding bubble intersected another. Such colonisation bubbles could be visible from afar, but transiently, on a scale perhaps of centuries or millennia. One could imagine a Galaxy full of failed colonisation bubbles a few hundred light years across, their resources depleted—ruins, but again, potentially observable. We have yet to observe any of these phenomena.

Von Hoerner's gloomy analysis, however, may itself contain a hint of how to evade the light-cage trap, and grow to colonise the Galaxy: that is, to proceed much more cautiously and sustainably. As an example, if a lightspeed expansion limit is not to be reached before $R = 120{,}000$ ly (the diameter of the Galaxy) then by the previous analysis, given $k = 3 \times c/R$, we require $k \sim 3 \times 10^{-5}$/y or less. (The Galaxy is of course not spherical, but an analysis of a spread across a disc gives a similar order of magnitude result.) This corresponds to a doubling time of 23,000 y, a remarkably slow and cautious expansion: a civilisation growing slower than a tree. Thirty-seven doublings would be required to reach all the Galaxy's ~10^{11} stars, a total time of 851,000 y, at an average colonisation speed of 14%c. However, the Galaxy is ~10,000 times older than this, and so this argument cannot be a candidate solution to the Fermi Paradox: slow as the process seems, there has been time for such expansions, even at this rate, to have happened many times over. But in human terms 800,000 years is an immense, indeed an evolutionary, timescale: 800,000 years ago (Lewis and Maslin 2018) our ancestral species *H. heidelbergensis* was speciating from *H. erectus.* It may be that 'we' will have speciated by the time any human-descended colonists arrive at the centre of the Galaxy; perhaps the setting of a K-III culture is simply too 'big' for us modern humans.

Newman and Sagan (1985) gave an early version of such an analysis. In essence they adapted models of the spread of animals under population pressure to consider a possible 'diffusion' of mankind across the Galaxy. Repeating von Hoerner's analysis, they pointed out the sensitive dependency of the rate of colonisation of the Galaxy on human growth rates, but noted that contemporary population growth rates were already falling, and over human history have averaged order $k \sim 3 \times 10^{-4}$/y, and were probably lower yet in hunter-gatherer days. Such growth rates, as above, predict colonisation times of the order of hundreds of millions of years. In 2009 Haqq-Misra and Baum formalised these thoughts in a 'sustainability solution' to the Fermi Paradox, and Mullan and Haqq-Misra (2019) revisited this work. Such slow growth might not be visible to our SETI observation programmes which to date span only decades.

Surprisingly perhaps, however, mature K-III cultures, in our Galaxy and even others, ought to be readily visible.

4.5 The Visibility of K-III Cultures

The further we look into the future the harder it is for us to extrapolate ETI our own behaviour and capabilities. Perhaps a K-III culture would choose to modify the evolution of the stars themselves (Beech 2008). Perhaps they would be capable of such remarkable engineering feats as faster-than-light 'warp drive', which might involve manipulating relativistic mass-energies magnitude greater than the Sun's (Krauss 1995), or mining the supermassive black hole at the centre of the Galaxy (Baxter 2018). Some of this we may observe without understanding, or misinterpret as exotic natural processes.

But even K-III cultures are subject to physical law; even they will produce waste heat. How would a heavily industrialised galaxy appear from afar? Annis (1999) pointed out that there are simple relationships between the measurable, large-scale properties of a galaxy, given theoretical astrophysical models: properties such as the galaxy's radius, its intensity (surface brightness) and a 'temperature' based on the averaged velocity of its stars. Annis used a sample of 31 spirals and 106 ellipticals to show that not one outlier from the expected relationships existed, as would be the case if, for instance, many stars in a galaxy were cloaked by Dyson spheres, and the overall intensity reduced.

Two decades later, Garrett (2015) reported a study of galactic mid-infrared emissions from a sample of ~200 galaxies. These showed only natural-looking IR spectra, leading to the conclusion that 'Kardashev Type-III civilizations are either very rare or do not exist in the local universe.'

The biggest of Big Histories then, are so far invisible to us.

4.6 Where Are They?

As noted above, the Fermi Paradox encapsulates a deep mystery in a simple question. We exist as an intelligent technological species, visible across light years. The principle of mediocrity predicts that we should not be unique in this, yet we see no others. Where are they?

In the decades since the formulation of the Paradox there have been multiple candidate solutions (Cirkovic 2018). Hart (1975) published a devastating critique of candidate Fermi 'solutions' proposed to that date, concluding, brutally, that ETI does not exist within our observable Universe and so SETI is a waste of time. This argument was so forceful that is seems to have discouraged the then-current Soviet experiments in SETI. Alternatively, it may be that the whole universe is somehow false, a fake; perhaps what we see is, through intelligent design, not the true reality at all (Ball 1973; Baxter 2001).

Or it may be that we simply misunderstand what we are seeing. A culture following the 'sustainable', 'diffusion' growth rates discussed in the previous section could display very long developmental stages even in earlier Kardashev stages. At a growth rate k = ~3×10^{-5}/year—three one-thousandths of a percent per year—a culture starting from our present status might take, not a millennium to reach the K-I level, but some 300,000 years, and perhaps a million years to reach K-II. Perhaps they are out there, developing patiently and slowly: again, civilisations growing like trees, now in a peaceful forest.

In any event, it seems that we must assume that our present and past is available for ETI to examine in arbitrarily fine detail, in principle at least. But our guesswork at the nature of *their* present and past is based on dreams of a human future—dreams which seem flawed, the guesswork faulty. The implications for Big History are challenging, if so. Not only do we fail to understand the Big History of the universe, we fail even to anticipate our own Big Future.

5 Conclusions

As noted above Big History may be a philosophical companion of SETI, a contemplation on the nature of life and intelligence beyond modern human limits. But Big History may also be a companion of science fiction, which at its best explores what it is to inhabit the universe revealed by modern science—how it *feels* to live in this Universe, this great, entropically slowing, cosmological engine.

This is exemplified by one of the most famous works in the field, *2001: A Space Odyssey*, in Kubrick's movie (1968) and Clarke's novel (Clarke 1968). This is a drama of the sudden amplification of our own Big History to the cosmic scale, which hinges on a moment when scientist Heywood Floyd confronts an alien artefact, a monolith buried on the Moon. Whatever becomes of this discovery, Floyd reflects, mankind would know it 'was not unique in the Universe... Those who had once stood here might yet return; and if not, there might be others. All futures must now contain this possibility' (Clarke 1968, p. 82). Everything has changed, has pivoted, just from the mere discovery of this one (apparently) mute artefact.

Such considerations have immense implications for Big History.

If we are alone in the universe, astounding as the idea seems—if ours is the only advanced consciousness—then in a sense the Big History of the *entire universe* culminates in us, because only in us have the cosmic forces conspired to produce an entity capable of reflecting on those forces. Nobody is watching us or listening to us, but our significance is huge, for we are unique. And the biggest of Big-Historical questions in that case must be: why do we exist at all? Why mind here, and nowhere else?

But if we are not alone in the universe, if out there are other minds in some way comparable to our own, capable of observing and deducing—even if we are on quite different cultural trajectories—then two further possibilities exist.

Perhaps they are evolving as much in ignorance of us as we are of them (and there may be many 'thems')—analogous perhaps to the parallel but isolated developments of civilisations in the Old and New Worlds before Columbus. Perhaps multiple Big

Histories will someday merge, or be revealed as strands of a grander cosmic picture (see also Garrett, this volume).

Or perhaps they are already watching us, and are either incapable of letting us know—or unwilling.

In any of these cases, in a cosmic context our Big History is *already* big in space as well as time. And, possibly, if others are covertly observing us, our Big History so far may already have been witnessed, and judged.

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Chapter 8
Re-encountering Signs of Agency: Surveying the Appearance of 'Layering' Patterns Within Our Interstellar Messaging Record as Representational Signs for Earth

Paul E. Quast

Abstract The tentatively recognised Anthropocene epoch illustrates the growing exigent impacts of modern human interactions across multitudes of ecological services. However, this age also draws into sharp focus the entwined cognitive and spatiotemporal dimensions of various active legacies which locally impact our world, yet have now come to also distantly represent human behavioural patterns within phenomena beyond our biome. These remote legacies include the unfolding futurescape of anthropogenic technosignatures, but also the advent of deliberate 'messages' using aerospace technologies that varyingly re-present human pantomimes beyond this terrestrial stage. The bulk of these disconnected messaging legacies are extensively dispersed across our spatiotemporal environments. However, there are occurrences of 'layering' across select regions—especially within interstellar transmission ventures that intermittently re-target particular stellar systems. These sequences of electromagnetic message-signals arguably remain as the furthest recurring traces of purposeful human agency and representational material practices, but they also reshape the mindscapes of described societies at home. The symbolic relationships encoded within our message-signals, as argued herein, will likely remain equivocal for foreign recipients. However, by taking a closer look at the meta-semiotic features of encountering multiple messages directed towards some targets, what insights can we ourselves glean about our transmission behaviours and expanding worldviews?

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1 Introduction: Thinking Through Abstraction

When did abstract representational practices or intentional symbolic depictions of internal mental faculties, indicative of those we describe as elements of behavioural modernity, appear in the externalised material record of *Homo sapiens* societies[1]?

This ongoing quandary is a rather cumbersome, culturally-loaded and historically contested arena; encompassing a long genealogy of analytical methods conjured by divergent epistemic domains, sometimes heated disciplinary exchanges about popular history, and equivocal evidence from a broad range of disputed archaeological sources retrieved from 'the dirt.' Coupled with this, there is much philosophical, neurobiological and psychological debate within various scholarly communities as to what exactly constitutes representational human behavioural practices, and the myriad of neuro-semiotic thresholds necessary for the recognition of these prescribed mental faculties (Mellars and Gibson 1996; Tomasello 2001; Gärdenfors 2006). Despite this enduring disparity in debates—essentially between evidence acquisition, data interpretation, and how disciplinary orientations can vary (Denning 2010a; Renfrew 2008)—most interdisciplinary studies tend to corral around the identification of symbolic representational depictions, apparent across layered deposits of material culture, as a reliable proxy indicator for the emergence of behavioural modernity in material practices.[2]

It is likely the psychological, conceptual and philosophical 'roots' of early human symbolic representational practices developed across different patches of time, and different social settings, with divergent outcomes that may not correspond with the lineage of *etiquettes and customs we tend to subliminally and uncritically project upon erstwhile human minds*. We may never truly uncover suitable answers for how the entwined big histories of various human societies initially culminated in the development of abstract representational behaviours through our material engagement theories and range of fieldwork methods. This, I hope, is a relatively incontestable statement to make at this early point in the chapter.

Parallel to many of my colleagues involved within these studies, my interest in approaches taken to the above quandary lies within its cognitive and philosophical relevance for *our evolving worldviews* since pre-antiquity, the heritage significance, and conflation of organised analytical methods in assembling different kinds of theoretics, models, opinions and truths from indirect patterns underpinning ancestral

[1]For the moment, I refer to the ostentatious manipulation of objects beyond utilitarian tool making (habitual, accumulative and modification tasks that other homininae and non-hominoidea species also exhibit) which denote symbolic thinking mediated through mental-material engagement behaviours. This is a loose description as techniques used to produce tools are often also a reflection of a societies' symbolic rather than solely utilitarian functions. Creating attractive forms and appearances in materials reshapes our thinking and value relationships with myriads of things—interactions that lead to symbolic signs and identity-crafting practices.

[2]This position privileges the idiom of visual images as an imperative signifier for such practices, despite probably having come last in the chronology of other cognitive representational schema within material culture.

evidence. Moreover, should we expect artefacts of material culture—as an archaeological resource, now severed from that societies’ lived social experiences—to even transition back into a systemic context (Schiffer 1972), to perhaps ‘re-present’ clues about the lifestyles and voices of its creators *for foreign audiences*? Aside from an interest in the meta-factors underscoring these active debates, I am intrigued by the significance these discussions may possess for probing *our future representational legacies, emanating from today’s technological and ecological interactions*—behavioural residues, endowed in new and dynamic environmental records.

In drawing parallels with the early emergence of behavioural modernity on the material record, I offer the following simple observations as my point of departure: representational mental-material engagement practices expressing human world-views varyingly appear across an assortment of geological strata—stretching from pre-antiquity lithics to the growing *post hoc* academic intrigue in refuse deposits, the decline of architectural sites from modernity, and remnants from contemporary explorational activities in outer space. Some, if not most, of these material legacies possess an indelible reach across deep-time environments, and may plausibly be encountered someday and studied as some of the earliest perceptible evidence for the representational behaviours of modern *Homo sapiens* societies; either by human posterity or—as suggested by the nature of unidirectional electromagnetic transmissions—distant Extraterrestrial Intelligences (ETI). In context with probing this unpredictable futurescape, can the scholarly lessons garnered from our traditional archaeological excavation methodologies—techniques employed in studying the stratigraphic layers of ancestral sites—allegorically benefit an ‘armchair’ examination of emergent representational practices across our relatively modern, interstellar archaeological record?

As an interdisciplinary scholar working in the humanities and social sciences, I would personally err on the side of caution when answering this in the affirmative through any particular vocational lens. But I will complicate the issue further by focusing my attention upon a seldom recognised epiphenomenon which emerged as an intellectual curiosity while co-penning a publication on deliberate ‘messaging’[3] practices in outer space (Quast Forthcoming). What can the ‘layers’ of interstellar signal[4] projects, sent towards some overlapping stellar targets during different points in our recent history, provisionally teach us about our mental-material behavioural interactions which intend to function across cosmic distances and timescales? Granted, this is an unusual way to introduce a chapter essentially about the

[3]By using the term ‘messages’ here, I refer to the broad range of artefacts, inscribed content-bearing data carriers, and encoded interstellar transmissions, alongside the media included within these artifices. The nondescript term ‘messages’ is ubiquitous when discussing cultural objects used in space activities and is interchangeable with ‘depositories’ as outlined in the book *Time Capsules: A Cultural History* (Jarvis 2003).

[4]Herein, I use the term ‘signal’ to differentiate between an unrecognised phenomenon (which all transmissions initially start off as), and the latterly recognised signals as ‘signs’ with a meaning—or ‘agency’ (as a recognised act of influence on materials—a narrow anthropocentric viewpoint is taken, given the subject)—as ‘messages.’

intersecting cognitive and material life of messaging-signals as recurring artefacts—or signs—for human representational practices; products that will sequentially reach targeted stars over varying intervals of time—i.e., as prospective 'layers.' Nevertheless, incorporating such allegorical reframing about *how we initially encounter material signs with perceptible acts of agency,* has previously enabled us to examine presumptions around our broader spatiotemporal influences, while also elucidating often overlooked features of these abstract legacies that now operate across a cosmic stage *on behalf of all Earth's inhabitants*.

The approach of studying stratigraphic layering, across physical and temporal columns in archaeological excavations, has proven to be an integral and powerful contextual indicator when searching for a 'meaning' discretely codified in material 'things'; sometimes referred to as metadata context, or a "metasemiotic cue", that causally ensures signals (intentional or not) are recognised as artificial signs of explainable intent as part of an interpreters' "reception phase" (Saint-Gelais 2014). In this context, what do our overlapping sequences of electromagnetic signals—as purposeful 'bio-indices,' 'bio-icons' and 'bio-symbols' for Earth (Dunér 2018)—'speak to' at this intersection point between reception, and an initial extrapolation from signs? Might taking a fresh view at the overlooked metadata of 'layering' messages onto particular target stars across staggered time intervals, provide insights into our material engagement practices as a unique storehouse of archaeological evidence for a comparable 'emergence of behavioural modernity'?

2 Layering as an Instrumental Storehouse of Contextual Knowledge

As a prerequisite tool of the trade, archaeologists tend to be conceptually skilled in balancing creative and pragmatic intuition with cautionary analogous reasoning, when making inferences about the periodic generations of hominid settlements and their behavioural activities *without first-hand observations for these denizens of study*. In the absence of H.G. Wells' time machine for studying the scope of ancient human behaviours, most insights have had to be carefully gleaned through bridging theoretical arguments for overarching contextual trends using impoverished material remnants, clever technical examinations of relics, and adaptive learning from cautionary tales cultivated over successive vocational generations (frequently garnered by learning retrospectively from mistakes and counterproductive hypotheses that have refined this disciplinary toolkit). Given these sweeping differences in carefully acquiring, interpreting and deducting meaning from particular disciplinary datasets, there is a deep appreciation for how these rational inferences relate to *the social construction of knowledge about others*; both in terms of how theories may accurately map onto described societies from antiquity and, on the other hand, how these inferences are not neutral but *framed by us*—an active interrogating agent, guided by its own substrates of beliefs, traditions, epistemic domains, prejudices and personal dispositions.

Even without having to rely on a competency in abstract symbolic or lingual expressions pioneered by ancestral cultures, or resorting to drawing provisional deductions through ethnographic analogies with present-day human societies, the particular methods by which an archaeological site is simply excavated may serve as perhaps the most fundamental and reliable storehouse of knowledge for extrapolating clues as to what happened in human history, when and why this was the case, and how material evidence may be used for studying processes of long-term change across intergenerational timescales (Plog 1974). To think about how these practices of excavation may contribute insights towards our understanding of the encountered layers within an interstellar archaeological record, we might begin by cautiously indulging in a terrestrial anecdote from recent history to better explicate this semiosis dilemma of discovery and rediscovery further.

2.1 Thinking Through Accumulative Layering Within Material Deposition Practices

Two decades ago, at the beginning of a new season of field excavations in Blombos Cave, perched high on a cliff face in the Southern Cape of the Still Bay coastline, archaeologists uncovered a number of peculiar artefacts in the Middle Stone Age layers of this ancient lithic dwelling (Henshilwood 2002; Henshilwood et al. 2002, 2009, 2018). Amongst the undisturbed stratigraphic grids containing ‘sustenance-economics’ relics, shells, bones, hearths, bifacial tool flakes and other ancestral debitage haphazardly laid down over time, a piece of red ochre (M1-5) was uncovered in the designated ‘CC’ layer, featuring what looked to be an engraved pattern. Scepticism ensued over the importance of this motif. The following year, while excavating a nearby grid of sediment, another similar lithic ‘drawing’ (M1-6) was unearthed beneath the original discovery in the ‘CD’ layer, detailing finely-engraved striations that map out a simple cross-hatched pattern; presenting a tantalising comparison of two unequivocal engravings which may serve as corroborative evidence for our ancestors’ emerging cognitive capabilities in undertaking symbol-mediated thinking through material practices. The intricate plotting of these artefacts in the sediment columns, and its structural composition, would reveal a timestamp for the prospective origins of these material artefacts; stretching *our theories* of emerging human representational practices back to circa 77,000 BP.

The ensuing seasons of excavations would tease out these sediment layers further, revealing other stylised patterns on several fragments of ochre occurring in parallel or beneath the prior strata (Fig. 8.1), in addition to uncovering artisan paint palettes and lithic tools from an earlier pigment workshop. The implications of these artefacts were remarkable for debates in the scientific community as they conserved episodic behavioural signs about the earliest ancestral populations at this site, such as their

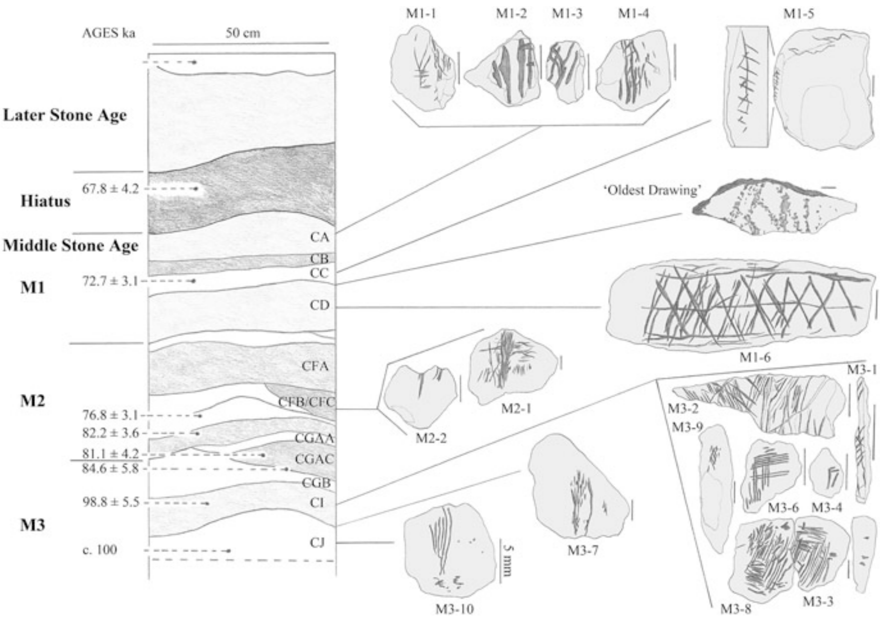

Fig. 8.1 Stratigraphy of the south section of Blombos Cave, plotting depths (from various grids) of engraved ochres, alongside the silica flake with 'oldest-known' line drawing (Re-drawn after Henshilwood et al. 2009)

customary importing activities (the ochre and other lithic tools were mined and transported to Blombos from unidentified locations, implying active planning and forethought in workshop preparation), the formulation and adherence to pigment 'recipes' (ingredients include multiple kinds of ochre mixed with mammal bone marrow), and the conscious adaptation of found or fashioned objects to bootstrap creative traditions—perhaps stretching our grainy snapshots of abstract representational faculties to about 100,000 BP.

Sometimes, a piece of ochre is just a piece of ochre—or is it? A single fragment of engraved ochre possesses a tantalising but only peripheral semiotic relationship with prescribed abstract representational behaviours, owing to the precondition for archaeological deductions to be firmly refined through multiple corroborating samples, rather than single evidentiary sources. The marks are only important—and therefore only have value—if shown to be anthropogenic, a burden of proof which a single example does not satisfy. In this sense, the pattern engraved on a portable material relic may indeed be a material sign emanating from abstract ritual practices or elements of cultural identity and expression, but it may equally be incidental; an offshoot resulting from tool fabrication or other passive trace activities that took place in an identified ancestral dwelling. This premature determination, of course, becomes contestable once the archaeologist—as a practicing semiotician working on an opaque jigsaw pattern—factors in the connected material signs found across undisturbed strata, depicting other cross-hatched designs from deliberate grinding actions, in addition to the earlier chronological evidence of utensils from the ancient pigment workshop.

Taken as a whole contextual sample, the substantial efforts to detangle these stratigraphic layers cultivates a meaningful interpretation that the early, multigenerational occupants of Blombos Cave were likely engaged in hallmark expressive, identity-crafting mental practices across a range of media and clear chronology, rather than passive pawns merely living out their lives on an environmental stage. But whether these activities imply that the practitioners were consciously aware of engaging within representational behaviours of using one thing to signify another (i.e., thinking about thinking), or simply using such media as prostheses to mentally ‘probe’ the outside world outside of depiction activities, is also crucial for our inquiry (cf. Humphrey 1998; Malafouris 2007, 2013). Personally, I am conflicted as to whether these engravings symbolise (in a Peircean sense) anything meaningful as discussed momentarily. But such mark making is certainly meaningful, as it enabled the exploration of a new creative material ecology useful for inspiring and shaping further forms of cognitive interactions.

2.2 Learning from Stylised Signs, What Is Symbolised Within the Ochres?

Before we proceed, a moderate digression into perceptual theories and cognitive semiosis in materiality is warranted. As discussed momentarily, we do not simply ‘see the world for what it is,’ but rather through our particular looking glasses of cultural, sensory, cognitive and epistemic domains, which subjectively colours, and favourably intermixes, our anthropomorphic experiences of environmental settings. The case of patterned, cross-etched lines presents resonance, and much uncomfortable rumination, for us as a simple yet defining exposition of our limits to perceptually extract meaning from dissevered abstract mental signs, depicted on extraneous mediums. But these vignettes also draw our attention towards the related, inverse challenges of how we may purposefully convey an experienced noetic concept, signifying displaced referents with signs on a material vessel, across an increasing spatiotemporal disunity between the creator’s heritage, and that of an unknown recipient’s customs and perceptual experiences.

2.2.1 Ways of Seeing, and Thinking, and ‘Thinging’

Often, we do not need to excessively examine modern cultural formats like pictures to (in a Peircean sense) ‘abduct’ what they depict. In broad strokes, these abductive faculties are owed to mutual life-world features and experiences such as; a common mental architecture; shared perceptual preferences; distributed cognitive interactions between other living minds, environmental settings and material things; and a historical scaffolding of socio-cultural conventions (amongst other affiliated value codes) which covertly operate on different spatial settings (internal, interpersonal etc.) and temporal scales (e.g., neural, cultural, generational) in global syntactic patterns *for inducted audiences*. The ease by which we navigate these networks when leaping from, in this case, a visual percept of a recognised sign (e.g., a lingual expression in script, or conventional pictograph) to signified meaning between present-day individual brains, belies the complexity underpinning these cumbersome deductive steps that usually operate in the mental background for competent 'readers.'

Drawing out some of the most salient constituents involved within our cognitive information processing faculties, naturally requires us to begin by briefly delving into the realm of perceptual psychology. This will highlight what stimuli we are prone to respond to, and how preferences in (for example) our visual system collectively underscore our particular domains of seeing through abstract mark making practices. I do not wish to meaningfully tackle *gestalt principles* here, or the dimensions of related neuroscience, perceptual ecologies, and cultural material engagement theories that disparately identify and discuss human cognitive predilections in specific niches—otherwise known as human *umwelt* experiences (Halverson 1992; Sonesson 1993; Gillespie Forthcoming). Without straying too far out into this expansive and often discordant literature, some dominant visual preferences underscoring our perceptual experiences are primarily framed by several optical triggers which our visual system actively responds to, including; bilateral symmetry, the presence of corners, occlusive boundaries, chiaroscuro in shading or colour, motion parallax, proximity, contour integration, observed similarity or feature saliency, canonical perspectives, and directionality for regions of contrast. The accumulative effects resulting from only some of these simple principles, can be seen at work in Fig. 8.1 to deliver an apprehendable graphic for demonstrating the prior ochre analogy. We occasionally become aware of how our minds overrate the naturality of these perceptual value codes from an external prerogative, for instance when we disabuse ourselves in viewing ambiguous Rorschach inkblot patterns or Müller-Lyer illusions, but our other sensory channels each possess their own unique evolutionary partialities and stimuli preferences in responding to our encompassing ecologies and broader planetary surroundings.

Coupled with this is our shared practice of varyingly expressing mental thoughts across an established semiosis framework; cognitive skills for thinking, endowing meaning, and conceptually conveying our 'human lifeworld' experiences to others (Dunér 2013; Dunér and Sonesson 2016). Generally, we do not think about 'real' objects, but rather the surrogate memory values and typologies of encoded signs that collectively substitute for experienced referents in a participant's inducted mind—indexical, iconic and symbolic expressions[5] whose meaning is varyingly shared, and continually re-shaped within particular social settings as functional contexts or

[5]Peirce's semiotics theory proposes more than 76 typologies and definitions for signs that may largely be distilled into three canonical typologies; 'icons,' 'indices' and 'symbols' which I will

"implicit cues" (Saint-Gelais 2014). For instance, drawing the readers' attention to the pen in front of me, brings forth a mental image of the signified object. The reader actively abducts from my substitute sign 'pen' (a symbol for a previously experienced object) to interpret what I wish to signify to them, alongside its functional contexts—despite the reader not directly experiencing 'my object,' nor it's quirky aesthetics.

Often these social signs operate as stylised, highly ordered conventions for expressing short-hand referents in resident cultural settings (with language, drawings, body gestures etc.). But this abstraction, in turn, comes at the expense of rendering these experiential signs largely unintelligible for external agents to access without aids, due to the oft-lack of clear epistemic, cognitive or isomorphic associations with referent objects or concepts. This may be plainly seen in the lengthy contextual information supplied by these paragraphs of text for symbolically describing features of etched ochre, symbolically depicted in Fig. 8.1, without which, an unfamiliar reader is left with a relatively puzzling series of notations. The field of cognitive semiotics (Zlatev 2015), in part, studies our comprehension of, and the origins for, these mental meaning-making signs as expressions that stand for, refer to, or denote something else, alongside the triadic relationships established between the interpreter's mind, signifier expression, and the signified thing within particular settings. However, as mentioned above, for a number of reasons these mental constructs often do not readily translate to signified meaning outside of their resident cultural or historic settings, let alone mediate these referents across spatio-temporal distances as dissevered, noetic fragments in material culture.[6]

As I have summarised above, we generally think by socially constructing mental signs to stand-in for signified referents, and cultivating surrogate mark making practices according to perceptual preferences. However, these internal sign-relations are varyingly externalised as intelligible gestures through associations of prosthetic memory aids in an immense variety of material domains, mostly for archival, votive and ceremonial services (among other applications). But does material externalisation merely play a passive role in this mediation of expression? Today, debates over the varying influences, impacts and cognitive features of material practices vigorously continue, with recent practical and theoretical work centralising around exploring the territories of enactive, situated, distributed, extended and embodied cognition. Thinking with and through matter usage, or cross-modal 'thinging'[7]

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contend with here, with a particular emphasis on indices as a causal sign that maintains a close relationship with its signified thing.

[6]For example, natural E-languages—external[ised] languages as intersubjective sharing and socialising systems—are notably contingent upon idiomatic properties, alongside integrating other implicit contextual clues embedded in supportive networks of behavioural patterns, social etiquettes, and vocal inflections that are seldom transferable within graphemic systems rendered onto displaced material artefacts. These living 'gestures' likely reduce the cognitive load of using these systems, freeing the mind to perform other tasks (e.g., memory crafting).

[7]As Malafouris notes; thinking is usually understood as something we do about things in the physical absence of things. 'Thinging' however, denotes the kind of thinking we do primarily

through interactive engagement with the material world (Malafouris 2019), in fact plays a pivotal role in mediating these semiotic relationships between brains, but it also supports, informs, shapes, restricts and complements these practices through how we interface with matter while storing graphemic and aesthetic systems as intended gestures of 'distributed cognition.'

Let me rephrase the above argument using a simple example. The traditional malleability of obsidian for instance, brings forth a means of developing cultural skills to enact intentions and fashion objects to satisfy structural, textural, and other perceptual qualities which appeal to our cognitive preferences. But the 'behaviours' of this medium also varyingly challenges, resists and delimits what things or signs may be feasibly constructed through mental pre-planning by methods such as knapping; thus constraining and actively reformulating some physical and mental behavioural engagements through discoveries, while influencing other technologies to arise for continually engaging our imaginations and actions through this medium. Moreover, our hands—the predominant conduit for how our material world interacts within and through us in tactile, interpretative and demarcative tasks—are augmented through these technological approaches, altering our mental and sensory experiences, alongside our gestures in and across this materiality. In this case, questioning the boundaries of our minds when making, while thinking in and through our material world (thinging), naturally leads us to re-thinking about both our tactile interactions, and our thinking processes as a form of 'metacognition' (Malafouris 2013); in the process, reshaping our minds, bodies, techno-cultural interactions and graphemic projections in return.

The cognitive archaeologist and anthropologist Lambros Malafouris, whose work within Material Engagement Theory (MET) I have moderately drawn from throughout this chapter, contends that "[c]ognition, perception and action arise together, dialectically forming each other" (Malafouris 2007). As such, the cognitive life of a displaced artefact of material culture should be perceived as an interplay of its symbolic form, action in expressing intent, and mediated meaning; inseparable background values that, in turn, further support, inform, restrict, enhance and complement interpretation *in specific living social settings* (Malafouris 2018). We shouldn't expect external observers that recover *our artefacts* to easily backwards read these sign-relation histories while missing crucial pieces of this cognitive puzzle which, as surmised by the philosopher Don Ihde (2012), can be considered "a continuum of human-prostheses inter-relations", entrenched in particular social factors across historical, sensory and environmental contexts. The semiosis we associate with these material signs may be better understood as *instantiating a concept*, rather than (in most cases) simply bringing one forth through arbitrary mental signs. This distinction may be plainly seen between the expressive form of material artefacts as a meaningful domain of direct experience (i.e., how properties and interpretive contexts for the medium of representation itself affect the semiotic

within and through material things. Despite a perceptible difference, both are seen as a singular, inseparable process for our material engagements.

process), against symbolic representations *rendered on material forms* as a conventional abstract mapping of conceptual experiences for an equivalent meaning (Malafouris 2013).[8]

The cultural theorist Stuart Hall once acutely remarked that “[r]epresentation is a very different notion from that of reflection. It implies the active work of selecting and presenting, of structuring and shaping; not merely the transmitting of an already-existing meaning but the more active labor of making things mean”. To integrate my points, an abstract representation using signs in material culture deposits may be crudely understood as a link in a larger chain; an individual’s deliberate ‘re-presentations’ (externalised gestures of internal thoughts using sign systems, intended for peer review in shared social settings), of a mental representation (articulations according to the creator’s prescribed worldviews and comprehensions of phenomenology), of the creator’s representation (their sensorimotor experiences and percepts of specific ecologies). Further orders of re-presenting are introduced to these ‘mindscapes’ when creating *a priori* artefacts[9] to export our lineage of traditions, histories, nomenclature categories and substrates of mental-material relationships onto distant others we assume share in, or are familiar with,[10] *our cultural value codes and conventions of sign expression*.

This is a coarse oversimplification for only some of the varyingly disputed theoretical problems behind ‘making things mean’ *in living cultural and social settings* through elaboration from an essential arbitrary material sign by pre-inducted interpreters. However, even briefly discussing the literature behind some of these selective domains in modular paragraphs broadly illustrates some disciplinary tendencies to misrepresent our capabilities for deducing meaning (for displaced referents) from isolated symbolic artefacts as a reduced encoding-storage-reception-retrieval scheme. This also imposes unhelpful antinomies such as Cartesian divides between internal cognition and externalised material expressions, as per the allegorical software and hardware dualism found in our computational theories of mind (van Gelder 1995). Furthermore, it also privileges the location of

[8]For example, a physical bottle brings forth a broader range of possibilities for meanings to be construed (abducting from the materials, form, shape, texture etc.), in comparison to the surrogate word ‘bottle’ which equates with a specific mental definition, and requires prior object and symbolic experiences to extract meaning.

[9]It is imperative here to also acknowledge the obvious distinctions in networks of intent, agency and actors between unintentional *a posteriori* artefacts (that were not crafted for audiences outside of the creators own socio-cultural setting), and *a priori* practices of material culture engagement (as purposeful artefacts that deliberately bequeath information for foreign audiences). A synoptic typology of exoatmospheric practices has been developed by this author (Quast forthcoming) to illustrate the differences between these artefact-crafting approaches, in addition to the seminal strategy pioneered by William Jarvis (2003) for terrestrial time capsules.

[10]It is worth noting that both familiarity, and similarity, are forms of convention that are contingent on the virtue of pre-existing associations or relationships between cultural, historical, semiotic, and other imperative contexts. For example, Paul Revere’s lantern symbolism of “one if by land, two if by sea” required the sign receivers to already be familiar with a pre-established code to decipher a visual signal as a warning sign for British arrival.

'intelligence' to the innards of the brain, as opposed to the wider coalescences of living, externalised mental-material-action practices in techno-environmental settings as part of a *situated cognition* (Hutchins 1995; Donald 2002; Knappett 2005) while, in my opinion, rendering imperceptible some crucial insights underscoring our analyses of mnemonic relics, and the flexibility of material signs.

2.2.2 Ochre Effigies; What Could—or Should—We Understand?

Let us return to our fragments of cross-hatched ochre as visual examples to unpack some of this baggage associated with the cognitive life of materials, and the causal semiotic chain of 'making matter mean' to other minds. What do we see in these abstract patterns, and what should *a posteriori* engraved material signs mediate to us as *unintended observers*, embodying alternative aesthetic principles, cultural conventions and a panoply of other social traditions? Perhaps more fundamentally, do we even need to subjectively insert the lineage of our social customs into the fray to understand the intent of other minds *on our terms*? We should not definitively rule out such convergences in signs, but we should be mindful of the uncritical ways we transpose such experiences to suit our ethnocentric presumptions—our subjective viewpoints, of our intended objective observations, of others' subjective cultural practices and ways of seeing *their* material worlds. As Malafouris (2019) neatly surmises:

> "in order to study the cognitive life of any species we need to understand the lines, forms and material traces left or made in the course of it's becoming. That is, we need to follow the variety of mind-stuff as they fold and unfold, entangle and disentangle, in different temporal and spatial scales of a species' phylogeny or ontogeny. With mind-stuff I refer to the dynamic ensembles, flows and configurations of matter and energy by which sentient creatures become organized and relate to their surrounding environment and to each other".

We can understand the intentional "mind-stuff" gestures and choices which led to the sequenced creation of an artefact through networks of agency—the associations and relationships of motions, grips, pressures and focus required to deliberately incise contours of hatched lines on an artificially smoothened surface—but contextual elements like the mindful intent, any perceptual symbolism, and the influential connections of such material traces with related conceptual worldviews, are all perhaps lost to the ages. The motifs—*to our eyes*—don't conform to figurative or zoomorphic typologies, do not embody many aesthetic preferences we are familiar with, nor do they exactly correspond with any geometric configurations that resemble modern decorative effigies. Sometimes, recognising a series of purposeful lines as a remnant of active agency is, in itself, the answer that we should only expect to gain.[11] It is impractical to define what other minds may have attempted to signify

[11] This is premised on the simple observation that our attempts to interpret externalised sign-relations in material artefacts is not the same as attempting to apprehend the internalised mental faculties of the sign system creators. We should not look to these systems of signs as a means to

within symbol-mediated behaviours principally cultivated for their initiated peers, without wholly understanding that society *through the eyes of its own customs and lineage of material engagement practices*. Sometimes, there is wisdom in recognising these immanent limitations in knowing what can be known, against that which is irrecoverable. Even with multiple similar ochres to engage with and extrapolate from—indicative of imitative behaviours or otherwise—our provisional assumptions about the symbolism (if any) etched on the facades of these cultural documents remain as *deterministic inferences according to our worldviews* on how societies are generally shaped under particular ecological and technological settings.

My point in offering this contention here is not to undercut serious scientific efforts to disinter vital contextual clues for studying these ancestral heritages—endeavours which I respect immensely. Rather, I wish to emphasise the inherent limitations for our mental time travel capabilities to grasp fragments of stylised symbolism, mediated through dissevered artefacts, fabricated by social lifestyles far removed from the lineages of our own customs and sign-relation systems. What is clear in these striations on displaced ochre fragments (and the surrounding tools and debitage in this ancient dwelling), is that these externalised signs of material-engagement practices brought forth a new perceptual ecology for these cultural identities to think within, and interact through, their material world, while these externalised objects of material culture also likely reshaped the neural plasticity of their creator's minds in return. Our perceptual experiences of absorbing information from the surrounding environment, and our material thinking through enactivist engagements with myriads of artificial 'things,' are evidently two inseparable sides of the same coin for mutually catalysing these abstract representational practices. They *cannot* be ontologically divorced from the others' accumulative influences, indicating that immersion within specific settings (material, cultural, historical, ecological) is likely a fundamental factor for construing the meanings behind social signs in isolated artefacts of others' symbolic material culture.

Clearly there are broad, systemic incommensurability issues associated with the enterprise of interpreting what distant minds may have perhaps desired to mediate through their detached cultural symbolism—owing to this unique concert of cognitive-material relationships cultivated behind configurations of allegorical signs, familiar anchor points, and the phenomenology of experienced settings mediated through other living mindscape filters. The consequences these principles have for deciphering what other minds—even past humans we shared crucial contexts with—signify within displaced material artefacts are quite obvious for planning interstellar communication strategies, in addition to the enduring

'read' cultural histories, thoughts and emotions of erstwhile human societies, but rather as more general flows of information exchanges between embodied minds, encompassing cultural and social interactions amongst intelligible actors in their spatial and temporal settings.

implications for initially recognising signals as encoded material signs with a specific intent in the first place (Dunér 2013; Sonesson 2013; Saint-Gelais 2014; Denning 2014).[12]

I've broadly sketched out what, in my view, I believe to be some of the most apparent, entangled relationships governing the limits for *our extrapolation of meaning from symbolic forms and material expressions*. But for the purposes of this chapter, I wish to now mainly steer away from these daunting issues associated with endowing signified meaning across spatiotemporal distances to imagined minds using symbolic relationships, and instead re-focus on the more fruitful aspects of signs relevant for contextualising transmission practices. What do fragments of engraved ochre and interstellar messages have in common? Peripherally not a lot, however there are deeper intelligible connections; attentiveness to the cognitive lives of these media as an interplay of action, object and sign, allows us to see the residues of an attributable agency in construction left behind within these traces—in other words, indices as efficacies, or artificial material signs, for their signifiers (i.e., humans).

In particular, indices possess a direct causal relationship with the referent or phenomenological feature they signify, as seen in the oft-cited example of a hunter deducing animal features via footprint impressions. Personally, I prefer the comparison of indices to 'shadows' for things; denotative signs that maintain contextual elements useful for deducing the connection between a recognised expression (signals as signs), and the context (the transmitting organism's agency in designs, i.e., 'the signifier'), needed for the recipient to construct their own new signs (what Saint-Gelais refers to as "interpretants") to make sense of possible meanings (ideally, what we intended to be signified). In context with our prior analogy, the ordered layering of relics in the Blombos Cave stratigraphy—as indices for direct human agency over time frames—enabled archaeologists to constructively recognise early material-engagement practices,[13] and raise provisional questions about the generational development of patterned ochres, the roles of cognitive and aesthetic principles in producing material signs, local ecological conditions, and how cultural technologies in ochre deposits relate to broader trace signatures buried in and around the site. Might encounters with the sequential patterns of deliberate interstellar messages as layers—that is, collections of separate signals (see Table 8.1), targeted at the same stellar systems, with staggered time intervals between anticipated 'receptions' (as visualised in Fig. 8.2)—similarly help us to gain alternative outlooks for these prospective communique practices? Perhaps, but if so, how so?

[12]These generalisations, of course, also pose the question of whether we should erroneously expect uniformity in ETI's attitudes, behaviours, experiences and reactions for loosely-collectivised societies and civilisations—if any. These difficulties are, in turn, further exasperated if the artefacts makers and 'end-readers' do not share in a common embodied cognitive-material relational history, or the panoply of related social traditions, bio-cultural coevolution properties, and species-specific sensory and perceptual orientations to dimensional topographies.

[13]These determinations were, of course, also partially advanced by our foreknowledge of hominid evolution, verified migration patterns and timescales, alongside material clues recovered from other African ancestral sites.

Table 8.1 List of interstellar transmission layers, order according to chronology and number of overlaps to targeted systems/exoplanets

Target location	Distance (ly)	Message name	Transmitted	Power	Est. arrival
Hip 36208/ GJ 273b	12.2	• *Sónar Calling GJ 273b*	• 16 Oct 2017	• 1.5 MW	• 16 Oct 2030
		• *Sónar Calling GJ 273b*	• 17 Oct 2017	• 1.5 MW	• 17 Oct 2030
		• *Sónar Calling GJ 273b*	• 18 Oct 2017	• 1.5 MW	• 18 Oct 2030
		• *Sónar Calling GJ 273b*	• 14 May 2018	• 1.5 MW	• 14 May 2031
		• *Sónar Calling GJ 273b*	• 15 May 2018	• 1.5 MW	• 15 May 2031
		• *Sónar Calling GJ 273b*	• 16 May 2018	• 1.5 MW	• 16 May 2031
HD 75732, Cancer	41.06	• *Cosmic Call 2*	• 6 Jul 2003	• 150 kW	• May 2044
		• *Wow! Reply*	• 15 Aug 2012	• 1 MW	• 2053
		• *JAXA METI Experiment #1*	• 22 Sept 2013	• 20 kW	• 2053
		• *JAXA METI Experiment #2*	• 23 Aug 2014	• 20 kW	• 2054
HD 95128, Ursa Major	45.9	• *Teen Age Message*	• 3 Sep 2001	• 96 kW	• Jul 2047
		• *Cosmic Call 2*	• 6 Jul 2003	• 150 kW	• May 2049
		• *Doritos Advertisement*	• 12 Jun 2008	• –	• 2050
HD 50692, Gemini	56.2	• *Teen Age Message*	• 3 Sep 2001	• 96 kW	• Dec 2057
		• *Wow! Reply*	• 15 Aug 2012	• 1 MW	• 2069
Hip 74995, Libra	20.56	• *A Message From Earth*	• 9 Oct 2008	• 150 kW	• Feb 2029
		• *Hello From Earth*	• 28 Aug 2009	• –	• 2029
HD 8890, Ursa Minor	323-434	• *Across the Universe*	• 4 Feb 2008	• 18 kW	• 2442
		• *A Simple Response to an Elemental Message*	• 10 Oct 2016	• 20 kW	• 2450
HD 10700, Cetus	11.9	• *Poetica Vaginal*	• 1986	• –	• 1998
		• *Toronto Science Fair*	• 2013	• –	• 2025
HD 119850, Boötes	17.7	• *Lone Signal* (around 70 intermittent messages)	• 17 Jun 2013–29 Aug 2013	• –	• Jul 2030

The symbol '–' denotes current lacunae within the table information (Quast 2018)

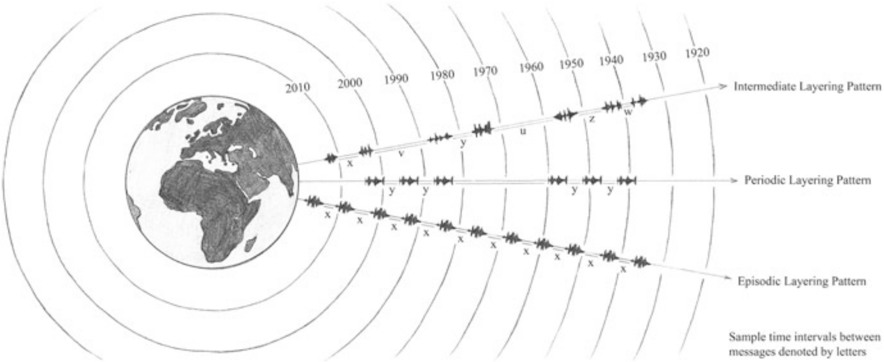

Fig. 8.2 Example of interstellar message layering (i.e., multiple transmissions over staggered times to target stars—durations are exaggerated for scale) and types of layering, set against background chronology of radiosphere leakage (marked in decades)

3 Layering in the Exoatmospheric Archaeological Record

Let us briefly return to the dilemma posed at the beginning of this chapter; when did abstract representational practices, or intentional symbolic depictions of defined internal mental faculties, appear in the material record of *Homo sapiens* societies? Blombos Cave provides us with an excellent window, and an appealing analogy, for several good reasons. Firstly, it presents an extensively documented reference point for discussing the past mental faculties and activities of pre-antiquity *Homo sapiens* that already seem to be well established across generations over 100,000 years ago. This Middle Stone Age site also presents sobering implications for initially recognising these mental-material mark making practices from our own species' lineage, but it also poses an excellent contrasting period between the various capabilities of other hominid populations that concurrently occupied Eurasia during the Middle Paleolithic—thus at least partially dissolving the privileged, unilinear evolutionary narrative we favourably and solely assign to the cognitive faculties of our own species. *Homo neanderthalis*, the prescribed artisans of numerous early parietal artworks (Hoffman et al. 2018), were every bit as inventive and capable as their latter, close genetic cousins still living on the African continent—being an 'older species' might not confer the advantages we regularly evoke as analogies in SETI literature.

However, I wish to principally draw focus towards the noetic interpretation of simple ochre vignettes—as material signs supporting indexical information about agency, purpose and expression—sequentially encountered across stratigraphic columns as a temporal record. This phenomenology of encountering recurrent signs through static layers, invites us to consider how these same lessons may apply towards reframing our understanding of our own emergent symbolic patterns in the expanding spatiotemporal dimensions of our outer space activities—a relatively modern record, arising from the material engagement practices of our societies during the defined Space Age era. How can the processes of 'layering' within this dynamic exoatmospheric archaeological record, in the broadest and most general sense, contribute similar behavioural insights into the legacies we consciously—and sometimes unwittingly—dispatch into deep space and cosmic time?

3.1 Identifying Exoatmospheric Archaeological 'Layers'

At the recent *Expanding Worldviews* meetings organised at Birkbeck College (reported in this volume), for the purposes of stoking critical discussions about various space-message crafting enterprises, I presented an imaginative layout of physical artefact locations (such as the Voyager Records (Sagan et al. 1978) and Lageos plaque (O'Donnel and Worrell 1976)), in addition to comparatively mapping out interstellar transmissions (such as the Cosmic Call series (Dumas and Dutil 2010)) along the same, unilinear distance scale. This chronology primarily sufficed as a conceptual bridge for contemplating the propaedeutic resources that intend to re-present aspects of modern human behavioural engagements at meaningful spatiotemporal distances from Earth. If anything, this ephemera demonstrates how small cohorts of individuals—rather than broader societies, nations or civilisations—with access to aerospace technologies interacted with, and in turn were reshaped by, their surrounding celestial environments through purposeful material engagement practices. But it is acknowledged that this layout was merely a conceptual exercise; a thought-experiment for understanding the frequent *imbroglio* and lack of clear democratic, moral or ethical agreements on many Earthly issues, alongside how these same disparities retrospectively transpire within intractable legacies beyond our traditional planetary boundaries—"revenge effects" (Tenner 1997) or unintended consequences, resulting from technological expressions that far outpace social adjustments, ethical foresight and legislative guidelines not yet written (Herkert 2011; Marchant 2011).

In truth, the increasing spatial dispersion of myriad types of messaging artefacts will likely permanently inhibit prospective recovery; certainly by human posterity, and perhaps also by imagined ETI cultures who operate [at least] comparable observational technologies. As such, these projects may be better understood through their public relations appeal and outreach value for engaging contemporary audiences with the rhetorical tropes of space as *a frontier for transcendent human destinies* (Noble 1997), or perhaps as intertwined "technologically-mediated prayers" (Brin 2019) that retain a fleeting chance of recovery by foreign cultures which we may not recognise as 'human.' Within the physical realms of these material legacies, instances of layering or superimposition do seldom occur—often as a result of passive deposition activities (i.e., discarding of wastes), loss, abandonment and the votive burial of artefacts as haphazard social activities—all of which, varyingly contribute to our off-world record as *a posteriori* material signs. Amongst the fascinating layers of this record, there are numerous deposition practices with physical *a priori* messages as mentioned above but, in the interest of space, I will not digress into these votive and disparate social activities.

The processes of material layering—to a lesser known and comparatively poorly studied extent—also transpires within the artificial cacophony of electromagnetic radiation propagating outwards into our surrounding, interstellar neighbourhood. The concept of the radiosphere, which perhaps best exemplifies my usage of the term 'layering' in context with interstellar space, presents us with a radically alternative archaeological landscape, whereby; the two-dimensional Euclidean geometric grids of discrete 'site' coordinates are substituted for spherical Equatorial coordinates computed relative to Earth's position; terrestrial stratigraphic deposits comprised of sediment layers are replaced with immense four-dimensional matrices of interstellar space, sparsely populated by dust clouds (and seldom by larger objects); and geologically-active soil strata with diagenesis processes, are swapped out for a diverse range of electromagnetic noise propagating outward from celestial sources—astrophysical phenomena that spatially constrain and degrade signal detectability.

The potpourri of terrestrial signals that contribute to these expanding artificial fields are epiphenomena—leakage that has been passively emitted from terrestrial activities such as telecommunication services, radar mapping programmes for asteroid observation missions, and defence installations operated by nation states (Haqq-Misra et al. 2013, 2017). Stephen Baxter, in this volume, discusses the visibility for some of these 'big histories' within technosignature legacies as another involuntary material bio-sign for Earth; a relatively bewildering and haphazardly-fabricated epiphenomenon, supporting often conflicting, incoherent and illogical narratives about this evolving terrestrial stage at differing spatiotemporal distances. Here, I will metaphorically treat this radiosphere as an extended terrestrial stratigraphy of artificial design—asymmetrical strata travelling outwards at the speed of light, with older layers deposited further away from our planetary surface than contemporary editions (see; Fig. 8.2).[14] Clearly these dynamic 'sediment layers,' as *a posteriori* bio-signs of material deposition activities, possess relevance for the big histories of various human populations and the Earth system. However, these legacies are also spatially constrained by the inverse square law of signal propagation—essentially, ensuring that the outer limits of this 'bubble' dissipate beyond detectability over increasing spatial distances.

[14]For example, the photons which comprised the first broadcast of the US sitcom '*I Love Lucy*' in 1951 are now 70 light-years away. By comparison, Proxima Centauri, the closest star to the Sun, is only 4.24 light years away.

3.2 Excavating the Radiosphere

In contrast to this stratigraphy of electromagnetic noise, the range of narrow-band electromagnetic signals consciously emanating from Earth, as deliberate interstellar messaging activities, are much 'brighter' across specific frequencies; *a priori* signals which extend the bio-semiotic signatures of modern human representational behaviours much further than the weak murmurs we unintentionally leak as epiphenomena. The author David Brin (2019), a staunch opponent of these transmission ventures, has likened this distinction between the apparent visibility of these message-signals from background emissions as tantamount to the differences between "slapping your hand against the water in Morse Code... [hoping] scouts might detect and decipher the ripple waves you are sending [across a large mountain lake]", in contrast to aiming pulses from a laser pointer at their shoreline.[15]

The domains these messaging activities service are extensive, frequently inconsistent and highly divergent, with applications ranging from; artistic expressions, space agency outreach tasks, votive gestures to eternity, cultural immortalisation effigies, educational activities and ill-considered commercial schemes, to Messaging Extraterrestrial Intelligence (METI) experiments (Quast 2018, Forthcoming)—with considerable variation observed in the latter field alone. Despite the emphasis to contextualise METI activities under scientific paradigms, there is a lack of clear scrutiny for the roles of contributing material culture customs, deep-seated social attitudes, intellectual traditions and competing agendas in inspiring these search strategies—in addition to the general vacillation and scepticism for appraising active exo-social experiments as a vigorous scientific enterprise, when compared with the passive operations usually undertaken by these astronomical technologies. In the absence of best-practice guidelines, METI remains as a controversial enterprise owing to, as the anthropologist Kathryn Denning (2010b) excellently summarises:

> "different models of the scientist's role as citizen and/or leader; disparate ideas about society's readiness to cope with frontier science; variable political substrates, particularly ideas concerning individual freedom and state control; competing ideologies of globalization; and the perceived relative risks and benefits of contact . . . derive partly from different thinking styles, including tolerance for risk, and partly from inferences based upon . . . contact on Earth".

Given the divergent goals and cited motives for electromagnetic transmissions, it is perhaps not surprising to observe that these messages are targeted at a disparate range of astronomical objects including human spacecraft, exoplanets, exosolar

[15]The visibility of such technosignatures at cosmic distances is contestable and often debated within the context of the brightness of background stellar emissions across a potpourri of EM frequencies at a particular point in time, the historical strength of leakage radiation, and projected sensitivity of ETI's observational technologies.

systems, distant star clusters, and sometime other exotic interstellar phenomena.[16] A co-authored study on the *Cosmic Call 1* series (Billingham and Benford 2011) has contested the detectable limitations for these narrow beams of frequency-modulated binary 'bits' to reach nearby interstellar objects—under the assumption of integrating the pulses of energy, at the expense of the autobiographical media we encode within these envoys. But, in the absence of information about the technical capabilities of a foreign observer to detect and access these media, there is little value in contributing to speculative literature about how prospective observers may intercept, and therefore interpret, the ostentatious symbolic material culture we continue to send as signs for Earth. Given these limitations, we do not know anything empirical about the known behavioural activities, material practices, semiotic relationships, or social traditions of ETI cultures necessary to apply suitable analogies from our cultural histories for 'contact'—or whether we should even pragmatically apply such *human tales* to independently-evolved minds (Denning 2011). Obviously, there are deep, quantitative foundations for these discussions but, setting aside the technical arguments underpinning the improbabilities of detection for radioastronomy authorities and metrics to delineate further, *what can we simply learn from our signal patterns retrospectively*? Can the stratigraphy of rationalised bio-signs for Terran life, teach us anything *about us*?

The history of our mental-material engagement with modulated streams of photons across a potpourri of 'magic' frequencies and intensities—as a theorised medium for communication or mnemonic activities in space—is a relatively nascent endeavour, in contrast to our species' millennia-long engagements with earthly matter. Space does not permit me to elaborate on a cultural history of electromagnetic signals as a mental-material engagement practice—METI within the MET framework so to speak—but needless to say, thinking about communication using electromagnetic frequencies far predates the relatively modern musing and experiments of Nicola Tesla and Guglielmo Marconi with radio technologies (Raulin-Cerceau 2010),[17] and the popularised unilinear trajectories for human applications underpinning the developmental history of these systems (Denning 2010c).

Despite this cultural history of engagement with electromagnetic signals as a conduit for ETI communication, most practical ventures approach these photon streams as, essentially, a convenient vehicle for transferring encoded cultural contents *we choose to transmit as intended meaning*; cultural autobiographies, propaedeutic guides and aesthetic conventions in particular formats that are hardly self-evident, or objective representations of phenomenology. Borrowing from the philosopher Marshall McLuhan to delineate my point further; *the medium is ignored,*

[16]For example, the 1987 Nançay transmission '*Message from Human Beings to the Universe*' was sent to Sgr A*, and ESA's *Stephen Hawking Memorial Broadcast* was targeted at the nearby black hole 1A 0620-00 in 2018.

[17]Tesla alleges to have received radio broadcasts from Mars while initially experimenting with the wireless transfer of energy as a communicative medium between worlds in the onset of the twentieth century, while a 1919 edition of the New York Times claims that Marconi sent the first [weak] broadcast into outer space in 1909.

in preference for the arbitrariness of our defined message. But what if the materiality of our produced signal *affects the measure of meaning we can convey as a message?* Moreover, these signals require a bonus semiotic step in that they must be initially recognised as artificial constructs encoding a form of message (Saint-Gelais 2014)—akin to associating a knap of ochre, discarded kilometres from an archaeological site, with prescribed traces of human agency, acts of purpose, and meaning.[18]

In examining the cognitive life and mindscapes of crafting message media, my opinion is that indexical information is, perhaps, the most reliable indicator to emerge from a prospective recipient’s encounters with layers of anthropogenic signals as bio-signs (if recognised as such), though some second-order iconic signs may perhaps also be available, given messages are not composed of one sole sign but combinations of several sign types. This is certainly the case for the intricate combinations of symbolism used in natural languages that comprise crowd-developed messages, but it also impacts the range of serious METI transmissions structured under the narratives of our ‘language of science’ (Capova and Quast Forthcoming). Most scholars tend to disparately share in this perspective across disciplinary divides, but in some instances, it may still be seen as a controversial statement. By taking this stance, my remarks are not intent on definitely ruling out that some form of acute semiotic exchange of signified meaning could eventually take place using simple iconic signs and expressions for modelling processes (for example, see Vakoch 1996, 2008, 2010).

In any case, while the debate ensues over whether symbolic surrogate media will remain inaccessible due to its prescribed sign-relation qualities, the physical properties and material signs arising from encounters with multiple signals (as representational biosignatures with indexical value) may provide unique insights into the rational agency that underscores such constructs—after all, “[t]he interpretation of indices requires empirical knowledge of the recurrent connection between the sign and what it refers to” (Dunér 2018). This ‘recurrence connection’ is perhaps technically mediated through the causal patterns of artificial signals, emanating from a single source, that could re-contextualise initial one-off encounters with obscure ‘messages’ as indicative of a larger behavioural phenomenon, manifesting over a staggered timeframe. A presumption of recognising intelligible agency when encountering sequential layers of configured signals as unintelligible messages (i.e., without accessing contents) is my principle assumption herein—though it should be acknowledged that this recurrence connection also presents grounds for some conventions of familiarity to arise between signals, alongside interrelationships between other types of secondary-order signs.

[18]One could infer that this analogy is problematic as physical artefacts, with markings, are clearly more easily perceived than an encoded string of photons, or other sophisticated culture mnemonic formats. However, an intriguing counterexample for this case may be seen in the slow recognition of Paleolithic-era stone tool relics. Mythical folklore and meteorological origins were astoundingly proposed as the sources for widely found material relics such as ‘elfshot’ arrowheads, before ancestral humans were eventually accredited. These theories also tended to accord well with the expansionist agendas and founding mythos behind emergent nation states.

4 A Stratigraphic Profile of Humanity

As a supportive index for investigating the broad archaeological and philosophical implications for messaging practices across a range of material engagement practices within outer space, the '*A Profile of Humanity*' (Quast 2018) catalogue was assembled to simply document and demarcate the varying initiatives that contribute to our expanding, spatiotemporal legacies beyond our terrestrial biome—purposeful messages and other varying 'space oddities' using cultural properties, that are disparately packaged for foreign recipients, or *us* as time-binding projects for human communities. The sprawl of messaging practices is quite extensive and eclectic. This catalogue is very much still a work in progress, aspiring to simply document the growing representational activities that now reside in the exoatmospheric archaeological record. But compiling this index enables us to observe previously obscure trends or construct simple metrics, such as convergences in selected targets for several types of separate messaging practices, and resulting transmission patterns.

Table 8.1 crystallises both sobering, and somewhat awkward, implications for the human enterprise; not only in regards to the number of overlapping message layers that have been steadily deposited across the cosmos over the initial 60 years of the Space Age, but also due to the stark recognition of the spatiotemporal dimensions now involved within continually expanding the influences of human worldviews across the boundaries of other stellar systems—a property of the messaging enterprise which, as the communication theorist Rachel Schmitt (2017) surmised, provides "new ways of understanding how colonization is narrated—even voiced—on an extraterrestrial scale". This table specifically documents sequences of separate messages—each with a start and end point—with overlapping targets, but it does not, by any means, fairly illustrate the entirety of these scattered practices. Let us briefly sketch out some observable patterns and distinctions between subsets of these layering practices that are identifiable in this record, in context with the prior Fig. 8.2 visual.

4.1 Intermittent Transmissions Containing Discordant Media

It is relatively incontestable to state that the majority of interstellar messages undertaken to date are developed independently from the direct influence of antecedent transmission initiatives. This discord is likely due to the authoring agents wishing to imprint their own personal thoughts, distinctive opinions, ideologies and quirky designs onto other worlds, as opposed to replicating extant message formats for consistency. This could also seem to correlate with interstellar message workshop recommendations (Vakoch 2011), which advocated for developing a diverse array of messaging strategies to increase the likelihood of prospective recipients deciphering one scheme as part of the 'dialogic models' approach (Vakoch 1998). However, it may also likely derive from a very human desire to simply transpose idiosyncratic legacies and personalised ‘gestures to eternity’ into the interstellar void, as discussed extensively elsewhere (Quast Forthcoming). Nevertheless, a number of unrelated messaging activities have intentionally [or unwittingly] been beamed to specific systems, such as the three distinctive parties who each sent a signal to HD 75732.

4.2 Periodic Transmissions Containing Comparative or Relational Media

In contrast to the perceptibly random broadcasting schedule, and discordant media contained within non-related messaging activities from the prior category, several recent projects have instead concentrated on transferring facsimile (or at least similar) cultural and semiotic properties over a sequential series of predetermined transmission windows. The recent *Sónar Calling GJ 273b* is a fine example of these periodic messaging patterns, initiated by the same authoring agents; an organised transmission schedule consisting of three 13-h duration signals, broadcast to the same targeted exoplanet over three sequential days, before repeating this series (albeit with some modification to several of the contents) over 6 months later. While this initiative is the only example that strongly meets the proposed properties for this layering category, there are also a number of cross-over messaging projects that bear a near-set resemblance, such as the Cosmic Call and Teen Age Message projects that arose from subsets of the same minds, using subsets of the same cultural properties as communicative contents, both of which transmitted to HD 95128.

4.3 Episodic Transmissions as a Proto ‘Beacon’ Containing Largely Static Media

The *Lone Signal* initiative denoted at the end of Table 8.1 is technically the only sustained transmission series that loosely conforms to this proto-beacon category, given the consistent broadcast schedule from the Jamesburg Earth Station over an extended 2-month period (with occasional downtime). By in large, the transmission phases consisted of two staple segments; a continuous hailing component, comprised of a facsimile binary-encoded primer guide (detailing 8-bit representations of numerical characters, mathematical operators and other symbols akin to the processes of the artificial language Lincos), and another more complex, public messaging component which was subject to variation (i.e., 144-character long public statements with diverse visual imagery included). Given this episodic broadcast campaign, HD 119850 possesses the most intentional narrow-band signal layers of any extrasolar object, with the first and last layers due to arrive by the year 2030.

5 Discussion

The crucial questions facing us then are how the layers of different message-signals could be understood (and by whom?), and what perceptible properties should we focus on here? It remains to be seen whether such layered messaging practices may suitably introduce the highly symbolic and frequently conflicting ideologies, principles, value codes and schools of thought to an intelligent interlocutor. But clearly our speculations and conjectures about these prospective encounters are derived from the predispositions and psychologies of the various individuals and groups that choose to author these cultural exchange devices[19]—a substantial body of inferences, essentially tethered to nothing yet known to us. I will briefly touch upon these symbolic contents at face-value for ETI but, in my opinion, factoring in abstract materials often leads to us asking the wrong questions, or missing out on the more intrinsic meta-semiotic assumptions that populate the spaces outside messages as indices (alongside if these signs may translate into novel iconic conjectures).

In the present absence of evidence for an intelligent other, the terrain of the forthcoming musings may therefore be framed under two interlinked vistas. On the one hand, and from our perspective as a scientific community, interested in encountering (and perhaps having intelligible exchanges with) an independent intelligence species we share no kinship with, how might the indexical layering of sequential messages be theoretically construed by ETI? Secondly, from our own perspectives and in a rather counterintuitive sense, how might encountering this stratigraphic layering of material signs reveal insights *about us, to us, as transmitting societies* (or small groupings thereof)?

It is imperative to acknowledge here we are not contending with data about ETI in any astrobiological or astro-cognitive sense (as we have none), but rather our social and culturally-inspired ideologies of what we fathom to be sentient alien life—or 'advanced' human posterity—loosely framed by our rational belief systems and perceptual experiences, coupled with rich intellectual substrates of scientific and fictional inferences, alongside highly persuasive and overextended analogies from our historical backgrounds. In recognising these underscoring factors, this grants us creative license to better reframe the first part of this discussion as a novel extension to communicating with human posterity; distant, sentient agents which, to varying degrees of resemblance, embody relatable cognitive faculties, sensory-perceptual apparatus, and a panoply of divergent experiences as embodied minds living in a world (specifically, *a comparable rendition of our world*). Under this pretence of what the philosopher Frank White (1990) refers to as 'Searching for Extraterrestrial Intelligence Like Ourselves (SETILO),' and without extensively delving into the

[19]The framework for exchanges in METI practices is often shaped under an assumed dialogic model, with connotations of an implied 'cargo cult'; based upon our principles of reciprocity and shared habitual customs, social developmental history, and our theories of mind when interacting with fellow members of *our species*. It also frequently confuses uni-directional monologues with dialogue established on any familiar contextual basis.

perplexing cognitive, technical, cultural, environmental and sensory incompatibility issues that feed into these debates, let us briefly summarise some of the rationalised observations that may emerge when other 'SETILO' minds encounter sequential messages—as signs—across staggered timescales.

5.1 The Benefits and Harms of [Repeatedly] Transmitting into [Specific] Space

It is not always easy to see what you are not looking for, or to know what can be known outside of that which is expected to be known, when crafting communicative devices intended to be viewed under particular vistas, settings and paradigms. Nevertheless, some contentious 'anthropology at a distance' (cf. Traphagan 2014) deductions and cautious inferences do percolate to the mental foreground when teasing out assumptions made while positioning ourselves in a recipient's proverbial shoes (if they even have feet).

To begin with the rather trivial observations,[20] while statistically it is unlikely that ETI civilisations may chance encounter transient messages to begin with (owing to the colossal spatiotemporal dimensions associated within these blind signalling efforts), layering approaches present an incrementally-heightened likelihood of signal detection above their one-off counterparts. This simple assertion on my part, is based on the fact that multiple overlapping messages are no longer constricted to a singular observational window for ETI, while encountering multiple recognisable signals also affords time for verifiable hypotheses to evolve (at least in accordance with our scientific principles of investigation). This is, of course, premised on whether ETI think in 'factorality' terms—that is, recognising these separate electromagnetic signs as part of something else, or indicative of a larger behavioural pattern manifesting over time (Sonesson 1994). It is incumbent to state that this detectability increase is likely minimal—if at all apparent—as it still postulates an unobserved ETI civilisation resides within the targeted stellar system without any evidentiary basis for these imaginative inferences. Whether these *de novo* messages can be recognised as artificial, bio-symbols of human material culture, or even as attempted cultural exchange devices, is far from clear, though it is contingent upon several implied touchstones, including; holistic reception of the intended compositions, signal processing analytics, and usage of mutually accessible pidgins as a foundation for initial extrapolation from the signal to signs.[21] Note these

[20]Artificial signal properties will also reveal subtle metadata contextual clues about Earth's location and distance, the existence of another intelligent species with communication technologies, the state of advancement for these technologies on our planet (e.g. power, modulation modes, pulsation periods, preferred frequencies), alongside recognition of the signal as an abstract mental construct using material culture practices.

[21]Additionally, a number of observational prerequisites need to be fulfilled on the recipient's end, including; the need for ETI to constantly stare at a small portion of sky while monitoring specific

criteria are merely thresholds to be satisfied for simply detecting a signal structure and initially recognising it as an artificial construct; observational properties that do not readily enable analytical methods to bypass the previously discussed material-semiotic obstacles.

In transitioning towards more indexical-iconic features of identified messages, what about the architectural configurations of inaccessible symbolic information coming from the reception of multiple separate transmissions? This is perhaps less clear, given the extensive overlaying substrates of mirrored assumptions, initially built upon shaky foundations of presuppositions about ETI capabilities to begin with. Nonetheless, ETI's equivalent signal processing procedures to the DISC quotient (Elliott and Baxter 2011), or Shannon's Law of Entropy (Doyle et al. 2011), may quantitatively reveal subtle idiosyncratic clues into the complexity, ordering and density of information present, without having to meander towards translation campaigns for signified meaning encoded in each separate message. In this case, periodic and episodic signals may serve to collectively reinforce error-correcting analytics, but it becomes less clear how unrelated intermittent messages exhibiting alternative structures or cultural media may influence these initial interpretations through secondary-order signs.

Taking the *Poetica Vaginal* and latter *Toronto Science Fair* messages as an example of unrelated messages, perhaps ETI's counterpart analytics may interpret such overlaid configurations as 'period styles,' similar to the superimposition of parietal art deposits found at the Nawarla Gabarnmang archaeological site (Gunn et al. 2017). This presented scenario is likely more optimistic than what will be encountered by ETI as, in addition to the narrow 27 year window between these transmissions, there are clear, conceptual crevasses between the two signals for such astute observations, including; discrepancies in chosen transmission frequencies, signal bitrates and modulation techniques employed, not to mention the stark contrasts found between encoding formats and contents (Poetica Vaginal consisted of 'vaginal contraction sounds from ballet dancers' somehow translated into text and other sounds, while the Toronto signal was allegedly composed of 100 words encoded as a video).

What about the indexical information supplied by the staggered 'arrival time' periods between message signals? Again, there is much ambiguity apparent within interpreting such semiotic evidence owing to, in some cases, a lack of causal relationship between perceived reception times, pre-comprehension of the diverse rationales behind human messaging practices, and what these factors may imply for the recipient's interpretation of sequential signals. The measured interval of time between reception of one message and the next might be construed as a transmitter 'dwell time' between targets, similar to those employed in traditional SETI 'listening' programmes. Perhaps, this may insinuate a more expansive (and unified) active

frequency ranges, estimating signal bit rates while storing the signal sequence for interpretation, and deducing what modulation systems were applied for encoding information in streams of photons (Billingham and Benford 2011).

search programme than humanity is presently capable of undertaking, whereby reception of subsequent signals is interpreted as the follow-up pass of an active search cycle. The temporal voids between messages might also prove insightful, providing a crude frame of reference for understanding how these layers may have formed and why. This may present some rudimentary—and perhaps incorrect—insights into human psychological factors for instigating such searches, including the emphasis these ‘loud neighbours’ seemingly place on highly energetic practices in the face of apparent diminishing returns.

This inferred cycle theory for how we use our technology, of course, becomes untenable once the predicted observation window is interrupted, as seen in the lag variations between three intermittent signals to HD 95128 of approximately 2 and 5 years respectively. However, this disparity could also insinuate other symbolic connections that a foreign culture, as the theorist Mieke Bal (1997) suggests (in context with human narrative-crafting literature practices, not METI), will likely imagine to fit their presumptions—as is often the case when little comprehendible informational context is available for our own analyses of erstwhile human societies. We cannot dictate or control these conditions for unknown ETI civilisations to extrapolate from, or indeed the presuppositions about these information packets as cultural viruses or constellations of ‘memes’ (Dennett 2010), which will inevitably arise in the absence of context—and be continually reshaped, again and again, by successive transmission ventures. But we could at least attempt to self-examine, and optimistically sign-post or mitigate factors that lead to gross misconceptions about *the social construction of knowledge about us, from our signs*.

Certainly, such reasoning will, at least in part, form the basis for meta-semiotic interpretations behind the layering of sequential message detections. But it is worthwhile considering how such temporal anchors may mutually aid, or inhibit, consecutive messaging praxis should we choose to respond to ETI messages with periodic or episodic beacon-like approaches, or persist in occasionally conducting *de novo* transmission strategies across intermittent schedules. These brief portrayals, of course, do not even factor in the profoundly unknowable sociocultural settings and other circumstances that layers of messages may intrude upon and be conceptually shaped by, e.g., agitating existing social tensions between comparable ‘nation-state’ entities or, on the other end of this scale, mistakenly intervening within theological beliefs (cf. Raybeck 2014). Other sentient life will always have its own agendas, and we shouldn’t expect these goals to overlap with our own. In evoking our ochre allegory, perhaps the most probable contextual evidence we should hope an ETI to extract from these wide-ranging practices is simply the recognition of signals as semiotic products, arising from ongoing mental-material culture practices; signs that, to some extent, represent enactive agency and behavioural patterns within the technological media available to the social frameworks, and defined cultural world-views, of the subjects producing these signs.

5.2 *The Multilinear Mosaics of Earth*

At this point, and to literally bring our discussion back down to Earth, I think it is appropriate to transgress from the far-fetched hypotheticals of interpreting signs in layering from the perspective of imagined recipients, and instead tease out some of the more credible, modern earthly implications for crafting this stratigraphy. What do such externalised mental constructs, encoded within layers of transient but recurrent messages, mean for our literally expanding worldviews and representational behaviours of humanity beyond the Earth? This quandary may be broadly segregated into two related sub-legacies relevant for us as an inducted audience, familiar with the signs underpinning these practices; firstly, knowledge of these signals as essentially dissevered material evidence with indexical values, washing over other stellar systems across different time intervals. And secondly, the broad recursive effects and ongoing dialectics these symbolic material resources seem to retain in reshaping and remaking the living minds, things, ecologies and social settings they apparently represent.

5.2.1 A Dissevered Legacy from Afar

Perhaps the most logical implications for expanding the presence of human representational behaviours into foreign stellar systems is the enduring moral, democratic, psychological and ethical deliberations arising from our simple knowledge of, and scrutiny of, these expansionist legacies; as best exemplified in the ongoing controversy surrounding the METI debate. Much of METI ethics literature is devoted to the consequences of signal detection by profoundly unknowable civilisations, and the inconceivable reactions that may ensue from detection of *de novo* material signs. Seldom discussed are the implications for 'raising the stakes' on particular "cosmic wagers" (Smith 2019) through the intermittent, periodic and episodic layering of multiple signals onto candidate systems—a difference that may be plainly seen within the periodic transmission schedule for *Sónar Calling GJ 273b*.

By this comment, I am not implying that we are already engaged within some form of unidirectional interstellar discourse (i.e., the Barn Door argument). Rather, I wish to again highlight how sequential messaging strategies may perhaps increase the likelihood of detection by opening multiple observational windows, and re-interpretations for recurring signs. We often do not consider the indexical implications for these layering strategies, owing to the assumption, wrongly in my opinion, that ETI operates more advanced omnidirectional observational instrumentation, and therefore any deliberate signal we initially send will be decisively intercepted. This assertion is founded upon precarious grounds, arising from a very truncated techno-scientific perception of ourselves, extrapolated into the futurescape of the Tellus system (and *how this socially-constructed knowledge* *about us*, thereafter calibrates our minds, theories and studies to suit the hallmark signs for *any* ‘advanced civilisation’).[22]

Synonymous examples from our own modern astronomical observations of natural phenomena, reveal commensurate lessons to this effect. Pulsars were discovered only after Jocelyn Bell Burnell had reviewed hundreds of metres of printed observational data to interpret the curious “bit of scruff” on a single page from the designated “Little Green Man 1”, as part of a protracted pulsing period from a new kind of astronomical object (Penny 2013). Recent observations for fast radio bursts have also continued in this tradition of challenging our expectations by identifying new exotic interstellar objects, through the indexical value supplied by encountering episodic layers of emissions. In contrast to these astronomical observations, layered METI activities generally operate on much less predictable broadcast schedules, power levels and frequency ranges. But these inconsistencies may further convey a distinctively artificial origin over subsequent observation periods; fluctuating bio-indices which may preserve meta-semiotic information about the authoring population(s) signalling habit, social capabilities and technological infrastructure.

It is difficult to assess how important such transient layering paradigms may be for space ethics communities and associated metrics that attempt to quantify the impact of signals. Perhaps the San Marino Scale (Almár and Shuch 2007) needs an ‘R’ value to denote signal ‘recurrence’, or have multiple signal values tabulated together for specific star system measures. If Tables 8.1 and 8.2 reveal anything significant however, it is that there is an abundance of layers across a series of stellar systems that may be retrospectively studied as conceptual guides for the increasing visibility of signs for human representational practices.

5.2.2 Engagement Begins at Home

At this stage, our discussion about the record of layered interstellar messaging practices naturally transitions us from an archaeological and retrospective context, to a more anthropological and sociological one. From a face-value overview of these prolific messages, what might the motivations and resulting encoded contents from these variegated broadcasts symbolically reveal to us about our expanding world-views as *collective mosaics for Earth*? This questions phrasing is a misnomer for several reasons, but it accounts for the implied perceptual status of these layered messages as emanating from a unified terrestrial civilisation, not the “different civilizations with major disparities in worldviews and modes of thought” (Denning 2010a) we are readily familiar with as assorted planetary residents.

[22]For instance, much literature tacitly focuses on our initial reception of such electromagnetic ETI signals, with a tendency to collate around a classic ‘first contact’ idiom of a transient discovery and response affair. However, intermittent contact, or reception, may continually influence our invention of an ETI culture, and create new dynamic contexts for how information is initially deducted and comprehended—prior to signal decipherment.

Table 8.2 Broader list of overlapping interstellar transmissions, according to reoccurring targeted constellations rather than individual stellar systems

Constell.	Target(s)	Message name	Transmitted	Power	Transmission facility
Canis Minor	• Hip 36208/ GJ 273b (all)	• *Sónar Calling GJ 273b*	• 16 Oct 2017	• 1.5 MW	• EISCAT, Tromsø
		• *Sónar Calling GJ 273b*	• 17 Oct 2017	• 1.5 MW	• EISCAT, Tromsø
		• *Sónar Calling GJ 273b*	• 18 Oct 2017	• 1.5 MW	• EISCAT, Tromsø
		• *Sónar Calling GJ 273b*	• 14 May 2018	• 1.5 MW	• EISCAT, Tromsø
		• *Sónar Calling GJ 273b*	• 15 May 2018	• 1.5 MW	• EISCAT, Tromsø
		• *Sónar Calling GJ 273b*	• 16 May 2018	• 1.5 MW	• EISCAT, Tromsø
Libra	• Venus/HD 131336	• *Morse Message*	• 19 Nov 1962	• 50 kW	• Pluton-M, Yvepatoria
			• 24 Nov 1962	• 50 kW	• Pluton-M, Yvepatoria
	• 'Libra constellation'	• *NASDA METI Message*	• 22 Aug 1995	• –	• 64 m Usuda Antenna
	• Hip 74995	• *A Message From Earth*	• 9 Oct 2008	• 150 kW	• RT-70, Yvepatoria
		• *Hello From Earth*	• 28 Aug 2009	• –	• DSS-43, Canberra
Cancer	• HD 75732	• *Cosmic Call 2*	• 6 Jul 2003	• 150 kW	• RT-70, Yvepatoria
		• *Wow! Reply*	• 12 Aug 2012	• 1 MW	• Arecibo Observatory
		• *JAXA METI Expt. #1*	• 22 Sept 2013	• 20 kW	• 64 m Usuda Antenna
		• *JAXA METI Expt. #2*	• 23 Aug 2014	• 20 kW	• 64 m Usuda Antenna
Cetus	• HD 10700	• *Poetica Vaginal*	• 1986	• –	• Millstone Hill Radar
		• *Toronto Science Fair*	• 2013	• –	• Algonquin Observatory
	• HD 20630	• *RuBisCo*	• 7 Nov 2009	• –	• Arecibo Observatory
Gemini	• HD 50692	• *Teen Age Message*	• 3 Sep 2001	• 96 kW	• RT-70, Yvepatoria
		• *Wow! Reply*	• 12 Aug 2012	• 1 MW	• Arecibo Observatory
	• HD 54351	• *Wow! Reply*	• 12 Aug 2012	• 1 MW	• Arecibo Observatory

(continued)

Table 8.2 (continued)

Constell.	Target(s)	Message name	Transmitted	Power	Transmission facility
Ursa Major	• HD 95128	• *Teen Age Message*	• 3 Sep 2001	• 96 kW	• RT-70, Yvepatoria
		• *Cosmic Call 2*	• 6 Jul 2003	• 150 kW	• RT-70, Yvepatoria
		• *Doritos Advertisement*	• 12 Jun 2008	• –	• EISCAT, Svalbard
Sagitta	• HD 190406	• *Cosmic Call 1*	• 30 Jun 1999	• 152 kW	• RT-70, Yvepatoria
	• HD 178428	• *Cosmic Call 1*	• 30 Jun 1999	• 152 kW	• RT-70, Yvepatoria
Ursa Minor	• HD 8890	• *Across the Universe*	• 4 Feb 2008	• 18 kW	• DSS-63, Spain
		• *A Simple Response to an Elemental Message*	• 10 Oct 2016	• 20 kW	• ESA Cebreros Station, Spain
Centaurus	• HD 128620	• *The Day the Earth Stood Still*	• 12 Dec 2008	• –	• DSCN system[a]
	• Hip 70890 b	• *Message to Proxima Centauri B*	• 27 Nov 2018	• 20 kW	• ESA New Norcia Station, Canberra
Orion	• HD 245409	• *Cosmic Call 2*	• 6 Jul 2003	• 150 kW	• RT-70, Yvepatoria
	• M42	• *Break the Eerie Silence*	• 12 Mar 2010	• –	• Sent Forever system[a]
Cassiopeia	• Hip 4872	• *Cosmic Call 2*	• 6 Jul 2003	• 150 kW	• RT-70, Yvepatoria
	• Cassiopeia A	• *Lone Signal Test*	• –	• –	• Madley Earth Station
Cygnus	• HD 186408	• *Cosmic Call 1*	• 24 May 1999	• 148 kW	• RT-70, Yvepatoria
	• HD 190360	• *Cosmic Call 1*	• 1 Jul 1999	• 152 kW	• RT-70, Yvepatoria
Virgo	• HD 116658	• *NASDA METI Messages*	• 12 Aug 1997	• –	• 64 m Usuda Antenna
	• HD 126053	• *Teen Age Message*	• 3 Sep 2001	• 96 kW	• RT-70, Yvepatoria
Boötes	• HD 124897	• *Message to Qo'nos*	• 18 Apr 2010	• –	• Dwingeloo Observatory
	• HD 119850	• *Lone Signal* (around 70 intermittent messages)	• 18 Jun 2013–29 Aug 2013	• –	• 30 m Jamesburg Earth Station
Aries	• L1159-16	• *RuBisCo*	• 7 Nov 2009	• –	• Arecibo Observatory
	• Teegarden's Star	• *RuBisCo*	• 7 Nov 2009	• –	• Arecibo Observatory

[a]Denotes short-range, commercial transmission equipment (Quast 2018)

The reader will, by now, not be surprised to learn that there is no overarching logic or grand synthesis to rely on at present for why subsets of our species, with access to aerospace technologies, craft such intangible legacies for consumption by unknown spatiotemporal denizens. The answers lie along a bewildering spectrum, but this, in itself, may perhaps be an inadequate frame of reference for conceptualising the broad dimensions and disparities in these material practices. Despite these defining inconsistencies, interstellar messages can generally be situated within the contextual backdrops of related expressional practices that peripherally follow recognisable contours in material culture engagement histories. These include; our urgency to craft mnemonic legacies as immortalising personal gestures to eternity, or as imperishable cultural documents of humanity; proposed information preservation archives (largely as a result of the rhetoric associated with public infatuations with memory, and social anxieties over 'cultural amnesia' (Haskins 2017)); prospective culture exchange devices with ETI (most with 'cargo cult' connotations implied); outreach, artistic, and educational activities; and thinly-veiled pseudo-colonialist enterprise, intent on expanding specific social, and political values into the 'higher frontier' (Quast Forthcoming).

Such constructs tend to varyingly mirror the compelling, passionate drives present in establishing similar terrestrial time capsules activities (Durrans 1994; Jarvis 2003), alongside other ancient arenas of votive mark making practices; expressions which aim to powerfully bridge our voices and thoughts across lifespans to unknown others, such as deities, angels and ancestral spirits, to modern conceptualised recipients like human posterity and ETI. These durational time-binding activities are broadly appealing, highly emotive, and usually tap into our desires for undertaking captivating journeys into the immortalising unknown; perhaps revealing some intriguing insights into the interrelationships between how our minds are 'programmed' when mentally construing our psychological dimensions, and how we varyingly wish to connect with the unseen beyond our conceived locations in space-time (Liberman and Trope 2008). Overall, there are no precise either-or demarcations between the *imbroglio* of these overlapping messages from Tables 8.1 and 8.2, but each avenue possesses its own broad intellectual lineages of engagement histories; perhaps revealing conflicting and illogical legacies for the signals already 'out there.'

In slightly drifting away from the spirit of the original question, from our perspective as a contemporary human audience, largely inducted within the same social, cultural, symbolic and linguistic conventions embedded within these messages, what can we glean from the range of divergent thoughts, expressions and values that 'speak for Earth' at each of these targeted stellar systems? Prior analyses of singular message contents, or consensus-building projects, have revealed overarching glimpses into some of the internal needs, hopes and virtues of humanities' psyche, alongside societal concerns of an era (Lower et al. 2011; Vakoch et al. 2013; Quast 2017; Schmitt 2017), in addition to some general correlations and broad sociological insights through cross-message examinations (May 2020; Capova and Quast Forthcoming); truths packaged as old stories that varyingly seek to discover our positions as individuals and societies across new cosmic horizons.[23] Presently, there are no target-specific studies for the aggregate of contents sent to individual stellar systems under this established layering premise.

It could be an intriguing, but perhaps futile, exercise to begin piecing together such a distorted picture of terrestrial history and biota from these messages sent to specific target systems. However, examining the flaws in these constructs may enable us to understand how they are at least supposed to relate to our lived environment, while identifying the obvious follies that lead to misconceptions. Regardless of this, these prospective social-exchange devices can provide us with a partial retrospective window to raise provisional questions about *our* conscious relationships between people and material resources, cultural re-invention, place, semiotic activities, memory, ritual exercises, and whether social attitudes of individual authors correlate with selective patterns of cultural identity or, in the very least, reliably contribute new concepts, principles and heuristics to the behavioural toolbox to inform [our] future material culture studies. Aside from these generalised, cross-analytical conclusions that have been previously drawn out from these message studies, it would be remiss to spill further ink by scouring these constructs for more precise, concrete sociological indicators that correlate nuanced conclusions useful for this layering argument—owing to the diversity and frequent disparities present in the multilateral applications for such messaging practices.[24] It suffices to state that in unaffiliated message contents, there is very little crossover or convergences in opinion, expression, tradition or approach; a *consensus about the lack of a consensus* if you will—an oxymoron, I think, is a recurring theme in re-presenting terrestrial societies.

Setting aside any potential outcomes arising from these prospective communiques, our influence over interstellar messages is implied to logically end once the signal physically departs the transmitter. But does this classic portrayal readily delineate *an end* to our material engagement with those dissevered material signs? I'd argue this to perhaps be the case for the physical photon streams which remain on a permanent diametric trajectory—cognitive residues or snapshots of their creator's distributed cognition, frozen in time, that immediately become redundant antiques of those eras once removed. But I think this rational is emblematic of an intriguing noetic division within our conceptual frame of reference for material

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[23]There is a certain degree of hesitancy in drawing further comparisons directly between message contents as a cross-indicator for study, as I think it would be wrong—even impertinent—to imply that there is any deeper meaning, or conclusive parallel evidence, apparent in uncoordinated projects with differing agendas and intents.

[24]Taking HD 95128 as an example of intermittent message layering with discordant media, this stellar system is awaiting two METI transmissions from the related *Teen Age Message* and *Cosmic Call 2* series, but it is bewildering to contextualise why these two scientific signals are closely followed by an advert for Doritos. It is difficult to actively interpret such eclectic legacies as part of our expanding worldviews using symbols of food stuffs as artefacts for material culture expression—or contemplate why the possible denizens of Chalawan (Chalawanians?) should be captivated by signs of comfort foods, much less the generations of humans who will live out their lives trusting that their outer space diplomacy interests are represented by the PepsiCo corporation.

engagement practices as linear input-output products, externalised from internal 'brain in a vat' processes (Putnam 1982), as opposed to entwined cyclical feedback patterns where minds, bodies, instruments, cultures and actions conflate and reinvent through material manipulation (i.e., gestures that stimulate other gestures to arise—and reflect). In other words, we need to "understand not what things are (as entities), but instead, how things come to be (as 'events')" (Malafouris 2019)—in our case, messages as ongoing, dynamic processes. An alternative way of looking at the enduring nature of our signalling practices, can be seen through the lens of MET under Malafouris's analogy of pottery throwing in collapsing "the divisions between perception, cognition, and action and rejecting the methodological separation between individual creative experience and the material mediational means and collective structures through which it becomes realized" (Malafouris 2013).

Consider the usual way in which we describe the processes of creative agency when using radio astronomy technologies to produce an interstellar message. An authors' intention is to produce a specific form for a particular purpose; the intention is translated across a sequence of appropriate bodily commands, using embodied skills and surrogate technological interfaces, which generates a series of mental concepts on a visual display to be transcribed in modulated photon streams. Eventually, the form of the message emerges as a consequence of those stages, implying a temporal directionality from mind to matter, mediated through isolated "entity" occurrences. This hierarchical process can be described as an 'internalist' approach, whereby the origins for creative agency lies in the mind, with subsequent surrogate actions in materials doing little more than executing the intentions of the author's brain.[25] There is an ordinal division of beginning and end to this process, which usually overlooks the conscious engagement and history that led to the message, and subsequent impacts the signal has *on us*.

By contrast, the pottery analogy draws our attention to rethinking the perceptual mental boundaries, temporal anchors, and hierarchical judgements committed for these creative processes, by focusing on the dynamics of the making process itself as an active site for the conflation of both internalist and externalist approaches, alongside the role of feedback arising from these experiences. In this sense, the potter's creative agency is attributed to arise from the varyingly enmeshed elements constituting the pot throwing process as a form of 'cognitive ecology'; the dynamic coupling of the potter's predispositions; sub/conscious and passive intents; mental pre-planning; embodied sensorimotor gestures and reactions through their hands; perceptual preferences; social histories of prior experiences alongside established cultural conventions; the material constraints and behaviours; affordances of the potter's wheel (as an extension of the body); and intervals of time—all of which varyingly contribute, feedback and causally modify the creation of a simple pot from an amorphous mass of clay. Moreover, these experiences do not simply end once a

[25] An 'externalist' approach, by contrast, centralises around studying the final products of these actions through perceptible properties of techniques, things and their constituent materials as the static site for creative agency.

pot is formed, but rather filter back into the creation of these structures as an enactive material engagement practice—in our case, a loose cultural history of message construction, which then informs the ecology of future projects. I will leave it to the reader here to ascertain whether interstellar messages may be beneficially explored through this refractive lens of cognitive archaeology, but such alternative approaches to understanding our signals as anthropomorphic expressions of material agency, may certainly prove insightful for contextualising their apparent legacies for the Sol System and far beyond.

6 Cui Bono?

Far from being a comprehensive overview of accumulative layering processes within this archaeological record of interstellar messages, the chapter has instead focused upon wading through unfamiliar, contested territory and detangling several prevailing threads of debate within mental-material engagement practices, in order to flesh out some of the thought-provoking semiotic queries behind signal reception for discussion. Much of these lines of argument presented in this chapter have their respective strengths, weaknesses and subject-orientated challenges—but also opportunities—which should be kept in mind when working between disciplinary boundaries. Pushing through this overarching dissonance is essential for recognising, and studying, the limits of our present understanding for the futurity of disconnected material cultural legacies, in the absence of any reliable long-term data.

Others may disagree with these sentiments, or my choice in focusing upon particular elements of signals that I believe may prove fruitful in further study, at the expense of leaving other properties firmly packed. Answering such unusual complexities might not help us to understand what these messaging devices may—or can—mean for foreign cultures, but they do certainly help us to rethink how they materially *mean something to us* through rephrasing the questions we pose in more productive manners. The fact that we have so much to provisionally debate about these electromagnetic surrogates after 60 years (as exemplified by my selective points discussed and message plotting in Fig. 8.3) suggests either that we are not yet in possession of all of the pieces to even begin mentally probing these enigmatic puzzles or, on the other hand, that we have strong intuitions about signal reception, and consider the current limits to our knowledge to be irrelevant for an interpretation of these legacies. I hope for the former, but to move forward requires us to put away our telescopes and ironically look into mirrors—reflections are perhaps more beneficial for grounding our obtuse projections.

Attempts to craft 'metonymy'—that is, concise messages from Earth as an adequate substitute for the planet they intend to signify—as a *pars pro toto* representation have, more often than not, been attempts to modernise and homogenise the deep cultural contours that define the range of cultural and ethnic diversity for human societies available on Earth. Asking ourselves *cui bono?*—or who stands to benefit from these layers—may serve to waver through some of these presuppositions, and

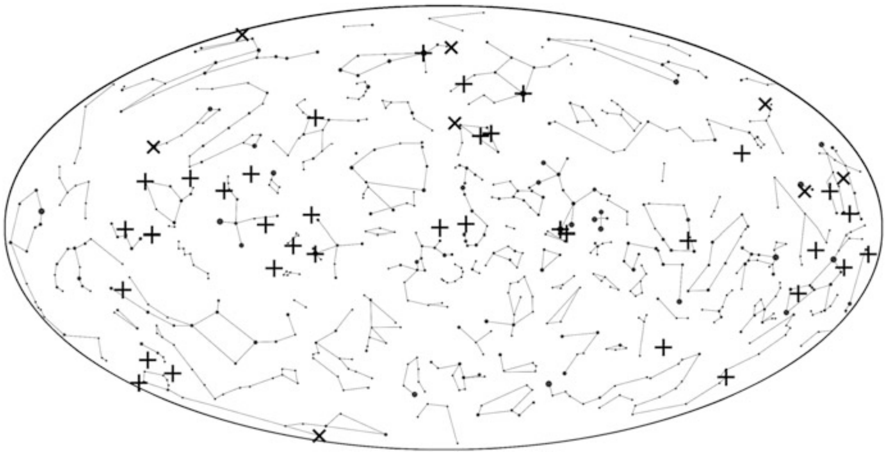

Fig. 8.3 Simple Mollweide constellation map documenting various defined interstellar transmission targets between 1962–2020 listed in 'A Profile of Humanity' index, plotting (with 'x') locations of known overlapping messages, and (with '+') locations of single transmission targets (i.e., non-repeating messages of various types)

reveal other deep-seated assumptions about our minds, memories and influences through the emergent ages across new, dynamic environmental records. After all, the stories we know about 'life on Earth' are not always the stories we are interested—or indeed even comfortable—in telling. In the end, I think this chapter raises an abundance of more valuable questions than verifiable answers in regards to how identifiable human representational behaviours and encompassing worldviews—from unintentional ochre, to deliberate interstellar electromagnetic signals—are varyingly expressed on timescales surpassing the lifespan of their re-presented minds, communities, creeds, nations and perhaps civilisations; 'big pictures,' often framed under the nuanced paradigms of social evolutionary narratives (Denning 2010a). A fair assessment for these imaginative messaging practices is that they open doors for some, narrow doors for many, and create back doors for others to characterise the evolving nature of such activities; essentially as commentary *about us, our shifting worldviews, and recombined projections for our perceived cosmic and temporal positions*.

7 Conclusion

When did abstract representations of Terran behavioural patterns appear in the extra-terrestrial record of articulate media emanating from the Sol System? Perhaps one day, in the far distant future, foreign ETI cultures may pose such a question, in response to the perplexing, faint barrage of passive technosignatures as discussed by Stephen Baxter elsewhere in this volume, or detection of highly complex, narrow beams of symbolically encoded photons layered across staggered timescales. For the time being, we must be content with attempting to unravel the various threads contributing to these self-constructed mysteries for ourselves. If anything, such murmurs (or mumbles), as material signs for Earth, should ideally give us pause to seriously engage with the myriad of intents, motives and agendas apparent in these patterns of signals; dynamic layers that may formally re-present Earth's story within the 'Bigger History' of an evolving, and perhaps conscious, cosmos.

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Chapter 9
COGITO in Space

Daniela de Paulis and Frank White

Abstract *COGITO in Space* is an experiential narrative based on sending thoughts into outer space as radio waves. The project exists both as a mobile installation and as a performative event staged inside the cabin of the Dwingeloo radio telescope in The Netherlands. For both versions of the project, a team composed by three neuroscientists prepare the subject with a lab grade electroencephalogram (EEG) device and a virtual reality (VR) headset, showing an experimental video of the Earth seen from space. The brain activity stimulated by the video is recorded and simultaneously transmitted into space in real time, using the antenna of the Dwingeloo radio telescope.

1 Introduction

In 1977, the first brain activity was sent into space, etched as sound by Carl Sagan and his team in the Golden Record on the Voyager spacecraft. On June 3, 1977, with the aid of Julius Korein and Tim Ferris of the New York University Medical Clinic, science writer Ann Druyan's brain activity was captured for 1 h as a single electro-encephalography (EEG) channel and compressed into a 1-min sound recording. Druyan recalls "I had this idea, that we should put someone's EEG on the record.

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We know that EEG patterns register some changes in thought. Would it be possible, I wondered, for a highly advanced technology of several million years from now to actually decipher human thoughts?" (Phillips 2011).

Although a highly poetic gesture, the brain activity etched in the Golden Record does not convey actual information about human mental states or the human existential condition. Neuroscience has progressed much since then, with modern EEG recording and analysis techniques allowing sufficient fidelity to capture individual brain states to the point where they can be used as individual 'fingerprints,' and for the decoding of subjective and cognitive processes.

COGITO in Space began as a thought experiment in 2013, with the first public presentation of the project as a talk as part of the art-science festival Kosmica in Mexico City in August 2013. The project required several years of research and development, with several performances hosted internationally between 2014 and 2018 that allowed for it to be tested during the work in the progress, eventually leading to the presentation at the Dwingeloo radio telescope in The Netherlands in November 2018, during which *COGITO in Space* finally achieved its full potential and artistic vision (de Paulis 2019, 2021b).[1]

2 Conceptual Background of the Project

COGITO in Space is a collaborative, interdisciplinary project resulting from 6 years of research at the Dwingeloo Radio Telescope and the Dutch Radio Astronomy Institute (ASTRON). Through the contribution of experts from various fields, the philosophical background of the project evolved over the years, however my thinking behind it focuses primarily on the concept of Mind and Body Dualism and the *Overview Effect*. Another relevant reference is Stanislaw Lem's novel *Solaris* and Andrei Tarkovsky's eponymous film (de Paulis 2019, 2021a, b).

The rationale behind the project began as a reflection on the use of the electromagnetic spectrum by radio astronomers, and especially radio waves, to collect data on cosmic phenomena, and on the type of information we obtain from the detection of such remote events that cannot be recognized by direct sensory experience. Over the years, working alongside radio astronomers, I had the opportunity to gain first-hand insight into the method of image creation in astronomical science. This prompted me to delve into the cultural meaning of images transmitted from space

[1]During the work in progress, *COGITO in Space* was presented as part of the 24th Biennial of Design in Ljubljana, with the transmission of recorded brain activity from the Dwingeloo radio telescope in November 2014. A live performance as part of the GOGBOT new media art festival in Enschede in The Netherlands, in September 2017 followed, together with a live performance in February 2018 as part of the TEC ART international festival in Rotterdam. During this event, the brain activity of participants was recorded and transmitted into space as part of a live audio-visual performance, in remote connection with the cabin of the Dwingeloo radio telescope and in collaboration with radio operators of the CAMRAS team.

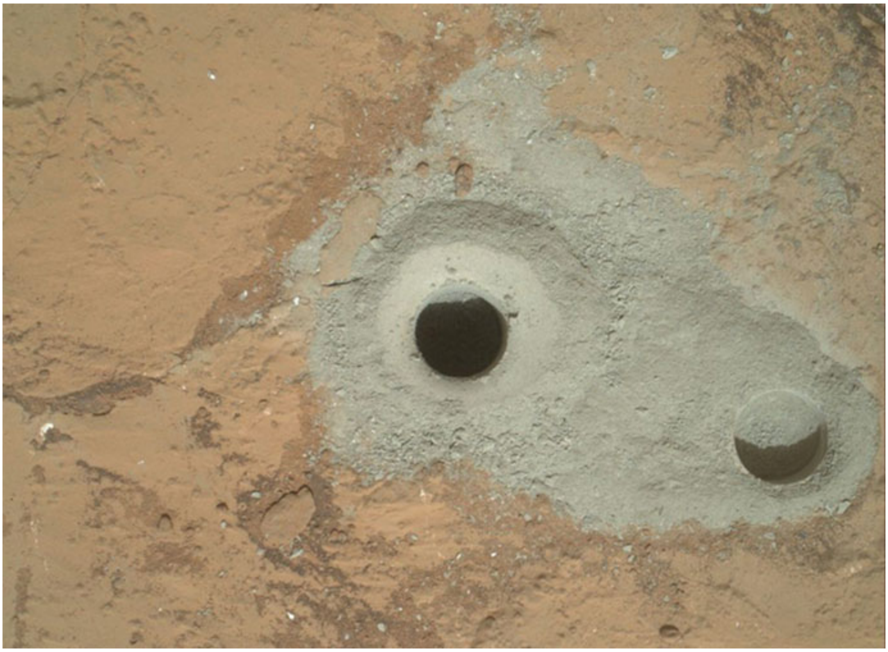

Fig. 9.1 A photograph of the first sample drilled on the surface of Mars. The hole called John Klein (on the right) was drilled by NASA's Curiosity rover on Feb. 8, 2013 (Wall 2013). Credit: NASA/JPL-Caltech/MSSS (de Paulis 2019, 2021a, b)

probes back to Earth as radio waves, while exploring distant planets. One of the problems that emerged from my research and that ultimately became one of *COGITO in Space*'s leading concepts is "how does the knowledge acquired through remote observation of the universe influence our cognition and how does the mind interact with the matter of such a distant universe and vice versa?" (de Paulis 2019, 2021a, b).

In questioning the relationship between the body and the mind in contemporary cosmology, the sight of the first hole drilled on the Martian surface in 2013 (Fig. 9.1) was pivotal for me. The picture depicts a landscape on which human activity has imprinted its mark, displaying the essence of the action and the surrounding landscape in great detail. The uncannily realistic scene is symbolic of what I call the Dualistic Problem in Contemporary Cosmology (de Paulis 2019, 2021a, b). With the increasingly realistic representations of the landscape of celestial bodies as relayed by radio-transmissions, this dualism between body and mind emerges. The fruition of these highly detailed images could prompt an intuitive sensory reaction of embodiment to the viewer as if looking at pictures of familiar earthly landscapes, as if imagining being there and experiencing the star light, the clouds, the extra-terrestrial sand's texture directly. However, these photographs demonstrate the limits to which we can apply our traditional sensory and cognitive abilities to intuitively embody the alien world encountered by the instruments, precisely tuned to our life on Earth, revealing a distant, eerie-looking reality whose physical conditions have never been directly witnessed by humankind.

In addition, the distance between the real extra-terrestrial landscape and our understanding of it through radio reception of a human-made instrument is highlighted by this type of remote exploration. Although these mysterious views of cosmological objects transmitted back to Earth by radio-waves inevitably find a place in our minds as abstract concepts of a reality that in some remote future could come to direct fruition, they also enrich our collective imagination with dreamlike possibilities. Radio waves allow us to move further and faster than our senses with our thoughts across a domain of abstract cosmological spaces in this regard (de Paulis 2019, 2021a, b).

After my reasoning on the idea of dualism, I called the project *COGITO in Space*. In fact, the title refers poetically to the changes in the perception of fundamental concepts in Western thought, such as the concept of 'cogito,' towards a contemporary culture that is increasingly defined and influenced by space exploration. The title indicates the extension of the cogito concept, as formulated in an age in which conceptions of human shape and movement were driven by anthropocentrism and framed within Euclidean space, into the contemporary understanding of relativity and cosmological phenomena.

The anthropocentric perspective is questioned by contemporary physics and argues that space and time are not absolutes that spread uniformly throughout the universe. Indeed, space and time vary according to the movement of the observer in the Theory of Relativity. In *COGITO in Space*, the virtual cosmonaut begins her journey inside the mind, situated in the brain and accurately measured by electrical signals, along the Cartesian coordinates, reaching interstellar space where spatio-temporal references blur and gradually disappear into the unknown, much like the radio signal carrying the thoughts (de Paulis 2019, 2021a, b).

COGITO in Space delves into the field of philosophy of mind, in particular the Extended Mind Thesis (EMT), conceived by Andy Clark and David Chalmers in 1998 (Wilson et al. 2011). The EMT proposes that the mind extends into its physical surroundings that become part of its cognitive development. In the EMT, the mind embodies space in a continuity of mutual interaction. In *COGITO in Space*, radio waves become the extension of human thoughts and actions, thus an extension of the body-mind, posing questions on the limits of human presence in space. As radio waves can travel indefinitely, they potentially extend the human presence into the infinite and towards the edges of the universe (de Paulis 2021a).

Since its early development in 2013, *COGITO in Space* has been informed by conversations with space philosopher Frank White, co-founder of the Overview Institute and author of *The Overview Effect, Space Exploration and Human Evolution* (White 2014), an influential essay in which he investigates the cognitive shift happening in the mind of the astronauts after witnessing the sight of the Earth from outer space. White reports that as a result of the *Overview Effect*, the mind of the astronaut develops a notion of a unified planet and of greater ecological and social awareness. This concept deeply influenced the development of *COGITO in Space* (de Paulis 2019, 2021a). The immersive video I created especially for the project in collaboration with filmmaker Sandro Bocci, aims at evoking the *Overview Effect* while at the same time leaving space for open interpretation and critique, rather than functioning as an outreach platform by endorsing a particular current of thought. The video includes some of the footage captured by the camera onboard the International Space Station, showing the curvature of the Earth as the station orbits. The footage however combines the documentary material with experimental film techniques evoking memories, an aesthetic experience as well as sensory feedback (de Paulis 2019, 2021b).

The images mimicking organic forms, intend to induce flickering, ancestral memories of our evolutionary past, from stellar dust up to our present place in the cosmos, for which the evolutionary history of the universe, life and consciousness is perceived as a narrative intrinsic to one's body and mind. The footage in virtual reality brings the images as close as possible to the retina, engaging the deep mind directly, rather than creating a field of view. Combining experimental footage with realistic views of the Earth seen from space, the video attempts to disrupt the familiar image of our home planet, inducing a more introspective journey into the perception of our place in the cosmos, delving more deeply into subjective memories and mental associations. While the participant experiences the virtual reality film, the images are fed into their mind while at the same time their subjective response to the images is transmitted into space, creating a fluid continuity between inner mental space and outer space (de Paulis 2019, 2021b).

Another pivotal concept in the *COGITO in Space* video is the '*Oceanic Feeling*' , first suggested by art historian Romain Rolland in his letter to Sigmund Freud (Roberts 2016), in reference to mysticism in art. Rolland defines the *Oceanic Feeling* as "*the feeling of the 'eternal'* (which can very well not be eternal, but simply without perceptible limits, and like oceanic, as it were" (Parsons 1999). Towards the end of the *COGITO in Space* video, the image of the Martian dunes soaked in the deep blue hue first mixed by French artist Yves Klein,[2] fills the retina, invoking the universal intuition of something larger than oneself, a deeply rooted intuition of some form of unfathomable infinity.

In the video the image of the ultramarine dunes is followed by the iconic Blue Marble image, taken during the last manned lunar mission (Apollo 17) in 1972; despite being one of the most widely known images, the photo seems to emphasize that we know our home planet only through distant photos (for a discussion of the social reception of these images, see Spier 2019). We don't know our home, we only know it through our subjective interpretation of remote images, filtered through our individual memory and thought process (Fig. 9.2). As humans we are faced by the enigma of being intrinsically connected to Mother Earth without really knowing her identity. In my opinion, the lack of understanding of our home planet plays an important role in the struggle for the search of our identity as earthlings and our role in the universe. By receiving feedback from some of the project's participants, I realized that the sight of the blue planet, following a series of abstract images, surprises the viewer and inspires in their mind deep emotions of belonging and an almost mystical resonance beyond thought (de Paulis 2019, 2021b).

[2]https://en.wikipedia.org/wiki/Yves_Klein.

Fig. 9.2 *COGITO in Space* VR video still image. Image by Sandro Bocci, 2017 (de Paulis 2019, 2021b)

From the start of the project, I was interested in the idea of sending brain waves into space generated by the sight of our home planet, shifting the Earth-centred perspective to the Cosmos-wide mindset. This vision seemed to me evocative of a universal enough existential narrative, for which the human being is compelled to explore the unknown while grieving the consequences of leaving a part of herself behind.

COGITO in Space thus speculates about a hypothetical future in which humans might be confronted with the possibility of leaving planet Earth for the void of outer space. What would be the impact of this extreme journey on the human existential condition? The poetical reference for this aspect of the project is the novel *Solaris* by Stanislaw Lem, which addresses the psychological conflict of losing one's identity and memories of terrestrial life, letting go of one's sense of belonging to Earth during space travel. The experience of the project aims at creating a mirroring effect between the unknowns of the cosmos and inner subjectivity, echoing the thoughts of Dr. Kelvin, *Solaris*'s main character: "Man has gone out to explore other worlds and other civilizations without having explored his own labyrinth of dark passages and secret chambers, and without finding what lies behind doorways that he himself has sealed" (Lem 1970).

3 *COGITO in Space* in Relation to Previous Interstellar Messages

The questioning behind the creation of *COGITO in Space* led me to focus on the complexity of human thought as probably the most identifiable signature of our life experience. When asked by the neuroscientists about which aspect of the thought process I wished to highlight in the brain activity recording for the project, I opted for the possibility to record the whole dynamics of the brain and capture the contrasting and sometimes opposing aspects of the thinking process as much as possible. As a result, the neuroscientists and I focused on recording spontaneous cognition, also known as 'stream of consciousness' (Cuddon 2012).[3]

The principle of capturing and transmitting a 'stream of human consciousness' into space, dialogues with the notion of interstellar message as conceived by scientists, including Frank Drake and Carl Sagan, who wrote and transmitted the Arecibo message into space in 1974.[4] This and the following interstellar messages centred on the scientific and technological knowledge of humanity (see, e.g., Quast 2018), stressing the mathematical and logical notion of intelligence. The Arecibo message was conceived as an example of the basic biological and cosmological concepts known to humans and was aimed at communicating with a potential extraterrestrial intelligence through the presumably universal language of mathematics. The message depicted humans as a highly intelligent species, for which intelligence is synonymous with rational reasoning, however the message did not disclose any of the cultural, psychological, existential explanations for which humans might attempt to interact with a civilization so far apart (de Paulis 2019, 2021b).

COGITO in Space focuses instead on the continuous thought process that occupies most of our individual narrative, on the existential struggle and controversial nature of a sentient being, on their deepest thoughts and doubts, asking a potential extraterrestrial listener "are you as conflicted as we are, do you share our inner struggle? Can we empathize with what we don't know and cannot understand about our existence and the meaning of life?" (de Paulis 2019, 2021a, b).

In the novel *Solaris*, the probability of non-mathematical verbal contact with an alleged extraterrestrial intelligence is also underlined. While hovering over the surface of the sentient planet *Solaris* on a spacecraft, Dr. Kelvin, the mission psychologist, is prompted by the mission scientist to relay his brain activity to the planet, while concentrating on the scientific intent of the task. However, Dr. Kelvin lets his mind wander through various memories of his life, contaminated and overlapped with dreams, while the electrodes are connected to his head and the transmission of his brain activity takes place (de Paulis 2019, 2021a, b).

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[3]The term 'stream of consciousness' was coined by philosopher and psychologist William James in *The Principles of Psychology* in 1890: "consciousness, then, does not appear to itself as chopped up in bits . . . it is nothing joined . . . it flows. A 'river' or a 'stream' are the metaphors by which it is most naturally described. In talking of it hereafter, let's call it the stream of thought, consciousness, or subjective life."

[4]https://www.seti.org/seti-institute/project/details/arecibo-message (Accessed 28 November 2020).

Fig. 9.3 The 32 electrodes EEG device used in *COGITO in Space*. Photo Sandro Bocci, 2017 (de Paulis 2019, 2021a, b)

4 Code for Interstellar Transmission

The artistic requirement of recording the brain activity of the entire brain and conveying the complexity of human thought proved to be very challenging from the scientific and technological point of view. As an artist I value scientific accuracy, in fact I consider the scientific language as the 'material' of the project, making it an essential requirement that people experiencing *COGITO in Space* would not be deceived regarding the accuracy of their experience, within the limits of current understanding of brain activity analysis. For the project we use a laboratory-grade electroencephalogram (EEG) device. The EEG research has been developed in collaboration with neuroscientists Robert Oostenveld, Stephen Whitmarsh and Guillaume Dumas, together with radio operator Michael Sanders.

The EEG reading is able to detect the complex activity created by the electrical signals in the brain in time, showing that the mind is engaged in negotiating different stimuli, produced both by the sensory and psychological experience. The EEG reading however is not invasive and cannot detect the object of thoughts, therefore it presents no privacy concerns (Fig. 9.3).

For *COGITO in Space* a unique code for interstellar transmission was developed, the first of its kind, accurate both from the artistic and scientific perspective. The code manages to reliably convert the 'river of consciousness' measured by 32 electrodes, into a mono sound that can be converted into a radio signal which can be transmitted into space using a powerful antenna (de Paulis 2019, 2021b).

For the project, the EEG recordings are analyzed and converted into sound in real-time, using an open-source interstellar EEG-transmission protocol designed for the project by Guillaume Dumas and Michael Sanders and integrated in the EEGsynth fieldtrip software package.[5] The 25 m dish antenna of the Dwingeloo radio telescope instantly transmits this audio-stream into space while the participant's brain activity is recorded. The antenna uses amateur radio equipment, with a Single Side Band (SSB) 120 W power transmission with a fixed dish position. By spreading transmissions over the sky the chances of possible detection by an alien civilization are limited. One of the challenges of the project was the real-time conversion of 32-channel EEG into a mono 3 kHz audio signal for a linear SSB modulated radio transmission, including the 3D electrode positions that would allow the reconstruction of the cortical activity and topography by a hypothetical receiver (de Paulis et al. 2020).

The interstellar EEG-transmission protocol converts the EEG into a single audio channel as follows: first all the 32 channels of EEG are converted into the frequency domain. Since most human EEG signals obtained in frequencies are under 45 Hz (higher frequencies are dampened by electrical resistance of the skull and skin), only this frequency-range was retained. All the 32 channels are subsequently concatenated in the frequency domain using complex matrix multiplication, with each channel encoded into a 75 Hz bandwidth. Each 75 Hz part starts with a pure (identifier) tone at 1 Hz, followed by the 1-45 Hz spectrum of the EEG channel. The X, Y and Z-positions of the electrode are then encoded through frequencies of additional tones in three successive 10 Hz bands. The frequency representation is then converted back to a single audio channel with bandwidth of 2.4 kHz. This process occurs in real-time with fixed time (ca.1 s) fieldtrip buffer data slots and a minimal time-lag between recorded EEG and live transmitted radio signal. The conversion includes a 300 Hz shift and a non-linear transformation of the spectrum for compensating the filter effect of the hardware of the radio-equipment within the 0.3–3 kHz frequency limit (de Paulis et al. 2020).

For the project, my brain activity recording was reflected off the surface of the Moon ('Moon bounced') in 2017 using the Dwingeloo radio telescope in order to test the possible retention of the signal in interstellar space. After the test, despite the considerable loss of signal plus distortion of data, the message could still be retrieved and interpreted as a bio-signal. This proved the communication potential of EEG signals, distorted and dispersed over a distance equivalent of at least 2.6 billion km, using two telescopes-radio antennas identical to the ones used in *COGITO in Space* (de Paulis et al. 2020).

Due to the great cosmic distances, it is extremely unlikely that the radio signals carrying the brain activity will ever be detected and interpreted before they fade into the background noise of the universe. The project has been presented at several international SETI (Search for Extraterrestrial Intelligence) conferences and discussed with specialists in the field. As a member of the IAA SETI Permanent Committee, I am very aware of the controversy in transmitting powerful signals into

[5]The code developed for the Cogito in Space project and general documentation can be found at: https://github.com/eegsynth/eegsynth.

space in the attempt to communicate with an extraterrestrial intelligence. For this reason, I chose not to target a particular celestial object with the *COGITO in Space* transmissions, thus keeping the transmitting antenna still and spreading the signal across the sky instead.

The work in progress for developing the first code for interstellar transmissions using EEG signals, was a very interesting part of the work: every 2 months the entire team met for short research retreats at the ASTRON guesthouse, the living and working facilities adjoining the scientific facilities. The guesthouse as well as the cabin of the Dwingeloo radio telescope became our spaceship, our safe ground control for working together: radio astronomers, neuroscientists, radio operators, artists, brainstorming ideas, sharing languages and methodologies, having in depth conversations about all aspects of life.

5 Performance at the Dwingeloo Radio Telescope

COGITO in Space eventually settled on 5 November 2018 at the Dwingeloo radio telescope, its originally planned physical location. The project was intended from the outset to be experienced within the cabin of a radio telescope that would imitate the body's post-human outer shell, its life support system in a half-human-half technological system. The Dwingeloo radio telescope was built in 1956 and became national monument of the Dutch heritage in 2011. Together with modern amateur radio instruments, the cabin still contains some of the original radio equipment and its setting has become the iconic stage for *COGITO in Space*'s ongoing performances since 2014 (de Paulis 2019, 2021b).

I imagined the event at the radio telescope to be an experience for the visitors, with many events taking place during the day in the form of a cinematic reality that combined the exceptional and the ordinary. A symposium and keynote lectures by space philosopher Frank White, cultural anthropologist Fred Spier, retired NASA astronaut Nicole Stott and Dutch art theorist Josephine Bosma began the day in the ASTRON auditorium. Frank White presented the Overview Effect and his more recent Cosma Hypothesis (White 2019) concepts, suggesting that humanity should avoid repeating the errors committed during Earth's colonial exploration when exploring outer space. Fred Spier is a retired professor of Big History at the University of Amsterdam. Big History is a cutting-edge field of research investigating the development of both natural and cultural events, from the Big Bang to the present, working along a very broad timescale from an interdisciplinary perspective, merging human sciences with physics, astronomy and geology. Spier spoke about his experience of the Moon landing as a child and the cultural meaning of the Earth Rise photograph, which for many years had a strong impact only on the American narrative, leaving Europe and the rest of the world almost indifferent (Spier 2019). Astronaut Nicole Stott spoke about her personal experience of the Overview Effect from the International Space Station and her life on board, together with her crew mates (de Paulis 2019, 2021b).

The symposium was followed by a conversation between myself, the neuroscientists and Josephine Bosma, who asked about my background as a contemporary dancer and how that affected the making of *COGITO in Space*. In my answer it emerged that the physical division between oneself and outer space might be a perceptive illusion, as matter at the atomic level is a continuity, the difference between one's body and outer space being an instance of intensity and density of matter: the blood running through my veins as I write is in fact as close to my skin—the body's membrane between interior and exterior space—as the air and materials touching it. My internal organs are thus a continuity with outer space. In *COGITO in Space* the body streams beyond its protective skin into the infinite space beyond it, poetically drifting towards the unknown (de Paulis 2019, 2021b).

The talks session was followed by a meditative lecture-walk in the area surrounding the scientific facilities, the Dwingeldverveld National Park, mostly a flat landscape dotted with heath lands. The walk, guided by planetary scientist Maarten Roos, took the visitors along a straight line going from the radio telescope into the wide-open landscape and back, allowing for the visitors to gaze as far as the horizon, as if viewing the curvature of the Earth. The walk, lasting approximately 1 h, was interspersed by cogitations on the origin of the cosmos, of life on Earth, the existence of possible extraterrestrial life, and was informed by Fred Spier's book *Big History and the Future of Humanity* (Spier 2015).

The line of the walk symbolizes the circularity of time, with the present existing simultaneously as immanent future and immediate past, and with the action of walking expressing this clearly. In the first section of the walk the visitors were symbolically guided towards the wide-open landscape, the future, while the narration took them back into time, into the origins of life on Earth. Vice versa, while walking back towards the radio telescope, the narration took them into the future (de Paulis 2019, 2021b).

The walk, loosely inspired by the 1967 Land Art work *A Line Made by Walking* by Richard Long,[6] aimed at inspiring a sense of physical grounding and belonging to Earth before virtually leaving the planet, as well as creating room for individual existential questioning. The walk was followed by an introduction into the history of radio astronomy and the Dwingeloo radio telescope by astronomer Roy Smits and this led the visitors inside the cabin through a seamless transition between the different events taking place and the different people performing them. While the visitors started entering the cabin and taking their seats, I turned the drive of the radio telescope on, while the participant lying on a gravity chair was being prepared by the neuroscientists with the EEG device and the VR headset. As the people sat still, the radio telescope started tracking the star Betelgeuse and this triggered the rotation of the cabin. Having reached Betelgeuse, the target for the start of the brain activity transmission, the cabin stopped rotating, the curtains lowered and immediately after the video in virtual reality started playing (de Paulis 2019, 2021b).

[6] https://www.tate.org.uk/art/artworks/long-a-line-made-by-walking-ar00142 (Accessed 28 November 2020).

Fig. 9.4 The artist and radio operator transmitting brain waves into space, 5 November 2018. Photo: Sandro Bocci, 2018 (de Paulis 2019, 2021b)

Fig. 9.5 Live brain activity transmission into space. Dwingeloo radio telescope, 5 November 2018. Photo: Sandro Bocci, 2018 (de Paulis 2019, 2021a, b)

The brain activity of the participant was captured and transmitted simultaneously into space over the course of the video, with the antenna of the radio telescope pointing still toward the sky. The total transmission through the sky, starting from Betelgeuse, lasted 9 min, the exact length of the film in virtual reality (Fig. 9.4).

This action allowed for the brain activity to be spread across a large portion of the sky with the Earth's rotation. The brain activity recording and the radio transmission happening simultaneously were visualized and projected onto video inside the cabin in real time. The sound produced by the brain activity created hypnotic and repetitive patterns that generated a meditative mood inside the cabin: people experiencing the event seemed to draw their attention inwards and joined the participants in their intimate journey into outer space with the mind (Fig. 9.5). The entire performance lasted approximately 45 min and was repeated twice during the day. Following the event on 5 November 2018, participants contacted me reporting to have lived a special day and that the experience will remain in their memory as a unique moment. Their feedback suggested that my intention to convey the project as a subjective experience, as well as a personal sequence of neuro-images, was brought to reality (de Paulis 2019, 2021b).

The performance intentionally used an objective and abstract language, approximating the event to a scientific presentation, my intention being to allow for the experience to find its niche in the individual memory according to one's inner understanding, regardless of the specialist aesthetic appreciation or knowledge by the participant and the observer (de Paulis 2019, 2021b). The work in progress of the project and the event at the Dwingeloo radio telescope have been documented as part of a reportage filmed by Sandro Bocci that is touring internationally at the time of writing.[7]

6 Conclusions

COGITO in Space is a multi-layered art project, informed by diverse fields of study and sources of inspiration, whose purpose is to generate questions and meanings that can resonate and mirror quite differently from person to person. The project is intentionally left to be dualistic, divisive and open-ended and can be enjoyed by people of all ages and cultures despite its complexity. The written record of individual experiences that are gathered during the project's ongoing presentations could provide some informative material over time on the subjective interpretation of the Earth's visualisation from space (de Paulis 2019, 2021b).

Appendix by Frank White

Three aspects of *COGITO* drew me to the project:

First, Daniela told me that my work on the Overview Effect (White 2014) had influenced her shaping of the project in a significant way. I have made it a point to support anyone who has been inspired by the Overview Effect, and this was clearly the case with *COGITO*.

[7] A recording of the performance in November 2014 can be viewed here: https://vimeo.com/133392862. The reportage presenting the performance at the Dwingeloo radio telescope on 5 November 2018 can be viewed here: https://vimeo.com/352011408.

The second reason was that Daniela proposed to measure brain waves in response to seeing views of the Earth from orbit or the Moon. Almost all of my research on this topic has been based on self-reporting by astronauts, after the fact. While I have long been convinced that something is happening in the human brain while the person is having the Overview experience, we have little or no empirical evidence of this hypothesis.

Measuring brain waves and interpreting them is far beyond my capabilities, so I was delighted to hear that Daniela had recruited a talented team of neuroscientists who knew how to do just that.

The *COGITO* project included within it the notion of translating this brain activity into signals that could be sent outward into the cosmos. This part of the endeavour appealed to me less, but seemed like an interesting effort, nevertheless. (As I learned more about this aspect, it has intrigued me more.)

Daniela presented her work at the Overview Effect Symposium that took place in 2017 at the Columbus Earth Center in Kerkrade, the Netherlands, and I got a taste of what it was all about. However, her presentation occurred at the end of the day, and I was not able to focus on it for a variety of reasons. I truly came to understand the promise of the project at the *COGITO* event that was held at the Dwingeloo radio telescope facility in November of 2018.

This event brought together a wide range of people, including the neuroscientists, filmmakers, and technicians who had helped to realize Daniela's dream of translating brain waves into signals that could be seen, heard, and transmitted into the universe. During one of the meals that took place over the course of the meeting, a participant who had done the experiment with his son, said something to the effect of, "We are somewhere near the orbit of Pluto now." I realized he was speaking of their brain waves, but he personalized it as if they were themselves "out there" in the solar system. That brief interchange helped me to understand that this component of the project was creating a connection with the universe as well as a new perception of the Earth.

In addition to making a presentation about the Overview Effect, I had the opportunity to talk with many fascinating contributors to the project. Among them was Fred Spier, a well-known pioneer in the field of Big History. Fred gave a great talk about how Apollo 8 and the Earthrise photo had affected (or had not affected) people worldwide (see Spier 2019). In his own case, it had a dramatic impact and set him on a new course in life.

Following our presentations, Daniela recorded a conversation among the three of us, which is now available online.[8]

After a very enjoyable nature walk in the vicinity of the radio telescope, many of the attendees gathered for a demonstration of the technology Daniela and her colleagues had been developing. Seated in a control room nestled close to the telescope itself, we watched Marjolijn Dijkman, an artist friend of Daniela's, don

[8]The conversation between Daniela de Paulis, Frank White and Fred Spier can be viewed here: https://vimeo.com/321484428.

the virtual reality headset, relax into her chair, and begin experiencing the video that had been especially prepared for the experiment.

We were able to see and hear the translation of her brain activity on an instrument that was managed by one of the technicians. At a certain point, there was a marked shift in the tone and imagery, which was surprising, and it happened at the moment that Marjolijn encountered the image of the Earth in the presentation. It was quite a change and seemed to indicate that the Earth pictures had had a measurable impact on her brain, but we could not be sure of exactly what had taken place.

I spoke with Marjolijn after the demonstration and arranged to interview her after I returned to the United States. She readily agreed and we had a very good conversation a few weeks later. She reaffirmed that the change in brain wave activity had coincided with the views of the Earth as seen from orbit, but she expressed a caveat. She noted that all of the preceding imagery had been quite abstract, while the view of our home planet was the first concrete and recognizable picture in the presentation. For this reason, it was difficult to determine whether it was the appearance of the Earth itself or simply that of a recognizable object that triggered a change.[9]

The next day, Daniela and I rode to the airport with Stephen Whitmarsh and Guillaume Dumas, two of the neuroscientists who had collaborated on *COGITO*. We discussed at length how we might add a new element to the project, focusing on a larger sample size of people, and providing them with a similar experience to that of Marjolijn.

Creating such a database would add valuable knowledge to our understanding of the Overview Effect as a phenomenon. As we discussed on the drive to the airport, the project could also control for different variables, such as still pictures vs. video, or views from Earth orbit or the Moon.

We agreed that organizing an effort of this magnitude would require funding, which we have yet to acquire. However, I hope that an organization or individual will eventually see the value of such research and support will eventually be forthcoming.

If so, it would be a wonderful tribute to the dedication Daniela has shown to *COGITO in Space*!

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[9]Mariolijn Dijkman wrote: “This was the first time I ever really experienced VR. I had quite a strong reaction to the Earth imagery in the VR film, but I’m not sure how much of it occurred because it was an image of the Earth or because it was very different from the other imagery part of the film which was more abstract and aesthetic which made it a bit harder to relate to. The perspective on the Earth from outer space made for sure quite an impact through the enhanced experience of VR.”

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Chapter 10
The Overview Effect and Well-Being

Annahita Nezami, Lisa Marie Persaud, and Frank White

Abstract The Overview Effect (OE), a term coined by Frank White (The Overview Effect: Space Exploration and Human Evolution. Houghton-Mifflin Company, Boston, 1987; The Overview Effect. American Institute of Aeronautics and Astronautics, Reston, 2014), describes a psychological state that can emerge when witnessing remarkable natural landscapes from an expansive vantage point, and Earthgazing from orbit or the Moon is the epitome of this experience (Yaden et al. Psychol Conscious 3: 1–11, 2016). White (The Overview Effect. American Institute of Aeronautics and Astronautics, Reston, 2014) defines the OE as a cognitive shift in worldview experienced by astronauts when they view the Earth from space and in space. He further catalogues the experience as seeing the Earth as a tiny, fragile ball of life, eliciting a profound feeling of awe, an understanding of the interconnection of all life, and a renewed sense of responsibility for taking care of the planet. The OE can be considered an atypical method of engaging with the natural environment, yet it is one that offers demonstrable and perhaps enhanced benefits in terms of promoting self-transcendence, eudaimonic well-being and feelings of connectedness with nature. This chapter presents the case for self-transcendent interventions in mental health, inclusive of psychedelic-assisted psychotherapy, nature-based interventions, and the OE. It concludes with an analysis of how the OE can be understood, studied, and applied within the therapeutic context to promote individual, societal and planetary well-being.

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1 Introduction

The Overview Effect (OE), considered as a self-transcendent experience, can emerge when witnessing remarkable natural landscapes from an expansive vantage point, and Earthgazing from orbit or the Moon is considered the epitome of this experience (White 2014; Yaden et al. 2016). The term was coined by Frank White (White 1987, 2014) and documented in his book of the same title. White (2014) defines the OE as a cognitive shift in worldview experienced by astronauts when they view the Earth from space and in space (Fig. 10.1). He further catalogues the experience as seeing the Earth as a tiny, fragile ball of life, eliciting a profound feeling of awe, an understanding of the interconnection of all life, and a renewed sense of responsibility for taking care of the planet.

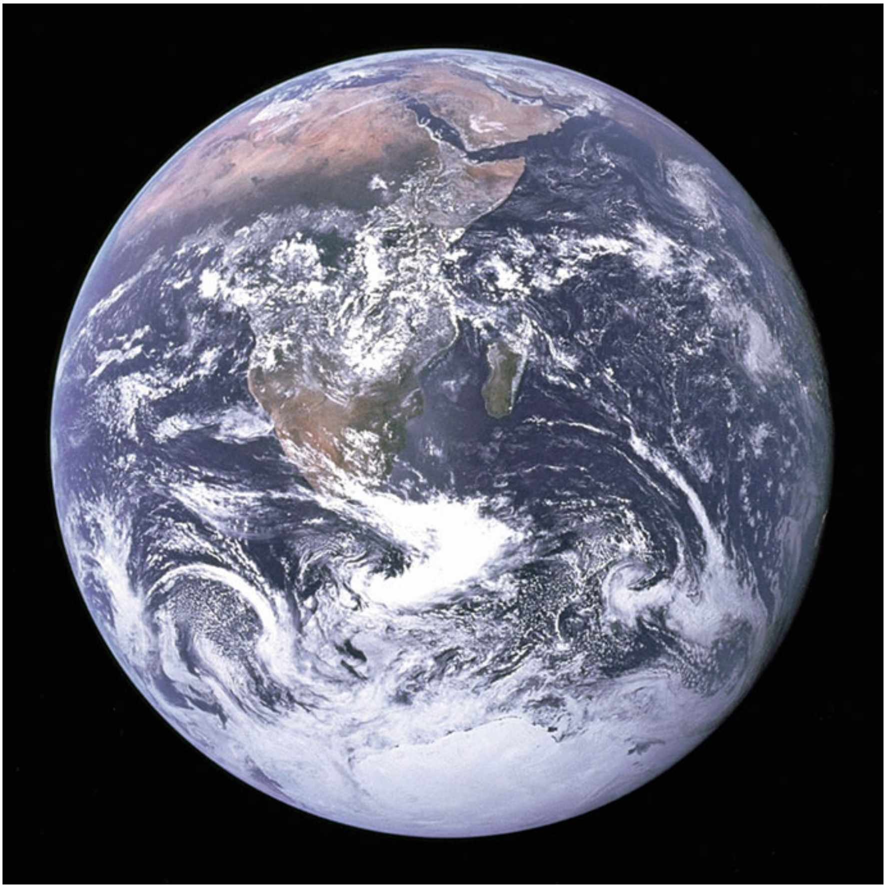

Fig. 10.1 The 'Blue Marble' image of Earth taken by the crew of Apollo 17 in December 1972, from a distance of about 29,000 km (NASA)

In this chapter, the OE is categorised as a self-transcendent experience that can result from seeing planet Earth from orbit or on a lunar mission. This allows for a distinction between the OE and other self-transcendent states and what spacefarers observe whilst they are Earthgazing (the sensory) from the subjective qualities of the OE (the emotive, noetic, and numinous).

Fewer than 600 human beings, most of whom have been professional astronauts and cosmonauts, have had the opportunity to observe planet Earth from this unique vantage point. This makes the OE largely inaccessible to researchers. In recent times, virtual reality (VR) has been utilised in a bid to simulate the OE, granting access to researchers interested in understanding this relatively unknown phenomenon (Nezami 2017; Stepanova et al. 2019; Yaden et al. 2016).

This chapter considers the benefits and applications of self-transcendent interventions in mental health, inclusive of psychedelics, nature-based interventions, VR, and the OE, and concludes with a summary of Overview Effect Virtual Reality (VROE)-assisted psychotherapy.

2 Mental Health

The United Nations (2019) estimates that over the next 30 years, the population of Earth will reach approximately ten billion, placing further emphasis on addressing global challenges such as food and water shortages, extinction of endangered species, sourcing sustainable energy, climate change, extremism, and the rise of mental illness. These global challenges have become even more pertinent today as we live through the Covid-19 pandemic. Our disregard for the symbiosis of natural life, evidenced by our incessant exploitation of nature, has contributed to the arrival of the Covid-19 pandemic, and reminds us of the consequences of our shortsighted acts on our way of life. Covid-19 has also unveiled the limitations of existing politics, policies, and infrastructures that fail to adequately address and meet the needs of our ever-changing world. It has marked the beginning of unprecedented times; abruptly halted all of our lives and forced us to engage in candid discussions about the world we want to inhabit, and the world we want future generations to inherit (United Nations 2019, 2020a, b).

There has been increasing acknowledgement of the important role mental health plays in achieving global development goals, as illustrated by the inclusion of mental health in the Sustainable Development Goals (2020). The rise in mental illness has led to an increase in demand for mental health services, and with it revealed some of the limitations of conventional psychotherapeutic and pharmacological treatments, which are, at best, only partially effective (Penn and Tracy 2012; Thornicroft et al. 2018). The aftermath of the Covid-19 pandemic will result in another sudden rise in the demand for psychological interventions, which are already overstretched (United Nations 2020a, b). In England, the Centre for Mental Health estimates that up to ten million people, almost a fifth of the population, will require mental health support as a direct consequence of Covid-19; children and young people under the age of

18, those with pre-existing mental health issues and from underprivileged backgrounds will be disproportionately affected (Allwood and Bell 2020; Unicef 2020; United Nations 2020a, b).

It is evident that some of our greatest mental health challenges (depression, anxiety, trauma, stress, etc.), referred to by Loizzo (2000, p. 34) as "diseases of civilization," stem in part, from the growing dysfunction in our societal systems. Cartesian Dualism is a philosophy that construes existence from a mechanistic, boundaried and individualistic perspective as opposed to a connected, relational or interdependent one, and its dominance has contributed to engineering a fragmented and disconnected world, incubating a form of capitalism where human beings and nature are seen as mere commodities, and their worth assessed on capital gains. At the same time, alternative societal structures, such as socialism, have not been able to provide adequate solutions to the global challenges that confront us all today. Humankind has outgrown the existing systems and it is evident that an evolution is necessary and inevitable (Bohm 1980; Levesque 2016; Milton 2016; Wilber 2001).

Two overarching perspectives that direct psychological research on well-being are hedonia and eudaimonia. A person with a stronger hedonic orientation is motivated by "feeling good" and tends to pursue instant pleasure (physical and emotional) and high levels of positive emotions, while avoiding pain and discomfort. A person with a stronger eudaimonic orientation is motivated by the pursuit of "the good life" and is more focused on flourishing in terms of character strengths and virtues. Hedonic pursuits are associated with greater immediate well-being, while eudaimonic pursuits are associated with sustainable and enduring well-being. Well-being interventions that utilize the hedonic perspective aim to decrease negative emotions and increase positive emotions, whilst eudaimonic interventions achieve well-being by encouraging meaning, authenticity, excellence, and growth. The individual and social benefits of eudaimonic well-being are widely recognised by psychologists, and the field of Positive Psychology in particular, has devoted itself to understanding it in more detail (Huta 2018; Passmore and Howell 2014b).

Hedonistic values (e.g., pleasure, reward, wealth, image and status) transpire into bourgeoning consumption and insatiable desires. Eudaimonic values concerning the well-being of others, as well as one's own personal and spiritual growth are in conflict with hedonistic values and in this way eudaimonia can be considered as the antithesis of hedonia. Yet, it is hedonia that dominates the world today, seeping through to influence all aspects of our lives. Some argue that hedonism has contributed to person-to-person degradation, ravaged the Earth of her resources, and to a degree, negated efforts to optimize mental health and well-being (Bohm 1980; Levesque 2016; Milton 2016). Thomas Moore (1994) forewarned that a culture that places excessive emphasis on individualism, ruthless competition and separation would slowly diminish core values associated with nature and human-connectedness, and intensify feelings of emptiness and meaninglessness within people.

David Bohm (1980), an eminent quantum theorist, presented the theory of implicit and explicit order, and ideas on wholism. Wholism attempts to understand life and the universe in terms of their interdependence, interconnectedness, and unfolding and enfolding qualities. It provides a broader framework for our relationship with nature and life. Bohm (1980) and other notable academics (Adler 1964; Milton 2016; Naess 1993; Wilson 1984) suggest that unless we change our relationship with the Earth and the cosmos, and re-define ourselves, solutions to human, environmental, and global problems will suffer from a myopic vision.

The dysfunction inherent in the system that Bohm and others forewarned us about is becoming more visible within our immediate environments, and sets the impetus for an evolution in the way we approach mental health and well-being. Self-transcendence taps into Eudaimonic wellbeing because it is a state that can encourage meaning, authenticity, and growth. To bridge the gap between supply and demand, and improve mental health services, trials are underway to explore alternative and once considered controversial interventions that show promise in eliciting self-transcendence and improving eudaimonic well-being (Yaden et al. 2017).

3 Self-Transcendence

Self-transcendence is an umbrella term that describes a cluster of experiences which are transient in nature and can vary in intensity, marked by decreased self-salience and increased connection to others and the environment. There are barriers to researching self-transcendence because it lies on a developmental continuum that is diverse in levels and features. Despite the challenges surrounding definition it is a state that is regarded as therapeutically potent because it can induce a cocktail of emotions, strengthen feelings of connectedness, shift attitudes, restructure world-views, and motivate positive behavioural change (Yaden et al. 2017).

Examples of experiences and practices that can induce various transcendent-states include regular participation in extreme sports (Boudreau et al. 2020), meditation (Van Lente and Hogan 2020), holotropic breathwork (Nardini-Bubols et al. 2019), near-death experiences (NDE) (Cassol et al. 2018; Royse and Badger 2020), Yoga (Chapple 2019; Park et al. 2020), psychedelics (Carhart-Harris et al. 2018; Griffiths et al. 2008), and engagement with beautiful and vast natural scenes, such as experiencing Earth from orbit or the Moon (Kanas 2020; Nezami 2017; White 2014; Yaden et al. 2016).

Although it is undeniable that self-transcendent experiences can produce psychological growth and are largely beneficial, it is nevertheless a powerful state that warrants careful consideration, particularly when applied within mental health settings (Yaden et al. 2017). Emil Kraepelin (1856–1926), a psychiatrist best known for his contributions to differential diagnosis and the birth of the International Classification of Diseases (ICD), considered self-transcendence as an antagonizer of psychotic states (Parnas 2011, p. 1124). Sigmund Freud (1930, p. 4), the highly influential psychoanalyst, also highlighted the negative aspects of self-transcendence, which he referred to as the “oceanic feeling.” Freud considered self-transcendence as a form of regression to a primitive state, a pathological and destructive state of mind. In contemporary psychology, these ideas are gradually becoming obsolete as we further develop our understanding and knowledge surrounding the nature of and differences between self-transcendence, psychosis and schizophrenia. Nevertheless, they serve as a reminder of some of the potential risks relating to self-transcendent states.

Abraham Maslow (1943), a world-renowned humanistic psychologist, proposed the Hierarchy of Needs, which offers a more balanced perspective on self-transcendence and its modulating factors. Maslow believed that our behaviour and actions are motivated by certain needs and categorised them within a five-tier model (e.g., tier 1: physiological, tier 2: safety, tier 3: love and belonging, tier 4: esteem, and tier 5: self-actualization and self-transcendence. According to Maslow, climbing the hierarchy prematurely, without sufficiently meeting lower-level needs, can ultimately lead to mental distress.

Viktor Frankl was a neurologist, psychiatrist, and the author of the seminal book, *Man's Search for Meaning* (1959), which describes his experience within the concentration camps of World War II. Frankl recounted the suffering he endured and witnessed, and how he was able to find some solace in his ability to transcend the self. Enlightened by his experiences within the concentration camps, Frankl (1967) later developed Logotherapy, a method of therapy built on the premise that the primary motivational force within a person is the drive to discover meaning in life. Frankl's experience is reminiscent of post-traumatic growth, a psychological theory that describes positive psychological shifts or self-transformation that can occur as a result of adversity or trauma (Tedeschi et al. 2017; Tedeschi and Calhoun 1995). Both theories suggest that self-transcendence can play a protective role, particularly for those whose safety needs have not been satisfied, and are in sharp contrast to the ideas of Kraepelin, Freud, and Maslow.

The aforementioned psychologists draw our attention to the plurality of views that exist and highlight that self-transcendence can involve both negative and positive valences, is a state that is modulated by individual differences (e.g., personality, age, spiritual affiliation, emotional resilience, and trauma), and the importance of mitigating risk by considering set, setting and implementing robust screening measures.

Self-transcendent interventions offer an alternative treatment path in mental health based on psychological growth and transcendence as opposed to existing psychopharmacological treatment, which can at times work to dampen desires, and suppress emotions. In recent times, self-transcendent interventions have shown potential in clinical trials in relieving some aspects of mental distress (Nichols 2016; Williams and Harvey 2001). Some of the subjective qualities of the OE (self-transcendence, awe, and nature-connectedness) are analogous to features of self-transcendent interventions such as psychedelic-assisted psychotherapy and nature-based interventions (Kettner et al. 2019; Van Lente and Hogan 2020; Williams and Harvey 2001). In the following segments, a summary of research on the psychological and therapeutic benefits of notable self-transcendent mental health interventions, inclusive of the OE, are presented.

3.1 Self-Transcendent Interventions: Psychedelic-Assisted Psychotherapy

In this chapter the term psychedelics is used broadly to refer to hallucinogens (e.g., lysergic acid diethylamide—LSD), dissociatives (e.g., ketamine), and entactogens (e.g., 3,4-methylenedioxymethamphetamine—MDMA). All are related agents, but have the potential to produce a variety of changes in consciousness (Nichols 2016).

Following the advent of greater pharmaceutical manufacturing and clinical trials, the mid-twentieth century saw the emergence of psychedelics within the scientific community and medical world. While early research with psychedelics demonstrated promising results in the treatment of a myriad of mental health issues (Greer and Tolbert 1998; Grof 1973; Hoffer 1967; Pahnke et al. 1970), methodological flaws, concerns over mass production, and recreational use resulted in a Schedule 1 order in 1985 prohibiting personal and scientific use (Nichols 2016).

In the early 1990s, with the advent of new technologies and brain imaging tools, and several robust, and well-designed studies (mainly with animal subjects), legal restrictions were eased and there was a revival of scientific research into the therapeutic benefits of psychedelics (Emerson et al. 2014; Nichols 2016; Strassman 1991).

The Vollenweider et al. (1998) trials are amongst the most notable, discovering that psilocybin acted upon the brain's 5-HT_{2A} serotonin receptor allowing for depersonalization, euphoria, and visual hallucinations; and the study illuminated treatment possibilities (e.g., risperidone and ketanserin) for acute psychosis. In a 14-month follow-up study examining the mystical experiences induced by psilocybin, Griffiths et al. (2008) found that 67% of participants felt that it was among the top five most important experiences of their lives, while 64% of participants reported greater well-being; and no participants reported a decrease in wellness.

Raichle et al. (2001) utilized positron-emission tomography (PET) and functional magnetic resonance imaging (fMRI) and found that in the absence of goal-oriented tasks, the brain's default mode network (DMN) was revealed; tonically active brain areas restorative in nature were then implicated within the posterior cingulate cortex, precuneus, and medial prefrontal cortex. Robin Carhart-Harris, and his colleagues at Imperial College London, utilized fMRI and found that psilocybin (Roseman et al. 2014) and LSD (Carhart-Harris et al. 2016) acted to interrupt the DMN and could be useful as an adjunct to psychotherapy (Carhart-Harris et al. 2012). More recent fMRI studies corroborate prior findings of global connectivity within the brain, greater openness to experience, and ego dissolution (Carhart-Harris et al. 2014, 2015, 2016, 2018).

There is growing evidence supporting the benefits of utilizing MDMA for the treatment of alcoholism and Post-Traumatic Stress Disorder (Marseille et al. 2020; Mithoefer et al. 2019; Sessa et al. 2019), and psilocybin for the treatment of psychological distress associated with terminal illness (Gasser et al. 2014; Grob et al. 2011; Ross et al. 2016) and symptoms of depression and anxiety (Doblin et al. 2019; Griffiths et al. 2018; Goldberg et al. 2020; Lyons and Carhart-Harris 2018).

More recently, Ketamine has been effectively utilized to treat symptoms of depression (Andrade 2019). Kettner et al. (2019) presented evidence for a context- and state-dependent causal effect of psychedelic use on nature relatedness and suggests this bears relevance for psychedelic treatment models in mental health and planetary health.

Psychedelic-assisted therapy offers an alternative treatment path in mental health; however, battles have ensued over ownership and capitalization, and a degree of uncertainty remains surrounding the risk posed to vulnerable groups, all of which continue to impede efforts to introduce psychedelics as a conventional psychiatric treatment. One way to mitigate risk and overcome some of the challenges involved in widening the scope of psychedelic-assisted therapy, is to create a range of evidence-based self-transcendent therapeutic interventions that do not rely solely on psychoactives, and vary in their level of intensity. In this way, we can offer self-transcendent interventions that are more appropriate, effective, and accessible. Therefore, the debate should centre on how we can change the landscape of mental health treatment to allow for the inclusion of a plethora of self-transcendent interventions, varying in levels of intensity, that target different symptoms and can help expand our conscious experience and worldview.

Transcendent episodes have been closely associated with nature. In the next segment, we explore the positive psychological effects of engaging with natural environments, and make the case for nature-based self-transcendent interventions.

3.2 *Self-Transcendent Interventions: Nature*

In *Biophilia* (1984), the American biologist E.O. Wilson states that human beings attach meaning to, and benefit greatly from, the Earth because they share in its biology. More recently, Howell et al. (2011) suggest that our innate biophilic tendencies can be cultivated through exposure and engagement with specific natural environments. Their field studies suggest that an authentic encounter with nature is fundamental to our well-being and flourishing, and to diminishing existential neuroses.

Arne Naess (1988), the eminent Norwegian philosopher and one of the founding fathers of ecosophy, made great contributions to the global awareness of environmental matters, placed emphasis on elevating consciousness, and advocated for the shedding of the inferior, underdeveloped egoic self, in favour of the holistic, enlightened, ecological self. In *Beautiful Action. Its Function In the Ecological Crisis* (Naess 1993), he cites Kant and Spinoza in his exploration of knowledge versus understanding, and states that the latter demands a new lens of reasoning. According to Naess (1993), beautiful acts within the ecological context that embrace diversity, foster readiness, and engage the natural environment diminish unsustainable practices and global crises. Naess points to the role of awe and wonder in magnifying the intrinsic value of the human-nature relationship. Independently of

Naess, ecosophy enjoyed a second founding father, French psychiatrist Felix Guattari, who emphasized three ecologies: the mental, the social, and the environmental. Guattari sought to empower and embraced anti-capitalist sentiments, and like Naess, he called for a radical shift in cognition and behaviour (Levesque 2016).

The influential triad, Wilson, Naess and Guattari, contributed significantly to the emerging field of ecopsychology, which aims to understand diverse issues, such as climate change, the development of sustainable behaviour, the psychological impact of the natural world, the deleterious effects of our separation from nature, and the symbiotic relationship between humankind and the planet. Central to ecopsychology is the transpersonal and decentralized self, which is essential to the goal of authentic, sustainable, and coherent relations with nature, and the principle that our connection to the natural world is innate (Higley and Milton 2008; Milton 2016; Wilson 1984).

Two theories in ecopsychology that attempt to explain the human-nature relationship by uncovering the processes that induce feelings of connectedness, and the enduring psychological effects, are attention restoration theory (ART) (Kaplan and Kaplan 1989) and stress recovery theory (SRT) (Ulrich 1983). ART examines the cognitive effects of the human-nature relationship, i.e., how the individual interacts and engages with the natural environment, and SRT examines the emotional response, or impact of the human-nature relationship, i.e., what does the human being feel about the encounter?

ART emphasizes the unique ability of nature to catalyse soft fascination, and reduce or remedy cognitive stress, or attention fatigue. ART categorizes restorative environments as those that induce soft fascination, being away (separating from mental activity and the everyday/stressful environment), extent (degree and level of fascination the stimuli provides), and compatibility between the environment and the person (Kaplan 1995; Kaplan and Kaplan 1989; Korpela and Hartig 1996). Kaplan (1995) argues that soft fascination is a crucial component of restorative experience. Williams and Harvey (2001) suggest that the concept of fascination may assist in accounting for transcendent, as well as restorative experiences in nature; hard fascination can give rise to self-transcendence yet might not be as restorative compared to soft-focused self-transcendent experiences.

According to Ulrich (1983), emotional responses precede cognitive processing of information because of our innate human-nature relationship. In the SRT theory, Ulrich (1983) recognized that restorative environments triggered positive emotions and reduced stress at both the psychological and physical levels. Ulrich (1983) states that we are attracted to natural settings because they provide advanced warning signs that help to keep us safe and alive, and trigger a cascade of stress-reducing psychophysical responses that promote well-being.

Numerous studies support ART and SRT propositions and have demonstrated the positive effects of natural restorative environments on remedying mental fatigue, improving focused attention and long-term memory, and stimulating focus (Berman et al. 2008; Berto 2005; Gonzalez et al. 2010; Hartig and Staats 2006; Kaplan 1995; Pilotti et al. 2015; Van den Berg et al. 2003), improving working memory and self-regulation (Kaplan and Berman 2010) and inducing relaxation and reflection (Herzog et al. 1997; Li et al. 2016; Ochiai et al. 2015). White et al. (2018) refers to bodies of water and vegetation as “blue” and “green” structures respectively, and notes their effect on heart rate reduction and stress; he suggests that “green” and “blue” structures may activate psychoendocrine mechanisms (e.g., the hypothalamic pituitary axis regulation of cortisol) that affects the brain and the body. Exposure to nature may also reduce rumination, influence meditative practices, improve immune system functioning, and influence pro-environmental behaviour (i.e., conscious actions that reduce negative impact upon the environment) (Martin et al. 2020; White et al. 2018). Mackay and Schmitt (2019) also found that nature-relatedness influences planetary protection. In their field studies, Passmore and colleagues found that a meaningful connection to nature can increase eudaimonic well-being, and noted a weaker association between hedonistic well-being and nature connectedness (Capaldi et al. 2015; Howell et al. 2011; Passmore and Howell 2014a, b). The WHO, in addition to numerous international research studies, concluded that exposure to natural settings decrease mortality, improve birth outcomes, and are associated with positive outcomes for mental health and overall well-being (White et al. 2018).

Natural scenes are also considered “prototypical awe elicitors” (Abrahamson 2014; Shiota et al. 2007, p. 951). Keltner and Haidt (2003) suggest that the awe state involves two cognitive appraisals: (1) the perception of vastness and, (2) the need to accommodate this vastness into existing mental schemas. More recently, Yaden et al. (2019) drew our attention to the fact that the vastness can be either perceptual (e.g., seeing the Grand Canyon), or conceptual (e.g., contemplating eternity), and that awe is an emotion that can carry both, positive and negative valences (e.g., reverence, admiration, surprise, wonder, dread and fear).

According to Jake Abrahamson (2014), awe is elicited from nature about 75% of the time and directs concern to the world around us. It seems that extraordinary (Joye and Bolderdijk 2014), and everyday natural sights and sounds (Forsythe and Sheehy 2011; Keltner and Haidt 2003; Richards 2001; Shiota et al. 2007; Terhaar 2009), as well as direct and passive exposure to nature, can elicit varying awe responses (Joye and Bolderdijk 2014; Shiota et al. 2007).

Research exploring cognition also demonstrates that awe is positively correlated with psychological benefits and facilitates complex cognitive processes (Griskevicius et al. 2010; Keltner and Haidt 2003; McPhetres 2019; Prade and Saroglou 2016; Sung and Yih 2016), the expansion of perception of time (Rudd et al. 2012), encourages eudaimonic well-being (Krause and Hayward 2015; Martin et al. 2020), influences prosocial behaviours (Guan et al. 2019; Piff et al. 2015), and decreases aggressive attitudes (Yang et al. 2016). Additionally, awe can temporarily increase spiritual-type beliefs (Bethelmy and Corraliza 2019; Van Cappellen and Saroglou 2012). Research also suggests that awe states can have a positive impact on physical health; for example, one study found that awe was a predictor of lower levels of pro-inflammatory cytokines (inflammation) (Stellar et al. 2015).

Extant research demonstrates nature’s therapeutic potential, in particular its capacity to reduce cognitive and emotional stress, and promote eudaimonic well-being. Nature is also recognised as a “prototypical awe elicitor” (Shiota et al. 2007, p. 951), an emotion that can re-orientate our values, and expand our sense of self (Martin et al. 2020; Piff et al. 2015). The evidence also suggests that extraordinary natural scenes are often more impactful in provoking positive psychological change compared to everyday natural environments (Kamitsis and Francis 2013).

Earthgazing from orbit can be considered an extraordinary natural scene that offers an atypical way of engaging with nature. Although Earthgazing is an activity that is largely inaccessible at this time, it can lead to OE self-transcendent states, and is therefore comparable to both psychedelics and every-day nature-based interventions in terms of potential impact on well-being (Higley and Milton 2008; Kettner et al. 2019; Williams and Harvey 2001; Weibel 2020). What follows is a summary of the research on the salutogenic effects of engaging with one of the most extraordinary natural environments, namely seeing planet Earth from orbit or lunar landings.

3.3 *Self-Transcendent Interventions: The Overview Effect*

The view of Earth from orbit or the Moon exposes space explorers to an extraordinary natural setting. Earthgazing describes the action of observing (i.e., what you see, where your attention is held, etc.); examples include being drawn to points of interest, observing that human-made borders are not visible, and seeing dynamic colours and the vastness of the universe. The OE describes the inner transcendent state that arises as a result of the Earthgazing experience. While research on Earthgazing and the OE is still in its infancy, preliminary studies and space veteran self-reports indicate Earthgazing, and other aspects of spaceflight, can lead to positive psychological change and promote well-being (Vakoch 2013). Accordingly, the following segment summarizes research on the salutogenic effects of spaceflight, paying particular attention to Earthgazing and the OE.

Astronauts on board the International Space Station (ISS) report that Earthgazing is a valuable and enjoyable activity that helps them to adjust to the physical, environmental and behavioural conditions of life beyond Earth. Astronaut accounts also relay the obvious beauty of seeing planet Earth. Yet it is increasingly becoming more apparent that something deeper and more intense occurs as a result of experiencing planet Earth from a distant vantage point (Nezami 2017; Stuster 2010; Vakoch 2013; White 2014).

Gallagher and colleagues conducted two influential experimental interdisciplinary studies (neuroscience, psychology, and phenomenology) on the experience of spaceflight (Gallagher et al. 2015). In one study, 45 astronaut texts (17 in-flight journals and 34 postflight interviews and reflections) were thematically analysed. In accordance with other findings (Nezami 2017; White 2014; Yaden et al. 2016), the study found that feelings of awe and wonder were salient characteristics of the spaceflight experience.

Gallagher et al. (2015) also simulated the spaceflight experience with VR and conducted a neurophenomenological study with students on the experience of awe and wonder. They found differences in theta (associated with sleep and meditative states) and beta (normal waking state) brainwave activity in participants who experienced awe compared to those who did not (Gallagher et al. 2015). Another finding was that awe and wonder were more likely to occur when watching the simulated Earth view instead of the view of space and the stars (Reinerman-Jones et al. 2013); overall, Earthgazing elicited a stronger emotional response compared to the deep space view. These studies provide evidence that supports spaceflight, and the activity of Earthgazing, as an impactful and awe-inducing experience.

Spaceflight may also affect astronauts' values; studies suggest that the experience can enhance spirituality, particularly in relation to the value of universalism (i.e., all forms of nature are equally deserving of protection, appreciation, tolerance, and understanding) (Suedfeld et al. 2010; Suedfeld and Weiszbeck 2004). Astronauts also report noticing heightened appreciation of the Earth's beauty and fragility (Brcic and Della-Rossa 2012; Kanas 2020), a strengthened connection to nature, and a stronger inclination to engage with virtuous and environmental issues (Gallagher et al. 2015; Ihle et al. 2006; Kanas 2020; Weibel 2020). In a recent study, Yaden et al. (2016) found that spaceflight encouraged self-transcendence and influenced astronauts' sense of meaning and purpose.

While spaceflight narratives contain commonalities between cognitive processes (e.g., reflections on the experience and presence of mind) and behaviour (e.g., post-flight social interactions and level of engagement with the environment), a few factors appear to contribute to variance in the extent and type of change, most notably culture and mission duration (Suedfeld et al. 2012). A survey of 20 retired Russian cosmonauts revealed that less time in space (less than a year) was positively correlated with higher levels of personal growth, compared to those who spent a year or more in space, and noted that while perceptions of Earth and space changed, shifts in values pertaining to spirituality, universalism and benevolence were not statistically significant (Suedfeld et al. 2012).

Brcic and Della-Rossa (2012), analysed the interviews and personal journals of seven Canadian astronauts (pre- and post-flight) in order to identify values. Results were compared to values reported by NASA astronauts and Russian Space Agency (RKA) cosmonauts. Common values reported were universalism, sense of achievement and security, and self-direction (or motivation). The study found that universalism amongst Canadian astronauts was significantly higher when compared to astronauts from NASA and RKA. Suedfeld et al. (2012) note that Russian cosmonauts were less likely to discuss universalism and reported no statistically significant changes to this value. Brcic and Della-Rossa (2012) add that Canadian astronauts related even more to universalism post-flight.

The variance between groups could be attributed to mission length, cultural differences, supression of emotions, or with the quantitative methods utilized. Furthermore, research examining the phenomenology of the OE notes that post-flight there is an ongoing process of appraisal and accommodation, which can occur over months, and sometimes years (Nezami 2017; Reinerman-Jones et al. 2013); studies that do not account for this could produce false-positive or false-negative results. This delay is accounted for when comparing descriptions in spaceflight journals, which are often more concrete (or less abstract), with descriptions in later reflections and interviews, which are lengthier and more emotive in tone (Gallagher et al. 2014). Other modulating factors could include diluted responses due to professional affiliation and personality traits. For example, space veterans exhibit higher levels of agreeableness, emotional stability, conscientiousness and openness to experience; and these traits are likely to influence interpretation of the experience. Space veterans are also likely to display higher levels of optimism, which could serve to negate negative expereinces and sustain the long-term psychological benefits of spaceflight (Gallagher et al. 2015). Despite these variances or perhaps because of them, present-day astronauts largely report spaceflight and Earthgazing as a psychologically beneficial experience (Stuster 2010; Vakoch 2013; White 2014).

The aforementioned studies provide some empirical support for the existence of the OE phenomenon, by demonstrating Earthgazing as a valuable and enjoyable activity (Stuster 2010; Vakoch 2013), that can play a significant role in shifting worldviews (Kanas 2020), and values (Brcic and Della-Rossa 2012; Suedfeld et al. 2012), can create a shift in cognition and behaviour (Kanas 2020; Nezami 2017; Reinerman-Jones et al. 2013), and induce awe (Gallagher et al. 2015). Perhaps more importantly, the research highlights the potential of the OE to epitomize the core message at the heart of ecopsychology, that we are interconnected and share in a symbiotic relationship with all life, and this may help to strengthen social cohesion and planetary responsibility (Kanas 2020; Kettner et al. 2019; Nezami 2017; White 2014, 2019). In light of this, we assert that the application of the OE in mental health warrants further inquiry, and present the case for VR as one technology that shows potential in eliciting experiences that mimic OE states.

4 Virtual Reality

As we continue to look for solutions to some of the global challenges we face, increasing attention is being placed on designing technologies that can support efforts to improve our well-being, namely “positive technologies.” Positive technologies are interactive technology-based systems, environments, and mechanisms that have the potential to target psychological and behavioural change, in tandem with existing treatment options. In recent times, positive technologies are promoting health and wellbeing by focusing on experience-driven designs that foster positive emotions (hedonia), meaningful experiences (eudaimonia), and promote healthier interpersonal and intrapersonal relationships (Botella et al. 2012; Capaldi et al. 2015; Kamitsis and Francis 2013; Laubmeier et al. 2004).

A growing body of research demonstrates that VR positive technologies can provide relief for a range of mental health issues, offering a possible solution to combat the global burden of mental illness (Dellazizzo et al. 2020; Formosa et al. 2018). On the commercial side, innovative tech companies, such as Qualcomm and Applied VR, have merged to pioneer the next generation of VR based digital therapeutics and medicine. The recent commercial and scientific interest in the utilization of VR for mental health heralds a revolution in treatment, and denotes the promise and power of positive technologies to revolutionize global systems (i.e., reform of mental, health and social care, as well as penal and education systems).

Within healthcare settings, VR has been used to assist children and adults with autism in improving communication and social interaction, and in mild manifestations of dementia, rehabilitate cognitive functions (Dellazizzo et al. 2020). In the elderly, VR may also help to foster social connection and improve technological literacy (White et al. 2018). In a recent meta-review, VR alongside analgesics, demonstrated efficacy in reducing pain associated with burns in patients undergoing dressing change and physical therapy (Luo et al. 2019). VR has also been utilized in the treatment of cancer to manage pain and anxiety (Botella et al. 2012; Gershon et al. 2004; Windich-Biermeier et al. 2007), and emotional distress during chemotherapy (Schneider et al. 2004, 2011). In addition, VR provides alternative access to extraordinary natural spaces that are positively correlated with greater health, without the risks that accompany movement and transportation for individuals with limited range of motion, or those physically constrained (Riva 1998; White et al. 2018).

The positive effects of VR have also been noted in the treatment of depression and anxiety-related disorders, and their associated comorbidities (Dellazizzo et al. 2020; De Kort et al. 2006; North and North 2017; White et al. 2018). Cognitive Behaviour Therapy (CBT)-assisted VR, has also shown efficacy in the treatment of agoraphobia, and is regarded as a more humane approach to exposure therapy (Castro et al. 2014). In the treatment of post-traumatic stress disorder, VR demonstrates efficacy in the rehabilitation of cognitive and social functions (Park et al. 2019). Researchers also find that VR interventions can help to facilitate mindfulness meditation (Nararro-Haro et al. 2016). De Kort et al. (2006) found that immersion in virtually simulated natural environments lowered stress and had restorative effects. In accordance with these findings, recent meta-analysis of VR applications for mental health suggest that the interventions are efficacious forms of psychological treatment that hold promise, and are complementary to existing treatment options (Freeman et al. 2017; Riva et al. 2016; Turner and Casey 2014).

VR's potential to offer therapeutic, controlled and bespoke self-transcendent experiences are also documented (Quesnel and Riecke 2018; Stepanova et al. 2019; White et al. 2018; Yaden et al. 2018). In a recent study exploring the psychological and physiological responses to a simulated mission to Mars, in which astronauts were isolated for 500 days, VR nature scenes were found to induce positive moods (Botella et al. 2016). Quesnel and Riecke (2018), utilizing VR to explore the Earth from ground and orbit, presented study participants with a variety of "awe-elicitors" based on natural landscapes with great aesthetic beauty. They evaluated awe responses and found that awe could be induced by applying VR and noted a positive correlation between awe and humility (previously established by Gallagher et al. 2015). In another study conducted by Chirico et al. (2017) assessing the effectiveness of 2-D video versus immersive videos, awe-inspiring immersive videos were found to trigger the parasympathetic nervous system more so than other stimuli (consistent with prior research conducted by Shiota et al. 2011), enhanced emotional responses, and contributed to a sense of presence with the natural environment. Other studies exploring the psychophysiological responses to VR immersive landscapes, noted increased parasympathetic responses supported by EEG brainwave data (Gallagher et al. 2015; Shiota et al. 2011).

At Stanford University, Jeremy Bailenson's Virtual Human Interaction Lab (VHIL) studies the social application of virtual experiences and how they can induce positive behavioural change. Stemming from the VHIL, Ahn et al. (2014), observed participants performing pro-environmental behaviour after virtually cutting down a tree, while Rosenberg et al. (2013) found that embodying a fictional superhero character such as Superman increased prosocial behaviour. Yee et al. (2009) found that embodying a taller avatar resulted in arguing more aggressively, and Ahn et al. (2016) observed how embodying a cow improved connection to nature. Yee and Bailenson (2006) discovered that embodying an elderly avatar reduced age stereotypes, and Bourdin et al. (2017) found that having a virtual out-of-body experience reduced the fear of death. These studies denote the power of embodiment in VR experiences and suggest that VR can affect our inclinations and attitudes, at least in the short-term.

Despite VR's promise, tension remains between the ethos of ecopsychology and positive technology. Ecopsychology argues that technology has exacerbated the disconnection between human beings with nature, which inturn has contributed to the rise of mental distress (Milton 2016). However, Lombardo (2006) highlights that we cannot dissociate from technology or stop technological advancement, instead he believes that the answer is for humanity and technology to form "a reciprocity" (p. 399); where humans and technology co-evolve. Lombardo (2006) argues that the future will not only continue to advance technologically but that technology will also promote the evolution of values, and enhance the human mind and spirit.

Nature-like VR therapeutic interventions and applications show promise in treating some symptoms of mental distress and promoting well-being, and can be utilised to restore interest in and connection with the natural environment (White et al. 2018). Yaden et al. (2018) remind us that immersive VR experiences that allow for holistic well-being, and induce feelings of awe, hold immense healing potential.

The following segment summarises descriptors of the OE in more detail, conceptualises the OE within the framework of psychological theories and principles, and presents one potential application of the OE in mental health, namely Virtual Reality Overview Effect (VROE). VROE is a meaning-driven positive technology that seeks to induce awe, self-transcendence, promote eudaimonic well-being, and to remind us of our interdependence and interconnection to one another and all life (Nezami 2017). Harnessing the OE through VR simulations can shed light on the meanings and processes involved in the development of stronger emotional ties with the natural world, and reveal the psychological benefits and social advantages of connecting with nature in this way. In addition, VR simulations of the OE will encourage further empirical inquiry into other therapeutic benefits of this novel experience (Nezami 2017).

5 The Overview Effect

Enlightened by astronaut accounts of Earthgazing from space and in space, Nezami (2017), Quesnel and Riecke (2018), White (2014), and Yaden et al. (2016) have studied the phenomenology of the OE, and collectively their studies suggest that the therapeutic benefits include:

1. Reduction of cognitive and/or emotional distress
2. Pathway to hedonic emotions
3. Pathway to eudaimonic well-being
4. Positive motivator of attitudinal and behavioural change (pro-environmental)
5. Encourages self-transcendence
6. Formation of ecological self (i.e., foster or strengthen a connection to nature)

The final segments in this chapter conclude with descriptors of the OE, a brief summary of the psychological mechanisms of change that are likely to be involved, and presents one potential VR application.

5.1 The Overview and the Effect

The OE can be divided into two categories: (1) The Overview, which involves seeing the planet as a whole system from a distance, and (2) The Effect, which includes the interpretation of the experience, the affective response, and finally the attitudinal and behavioural consequences of the experience. This differentiation between the act of seeing planet Earth from orbit or the Moon, which relies on sensory input (mainly the sense of sight), and the subjective qualities (emotive, noetic, and numinous) is important in advancing our understanding of the phenomenology of the experience.

Sight is the dominant form of sensory input whilst observing Earth from the Space Shuttle, the ISS, space walks, or lunar missions, suggesting that the perceptual processing (e.g., selection, organisation, retention and interpretation) that takes place in the brain and body thereafter relies heavily on visual input. Although some variance exists surrounding spacefarer's interpretation of the OE experience, the descriptors of what they see are extraordinarily similar.

The Overview (sensory input): The following visual aspects are commonly reported by space veterans (Nezami 2017; White 2014).

1. Fragile oasis (i.e., seeing the Earth or human civilisation as fragile)
2. Familiarity (i.e., geographical points of interest)
3. Dark vs. light passes (i.e., dark passes highlight technological ingenuity, Earth is seen amongst the stars; light pass, a lack of human-made architectural borders and boundaries, Earth is seen a lone)
4. Appreciation of sublime beauty
5. Dynamic and transient landscapes
6. Bright and vivid colours

7. Space (i.e., infinite, expansive, cosmic order and disorder)
8. Time lag and time distortion
9. Lack of borders and boundaries on the surface

The Overview (e.g., familiarity, dynamicity, motion, beauty, and fragility) serves as an entryway to further contemplation and the formation of a closer bond with planet Earth. The Effect aspect includes the interpretation of the experience, the affective response, and the observed attitudinal and behavioural consequences of the experience.

The Effect (visceral, noetic, and numinous): The following subjective qualities are commonly reported by space veterans when describing the emotional impact of seeing planet Earth from orbit or Moon landings (Nezami 2017; White 2014; Yaden et al. 2016):

1. Awe and wonder
2. Gratitude, reverence, humility, and compassion
3. Angst, guilt, and remorse regarding expansiveness of outerspace and negative changes on Earth
4. Self-transcendence (at varying levels of intensity)
5. Detachment
6. Belonging
7. Ecological self (i.e., foster or strengthen a connection to nature)
8. Responsibility and motivation to "do something" on returning to Earth, including sharing of the experience

5.2 *Psychological Theories and Principles*

5.2.1 Sublime Beauty

Space veteran accounts convey the appreciation of Earth's sublime beauty (Nezami 2017; Stuster 2010; White 2014; Yaden et al. 2016). The Earth seemingly levitating in deep space, displays fantastic and incongruous imagery that is perpetually in a state of flux and flow. This coming-to-be and passing-away of changes are witnessed from a detached aerial perspective. The depth of Earth's colours, and versatile, and dynamic landscape often require a visual adjustment. The global motion, rhythm and change seem to illuminate the inherent structure and interconnection of all life processes, pointing to a unified planet. Earth, as a biosphere, is imbued with vitality and life; increasingly, we hear astronauts referring to the Earth as a living being (White 2019). All of life is captured in a singularity and is set against the vast backdrop of space, which lends to the planet's sublimity. This engagement with the sublime elicits an array of visceral emotions, and cognitive appraisals.

5.2.2 Cognitive Dissonance

Earth's beauty, set against the vastness of space, lends to contemplation of existence. Earth is revealed as a lone, with some spacefarers refering to it as a fragile oasis. While observers often point out that the planet itself is not necessarily fragile, most do reflect on how isolated Earth appears and on humankind's degradation and subjugation of Earth. From this vantage point, it seems, civilization, which depends on the Earth for its survival, appears fragile. The experience gives rise to conflicting beliefs, and emotions; gratitude, reverence, compassion, and awe often emerge simultaneously alongside feelings of guilt, remorse and existential angst (Nezami 2017; White 2014; Yaden et al. 2016).

Our cognitive system strives for equilibrium, and has to adjust when dissonance is introduced, a state of tension referred to as 'cognitive dissonance' (Festinger 1957). Over time, the unpleasantness of this dissonance motivates the individual to reconcile the discrepancy, resulting in the promotion of one belief over another, or the integration of several belief systems. Reducing the discrepancy abates the uncomfortable feelings associated with experiencing cognitive dissonance. The action-based model of cognitive dissonance proposes that opposing beliefs can create a shift in attitudes that motivates people to commit to a course of action, and to seek congruence between their intent and behaviour (Harmon-Jones et al. 2015).

Cognitive dissonance creates a pathway between stress and satiation, and this tension produces the ideal condition for the emergence of self-transcendence, and can motivate behaviour change. Prior research supports the cognitive dissonance theory of change, for example, one of the reasons we can derive positive meaning from extraordinary and sometimes threatening natural settings is that they can push us beyond our comfort zone, diminish the self, and can elicit conflicting emotions (i.e., awe, wonder, and fear) that can lead to further contemplation and cognitive realignment (Fredrickson and Anderson 1999; Hartig et al. 1991; Kaplan and Kaplan 1989; Talbot and Kaplan 1986; Williams and Harvey 2001). The cognitive dissonance theory provides a plausible theory that accounts for space veterans' shifts in attitudes and increased motivation to act on pro-environmental and humanitarian inclinations after seeing the Earth from space and in space (Kanas 2020; Nezami 2017; Yaden et al. 2016).

5.2.3 Detachment Reinforcing Attachment

The physical detachment from Earth affords a panoptic perspective. From a vantage point of seeing Earth from orbit, a complete journey around the planet takes approximately 90 minutes, allowing the observer to familiarize themselves with its characteristics and features. The Earth reveals itself as a tangible object in space and time, endowed with instrumental value (useful for human needs and survival). Koffka (1935) refers to these values as "demand characters" and Gibson (1979/1986), "affordances"; namely the tangible resources and abstract qualities provided to the animal by its environment. In this instance, the affordances the Earth provides, such as shelter, life, water, food, raw materials and chemicals is expereinced in a tangible way.

The Biophilia Hypothesis (Wilson 1984) proposes that "specific sensory cues can elicit innate affective or emotional meaning" (Blascovich and Mendes 2000, p. 71). Similarly, the Prospect-Refuge theory (Appleton 1975) argues that attractive environmental characteristics offer optimal features for safety, shelter, and subsistence, and are more likely to elicit intense emotional responses and feelings of connectedness (Heerwagen and Orians 1993; Orians and Heerwagen 1992). The Earth offers both 'prospect' and 'refuge' to spacefarers, evoking feelings of protection, belonging and connection. In this way, the Earth is perceived beyond its mere form, usefulness, and affordances. Mental models gain sufficiency through further conceptualization of the planet involving abstract qualities such as safety, order, balance, unity, and harmony and archetypes such as "mother," "deity," and "sentient being," all of which enhance Earth's worthiness and numinousity.

Schroeder (1999) refers to this form of attachment as 'place attachment', and describes it as an emotional bond between a person and a place. Place attachment theory indicates that connections among living beings can occur with different organisms or objects, and to varying degrees of intensity; an individual can feel connected to family, friends, and community, as well as with animals and plants, but also inanimate objects. 'Topophilia', a term coined by Tuan (2013), describes the love that people feel for particular places.

The Tripartite Model outlines three central aspects of place attachment: person, process, and place (Scannell and Gifford 2010). This model suggests that people experience stronger attachments to places that they identify with, or feel proud to be connected with. Feelings of connection to a place relies upon a combination of affective (i.e., common emotions experienced during people-place bonding), cognitive (i.e., knowledge acquisition, and memory and meaning formation), and behavioural responses (i.e., the rituals, nostalgic reflexes, and proximity maintaining behaviours).

Florek (2011) adds that attachments based on meaningful encounters are stronger than attachments based on preference because meaningful attachments involve a synthesis of thoughts, feelings, memories, and interpretations evoked by particular landscapes. Kaiser and Fuhrer (1996) suggest that we form place attachments to environments that fulfil our emotional needs and serve the development and maintenance of our identities. Korpela and Hartig (1996) add that our "favourite places" seem to afford us emotional recovery and restorative experiences.

In conclusion, distance really does make the heart grow fonder, and the process of objectification, identification, and conceptualisation from this detached panoptic perspective strengthen attachments and the impetus to respect, honour, love, and protect the Earth (Nezami 2017). Attachment and relatedness are essential to kin selection, based on this premise, a stronger attachment to planet Earth may also elicit a sense of kinship, extending from family to humanity, nature, and to the Earth as a whole (Trivers 1971).

5.2.4 Existence and Self-Transcendence

Earthgazing and space travel can provide existential encounters that move one towards an engagement with the spiritual and existential dimensions of life.

Temporality is an important part of existence (Van Manen 2016). Our physical everyday existence involves three temporal dimensions: the past, the present, and the future (Heidegger 1962), and the future in particular, serves as a motivating force that helps us to realize possibilities (Van Manen 2016).

The perception of time plays an important role in the unique encounter spacefarers have with the Earth. The panoptic view of the Earth portrays vividly the impact of humanity's past actions (i.e., contribution to environmental damage) on the present, and it provides a palpable sense of our future fate. From this perspective the benefits of pro-environmental behaviour and humanitarian acts (survival of self and kin) are clearly understood and far outweigh the costs (annihilation or extinction). Spacefarers often return to Earth with concrete insights into the existential threat of climate change (Kettner et al. 2019; Nezami 2017; White 2014). Witnessing the thinness of Earth's atmosphere, climate changes, droughts, water pollution, extreme weather, and deforestation leads to further contemplation surrounding the fragility of life on the planet, and the potential extinction of the human species, engendering a form of emotional or existential distress caused by environmental change, referred to as "solastalgia" (Albrecht 2005). Frankl (1959) referred to this encounter of collective annihilation as "finality meanings" and states that it encourages a deeper appreciation of life, and the blessings, meanings, and lessons it provides (Frankl 1959; Yalom 1980).

According to Grof (1985), comprehension of the transpersonal demands an encounter with death. Heidegger (1962) states that the reality of death, and the finitude of time, allows individuals to confront the nature of being. This "being-towards-death," and the uncertainty surrounding it manifests in psychic expressions of anxiety. For Heidegger, death must be grasped, cultivated, anticipated, and endured in order to live an authentic life. Similarly, Gordon (2003) suggests that anxiety is an existential state of being that reminds us of our mortality and impending death, and can help to promote an authentic existence. An authentic existence is differentiated from an inauthentic attitude; the latter is numbing and dilutes the nature of being.

The OE experience is laden with conceptual dichotomies that are juxtaposed alongside one another. For example, simultaneously holding concepts such as security versus risk; safety versus danger; strength versus fragility, detachment versus connection, and significance versus insignificance, can induce intense emotional responses and catalyse potential meanings (Nezami 2017). This juxtaposition and existential meaning-making processes of the OE experience may serve as a precursor for stronger personal and spiritual growth (Laubmeier et al. 2004; Yaden et al. 2016).

This Overview of Earth, observed from the vantage point of space is extraordinary and does not align with existing mental models of the world, and in order to accommodate the new and conflicting information the mind needs to ascribe meaning and draw inferences. It is not uncommon for spacefarers to try to make sense of this experience in a way that imbues their life with purpose and meaning. For example, many astronauts report perceiving the universe as purposive and numinous, and see themselves as part of a larger and emergent system of exquisite complexity (Nezami 2017; White 2014, 2019). Common reactions to death and uncertainty are instinctual, and are followed by the imposition of order to regain control (Gordon 2003). According to Yalom (1980), cosmic meaning invariably refers to a sort of spiritual ordering of the universe and concerns itself with patterns and structure. White (2014) and Nezami (2017) reflect on astronauts' positive conceptual construction of meaning (i.e., connectedness to life, nature, and the cosmos) after experiencing the OE and note how it may help to mitigate and accommodate existential concerns. The OE seems to offer a unique opportunity to contemplate, on a deeper and more meaningful level, Humankinds' place and raison d'être (purpose) in the universe, and imparts reverence for the cosmos and Planet Earth.

In regard to Naess' (1988) 'ecological self', astronaut accounts reveal moments of profound identification with the Earth. Seeing the Earth as a mirror of life and astronauts appear to strengthen their emotional bond to the planet (White 2014; Nezami 2017). Astronauts' recognition of the Earth as part of the self, strengthens their protective instincts towards Earth; transforming an aspiration into a strong impulse to care for the biosphere (Naess 1988; Bragg 1996; Nezami 2017).

Research suggests that positive and meaningful experiences in natural environments do indeed promote ecological and pro-environmental behaviour (Dunlap et al. 2000; Higley and Milton 2008; Hartig et al. 2003; Mayer and Frantz 2004). However, positive feelings towards, and an affinity for nature (nature-connectedness) appears to be a better predictor of pro-environmental behaviour, compared to cognitive beliefs about the environment (Kals et al. 1999). Positive experiences in nature, environmental concerns, pro-environmental attitudes and beliefs, and nature-connectedness all are constituents of the ecological self, which has been shown to promote a sense of meaning and purpose conducive to eudaimonic well-being (Capaldi et al. 2015; Dossey et al. 2008; McCoubrie and Davies 2006).

In accordance with extant research, a common outcome of space travel is the strengthening of pro-environmental attitudes and behaviours. Also, commonly reported, is a stronger sense of nature-connectedness, particularly with the Earth. Additionally, some space veterans experience a strengthening or clarification of existing core values, while others notice a cognitive shift regarding life and existence. Earth-connectedness seems to be a factor that engages astronauts' virtuous dispositions and encourages their involvement in pro-environmental and humanitarian causes postflight (Gallagher et al. 2015; Ihle et al. 2006; Nezami 2017; White 2014; Yaden et al. 2016).

Solidarity and a sense of urgency driven by a self-transcendent purpose seems to be the impetus that continues to drive space veterans toward action post-flight. Spacefarers commonly report participating in proximity-maintaining behaviours often involving participating in planetary causes and activities (Scannell and Gifford 2010; White 2014). These behaviours often serve to procure an emotional tie to the Earth, improve life on the Earth, as well as relieve any discomfort that may arise from nostalgic and reflexive emotions that emerge (Cieraad 2020). Yalom (1980) regards acts of courage and heroism as an attempt to qualify for a better fate. Keynes (1932) adds that the "purposive man" tries to secure a spurious and delusive immortality through his actions, pushing forward in time his interests (p. 370). Both Yalom (1980) and Keynes (1932), view heroic and courageous acts as an attempt to evade disaster and transcend death.

5.2.5 Awe

Awe is a complex emotion often associated with self-transcendence (Gottlieb et al. 2018). Numerous studies report that awe and wonder are common responses to space travel and Earthgazing (Gallagher et al. 2015; Nezami 2017; Reinerman-Jones et al. 2013; Stepanova et al. 2019; White 2014; Yaden et al. 2016). In accordance with the two contemplative aspects of awe detailed by Keltner and Haidt (2003), the perceptual contemplation for space veterans often involves witnessing the planet's sublime beauty, as well as the technological signatures of human civilization; and the conceptual contemplation often involves witnessing the fragility and vitality of our planet and life, and reflecting on the vastness of space and time, as well as the significance of the Earth and human life (Nezami 2017; Yaden et al. 2016).

Stimuli that exude the vastness of space and time, and transcend everyday frames of reference, shift our focus and concerns from inward (self) to outward (natural and cosmic environments and forces). This shift encourages a meaningful engagement with things that lie beyond the self. In essence, awe acts as an emotional primer that encourages self-transcendence i.e., the expansion of views surrounding self, others, and the planet (Algoe and Haidt 2009; Bonner and Friedman 2011; Gallagher et al. 2015; Shiota et al. 2007). In this way, awe in the context of space travel, is a broaden and build type of emotion; it is not just pleasant in the moment to experience, but serves as a driving force that directs attention outward and strengthens the determination to act on associated eudaimonic virtues (environmentalism, humanitarian pursuits, and the development of the transpersonal self) (Fredrickson 2001; Gallagher et al. 2015; Keyes and Annas 2009; Keyes et al. 2002; Richardson et al. 2019; Yaden et al. 2016). Naess (1993) also believed that awe and wonder help magnify the intrinsic value of the human-nature relationship.

Consistent with prior research, feelings of awe can help to diminish the egoic self and strengthen universal and pro-social attitudes (Kaplan 1995; Kaplan and Kaplan 1989; Piff et al. 2015; Yaden et al. 2016). Hartig et al. (2003) adds that moral transformations are associated with emotions such as awe, gratitude, elevation, and admiration and highlights that these emotions are more powerful than others in motivating pro-social behaviours.

5.3 Theorising Findings

In this chapter we categorised the basic constituents of The Overview Effect, namely The Overview and The Effect. In relation to The Overview constituent, the typical visual focal points that space veterans are drawn to whilst observing the Earth were defined. In relation to The Effect constituent, the common outcome derivatives (cognitive appraisals, emotional responses and behavioural consequences) were presented. The broader definition of the OE provides a summary of the markers of the OE experience and in doing so sets clearer parameters for research purposes.

Past research and astronaut accounts indicate that the OE is likely to involve a developmental continuum varying in levels of intensity, adorned by both ‘positive’ and ‘negative’ valences. For example, emotions such as reverence, compassion, awe, wonder, and gratitude can simultaneously arise alongside angst, guilt and remorse (Nezami 2017; White 2014). The latter emotions seem to arise when confronted with the stark contrast between the beautiful view of the planet from orbit and acknowledging the suffering and pain on its surface. The visceral emotions often spark further contemplative responses which can create a degree of mental discomfort, particularly when holding conflicting beliefs and values (cognitive dissonance). The discomfort that can arise is one aspect of the OE that has received little attention, yet it appears to be one of the defining qualities that instigates shifts or changes in attitudes and behaviours.

Experiences that create a balance between discomfort and satiation may create the ideal conditions for psychotherapy. Seigel (1999) suggests that between the extremes of sympathetic and parasympathetic arousal lies a ‘window of tolerance’, where affect and cognition are suspended comfortably and can easily be inspected without resistance, creating the ideal condition for reframing and integrative therapeutic practices. Prior research on psychedelics have noted the role that mystical experiences, enhanced nature-relatedness, transformative emotions, and openness to experience, play in facilitating the therapeutic process (Carhart-Harris et al. 2018; Kettner et al. 2019). In recent times, emotion-based treatments that focus on creating conditions that allow entry into a window of tolerance, help regulate emotions in a healthy way, and encourage reciprocity, are galvanising clinical interest (Fosha et al. 2009).

Andrew Newberg (Newberg and Waldman 2017), neuroscientist and author, scanned the brains of people participating in self-transcendent practices, and noted that regular smaller self-transcendent experiences increase the probability of having more intense self-transcendent experiences. Future research could investigate if VROE assisted psychotherapy offers a controlled means to induce moderate self-transcendent states and explore the correlation with more intense experiences.

The panoptic perspective of planet Earth facilitates objectification, identification, and conceptualization processes. Together, these cognitive appraisals and processes encourage a stronger attachment with the Earth. Place Attachment has been closely associated with self-transcendent experiences. Inherent in the theory of place attachment is the understanding that some transcendent moments are the outcome of interactive processes between person and setting, which can lead to the perception of possibilities, and drive inclinations and actions (Fredrickson and Anderson 1999; Fullilove 1996; Mazumdar and Mazumdar 1993).

In Jungian psychology, symbolism is an important precursor to self-transcendence, and particular environments that move us towards deep emotional responses because of their general and symbolic meanings, are differentiated from mere observations of the characteristics of a given place. From this premise, when spacefarers respond to the Earth emotionally and develop symbolic representations in relation to it, they are more likely to transcend the self, as well as develop stronger attachments with the Earth (Jung 1963; Williams and Harvey 2001). With this in mind, OE can be utilised to help people form meaningful attachments with nature, this is important because nature-connectedness is a strong predictor of pro-environmental attitudes, which are in turn positively correlated with pro-environmental/planetary behaviours and well-being (Capaldi et al. 2015; Mackay and Schmitt 2019).

The OE shows promise in engaging people multidimensionally; for example, in regards to affect, it can spark powerful visceral responses and strengthen nature-connectedness; in regards to identity, it can encourage the development of the ecological self; in regards to the noetic, it can provide an expansive vantage point that reorientates our focus and can lead to complex cognitive processes and perceptual shifts; and lastly, concerning the spiritual, it engages us with symbolism and existential meaning-making processes (i.e., meaning, purpose, mortality and significance).

This suggests that expansive nature-based experiences, such as the OE, possess many important features that are therapeutically potent and therefore warrant careful consideration with regards to possible applications in mental health.

5.4 Applications

VROE applications offer VR experiences (involving meditation, music, haptic and bio-feedback), with the intention of inducing self-transcendent states analogous to the OE. The VR element can be utilised as an adjunct to psychotherapy in the treatment of specific mental health conditions or as a standalone well-being tool for individuals, groups and organizations.

Overview Effect Therapy (OET) is a form of brief-focused VR-assisted psychotherapy in development by Nezami (2017). Therapeutic work relies on existential dialogue (Socratic and reflective), reframing techniques, graduated meditative and visualization skills-training that encourage access to Overview Effect state(s), and assist in the integration of the experience.

The aim is to leverage VROE applications to determine if, how, and why, meaning-driven positive technologies promote eudaimonic well-being and the expansion of consciousness. The first phase will involve independent empirical research on VROE standalone applications and Overview Effect VR-assisted psychotherapy with low-risk groups to confirm or refute preliminary propositions, gather empirical evidence, and adapt the VR application(s) and psychological intervention. The second phase will assess the evidence, and where appropriate, commence clinical trials with vulnerable groups (i.e., in palliative care, medium-secure and penal settings).

As we move towards interplanetary travel, psychological insight into astronaut health and applications that optimise well-being will be central in mission planning and success (Stuster 2010; Vakoch 2013). In view of this, VROE applications could also play an instrumental role in offsetting the risk of mental health challenges associated with long-duration flights, particularly when the Earth is no longer visible.

5.5 Research and Dissemination

Attempting to recreate the OE via VR has several implications for research. Applications will allow researchers to test plausibility of simulating the phenomenon in immersive worlds, conduct scientific trials on effectiveness and efficacy, and will permit psychologists to develop a robust framework and model. This will serve as the cornerstone for the development of a series of ethical, viable, and effective clinical applications and interventions. Furthermore, OE simulations will allow researchers to widen the scope and reach of trials, offering the opportunity to gather robust evidence on correlations and effect-sizes in relation to well-being, interpersonal relationships, identity, and behaviours. With respect to neuropsychology, brain imaging could provide another layer of evidence, and can serve to confirm or refute whether the OE VR simulations can qualify as a self-transcendent intervention. For example, EEG, PET and fMRI can be utilized to investigate neurological patterns and processes, and contribute to mapping neural regions involved in the experience, assessing the impact on brainwaves, global brain connectivity, and influences on the DMN, posterior cingulate cortex, and medial prefrontal cortex, regions that are closely associated with self-transcendence.

6 Conclusions

In this chapter we investigated the potential the OE holds in terms of offering demonstrable and comparable benefits to other self-transcendent mental health interventions such as psychedelic-assisted psychotherapy and nature-based interventions. We also reviewed the case to adapt, study, and apply it as a form of VR-based transcendent mental health intervention (Nezami 2017; White et al. 2018).

According to the World Health Organization, depression will be the leading cause of disability by the year 2030 (Penn and Tracy 2012). Ecopsychologists ascertain that the "diseases of civilization" and the environmental crisis stem from the growing disconnection between human beings and nature, and believe technology exacerbates this disconnection (Kettner et al. 2019; Milton 2016; Wilson 1984). Bohm (1980), in accordance with the views of ecopsychologists, suggests that our well-being and our species' survival is dependent on the expansion of consciousness and the ability to re-discover its relationship with nature. Despite the warnings about how technology has fuelled human-nature disconnection, technological progress continues to accelerate exponentially. This expansion will continue, and it seems unavoidable that artificially intelligent robots and machines will gradually replace human beings to undertake many common tasks. Since destroying the machines we have created is out of the question, we need to consider and approach AI and technological design conscientiously. Evidence-based positive technologies such as VROE could provide vlauable insight about self-transcendence and could serve to promote wellbeing by strengthening human-nature connectedness, and supporting the development of characteristics that are unique to our species (i.e., empathy, compassion, creativity, ingenuity, social skills, and leadership) (Logan et al. 2020; Lombardo 2006; Wilber 2001; World Economic Forum 2020). With this in mind, perhaps positive technologies can assist humankind in its psychological and spiritual development and perhaps even contribute to ensuring our survival as a species.

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Chapter 11
The Biological Overview Effect

Charles H. Lineweaver and Aditya Chopra

Abstract While gazing at the Earth from orbit, some astronauts have described a cognitive shift known as the overview effect. Here we describe an analogous biological overview effect produced by looking at the tiny twig of humanity on the tree of life. We describe the increasingly precise phylogenetic tree of all life on Earth and how it shows us our place in nature among the other eukaryotes, metazoa, vertebrates and apes. We discuss problems with this tree including the assumption of sexual isolation, purely vertical gene transmission and the dependence of the epoch of LUCA (Last Universal Common Ancestor) on the completeness of the tree. We compile and present the most concise taxonomic overview of the evolution of our lineage from LUCA to humans. We conclude with a description of how the biological overview effect might help us survive.

1 Overview Effects

The overview effect is a cognitive shift in awareness reported by some astronauts during spaceflight, often while viewing the Earth from outer space. It is the experience of seeing firsthand the reality of the Earth in space, which is immediately understood to be a tiny, fragile ball of life, "hanging in the void", shielded and nourished by a paper-thin atmosphere. From space, national boundaries vanish, the conflicts that divide people become less important, and the need to create a planetary

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society with the united will to protect this "pale blue dot" becomes both obvious and imperative (O'Neill 2008) (Fig. 11.1).

Broadly speaking, the overview effect is a new larger perspective that shifts our ideas of where we think we are (White 2014, 2019). The effect can be induced by the awe-inspiring vista from a mountain top, or by mind-broadening experiences in foreign lands. It can come when a peasant farmer visits Paris for the first time, or when a renaissance explorer peruses a new, more comprehensive map of the world. The overview effect involves a new perspective that turns fanciful labels for the unknown ("here be dragons", "terra nullius", "sphere of the gods") into meaningful labels, and for the first time, embeds these regions into the rest of the known world or universe.

The overview effect can be personal and private, or it can be the transformation of an entire culture's *weltanschauung*. Seeing the Earth from orbit transformed astronauts (e.g., White 2014). Images such as Apollo 8's "Earthrise" and Sagan's "Pale Blue Dot" have helped transform a civilization (Brand 1968; Sagan 1994).

2 The Spatial Overview Effect

The original spatial overview effect of astronauts is a re-conceptualization of where we are, based on new spatial or astronomical information about the space around us. A spatial or astronomical overview effect comes from understanding the size of the universe and our place in it. One hundred years ago the size of the known universe was thousands of light years. Now it is billions of light years—an increase of about six orders of magnitude.

Figure 11.2 gives us a feeling for the enormous size of the universe compared to our tiny home planet. The comparison makes our bodies, homes, countries, planet, Solar System and even our Milky Way galaxy seem small and insignificant. Everything that was previously unimaginably large, becomes unimaginably small. We become more anonymous, trivial and humble—and we haven't even broached the topic of the multiverse.

We can make images of the universe and map the space around us to distances of billions of light years. The ability to produce such images and to understand how small we are is an achievement that few species can boast about. Apollo, Voyager, astronomy, cartography, GPS and Google Maps offer us a broader and richer spatial map of where we are. However, overview effects are not limited to a spatial re-conceptualization of where we are. They can be categorized into three classes: spatial, temporal and biological. All of these overview effects contribute to big history: the attempt to understand the integrated history of the cosmos, Earth, life and humanity (Rodrigue et al. 2017; Christian 2004, 2018). The combination of modern geology, paleontology, biology, primatology and anthropology gives us a broader picture of where we have come from, how we got here, who we are—and maybe even where we are going and why?

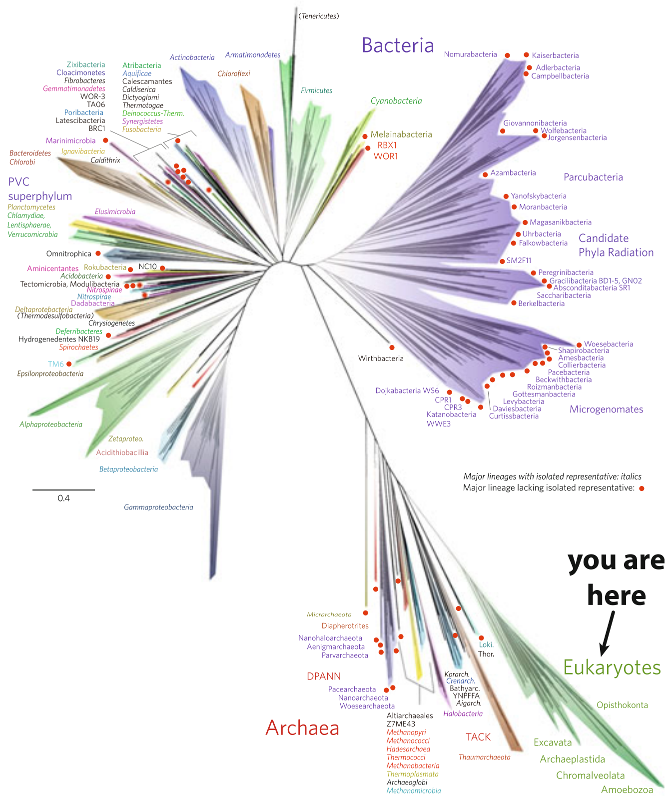

Fig. 11.1 Comparison of Overview effects. Left: the astronomical overview effect evoked by "Earthrise" taken on 24 December 1968 by astronaut William Anders during Apollo 8—the first time we humans travelled beyond low Earth orbit and saw our own home planet rising above the horizon of the Moon (NASA). Right: the biological overview effect evoked by a new more comprehensive tree of life including metagenomic sampling (Hug et al. 2016). The pale green sliver in the lower right corner, labelled "you are here" is our genetic home and encompasses all eukaryotes

Fig. 11.2 Hubble Space Telescope image of a patch of sky about the size of a sheet of paper, seen from 100 meters away. The ~15,000 galaxies in this image are millions and billions of light years away. A dozen stars from our galaxy are in the foreground. All the other points of light are other galaxies—each having hundreds of billions of stars. Hubble Deep UV (HDUV) Legacy Survey (NASA/ESA/Oesch et al. 2018)

Kuhn (1962) has coined the term "paradigm shift" to describe a re-conceptualization intrinsic to scientific revolutions: Copernican, Darwinian, Einsteinian and Quantum Mechanical. The overview effect involves a rapid paradigm shift, in which previous ideas and fundamental assumptions are undermined, rejected, and replaced by a larger, more accurate perspective.

For astronauts, the Earth was no longer a map divided into different coloured nations. Warring religions, ideologies and economic doctrines cannot be seen from space. The Earth is a blue marble hanging in the black void. This new bigger picture challenges our identity and offers us a better answer to the question: What is our place in the universe? What is our place in nature? We have wondered about this for a long time (Lucretius 1st C. BC; Huxley 1863; Wallace 1903; Lineweaver 2002, 2009; Harari 2015).

3 The Temporal Overview Effect

The temporal overview effect is a re-conceptualization of when we are, based on new temporal information such as: the universe is ~13.8 billion years old; Earth is ~4.5 billion years old; life on Earth is about 4 billion years old; and our species, *Homo sapiens*, is about 100,000 years old, or two million years old—depending on how one defines ‘our species’.

Big history is arguably best presented as a series of events viewed through the lenses of different sciences as one progresses chronologically from the Big Bang (cosmology) to the formation of the Sun and Earth (astronomy, planetary science, earth science), to the origin and evolution of life (biochemistry, microbiology and evolutionary biology), to the evolution of humans (archaeology, anthropology, history). For example, in Christian (2004), the sections are listed chronologically, starting with the Big Bang; “the inanimate universe”, then “life on Earth”, “early human history”, “the Holocene”, “modern era” and finally “future”. Christian (2018) also has chronologically arranged sections beginning with the ancient “cosmos”, then the more recent “biosphere”, and finally the most recent “us”.

Logarithmic scales of space and time are often used to encompass and understand processes that have a large dynamic range (e.g., Adams and Laughlin 1997, 1999). For cosmologists interested in the origin and evolution of the universe, the cosmological clock ticks logarithmically (Fig. 11.3). Every order of magnitude of time is examined for important events. Starting at the highest energy and earliest time possible (the Planck time 10^{-43} s after the Big Bang), the interval 10^{-43} of a second to 10^{-42} of a second is studied. Then the interval 10^{-42} of a second to 10^{-41} of a second is examined, etc. Equal attention is given to each such interval. The particle physicist Rocky Kolb (2006) explains:

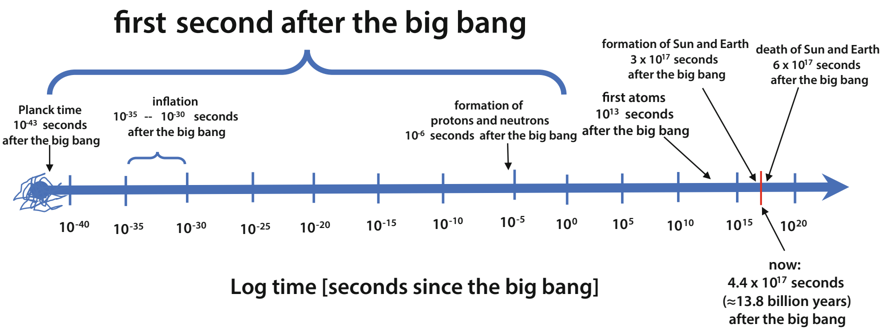

Fig. 11.3 The first second after the Big Bang. The cosmological clock ticks logarithmically. The biological clock probably also ticks logarithmically. For example, the earliest events of embryogenesis are paramount; “It is not birth, marriage or death, but gastrulation which is truly the most important time in your life” (Wolpert 2008, p. 12). The heat death of the universe is off the plot to the right at ~10^{207} s after the Big Bang (Lineweaver and Egan 2007; Adams and Laughlin 1997)

> In this presentation, I will describe events that occurred in the first second of the life of the universe. There have been approximately four-hundred-thousand-million-million seconds since the beginning of the universe, so to concentrate on only one of them might seem the ultimate degree of overspecialization. But the very first second was really something special.

4 The Biological Overview Effect

The biological overview effect is a cognitive shift in identity that occurs while viewing the phylogenetic tree of all life on Earth. It is the experience of recognizing how small our tiny human twig is among the vast genetic diversity of life. Our twig on the tree of life can be seen as just another species, hanging in the phylogenetic void. Our human twig is unique, just like the twig of every other species.

A large part of big history is the integrated history of life. Figure 11.4 is the best current map of our integrated biological history. The tree of life is constructed from the conserved and recognizably related sequences of DNA base pairs inside almost every cell of extant organisms. Our biological identity can be read from the hierarchy of taxonomic divergences in which we are embedded, along with every other living organism (Table 11.1).

Only the twigs of the tree of life are alive. The branches holding up the twigs represent the past lives of millions of ancestors and cousins. Our branch has grown as the bodies of our dead ancestors have piled up chronologically. The tree of life is principally arranged using the chemical fossils of conserved genomes in all extant life forms. The tree has been put together from the chemical footprints that our parents and earlier ancestors left inside us. Here and there, the tree has been calibrated by the petrified remains of fossilized distant cousins. Since the vast majority of species that have ever lived have gone extinct, dead fossilized individuals with no extant descendants vastly out-number the dead individuals who are our ancestors. Thus, when we find a fossil who looks remarkably like what we imagine our ancestors to have looked like, it is usually a dead distant cousin, not a great-great-great-great-. . . -grandparent (Dawkins and Wong 2016; Fournier et al. 2009).

In this tree of life, ours is a small voice in a chorus of hundreds of millions of voices. We often think we are the soloist, but in the tree of all life, we are a small new voice in an ancient choir of prokaryotes. New landscapes of biological diversity show us our little lonely eukaryotic valley. In the most recent phylogenetic trees, our peripheral twig reminds us of Sagan's pale blue dot (Sagan 1994). Ours is a tiny trivial twig amongst the enormous diversity of life. This new, comprehensive genetic landscape gives us an overview of biology—how we relate to other species—how we shared ancestors with modern mushrooms for ~3 billion years and only in the last ~1.1 billion years diverged from them. Like astronauts recognizing the common humanity of all people, this new deeper genealogy has us welcoming new members to our family. Now we can talk about "our close cousins the mushrooms".

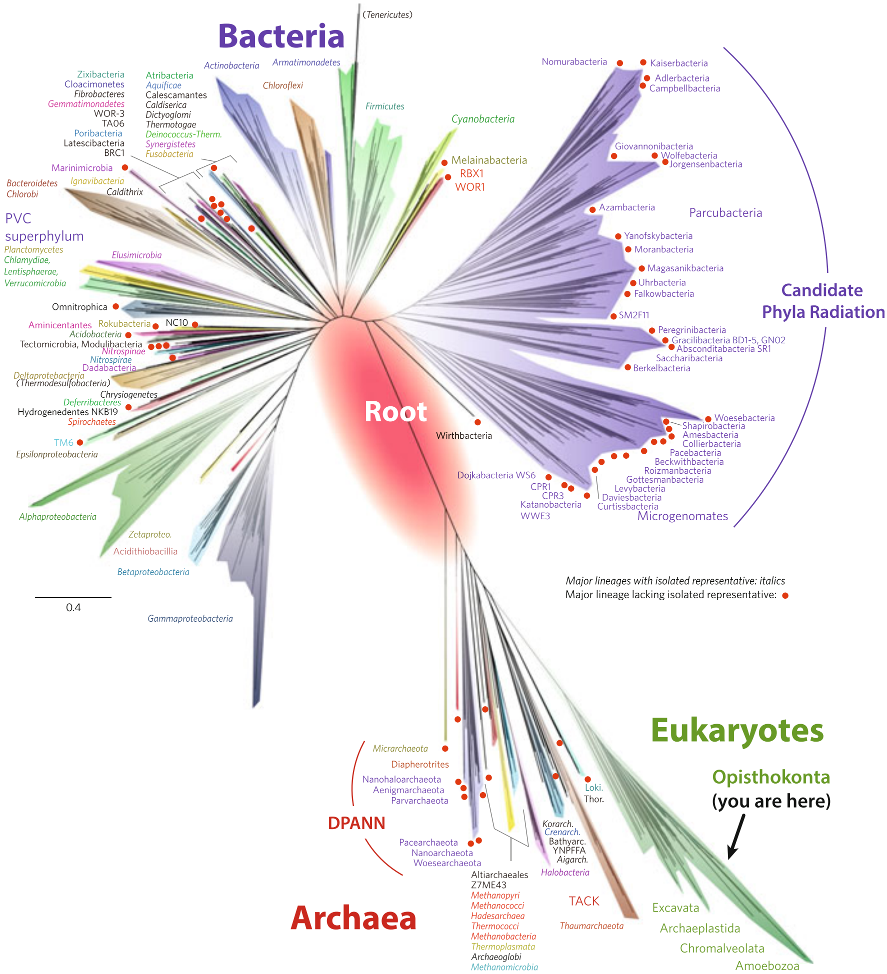

Fig. 11.4 The tree of life (modified from Hug et al. 2016). The diversity of all eukaryotes is represented by the green sliver in the lower right. On the right side of the green sliver, the small branch labelled "Opisthokonta" encompasses all animals and fungi (see node 35 of Table 11.1). The twigs with red dots are organisms that have been identified with metagenomics and have not been cultured. Whether through cultures or metagenomics, the microbial diversity on Earth is still far from complete. Also, viruses are not shown. The red oval in the center is an estimate of where the root of the tree lies. The "root" is another name for LUCA (Last Universal Common Ancestor). The large purple group in the upper right is the new "Candidate Phyla Radiation" (CPR). In the archaeal lower half of the tree, the very early branching organisms (closest to the red oval in the middle) have also been only metagenomically identified and therefore have a red dot at the end of their branches. Notice that most of the organisms with branches that emerge from the red oval are Candidate Phyla Radiation (CPR), DPANN and/or have red dots

Table 11.1 Hierarchy of Taxonomic Convergences Along Our Lineage (rendezvous with sister taxa)[a]

Node	The group that is joining our lineage	Our lineage before rendezvous	Our lineage after rendezvous	Rendezvous age (MYA)
1	*Pan* (chimpanzees)	Homo (humans)	Hominini	6.5 ± 0.5
2	*Gorilla* (gorillas)	Hominini	Homininae	9.1 ± 0.5
3	*Pongo* (orangutans)	Homininae	Hominidae (great apes)	16 ± 1
4	Hylobatidae (gibbons)	Hominidae	Hominoidea (apes)	20 ± 2
5	Cercopithecoidea (old world monkeys)	Hominoidea	Catarrhini	29 ± 2
6	Platyrrhini (new world monkeys)	Catarrhini	Simiformes	43 ± 3
7	Tarsiiformes (tarsiers)	Simiformes	Haplorhini	67 ± 4
8	Strepsirrhini (lemurs, lorises, bushbabies)	Haplorhini	Primates	74 ± 3
9	Dermoptera (colugos)	Primates	Primatomorpha	76 ± 11
10	Scandentia (tree shrews)	Primatomorpha	Euarchonta	82 ± 7
11	Glires (rodents, rabbits)	Euarchonta	Euarchonoglires	90 ± 5
12	Laurasiatheres (bats, whales, lions, dogs, horses)	Euarchonoglires	Boreoeutheria	96 ± 5
13	Xenarthrans (anteaters)+ Afrotheres (elephants)	Boreoeutheria	Eutheria (placentals)	105 ± 5
14	Marsupials (kangaroos, opossums)	Eutheria	Theria	160 ± 10
15	Monotremes (platypuses, echidnas)	Theria	Mammalia	175 ± 15
16	Sauropsids (reptiles, birds)	Mammalia	Amniota	310 ± 15
17	Amphibians (frogs, salamanders, caecilians)	Amniota	Tetrapoda	350 ± 5
18	Dipnoi (lungfish)	Tetrapoda	Sarcopterygii (lobe-finned fish)	395 ± 25
19	Actinistia (coelacanths)	Sarcopterygii	Dipnomorpha	415 ± 10
20	Actinopterygii (ray-finned fish)	Dipnomorpha	Euteleostomi (bony vertebrates)	435 ± 10
21	Chondrichthyes (sharks, rays, chimaeras)	Euteleostomi	Gnathostomata (jawed fish)	475 ± 25
22	Cyclostomata (lampreys, hagfish)	Gnathostomata	Vertebrata	615 ± 90
23	Urochordata (sea squirts)	Vertebrata	Olfactores	675 ± 130
24	Cephalochordata (lancelets)	Olfactores	Chordata	680 ± 90
25	Ambulacrarians (starfish, acorn worms)	Chordata	Deuterostomia	685 ± 130
26	Protostomia (arthropods, nematodes, molluscs)	Deuterostomia	Nephrozoa (coelomates)	795 ± 120
27	Acoelomorpha (acoel flatworms)	Nephrozoa	Bilateria (triploblasts)	820 ± 330

(continued)

Table 11.1 (continued)

Node	The group that is joining our lineage	Our lineage before rendezvous	Our lineage after rendezvous	Rendezvous age (MYA)
28	Cnidaria (hydra, jellyfish, anemones, corals)	Bilateria	Parazoa	825 ± 210
29	Ctenophores (comb jellies)	Parazoa	ParaHoxozoa	945 ± 220
30	Placozoans (trichoplax)	ParaHoxozoa	Eumetazoa (diploblasts)	950 ± 180
31	Porifera (sponges)	Eumetazoa	Metazoa	955 ± 200
32	Choanoflagellates	Metazoa	Choanozoa	1025 ± 330
33	Filasterea (*Ministeria, Capsapora*)	Choanozoa	Filozoa	1050 ± 90
34	Mesomycetozoea or Ichthyosporea (DRIPs)	Filozoa	Holozoa	1080 ± 90
35	Fungi (mushrooms, moulds, nucleariids)	Holozoa	Opisthokonta	1110 ± 360
36	Apusomonads + Ancyromonads + Breviatea	Opisthokonta	Obazoa	1420 ± 290
37	Amoebozoans (*Amoeba*, slime moulds)	Obazoa	Unikonta or Amorphea	1480 ± 350
38	Collodictyonids + Rigifilids + *Mantamonas*	Unikonta or Amorphea	Podiata	1600 ± 350
39	Metamonada + Malawimonas (*Trichomonas, Giardia*)	Podiata	Scotokaryotes	1750 ± 350
40	Bikonts (plants, algae, diatoms)	Scotokaryotes	Neokaryotes	2000 ± 260
41	Excavata (*Euglena, Trypanosoma*)	Neokaryotes	Eukaryota	2100 ± 260
42	Asgard (Loki-, Thor-, Odin-archaeota)	Eukaryota	Asgard + Eukaryota	2720 ± 370
43	TACK superphylum	Asgard + Eukaryota	Proteoarchaeota + Eukaryota	2940 ± 400
44	Euryarchaeota (methanogens, halobacteria)	Proteoarchaeota + Eukaryota	Eury- + Proteo- + Eukaryota	3150 ± 410
45	DPANN superphylum	Eury- + Proteo-archaeota + Eukaryota	Archaea	3300 ± 430
46	Eubacteria + Candidate Phyla Radiation	Archaea	Known Life on Earth	3950 ± 550
47	Second Life + Dark Life?	Known Life on Earth	All life on Earth	4150 ± 350

[a]Names in parentheses are common names. Estimated dates for nodes 1–40 are from Kumar et al. (2017). Dates for nodes 41–47 are from Betts et al. (2018). Kumar et al. (2017) do not have the same branching order and dates for some rendezvous points listed in Table 11.1. Thus, the dates for nodes 24, 29–31, 33–34, 37–40 are our estimates based on the catalogued divergence dates associated with the closest lineages described by Kumar et al. (2017). Uncertainties on rendezvous ages for nodes 1–40 are our estimates that account for the upper and lower range of divergence dates catalogued by Kumar et al. (2017). Uncertainties on rendezvous ages for nodes 41–46 are estimates reported by Betts et al. (2018). Some estimated dates reported in the table have been rounded to the

(continued)

nearest five Myr (nodes 14–32) or nearest ten Myr (nodes 33–47). We used the age of the Moon-forming impact ~4.5 Gyr (Stevenson and Halliday 2014) and the date associated with the putative earliest evidence for life on Earth ~3.8 Gya (Dodd et al. 2017; Nutman et al. 2016) to set the uncertainty associated with node 47. Branching orders and group names for lineages joining at nodes 1–31 are based on Kumar et al. (2017); nodes 32–41 are based on Cavalier-Smith et al. (2014) and Shalchian-Tabrizi et al. (2008); nodes 42–47 are based on Betts et al. (2018). TACK superphylum (Node 43) consists of Thaum-, Aig-, Cren- and Kor-archaeota. DPANN superphylum (Node 45) consists of Diapherotrites, Micr-, Parv-, Aenigm-, Nano-, Nanohalo-, Woese- and Pace-archaeota

Our position in the lower right of Fig. 11.4 can be described by paraphrasing Sagan's description of our pale blue dot (Sagan 1994—excerpt in Planetary Society 2019):

> Look again at this pale green sliver. That's home. That's us. Within its genetic boundaries every organism you have ever seen, every vertebrate you have ever loved, lived out their lives. The aggregate of our breaths, heartbeats, and sexual desires, every human and non-human eukaryote, every playful puppy and petunia, every meerkat and mite, every mammal, reptile, amphibian and fish, every mushroom and mayfly, every dandelion and dragonfly, every blade of grass and every innocent wasp larvae eating its way out of a caterpillar, every parrot and paramecium, every oak tree and antelope, every kookaburra and cuttlefish, every deuterostome and protostome, every ant and anteater, every poisonous snake and harmless tadpole, every orca and ostrich, every salamander and sardine, every top predator and bottom feeder, every amoeba and armadillo, every loving octopus mother guarding her eggs and every predator trying to eat them, every dinosaur and dinoflagellate, and every tree fern and trilobite, every elephant and eel, every jawed fish and every jawless fish, and every life form with a rib or a jaw or a brain, every vertebrate and invertebrate in the history of eukaryotes lived there—in a pale green genetic sliver that emerged ~3 billion years ago from a small branch of the Archaea.
>
> Eukaryotes are a very small genetic afterthought on the giant prokaryotic stage. Think of the rivers of blood and cytoplasm spilled by all those predators and parasites so that in glory and triumph they could become the momentary masters of a eukaryotic corpse. Our posturings, our imagined self-importance, the delusion that we have some privileged position in the genetic universe, are challenged by this trivial triangle. Our eukaryotic domain is a pale green sliver among the huge genetic diversity of life on Earth. The extent of our genetic diversity will fade even further if we can compare it to the diversity of life that may exist elsewhere. In the great enveloping genetic unknown—in our obscure sexually-isolated eukaryotic corner, among enormous diversity, there is no hint that help will come from elsewhere to save us from our swollen brains and multicellular megalomania. There is perhaps no better demonstration of the folly of human conceits than this green sliver of genetic space. To us, it underscores our responsibility to deal more kindly with other species, to preserve and cherish the diversity of life—the only life we've ever known.

5 Where Is the Root of the Tree of Life?

The branches in Fig. 11.4 show the extent of genetic diversity. We have inserted the large red oval to indicate the most likely position of the root. As we follow the eukaryotic branch back in time, we rendezvous with the Asgard group (represented in Fig. 11.4 by Lokiarchaeota ("Loki.") and Thorarchaeota ("Thor.") and then with the TACK group and then with DPANN and the rest of the Archaea (see nodes

42–45 and caption of Table 11.1). Notice that most of the basal or shortest branched Archaean lineages are in DPANN and have a red metagenomic dot at their tips. They have not been cultured.

If we want to know about the origin of life, and more specifically about the metabolism of the last universal common ancestor (LUCA) of all known life, we need to make sure we can identify where LUCA is. LUCA is located where the two deepest branches merge into one branch, but there is some ambiguity about which two those are. Hence, the relatively large size of the red oval. LUCA is sometimes called the root of the tree of life, but "trunk" is a better word. LUCA (or the root of the tree) should not be confused with the origin of life which precedes LUCA by some significant amount—perhaps by a few hundred million years.

As we find shorter branches in the tree of life such as the Candidate Phyla Radiation (CPR) and DPANN, estimates for the time of LUCA become earlier and come closer to the time of the origin of all life (Lineweaver 2020). This is shown in Fig. 11.5 as "LUCA" (in small font higher up in the tree) becomes "LUCA" (in larger font lower in the tree) after the inclusion of CPR and DPANN.

6 Hierarchy of Taxonomic Divergences Along Our Lineage

Inspired by Dawkins and Wong (2016) to get a better overview of our evolutionary identities, in Table 11.1 we have compiled the most concise taxonomic overview of the evolution of our lineage. The divergences seen in phylogenetic trees (e.g., Fig. 11.4) become convergences or rendezvous when we imagine travelling backwards in time along our lineage. In Table 11.1, the numbers in the first column are rendezvous numbers (also known as phylostratigraphic nodes, cf. Domazet-Lošo and Tautz 2010; Trigos et al. 2017). These rendezvous are when our closest relatives merge with us at the time of the common ancestor. We start our voyage backward in time at node 1, 6.5 million years ago where we meet our most recent common ancestor with chimpanzees. At node 12, 96 million years ago we meet our common ancestor with dogs and cats. At node 40, about 2 billion years ago we meet our common ancestor with apple trees and bananas.

Numbers (1–37) in the first column are the rendezvous numbers from Dawkins and Wong (2016) with the name of the new group that is joining our lineage at each rendezvous in the second column. The third column is the name of our lineage before being joined by the group in the second column. The fourth column is the name of our group after being joined by the group in the second column. Notice that there is redundancy in that the name in the fourth column in rendezvous N, is the same as the name in the third column for rendezvous N+1.

For some of the less well-understood, recently proposed branches, we have adopted the nomenclature of Cavalier-Smith and co-authors (e.g., Cavalier-Smith et al. 2014; Ruggiero et al. 2015). This was necessary because Dawkins and Wong (2016) gave the name of the new group that was joining our group, but sometimes ignored the name of our group before and after the rendezvous. For a given node N,

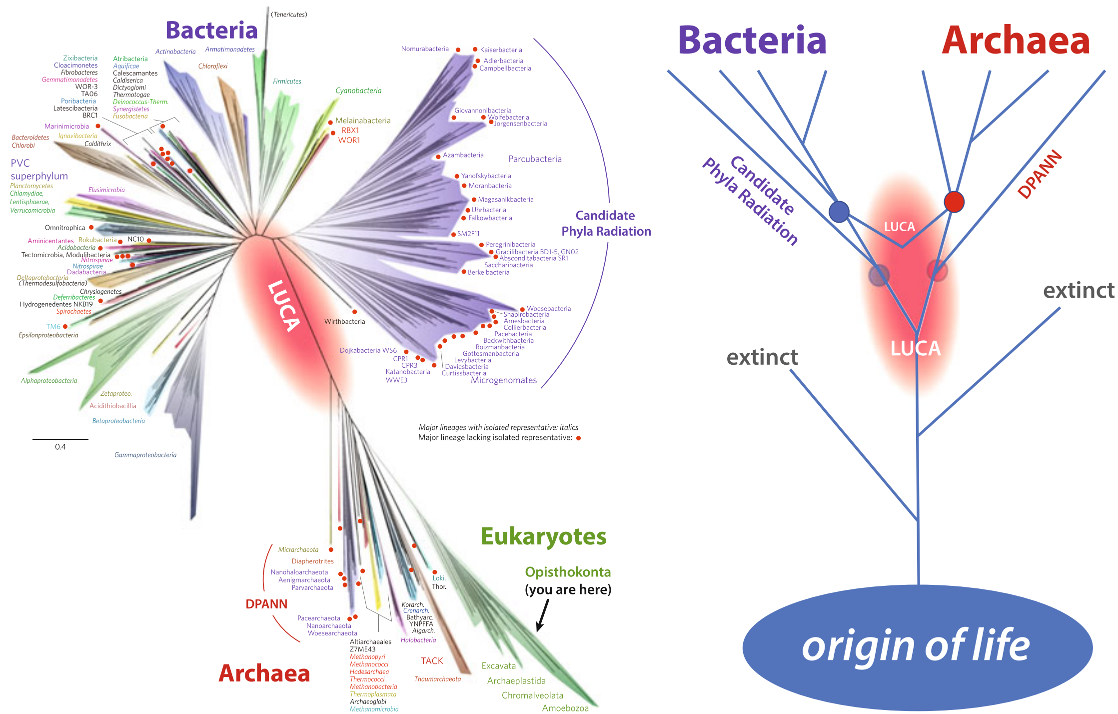

Fig. 11.5 Where is the Last Universal Common Ancestor (LUCA)? Left: Hug et al. (2016) identified many new short branches on the tree of life. The shortest branches extending out of the oval labelled "LUCA", are the best representatives of what LUCA was like. Weiss et al. (2016) did not use these short metagenomically identified twigs when looking for the metabolisms of LUCA. If they had, LUCA would have been deeper and LUCA's metabolisms at least slightly different. The illustration on the right shows how the position of LUCA depends on the deepest, shortest branches. Before the discovery of CPR and DPANN, LUCA was in the position of the LUCA label in small font. After the discovery of CPR and DPANN, LUCA is now earlier in the tree at the position of the LUCA label in a larger font. As long as we have an incomplete sampling of the deepest shortest branches on the tree of life, LUCA will appear more recent than it really is. We have the same problem with sub-branches. For example, the discovery of DPANN moves the common ancestor of all Archaea from the filled circle down to the transparent circle. On-line version in colour

the uncertainties on its date can sometimes overlap with the dates of nodes N+1 or N-1. The larger this overlap, the more uncertain is the order of the nodes (Fig. 11.6).

7 Problems with Phylogenetic Trees

The powerful perspective and simplicity of Fig. 11.4 and Table 11.1 are based on the vertical transmission of the most conserved core genes. Such trees are very useful as a reference for the vertical transmission of genes, but not as a full picture of evolution. More realistic network-like evolution can be informatively compared to this vertical-transmission-only tree (Doolittle and Bapteste 2007; Bapteste et al. 2009).

There are many well-known problems with such "vertical-only", "divergence-only" approaches to the evolution of life. What happens when two organisms from different parts of the tree merge? Where in the tree does the new chimeric organism belong? Some horizontal convergences have been well-documented as endosymbiotic events. Mitochondria and plastids in eukaryotes have endosymbiotic origins but many other organelles could have such endosymbiotic origins (Sagan 1967; Margulis et al. 2000, 2006). Deeper in the tree and even more prevalent is the horizontal gene transfer (HGT) between bacteria and archaea. A vertical-transmission-only tree should be based on genes that have not been horizontally transferred, but as we explore deeper and earlier in evolution, such non-HGT genes become rarer. Another problem is the discrete nature of the branches. The sexual isolation of most eukaryotic species is legitimately represented by discrete branches, but bacteria exchange genes with other bacteria, near and far—indiscriminately and promiscuously. This HGT undermines the genetic isolation of bacterial and archaeal "species" (Doolittle and Papke 2006).

Linnaeus, Darwin and modern biology have gradually shown us our place in nature. We know our position among the apes and primates and vertebrates and eukaryotes—but the deeper we go into the tree of life, the more uncertain the nodes of the phylogenetic tree become. As sexual species, it made sense to pretend that all life forms are sexually isolated and therefore uniquely identified as a lineage or a branch on the tree of life.

The branches of almost all sexual species diverge nicely like the branches of a real tree. But the tree of all life, especially as we get closer to the root, is not so simple. The earliest branches are vague. Without sex, bacterial species are not isolated and so aren't branches (Doolittle and Papke 2006). They are networks of molecules and genes and endosymbiotic unions—perhaps as many convergences as divergences. There are groupings on many scales. Overlay a few thousand gene-trees and an average species-tree will emerge, but the prevalence of endosymbiotic events during the origin of the eukaryotic cell, and the increasing prevalence of HGT as we go deeper into the prokaryotic tree produces a complex network of divergences and convergences that we are still trying to unravel.

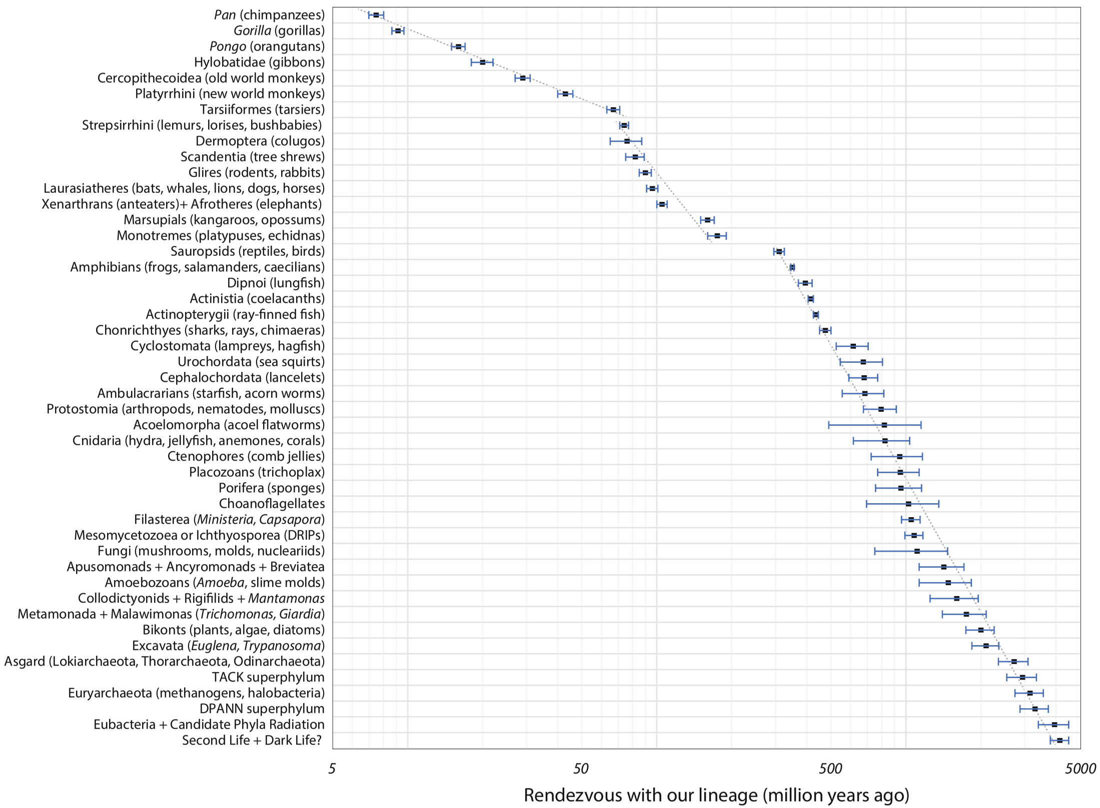

Fig. 11.6 Plot of the dates of the 47 nodes in Table 11.1. We have superimposed notional lines over three sections of the plot

As more genomes are sequenced, the resulting phylogenetic trees reveal more about who we are and our humble sliver of genetic space. These sequences have also become the most fertile sources of information about the Last Universal Common Ancestor (LUCA) and the origin of life on Earth.

8 Can the Biological Overview Effect Help Us Survive?

From space, national boundaries vanish (O'Neill 2008). On Spaceship Earth, recognition of our common humanity helps us envision resolutions to our conflicts. Similarly, perched on a small twig of the phylogenetic tree, the boundaries between species vanish. Differences between species fade as our twigs come together into branches full of common ancestors. Ancestors Tales are revealed (Dawkins and Wong 2016)—like the stories told by our elders at the family reunion, reminding us that we share grandparents with our cousins. Recognition of our common origin helps us envision sharing the Earth with our cousins.

The modern phylogenetic tree of all life is a new map of our shared biological heritage. Just as Shubin's *Your Inner Fish* (2008) explains how we resemble our fish-like ancestors who lived 400 million years ago, our deepest phylogeny and most basic physiology show us how we resemble our prokaryote-like ancestors who lived 4000 million years ago. Such a profound biological overview gives us an emotional connection and a scientific realization of how we got here (Table 11.1, Fig. 11.7).

The biological overview effect is based on Darwin's still-dangerous idea (Dennett 1995). It often comes with an emotional jolt to our assumed exceptionalism, epitomized by Katherine Hepburn in the 1951 movie *African Queen*: "Nature, Mr. Allnut, is what we are put in this world to rise above."

The belief that humans are somehow above nature or beyond nature is a pre-Darwinian human exceptionalism that we try to justify by our hypertrophied encephalization.

Unfortunately, we are imbued with this speciesism. When a bird makes a nest, we call it natural, but when we make a house, we call it artificial. This prevalent presumption that there is an unbridgeable gap and a morally important distinction between humanity and other species is what the biological overview effect can help cure. It can help undo the belief that we are removed and better than other animals and other apes. Maybe it can provide some antidote to the traditional belief that a god has given our tribe of *Homo sapiens* dominion over all the earth, including fish, fowl, cattle and "every creeping thing that creepeth upon the Earth." (Genesis 1: St James Bible).

A modern version of claiming dominion over the Earth is our current self-appointment to the stewardship of the Earth (Grinspoon 2016), hoping we can compensate for burning hydrocarbons, destroying wild habitats and causing the sixth extinction—the Anthropocene extinction. Interestingly, extinctions are not used to label epochs, periods or eras. Extinctions are the *interruptions* of periods.

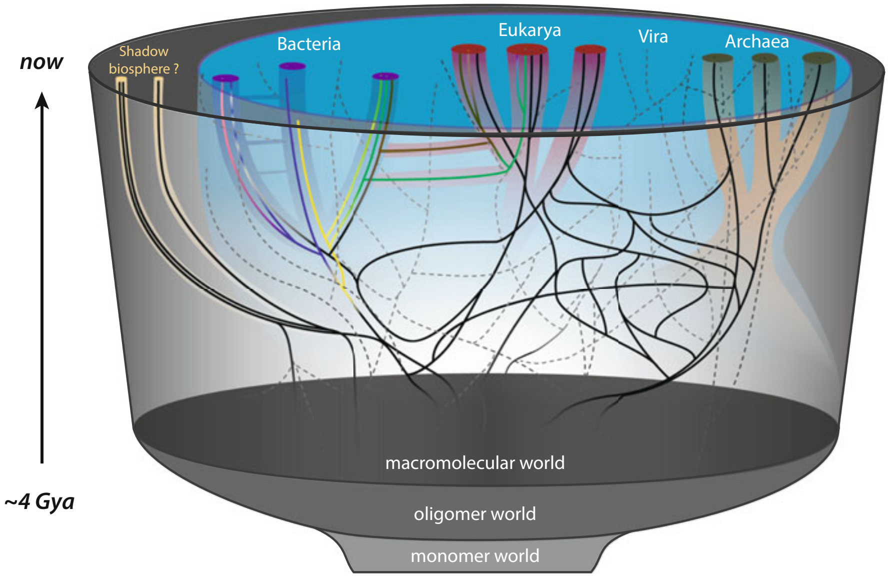

Fig. 11.7 Our attempt to improve on the divergence-only tree in Fig. 11.4 and Table 11.1. We have schematically added endosymbiotic convergences (horizontal solid lines) and the ubiquitous evolution and exchange of viruses and genes (dashed lines). On-line version in colour

They mark the boundaries; the end of one period and the beginning of another. Unperturbed, we rebrand our interruption as an epoch and put our name on it.

The biological overview effect can help us realize what most traditional societies have always known: the Earth does not belong to people—people belong to the Earth.

Before he died in 2018, Stephen Hawking predicted that humanity would probably not survive 1000 years. He was concerned that our big brains have given us many new ways to kill ourselves and our multicellular cousins: nuclear war, global plagues, over-population, biological weapons, global warming (Bostrom and Cirkovic 2008). But our big brains also give us the ability to create, examine and muse over the phylogeny of all life. We can appreciate how embedded we are in the biosphere and experience the biological overview effect. Perhaps that will help.

9 Summary

Just as the Apollo and Voyager missions showed us spaceship Earth as a pale blue dot (the spatial overview effect), we propose a biological overview effect produced by looking at the tiny twig of humanity on the phylogenetic tree of life. Modern genome sequencing shows us our humble, pale green eukaryotic island among the ocean of genetic diversity of life on Earth. Based on increasingly precise phylogenetic trees and molecular clocks, we compile and present the most concise taxonomic overview of our lineage as we evolved over the past ~4 billion years, from LUCA into humans. This biological overview can help us understand and navigate the integrated history of life and humanity, and maybe give us the wisdom to stay alive.

Acknowledgments We thank the big bang, an oxygenated atmosphere and our parents, without whose love we wouldn't be here.

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Chapter 12
Is the Universe Enough? Can It Suffice as a Basis for Worldviews?

Mark Lupisella

The Cosmos is all that is, all that was, and all that ever will be (Carl Sagan 1994, p. 4).

If the universe isn't enough, what are we to do? (Ian Crawford[1]).

Abstract The modern scientific cosmic perspective is unique and compelling, but it's not for everyone. Modern cosmology can be humbling and awe-inspiring, even motivating. It can also be overwhelming, even scary. The extent to which the universe we know today can form the basis of satisfactory worldviews rests largely on human psychology, preferences, and needs, as well as on what we mean by "worldview". This essay will explore some ways to think about worldviews and the universe, with an emphasis on exploring relationships between cosmic evolution and cultural evolution (Dick and Lupisella), including what might be called "cosmocultural evolution"—the coevolution of cosmos and culture (Lupisella, Cosmos and culture: cultural evolution in a cosmic context. NASA, SP-2009-4802: 321–359, 2009). We will touch on a few cosmocultural evolutionary perspectives as well as broader underlying "cosmological theories of value". With an eye toward psychology, we will consider if and how such perspectives might inform, or possibly suffice as worldviews, suggesting generally that the universe may suffice for some people some of the time, but probably not for most people most of the time. An earlier version of this chapter was originally published in the *Journal of Big History*, Vol. III (3), pp. 123-140 (2019).

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[1]Personal email, 24 April 2018.

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1 Introduction

The modern scientific cosmic perspective is unique and compelling. But it's not for everyone. Indeed, it may only be compelling to a small fraction of people. Modern scientific cosmology can be humbling and awe-inspiring, even motivating to some. But it can also be overwhelming, even scary. The extent to which the universe we know today can form the basis of satisfactory worldviews rests largely on human psychology, preferences, and needs, as well as on what we mean by "worldview."

When I first learned of the Australian National University Symposium on "*Expanding Worldviews: Astrobiology, Big History, and the Social and Intellectual Benefits of the Cosmic Perspective*" (summarised by Crawford 2018), I was immediately struck by the explicit reference in the title to "social benefits of the cosmic perspective." Much effort has gone into our modern understanding of the universe, but there appears to be a relative lack of attention given to the question of how such pursuits truly benefit society (Race et al. 2012; Dick 2018).[2] Maybe that's because the benefit is obvious enough since much of the human population seems to deeply value learning about our world—including learning about our broader universe that appears to be extremely old and vast and largely detached from everyday human life.

Indeed, even with some perceived detachment of human life from the larger universe, we still seem to be willing to conduct extensive exploration of our cosmos even though it doesn't have much, if any, practical relevance to our daily lives. This says something about the human species—many of us are compelled to learn about almost anything, and society provides resources to engage in what are often very expensive, time-consuming, life-long, multi-generational endeavours to learn about things we suspect won't have near-term, or possibly even long-term, practical relevance for most people.

We like to learn because we're interested, we're curious. We're presumably curious for evolutionary reasons since there have likely been strong selective pressures to be attentive to the broader environment, which would lead to a better understanding for practical living, which can then lead to better individual and group fitness. But many modern humans, who arguably now have more time and cognitive processing power to pursue "impractical" questions, are also intrigued by the often vexing philosophical questions regarding value, meaning, and purpose, and why we observe the universe we do, or why the universe exists at all.

I am personally charmed and awed by our universe (even more so by the possibility of a multiverse!), by wondering if it's "about something" and why it exists at all. I've spent a good amount of mental energy on such things (perhaps an irrational amount), but my fascination and intrigue is not necessarily widely shared by others—some of who presumably think they already have answers in forms of religions or other philosophies and worldviews that have been around for thousands

[2]A NASA workshop on the societal implications of astrobiology was held in 1999 (NASA Technical Memorandum 1999), and there have been subsequent efforts to explicitly explore the connections between astrobiology and society (e.g., Race et al. 2012; Dick 2018).

of years. And my interest arguably has something to do with personal psychological predispositions that don't benefit others that much, if at all. But given the importance of worldviews and the bewildering variety that complicates our ability to know what's true, and given the sometimes deeply problematic adverse effects that can result from many worldviews, it does seem worth asking whether the scientific universe we know today, or may know in the future, can at least help inform and/or form the basis of satisfactory worldviews.

It would seem that any hope for building satisfying cosmological worldviews would need to entertain some degree of integration, if not full integration, between physical cosmic evolution and the emerging meaningful powerful cultural evolution occurring here on earth and perhaps elsewhere in the universe. Fortunately, our modern scientific understanding of cosmology provides a significant amount of that integration. Modern cosmology tells us that stars, planets, life and humanity are the results of a long process of micro-scale and macro-scale cosmic evolution, including biological and cultural evolution—at least in our little corner of the cosmos. "The Cosmos is within us. We are made of star stuff"—as Carl Sagan (Sagan 1980, p. 244) famously proclaimed.

Taking a cue from our emerging integrated scientific story of the universe, this paper will explore a few ways to think about worldviews and the universe with an emphasis on exploring relationships between cosmic evolution and cultural evolution, including what might be called "cosmocultural evolution"—the coevolution of cosmos and culture (Lupisella 2009). We will touch on a few cosmocultural evolutionary perspectives as well as broader underlying "cosmological theories of value" developed in Lupisella (2020). We will address if and how a cosmic perspective might inform, or provide a basis for, alternative "cosmological worldviews" that might satisfy contemplative beings like ourselves.

This short treatment cannot include the myriad details of cosmic evolution and all details regarding the philosophy and psychology of belief and worldviews and how they impact human behavior, but we will certainly draw from some of that work, much of which can be found in academic and popular treatments, for example: Aerts et al. (1994, 1999); Babbage and Ronan (2000); Wilson (2002); Shermer (2002); Koltko-Rivera (2004); Gershenson et al. (2007); Bulbulia et al. (2008); Gabora and Aerts (2009); Johnson et al. (2011); Henriques (2011); Vidal (2012); Nilsson (2013, 2014, 2015); Hedlund-de Witt (2012); Saucier (2013); Saucier et al. (2015).

2 The Universe and Worldviews

2.1 Why Care About Worldviews?

> A belief is a lever that, once pulled, moves almost everything in a person's life (Sam Harris (2005, p. 12)

Beliefs and worldviews are different from each other, but they are usually intimately related. Many, but not all worldviews can include beliefs that are not necessarily grounded in much evidence or careful investigation or reasoning. But worldviews can also be evidence-driven. They can be highly complex and diverse, but there tends to be some common underlying drivers, motivations, and themes associated with the psychology and substance of many worldviews that can be used to help assess the extent to which our universe can serve as, or at least inform potentially satisfying worldviews.

We can start with a relatively simple definition of 'worldview', which is to define it essentially like it sounds: *a view of the world*. 'View' often implies particular perspectives and beliefs. 'World' often implies everything (or at least almost everything). A worldview, then, is a kind of "view of everything" that may matter in a person's life or a group's functioning: e.g., survival, human affairs, facts and values, meaning and purpose, death and afterlife, epistemology and ontology, transcendent realities, etc. This is not different in its essence from characterizations offered by others, and given this kind of characterization, we can see why worldviews can drive very specific details of what we believe, how we think, and why we act in certain ways (Koltko-Rivera 2004; Johnson et al. 2011; Vidal 2012). Worldviews can be comforting and inspiring, but also dangerous.[3]

Strictly scientific narratives and worldviews, including those based on our present state of physical cosmology, can be limited or even misguided, and perhaps dangerous as well, so we should be mindful of potential pitfalls, including what might be called "oppressive universalism"[4] or "over-foundationalizing" (Rockmore and Singer 1992). These are not just legitimate psychological concerns about the misuse of worldviews, but they are also legitimate intellectual concerns that are particularly important when engaging in speculative worldview building—especially when that worldview building is driven by contemplations of our entire universe and the associated complexities of modern cosmology. Keeping these sensitivities in mind (Denning 2009), we can explore "cosmological worldviews", which can be thought of as worldviews that are heavily informed by cosmology, i.e., by modern scientific cosmic evolution that includes fundamental physics such as relativity and quantum mechanics (that drives much cosmic evolution), as well as biological evolution, including the evolution of intelligence and culture (Dick and Lupisella 2009).

[3]Juergensmeyer (2003) looks closely at the links between violence and a number of religions, but it's important to note that while worldviews are often associated with religions and theology, they are not limited to those orientations.

[4]I use the phrase "oppressive universalism" here as a way to capture to the idea that "universe narratives" can be misguided and even oppressive, including to the extent that they may deemphasize individualism in favor of very broad narratives (Marshall 2002).

2.2 Theology

The universe and worldviews have been intimately connected for thousands of years. Ancient and modern religions have found many ways to integrate concepts of the larger universe into their worldviews. Western religions such as Judaism, Christianity, and Islam have tended to emphasize the universe as God's creation. Hinduism has proffered notions of a very long-lived, if not eternal, cyclical universe. Pantheism has generally equated the universe with divinity or "God", and *panen*theism has viewed the universe as imbued with divine spirit that also transcends the universe. More generally and more recently, some have referred to "cosmotheology" as an attempt to capture the idea that notions of spirit or divinity or God should tightly integrate, if not be fully constituted by, details of modern scientific cosmic evolution (Dick 2000).[5] Some eschatological treatments have tended to emphasize "end-points" of cosmic evolution, for example, leading to a super advanced intelligent "God-like" being, or state, at the end of cosmic evolution (e.g., Teilhard de Chardin 1955; Tipler 1994).

2.3 Speculative Cosmology

There are numerous scientific treatments, or what could perhaps be thought of as more "secular" speculative philosophical treatments, that have potential relevance for the universe and worldview building—at least by way of informing alternative worldviews, if not having the potential to fully constitute worldviews in and of themselves. There have been articulations of cosmic evolution that emphasize a kind of "spiritual" embrace of our universe without necessarily explicitly emphasizing theological or divine dimensions or heavy philosophical treatments that explicitly invoke metaphysics or value theory (e.g., Swimme and Berry 1992; Barlow 1997; Goodenough 1998). "Big History" treatments emphasize a cosmic-scale view of history and some level of comprehensive integration that includes the evolution of life and humanity (Christian 2004).

Anthropic views emphasize the idea that our observed universe appears as it does because is it consistent with the evolution of beings that can eventually observe it. Multiverse concepts posit the existence of many, possibly infinite, universes and is often used to explain our particular cosmic details (e.g., laws and constants) by noting that the existence of many other universes makes our particular universe less improbable than it may otherwise appear to be. Cosmological Natural Selection suggests that as universes give "birth" to other universes (possibly via black hole

[5]Kant appears to have coined the term "cosmotheology" in *Critique of Pure Reason* to capture the idea that a "supreme being" might be inferred by experience of the world. Steve Dick's (Dick 2003) more contemporary use is different in that it does not require a "supreme being".

production), a kind of selection process would tend to produce relatively stable and long-lived universes such as ours (Smolin 1997).

Information-based views of the universe have been proposed noting that the universe can be seen as a kind of computational system (Lloyd 2006). Ideas such as the "evolutionary developmental universe" (Smart 2009), taking cues from biological evolution, emphasize how the evolution of intelligent beings can lead to highly computational systems such as a "developmental singularity", perhaps in the form of a "black hole computing system" that can give rise to similar universes with incremental changes. Related to ideas of an information-based universe, it has been suggested that our universe is likely to be a simulation (Bostrom 2003).

James Gardner (2005), leveraging ideas from John Wheeler who suggested some degree of "retro-causation" might be possible, proposes a kind of participatory or "co-created" evolutionary model of the universe as a "closed time-like curve", which can provide a theoretical explanation for a "self-synthesized" origin and evolution of the cosmos. Paul Davies (2009) goes further, speculating that the universe and its specific bio-friendly laws might be "self-synthesizing" via cultural evolution leading to cosmic-scale "retroactive" observer-participancy in which the whole universe, eventually "saturated by mind", essentially "retro-actively" brings itself and its specific laws into being (at least by constraining "past" possibilities, in which case it can be thought of "retro-constraining").

2.4 Cosmophilosophy

For lack of a better phrase, I'd like to also add "cosmophilosophy" as a category that overlaps with much of what has been touched on prior, but adds a more explicit and systemic treatment on relationships between contemporary cosmology (scientific cosmic evolution) and an explicit emphasis on philosophical questions of value, meaning, agency, epistemology, and metaphysics. Cosmophilosophy asks, in part, questions having to do with what value might be associated with the universe and its evolution, whether there is any meaning or purpose in the cosmos, why it has evolved in the way we think it has, or why the universe exists at all. Here, we'll very briefly touch on three "cosmological theories of value" (*cosmological reverence*, *cosmocultural evolution*, and the *connection-action principle*) taken from a book chapter and recent book (Lupisella 2016, 2020). In the next section we'll assess to what extent these theories of value and other related ideas touched on previously might provide a basis for worldviews.

2.4.1 Cosmological Reverence

Similar to what was noted in the speculative cosmology section above (without the stronger "spiritual" invocations), cosmological reverence can be seen a sub-category of cosmophilosophy that captures ideas suggesting we can deeply revere the universe for a variety of reasons, including that we are intimately related to, and dependent on the universe since we arose from a long complex process of cosmic evolution and rely on the universe's material and energy for our existence and future evolution. We can revere the universe for purely scientific reasons, as well as any awe and majesty we might have in the face of the universe's magnitude, mysteries and complex evolution (Carroll 2016). The definition of cosmological reverence suggested here is a kind of one-way relationship in the sense that it is limited to the cosmos being significant for us, but not the reverse. Cosmological reverence recognizes that we are a product of, and sustained by the universe, but does not claim that we have any particular significance for the universe at large.

2.4.2 Cosmocultural Evolution

Cosmocultural Evolution emphasizes the idea that physical cosmic evolution and emerging cultural evolution are co-evolving and will continue to more tightly co-evolve in the future, with both having significance for each other—both are evolutionary dynamics that are in some sense on par with each other in terms of significance. One way to think about culture is as the "collective manifestation of value"—where value is that which is valuable to "sufficiently complex" agents, from which meaning, purpose, ethics, and aesthetics can be derived. Culture manifests value in many varied forms, from thoughts and knowledge to symbolic abstractions to social norms and organizations to mass movements and large-scale creations (Lupisella 2009).

We should avoid such a strong distinction between cosmic evolution and cultural evolution that they are thought of as completely distinct from each other. Cultural evolution is ultimately a part of cosmic evolution in the broad sense that culture has emerged as part of the physical evolution of the universe. However, we can make a useful distinction to the extent that culture is a different enough evolutionary phenomenon from the rest of physical cosmic evolution. It can be a useful distinction to the extent that it can help address the interesting question of how significant cultural evolution may be in a cosmic context.

One version of a cosmocultural evolution perspective can be thought of as "bootstrapped cosmocultural evolution" which suggests the universe has "bootstrapped" itself into the realms of value, meaning, and purpose via culturally evolving beings like ourselves—but for no particular reason other than the physical characteristics of the universe allowed for life and intelligence to emerge and evolve naturally. Stronger versions suggest that cultural evolution could become a very significant, if not dominant form of evolution with possibly infinite potential and significance—similar to ideas touched on previously. Cosmocultural evolution suggests that cultural beings may become, and perhaps already are, a kind of cerebral cortex for the universe—a source of self-awareness and intentional creators and arbiters of value, meaning, and purpose (Lupisella 2009). It seems we are a way for the universe to not only know itself, but to *value* itself.

2.4.3 Connection-Action Principle

Treading deeper into the stormy waters of what is arguably at least part metaphysics, we can ask why the universe exists at all and why its evolution appears to have been a very long-lived, highly dynamic and creative process. What is its "source", if any? A brute-fact explanation would generally refer to the laws of physics and/or initial conditions of the universe as facts to accept without cause or explanation, and those laws and conditions explain why and how the universe evolves and creates. More specifically, a purely scientific explanation would suggest that an initial high-energy, low entropy state naturally gave rise to expansion,[6] with cooling and "clumping" emerging over time, consistent with the second law of thermodynamics, gravity, and other physical forces, causing the aggregation or "creation" of objects like atoms, stars, galaxies and planets.

But we can still ask, as many have, why those initial conditions? Why these laws? Even more challenging, why any "order" or laws to begin with? Why an origin at all? And was it truly from "nothing" as some have suggested?[7] Merely being able to ask these questions does not mean they are well-posed or that they have answers, let alone scientific answers, but there have been many suggestions, some of which overlap heavily with what was touched on prior, including, for example: (1) design by a God or gods or some kind of entity or beings, including the possibility that our universe is a simulation of sorts (Bostrom 2003), (2) anthropic principles (e.g., Barrow and Tipler 1994), (3) an eternally oscillating universe, going back to the Greeks and forms of eastern worldviews such as Hinduism and now by some in modern cosmology (e.g., Steinhardt and Turok 2002), (4) cosmological natural selection (Smolin 1997), (5) a metaverse or multiverse that suggests the possibility of many universes (Tegmark 2003), to (6) even more provocative versions of anthropocentric thinking that suggest conscious beings in some sense create the universe and possibly even its laws via extreme interpretations of quantum mechanics—as touched on previously (Von Neumann 1996; Wheeler 1990; Davies 2009).

Regardless of the kind of explanation for our universe's origin and its particular laws and initial conditions, most suggestions seem to rest on, assume, or at least imply that our universe is dynamic. It appears we live in a universe of *action*—and action is central to our understanding of our universe (Turchin 1993; Mermin 2017).[8] Even contemplations of an origin as a quantum fluctuation from a quantum vacuum state or quantum "foam" (a realm of virtual particles which are wavelike

[6]The expansion may have included an extremely rapid and unusually accelerated "inflationary" expansion suggested by inflationary theory (Guth and Steinhardt 1984; Linde 1994; Guth 1998).

[7]See Krauss (2012) for a recent scientific exploration of an origin from nothing, but which nevertheless seems to fall short of explaining the emergence from truly "nothing"—at least in the traditional philosophical sense of truly nothing (itself a premise Krauss appears to challenge).

[8]Valentin Turchin (1993) explicitly, and seemingly necessarily, links the epistemological criticality of action with an action ontology. Mermin (2017, p. 89) emphasizes the importance of action when he writes of QBism: "in QBism, on the other hand, a measurement can be *any* action taken by any user on her external world. The outcome of the measurement is the experience the world induces back in that particular user, through its response to her action." This is very similar to Relational Quantum Mechanics which is touched on subsequently.

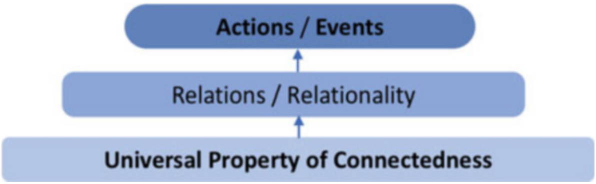

Fig. 12.1 Graphical representation of the connection-action principle

fluctuations in the quantum vacuum at "absolute zero") seems to imply there is still "something" that is "dynamic". The quantum vacuum state appears to at least posit, if not be in actuality, a realm of action, or at least a realm that gives rise to some form action—as if the quantum vacuum state itself is unstable and must produce action. We seem to live in a fundamentally action-laden universe. But why should there be any action all?

The connection-action principle (CAP), in its simplest form, makes the conceptual suggestion that *the universe's property of connectedness is manifested as action*—perhaps in ever-increasing degrees and perhaps *necessarily* in stronger versions, which might read something more like: the universe's necessary property of connectedness is necessarily instantiated as relations and actions and increasing degrees thereof (Lupisella 2016, 2020) as illustrated by the simple graphic below (Fig. 12.1).

This admittedly speculative suggestion leverages the old idea of the connectedness of the universe (Sciama 1959; Bohm and Hiley 1993), but goes further and suggests that for the property of connectedness to be realized, something needs to happen, some action or event needs to instantiate and realize any connectedness or relationship—where relations can be thought of as slightly more specific and more concrete forms of connectedness. In that conceptual sense, the property of connectedness is a source of action, a kind of "cause" for action. An action occurs to help realize connectedness and relations, i.e., to make connectedness and relationality *real* or *actual*, to manifest and instantiate what can be thought of as a kind of "relational potential" of the universe.

The connection-action principle is arguably consistent with relational metaphysics in general and process philosophy more specifically (for which Whitehead's "actual events" are a critical element of his ontology (Whitehead 1929)), and may provide a conceptual explanation for why there should be relations, processes, actions, and events at all. CAP is arguably consistent with a number of ideas such as Action Ontology (Turchin 1993) and other ideas such as Relational Quantum Mechanics (Rovelli 1996), quantum entanglement (potentially revealing an additional form of deep connectedness), and information-based ontologies (Lloyd 2006; Davies and Gregersen 2010), including Bohm's notion of "active information"

(Bohm and Hiley 1984, 1987, 1993; Bohm 1989)[9]—where information can be thought of as the details that characterize and specify relations.

Even quantum field theory (QFT), an increasingly prevalent and successful practical framework for quantum mechanics which leverages field constructs, can also be viewed as suggesting deep degrees of connectedness and relationality in the sense that the notion of a field is a singular seamless "*intra*-connected" construct that fundamentally drives and manifests physical dynamics. Notably, the field construct can arguably be traced back to Newton who speculated about some "action at a distance" between bodies to help explain gravitational forces, and more recently, QFT can be traced to a third major early formulation of quantum theory (the first two coming from Schrodinger and Heisenberg) which was first developed by Paul Dirac and has been called, notably, the *Interaction* Picture (Sakurai and Napolitano 2017).

For a stronger version of the connection-action principle that suggests the universe *increasingly* manifests its property of connectedness through increasing degrees of action, and hence increasing degrees of diversity and complexity, etc., then the connection-action principle is arguably consistent with Many Worlds interpretations of quantum mechanics, multiverse, and the temporal version of the Principle of Plenitude (Lovejoy 1936) in the sense that they are arguably examples of a robust realization of CAP since they produce increasing degrees of action in the form of complexity and extreme diversity and creativity more generally over time.

This kind of theoretical conceptual proposal can be interpreted to suggest that the universe is "about something"—something admittedly very general and perhaps highly open-ended and even vague, but if the universe is about something like realizing connectedness through action, we can further interpret that to suggest a kind of value associated with the universe's action-laden evolution—a value "intrinsic" to the nature of universe. In this view, cosmic evolution can be generally seen as a realization of the universe's potential, and specifically, the more "action" in the universe (where, again, action can be interpreted very broadly, including creating new relations, "objects", complexity, diversity, etc.), the more its nature is realized. This can then lead us to ask if and how this kind of speculative metaphysics might directly or indirectly inform worldviews, values, meaning, purpose, etc.

3 Can the Universe Be Enough?

Here we'll consider a slightly different question from the title and ask: *can* the universe be enough? This will allow for a more general, theoretical, and future-oriented assessment. Whether the universe can be enough to provide a sufficient basis for worldviews depends on many details—including details of the worldview itself and the needs of the individuals and groups holding the worldview(s). There

[9]There are a number of speculative and far-reaching applications of active information to psychology and mind, including connections to value and meaning (e.g. Pickering 1995; Pylkkänen 2016).

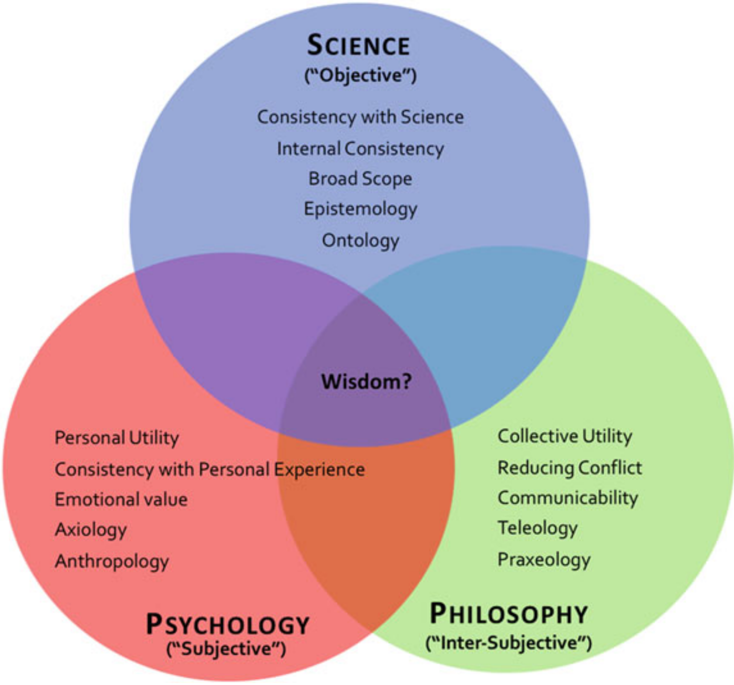

Fig. 12.2 Worldview Evaluation Lenses (on-line version in colour)

are many ways we can go about addressing questions regarding if and how the universe can suffice as a basis for worldviews. We will draw from a few sources to develop some lenses through which to assess the utility of the cosmological worldview ideas touched on prior, with an emphasis on the cosmophilosophy ideas that attempt to explicitly address philosophical questions of value, meaning, and purpose in the context of modern cosmology.

3.1 *Assessment Methods*

We can start by considering three general lenses through which to analyze the worldviews touched on in this essay: science, psychology, and philosophy—all of which overlap and inform each other as indicated in Fig. 12.2. Clement Vidal (2012) offers a comprehensive and detailed framework for evaluating worldviews, particularly in the context of modern cosmology (Vidal 2014), consisting of: (A) 6 philosophical dimensions (descriptive, normative, practical, critical, dialectical, synthetic), (B) a philosophical agenda for defining what a worldview is, (C) several "objective", "subjective", and "inter-subjective" evaluation criteria, and (D) a set of tests, including "first order" tests of is-ought, ought-act, and is-act.

This paper will loosely apply the evaluation criteria from item C above: objective criteria of *internal consistency*, *consistency with science*, *broad scope*; subjective criteria of *utility*, *consistency with personal experience*, *emotional value*; and inter-subjective criteria that address social factors such as *collective utility*, *reducing conflict*, and *communicability*.

Interestingly, as suggested in Fig. 12.2, while not a perfect mapping, Vidal's worldview evaluation criteria categories (objective, subjective and inter-subjective) map reasonably well to the categories of science, psychology and philosophy in the sense that science attempts to pursue objectivity, psychology is more about subjective personal experience (with increasingly powerful scientific methodologies), and philosophy has a lot to do with how people think, value and act with respect to each other (also subject to scientific investigation, e.g., including via social psychology). The philosophy lens we'll use here may differ from Vidal's inter-subjective category in the sense that his inter-subjective category is arguably a bit more pragmatic for group functioning, while the philosophy lens I have in mind is more aspirational, speculative, and theoretical (but with potentially important practical consequences). So, while there is critical overlap between these three lenses,[10] to simplify the usage in this essay, we might summarize by saying that science attempts to understand what is real about the world, psychology is more about how people actually operate, and philosophy is more aspirational and speculative.

While Vidal's framework is closest to the 3 kinds of lenses I'd like to use for this essay, Fig. 12.2 also includes key elements from other frameworks for how to think about worldviews. Johnson et al. (2011) suggest 6 general areas for worldviews that interrelate and can help integrate between culture and religion. I list 5 of those in Fig. 12.1: ontology, epistemology, axiology (proximate goals and values), teleology (ultimate goals), and praxeology (codes of behavior). Hedlund-de Witt (2012) builds on previous work and constructs a 5-part "integrated worldview framework", two of which are "anthropology" and "social vision" (the other 3 are ontology, epistemology, axiology—similar to Johnson et al). "Anthropology" is described as a perspective on who and what the human being is and any potential roles and positions we might have in the universe. This articulation is helpful for the purposes of this essay and is arguably different enough from other factors to list explicitly.[11] Hedlund-de-Witt's "social vision" is arguably captured by other elements listed such as collective utility and praxeology.[12]

[10]Psychology is obviously informed by science, empirical study, etc., including via emerging fields such as evolutionary psychology. Philosophical, speculative, normative explorations should be informed by science, but not limited by science.

[11]Hedlund-de-Witt's "anthropology" is also related to teleology and other areas shown under science and philosophy, but since it is somewhat narrow in the sense of having an important individualistic component and being limited to anthropocentric views, I've included it in the psychology lens.

[12]Obasi (2002) develops a 41 item "Worldview Analysis Scale" targeted primarily for people of African and European descent. Project Worldview is an online collection of many different facets of worldviews and provides diverse guidance for thinking about and analyzing worldviews: http://www.projectworldview.org/welcome.htm

Worldview evaluations would likely come out differently depending on any number of factors regarding how we think about the categories and criteria, including how they're weighted, but we can keep this overall kind of evaluation framework in mind as we briefly assess if and how the universe might suffice as a basis for worldviews. It is notable for our assessment that Vidal suggests twice as many subjective criteria than objective criteria, which is important for evaluating worldviews since they often need to address a range of complex subjective human needs and interests.

3.2 Cosmological Worldview Assessments

Most of the cosmological worldviews noted previously are arguably strong on the scientific/objective criteria (e.g., internal consistency, consistency with science, broad scope, etc.), with the exception that depending on the interpretation of traditional theological views (e.g., whether modern science is significantly incorporated) those views can be seen as weaker on the objective and scientific criteria. Indeed, the point of most of the cosmological worldviews noted here are to be more consistent with modern science and modern cosmology specifically. However, most of the views noted prior are arguably relatively weak on most of the subjective psychological and philosophical criteria, much of which are presumably driven by natural selection and evolutionary psychology, including group selection—e.g., coping with uncertainty and death, maintaining group cohesion and efficacy, etc. (Wilson 2002; Haidt 2012).

Cosmological Reverence suggests we can value the universe because we emerged from it and are intimately bound up in it, but we do not have any particular significance for the universe at large. So while there can be some emotional value as well as personal and collective utility (including communicability), presumably the emotional value would be limited, not just because we are not significant for the universe and can't discern important future-oriented implications, but also in part because it is arguably difficult for many people to personally or collectively identify with our immensely old, large, and seemingly impersonal and indifferent universe. More specifically, such a view does not have much, if any, specific practical consequence or utility for dealing with social challenges such as reducing conflict—with the possible exception that revering the universe can help us revere each other as products of cosmic evolution and hence deal with each other more respectfully. Cosmological reverence is primarily a kind of one-way "passive reverence" for the cosmos, but it can nevertheless inspire and inform certain ethical views such as how we might value certain cosmic creations, including each other and other life-forms more generally (Lupisella 2013).

Cosmocultural Evolution is a stronger view in the sense that it can suggest a certain amount of responsibility (perhaps a kind of "cosmic" responsibility?) for intelligent beings since cultural evolution has the potential to have much, perhaps unlimited, significance for the cosmos—but again, for no other reason than cultural agents arose via physical processes and now have agency and can choose and act on forms of cosmocultural evolution value systems or worldviews. On this view, we can see not only the kind of significance noted by Paul Davies and others that "Somehow, the universe has engineered not only its own self-awareness, but its own self-comprehension" (Davies 2009, p. 385), but also, as noted prior, that the universe has "engineered" its own *self-valuing*. This might have some emotional value in the sense that it can be seen to provide compelling cosmic significance specifically for beings like ourselves. We may see ourselves as a source of cosmic value where there otherwise may have been none prior. Such a view might have more social inter-subjective philosophical value in that it can provide groups of people, or perhaps all intelligent/cultural beings in general, with a common/collective sense of meaning and purpose within what may be the largest shared context possible—the universe.

The Connection-Action Principle goes much further and can be interpreted to imply value based on a claim about the nature of the universe. As touched on prior, while the suggestion is arguably supported by a number of lines of philosophical reasoning and has some consistency with scientific and philosophical ideas, it is nevertheless essentially speculative metaphysics that arguably lacks sufficient physical commensurate evidence or sufficient predictions and tests needed to be persuasive and adopted as a convincing worldview. Its value-based implications are not likely to be implications many people could easily identify with or defend. Manifesting the connectedness of the universe through myriad forms of relations and actions may have some appeal and moderate practical consequence in the sense that our connections with others and our wider world might motivate us to act on behalf of those connections and relationships, but details beyond that may not ring true for many people given the highly speculative, conceptual, and abstract nature of the claims.[13]

Cosmocultural evolution, particularly *bootstrapped cosmocultural evolution*, seems like it might be a tenable "meaningful" cosmological worldview for beings like ourselves because while it may seem somewhat speculative, it does appear to be defensible to say that the universe has essentially "bootstrapped" itself into the realms of value, meaning, and purpose—at least in the form of human minds, if not in others as well. This realm of value, meaning, and purpose has then emerged in the universe through cosmic evolution, through the evolution and emergence of our minds and perhaps other minds that may exist throughout the universe. And the potential for this valuing capacity, for the meaning-making and purpose-seeking we do with our cultural evolution, may have unlimited potential for the universe as a

[13]We should also be sensitive to concerns that in the worst case, tying a speculative form metaphysics to human affairs can be dangerously problematic depending on how certain details are developed and used.

whole. We may be a way for the universe to value itself and to find many different, perhaps infinite, valuable evolutionary paths forward.

There may be other forms of value independent of beings like ourselves, but it does nevertheless appear that beings like us are at least one means by which the universe is finding or "discovering" forms of value, meaning, and purpose in what may be an extremely large, if not infinite, possibility space of those qualities. If there is no broader objective meaning and purpose in the universe beyond that which is created by cultural beings, then that realization may help us value each other more.

The claim that value, meaning, and purpose have emerged in the universe as a product of cosmic evolution is in some sense a minimalist view (some may say it's trivially true), but it's potentially significant nonetheless. It is intellectually and philosophically minimalist in the sense there is no need to invoke some other kind of dynamic or force or substance in the world such as spirit or God. There is no appeal to a wholly other "transcendent" reality. However, the implications and significance are still notable in the sense that if value, meaning, and purpose has emerged in the universe through us, then we are arguably "responsible" for it. We are creators and arbiters of value that not only makes the universe valuable, but we also pursue very specific forms of value, e.g., having to do with morality and ethics and endless forms of creativity. Indeed, if we choose to do so, we can make the universe "purposeful" in the sense of enabling trends and choosing "directions" for the universe. It is up to us to decide, to choose. Presumably there will be many such diverse pursuits which call for careful deliberation and pluralistic meaning-making with each other.

4 Synthesis and Summary

If our worldviews need to be comprehensive and include specific guidance for human behavior and address most of our complex subjective needs, then the universe is probably not enough for most people most of the time—more would be needed to help address, and perhaps compel, certain kinds of human expectations and behavior. Also, there are broader questions such as why the universe exists at all, or more generally, why there is something rather than nothing, that modern cosmology arguably doesn't provide good answers for—and "brute fact" scientific explanations often don't suffice for many people—partly because they don't personally resonate for many of us.

From a more philosophical perspective, even if the universe is "about something", if there is some fundamental cosmic nature to be realized (e.g., as suggested by the connect-action principle, which in theory allows us to "derive" "intrinsic" value from something we think the universe may be about) it is still arguably too non-specific and abstract for most people to identify with. Further, it isn't clear that intelligent beings must adhere to, or adopt, pursuits consistent with what we think our universe is about. We may of course be wrong about what we think the universe is about, and even if we're right about the "facts", the science, or whatever metaphysics is relevant, the old philosophical fact-value or "is-ought" distinction (including the "naturalistic fallacy", Moore 1903) still arguably gives us an option to freely pursue aspirations beyond our understanding of how the world is.

Nevertheless, for some people some of time (possibly all the time for some people), the universe could suffice as a basis for a worldview depending on certain details of the worldview and the needs of the individuals and groups. If a person or group can sufficiently identify with the universe then the universe might be a sufficient overall worldview construct—particularly if some value or meaning, however loose and high-level it might be, can be inferred from cosmic evolution (e.g., forms of cosmocultural evolution). Those who don't need a worldview with many, or any, prescriptive details for guiding human behavior might also see the universe as a sufficient basis for a worldview to the extent that they don't need it to bridge into details of human life—e.g., to provide some sense of caring or how to deal with death, etc.

We might infer from some of the above reasoning that any "single" worldview might not be able to address the full breadth of human needs that many individuals or groups have. The universe can be a big part of a worldview or be one of a few simultaneously operating worldviews (inter-related or not). We can revere the universe, and maybe even see ourselves as integral to its evolution (e.g., cosmocultural evolution), but how we choose to guide our human actions can be independent of our broader cosmological worldview—as it appears to be today for many people. We can have a kind of hybrid worldview, or a 2-part worldview—one for the universe and one for the details of human life—for which there can be important overlap and relationships, but for which neither completely informs, determines, or depends on the other. As touched on prior, our broader scientific knowledge about the universe can lead us to see ourselves as having randomly evolved from cosmic evolution without any larger cosmic purpose, but with a potential implication that we can see ourselves as needing each other to make our way in an otherwise indifferent universe.[14]

We can also be sensitive to the idea that we might be asking too much of our worldviews if we expect them to provide answers to everything. We should be mindful of the idea that no combination of worldviews would necessarily provide complete and irrefutable answers or satisfying sources of comfort, meaning, and purpose for all of our questions and needs. We may be misguided, or at least unsatisfied—and possibly deeply disappointed and adversely psychologically affected—if we expect our worldviews to provide too much. Living with uncertainty is challenging for many, but we do it. Indeed, there appear to be many people who don't require worldviews that provide answers to everything. Those who claim they are "unaffiliated" with any religion make up the third largest group in the world—

[14]Secular humanism is arguably a minimalist science-based worldview that informs human ethics and can be added to more explicit cosmological perspectives that provide a broader sense of reverence and meaning beyond secular humanism, (perhaps something like "secular cosmism"?) which might then give rise to a more complete worldview for some.

about 16% as of 2015 (Pew Research Center 2017). This doesn't mean the unaffiliated don't have any theistic, deistic, or spiritual beliefs, but it does arguably imply that a large number of people don't need traditional "comprehensive" religious worldviews that prescribe details for human living and answers to many other questions. However, many of those who are unaffiliated with religion almost certainly have some kind of worldview(s).[15]

So for now, a reasonable conjecture as to whether the universe can be enough to suffice as a basis for worldviews is that while it might suffice for some people some of the time, it is not likely sufficient for most people most of the time.[16] However, one might further postulate that over time, many of the needs people have for worldviews could change or be reduced, perhaps increasing the receptiveness for the kinds of cosmophilosophical/cosmological views explored here (for example, including a kind of "secular bootstrapped cosmocultural evolution" worldview). A proxy, or analog, for this suggestion is research that shows the more socially stable, comfortable, and educated people are, the less religious they apparently are (Barro and McCleary 2003; Gill and Lundsgaarde 2004), perhaps further implying less need for comprehensive worldviews that definitively address uncertainties and fears for meeting human needs.

As we become more knowledgeable about human emotions and how to better deal with fear, uncertainty, fairness, and human relations more generally, we may find an increasing receptiveness to alternative worldviews that may be less specific, less prescriptive, less personal, less comprehensive, less definitive.[17] As our knowledge and "caring capacity" improves, we may be able to care for each other better (Lupisella 2013) and perhaps then increasingly tolerate a variety of uncertainties.[18] Decreases in religiosity in many parts of the world may be an indicator that this kind of trend is already underway. Our descendants may be better equipped to be more receptive to alternative worldviews, including cosmological worldviews.

Speculating further, forms of artificial intelligence may have very different needs regarding worldviews—including that they may not need any at all (at least in the way we think about worldviews today). Presumably, however, artificial intelligence

[15]A Pew Research Center report (2012), "The Global Religious Landscape", notes that many unaffiliated people still hold religious or spiritual beliefs such as believing in God or a "higher power" (68% in the United States).

[16]If it hasn't already, this question can probably be empirically addressed with psychological research.

[17]Van den Bos (2009) suggests that cultural worldviews are a way to cope with personal uncertainty. Van den Bos and Lind (2009) suggest that the way people assess fairness has much in common with the social psychology involved in defending worldviews. Related, Henriques (2011) suggests that humans are "the justifying animal"—uniquely powerful creators of justification systems. This seems consistent with the idea that one of the functions of worldviews is to help justify many aspects of the human condition—e.g. what we value and why, why we're here and do what we do, what our aspirations ought to be, etc.

[18]A significant challenge that many intelligent beings may face is to at least tolerate, if not ultimately accept, the enduring uncertainty of an apparently objectively "pointless" universe (Lupisella 2009).

will need something to guide actions, but such entities may not have the kinds of human needs we see today that are, at least in part, the result of Darwinian evolution. The more capable a species becomes, the more choices there are, the more values there can be, the more philosophy matters (Lupisella 2015). Artificial intelligence, or superintelligence more generally, will presumably be able to explore broad possibility spaces very quickly and have a high tolerance for uncertainty and indifference regarding a lack of broader "objective" meaning or purpose, or the need to be cared for, or to exist forever, etc. For our descendants, or for other advanced beings, either biological or "post-biological" (Dick 2003; Schneider 2015), the universe may indeed "be enough".[19]

The working hypothesis from this brief examination suggests that the universe, in the form of "cosmological worldviews" that focus on scientific cosmic evolution, probably isn't enough for most people most of the time, but could be enough for some people some of the time. However, the universe may increasingly suffice as we evolve and as more advanced intelligence evolves. If we're not satisfied with worldviews we see today, then we can keep working on new ones. Our evolving Cosmos seems to be a good place to start.

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[19] Bell (2016) explicitly treats questions regarding the relationships between superintelligences and worldviews.

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Chapter 13
The Universe Decentered: Transcultural Perspectives on Astrobiology and Big History

Mukesh Chiman Bhatt

The interpretation of all ancient systems requires a constructive effort; . . . of the translation of ideas into modern concepts. (K.C. Bhattacharya, 1956, p. 127)

Abstract Of the major nations with space capabilities, India and China represent almost a third of the world's population, are prominently represented in Western research establishments and technology companies and have cultures that differ from the West. Perspectives on astrobiology and alternative versions of Big History as accepted in these cultures are presented to complement a Euro- and Christo-centric Western focus. They integrate supposedly novel worldviews into an existing framework, with implications for science, society, politics and rights.

1 Introduction

Asian cultures have a long history and tradition of speculation, scepticism, science, technology and philosophy (Menon 2009; Bose et al. 1971; Needham 1962 onwards 1962; Lach and Van Kley 1998; Hobson 2004; Dusek 1999; Al-Khalili 2012; Joseph 2011; Sudan 2016, amongst others). Technologies continued to develop and be applied within Asian world views throughout the passing millennia. They did not require Western science or its paradigms for this. Further, it is inevitable that cultures mingle, assimilate and hybridise given the globalisation of the world since 1500 CE. For example, global cultural exchange is behind the acceptance of Western medicine through a process of transformation into indigenous concepts in parts of Africa (Baronov 2010), and the assimilation of witchcraft (or tribal practices) into the

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paradigms of development as per Western economic and agricultural practices amongst the WaTaita in Kenya. Acceptance and assimilation of new concepts into an existing framework is a common phenomenon: Smith (2010), a practising Jew and an astrophysicist, discusses the relevance of modern cosmology to Judaism and the Kaballah. Earlier, Confucianism, Taoism and Buddhism were brought into a common synthesis called neo-Confucianism (Capra 1975), which apart from Communism is the dominant philosophy and practice informing the lives of the Chinese. Japanese manga and animation successfully marry Shinto and Buddhist cosmologies with twentieth C. technologies (Arrighi in Rambelli 2019, Chap. 9; Nakamura 2001). Tradition and ancient practice may also linger despite later restrictions: Braudel (1995, p. 267) cites the example of a Muslim farmer in Indonesia who sacrifices to Shri, the Hindu goddess of fortune and wealth, for a bounteous harvest. Muslim Indonesia (which includes Hindu Bali) has erected a statue of Saraswati, the Hindu goddess of education and wisdom at its embassy in Washington, D.C., symbolising "values that parallel with several key principles of Indonesia-U.S. relations" (The Hindu 2013). Cultural continuity is shown by the numerous forms of the Rāmāyaṇa extant from Sri Laṅkā eastwards into the Pacific (Acri et al. 2011). In addition, modern neuroscience has taken inspiration from Buddhism and its models of psychology (Damasio 2005), applying old concepts to new observations obtained using new methods.

Given the adoption of scientific method from Islamic scientists (Al-Khalili 2012), the base pre-suppositions and assumptions of these borrowings must have been judged to be both consistent and coherent with Western philosophy and science. Capra (1975 on natural law and physics) and Damasio (2005 on neuroscience and Buddhism) have looked at unifying Eastern and Western conceptions, as has McEvilly (2002). Other notable examples are the similarities between the Buddha and Hume (Gopnik 2009) on conceptions of the mind; the exclamation by Oppenheimer upon viewing the detonation of the first atom bomb: "I am become the Destroyer of Worlds" a mistranslated quote from the Bhagavad Gita (Temperton 2017) or the numerous references to Eastern concepts and wisdom by (again) Oppenheimer, Schrödinger, and Bohr as quoted in Capra (1975); and Carl Sagan discussing Vedic cosmology in his series *Cosmos* (available on YouTube[1]). Thus Carlo Rovelli (Commissariat 2018), on reading the *Mūlamadhyamakakārikā*: "something new is not a threat, it's exciting". David Christian in his *Maps of Time* (2011) quotes from the Ṛg Veda (dated around 1200 BCE) regarding speculations of the origin of the universe. The cultures of India and China must have had some influence on Western science and technology.

The Indian cultures have also written a big history (Perrett 1999): based on speculation that includes oscillating universes with alternating cycles of creation and destruction, and a big bang equivalent, and worked out its ethical and other consequences from an atheistic non-soteriological, non-teleological, non-eschatological perspectives. The continual creation and destruction of matter, the universe from a singularity, materialism, evolution, deep time, multiple

[1]https://www.youtube.com/watch?v=gR-UEd6YNW8.

universes, possibly inhabited planets, and aliens are all seen to be part of the internal structure of Indian cultural hegemony. Speculations on planetary geology mentioned in Sanskrit texts have been presented by ISRO employees at UNOOSA meetings, an activity similar in principle to reports and papers on mediaeval European or seventeenth century speculations about the composition or inhabitants of the planets. These concepts are normal to those brought up in these cultures. As Lingam and Loeb (2020) have stated: "most of the major surviving South Asian religions" consider that "Earth is not alone in hosting life".

1.1 Context

India, China and their associated hegemonic populations comprise about 30% of the global population. Within the dominant economies, 22% of STEM students in the USA are of Indian or Chinese descent or nationality. China and India are global space and economic powers with military and civilian space capabilities, having used ASAT weapons to destroy satellites. In 2009, 17.2% of the employees in the Indian space industry at ISRO were women; in 2019, the figure remains under 20%. Figures for China are not available at the time or writing (Funk and Parker, Pew Research Centre 2018). In the USA, certain ethnic minority groups are more likely to go to university and then end up in research. Data is available for those attending university, but not for those actually engaged in research at PhD level or after. However, anecdotally the proportion of Indian and Chinese nationals engaged in research in the major research countries is high (Ecklund et al. 2016): 21% of Asians in STEM jobs have a postgraduate degree as compared to 11% in the total population; this compares with 13% in all professions at all levels, and with 6% in the general population. This 21% is about the same as the proportion of Indians, Chinese and Japanese (but not their hegemonic nations described above) as a proportion of the world's population.[2] In 2019, *Nature* placed the world's top scientific institution in China, with China and India ranking 2nd and 13th respectively in science. Asians also have the lowest attrition rate in STEM studies (Elliott et al. 1996). China, India and Japan are in the top ten for citations.[3] Saini (2011) has examined the contribution of scientists of Indian descent and nationality.

US astronauts Kalpana Chawla and Sunita Williams are of Indian origin: the former was the first woman of Indian origin to go to space, before her unfortunate death in the Challenger space shuttle disaster; the latter previously holding the record for the most space walks and the most spacewalk time for a woman with multiple excursions and stays on the International Space Station.

From my personal viewing and cultural knowledge, depictions of advanced, technological or alien cultures exemplify this influence. *Star Trek: The Next*

[2]Calculated from https://en.wikipedia.org/wiki/World_population.

[3]https://www.scimagojr.com/countryrank.php. Accessed 12 Nov 2020

Generation (Roddenberry 1987–1994) in the 1980s introduced the Ferengi and the Jemhadar, both words in common usage in the Indian languages; fictional advanced extra-planetary cultures have changed from wearing white robes or shiny synthetics in the original 1960s *Star Trek* (Roddenberry 1966–1969) to wearing colours of the sunset in *Star Trek: Picard* (Goldsman et al. 2020), i.e. rust reds and oranges which indicate enlightenment and compassion in the Indian cultures.

1.2 Aims and Objectives

Existing frameworks from Asian cultures may be cautiously adapted to the development of a narrative myth for modern science similar to that of astrobiology and big history, without denying the positive approaches of Western science and culture. A cross-disciplinary transcultural perspective can use alternative paradigms within indigenous perspectives of science, and thereby evolve new methods and approaches with significant impact on the political, cultural and social direction of the population. Although not part of a decolonial project, this approach extends our notions and understanding of narratives, and the philosophy and frameworks of science by how such antique approaches may be used to explain, or otherwise provide alternative paradigms, and thus make science a truly inclusive human endeavour. The specific aims of the present approach are:

1. To show that a culture with a narrative combining astrobiology and big history exists;
2. To show how non-scientists compare western science with their own cultural analogues;
3. To derive various consequences that structure political, social and personal attitudes within a culture that has such a narrative myth.

2 Astrobiology and Big History

Astrobiology describes the basis, conditions and processes that determine the existence of life. Unlike its related disciplines, exo-biology and xeno-biology, it focuses on parameters for life that may be similar to or of terrestrial origin, although not exclusively so. Big History on the other hand is a description of what are considered significant actions, behaviours and events in the history of life in the universe: "a new 'single reckoning of the past' that begins with the big bang and ends with the fate of the universe billions of years in the future" (Benjamin et al. 2020). Big History includes social, cultural, political, urban, agricultural and technological and other human aspects beyond simple chemical, physical and biological perspectives. David Christian states that Big History is universal, collaborative, collective — "an origin story for the Anthropocene Epoch and is the first origin story for all humans.

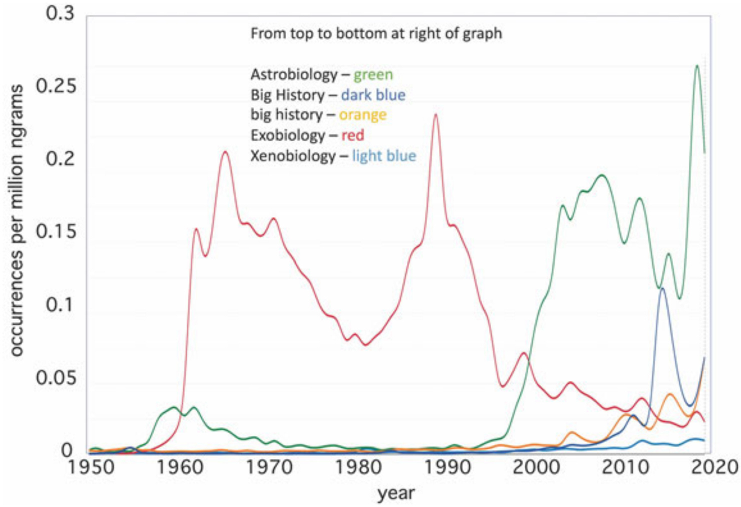

Fig. 13.1 Incidence of various terms in the Google 2019 all-English language corpus plotted from 1950–2019. Redrawn from Google Books Ngram viewer—terms include both upper- and lower-case initialization for astro-, exo-, and xeno-biology

The goal . . . is to empower us by helping us understand the world we live in" (paraphrased from his essay in Benjamin et al. 2020).

Astrobiology as a term has been extant since at least 1898.[4] It is listed as a subject classification for the University of Minnesota (Bulletin of the University of Minnesota Library 1898) for that year; the same year saw a definition for the term: "The question of Jonah and the whale is a problem in Astrobiology, or the science of the relation of humanity and the stars" in The Flaming Sword (Koresh (?) 1898, v13, p. 12). Although they do not include these early examples, and using the same techniques of data mining in Google Books and Google Scholar, Lingam and Loeb (2020) provide a fuller discussion of the etymology and later usage of astrobiology, including topics which fall under the modern purview of astrobiology, but which would not have been referred to as such in earlier times. Similarly, big history has been in use through the centuries for various purposes.

A judicious use of the Google Books Ngram viewer (Michel et al. 2011; which mines millions of texts in several languages for relevant search terms, here astrobiolog+[y/ie/ia/iya]) and Google/Books/Scholar (for inspecting in part the texts revealed by the Ngram searches) reveals several examples. Usage statistics for the various terms are provided in Fig. 13.1 (data mined using Google Books Ngram Viewer on 11 Nov 2020; note the all-English language corpus includes world Englishes with a dominance of British and American English). The y-axis on all

[4]Bhatt, M. C.: The UnCentred Universe: Transcultural Perspectives on Astrobiology and Big History from India and China; presentation at "Expanded Worldviews II" conference held at Birkbeck College, University of London, September 2019.

graphs provides a relative frequency of the term in relation to the total number of one-word or two-word phrases in the entire corpus of over one million digitized books, or ngram and bigram in Google's terminology. The term "astrobiology" correlates almost exactly with "big history", whether the initial is capitalized or not. Astrobiology has also been used in parallel with exo-biology and xeno-biology (Fig. 13.1), the latter two being inclusive of non-terrestrial and non-human definitions of life, whereas astrobiology appears to constrain its version of life in definite ways. Exobiology, xeno-biology, and their unhyphenated variants, have been generally used after 1955, with a peak use for exobiology in the 1960s, dropping towards 1980, and increasing again to peak around 1990, its use decreasing again from 1996 onwards. Exobiology appears more popular in usage than astrobiology from around 1960 onwards. The latter is less used until around the late 1990s. when exobiology usage drops off as the use of astrobiology increases. Xenobiology usage also increases and correlates with the increasing use of astrobiology. The French term "astrobiologie" appears much earlier (1930s and 1940s) in the French language corpus and is used earlier in both the all-French and all-English language corpuses, then drops off considerably in the all-French language corpus, with intermittent and increasing use of the French term in the all-English language corpus from 1960 onwards.[5] Although not shown here, there is similar increasing use from the mid-90s for the equivalent terms in the French, Italian and German respectively, but not in Spanish language corpuses. A likely reason for its later and wider adoption in all languages is that astrobiology as a field is strongly tied to the NASA program, providing practical and useful parameters in the search for life (Lunine 2005).

When the history of humanity and its development and artefacts is included in more detail in this history, the narrowing of perspective appears as a description of the fine-tuning of the universe, an approach which considers that for terrestrial, and especially for human life to exist, there must have been a set of very specific conditions that allowed life in general, and life on Earth in particular to originate, evolve and develop. It would seem that introducing a narrow human perspective is then a restatement of the strong anthropic principle by regarding current humanity as an evolutionary goal, and by then working out the consequences using a bottom-up approach. One aim of Big History (and history in general) is to understand, control and manage the future of humanity (Christian in Benjamin et al. 2020, pp. 16–34), a goal also shared by astrology (Christie 2019) and most religions and which in astrobiology must include the response of humans and terrestrial organisms to space, given the need for a supportive human environment for expansion into space (Lunine 2005).

[5]Why a French (or German, Italian or Spanish) word is being used when writing in English remains uncertain.

Table 13.1 Glossary of Sanskrit terms

Anekānta	"No single conclusion"; many perspectives or aspects to the same thing
Cārvāka	System of Materialism
Hināyana	"Lesser" School of Buddhism
ISKCON	Vaishnavite sect also known as Hare Krishna movement in the West
Jain	Adjective, follower of Jainism, also surname
Lokāyata	Same as Cārvāka; derived or based in the people, societal
Mahāyana	"Greater" School of Buddhism
Mīmāṃsā	System of Ritualism through Action
Mūlamadhyamakakārikā	Core text by Nagarjuna for Madhyamika school of Buddhism
Nyāya	System of Logic
Prakṛti (Prakriti)	Primordial substance, nature, active female principle evolving into the universe
Puruṣa (Purusha)	Catalyst, passive male primordial (later theistic) principle
Sad-darśana samuccaya	Overview of all systems; text by Haribhadra summarising various schools or systems of thought in Indian culture
Śakti (shakti)	Energy, power, strength, female agent identified with Prakṛti; all male deities act through their female aspect. Mother; Time (as evolutionary principle)
Sāṃkhya	System of Evolution
Śiva (Shiva); Śaiva (Shaiva)	Hindu deity; adjective, follower of Śiva
Tantrism	Set of spiritual practices through ascetism, geometric visualisation, sex, etc. Many different and exclusive versions.
Theravāda	Alternative name for Hināyana
Transcendental meditation	Vaishnavite sect also known as TM in the West
Vaiśeṣika	System of Differentiation and atomism
Vedānta	System; Conclusion of the Vedas (Hindu scriptures); several schools each offering differing interpretations of reality; what the West thinks of as the philosophy of Hinduism
Viṣṇu (Vishnu); Vaiṣnava (Vaishnava)	Hindu deity; adjective, follower of Viṣṇu
Yoga	System of personal development
Zen (chan, dhyāna)	Chinese, Japanese and Korean School of Buddhism
Yoga-Vāṣiṣṭha MahaRāmāyaṇa (YVMR)	System extolling deterministic agency (free will and liberty); not fatalism or destiny
Tattva	Building bloc, constituent, aggregated or transformed element

Transliteration using the International Alphabet of Sanskrit Translation (IAST; https://en.wikipedia.org/wiki/International_Alphabet_of_Sanskrit_Transliteration)
Pronunciation ś and ṣ = sh; ṛ = ru or ri; ṃ = preceding vowel is nasalised; ḥ = preceding vowel is lightly aspirated: consonant followed by h = consonant is pronounced with a heavy aspiration; ṭ, ḍ are hard; t, d soft. Vowels are long or short (a, ā, i, ī, u, ū) or long and short diphthongs (e, ai, o, au). The rest are pronounced approximately as in English. All translations are mine and provide a contextual, indirect equivalent meaning

3 Methodology

Subjects which are interdisciplinary need to ensure consistency of method, assumptions and pre-suppositions, without which the different approaches may contradict and undermine each other. Consider astrobiology and Big History, and indeed history in general—their foundational assumptions and pre-suppositions must be compatible and not contradict or undermine their blending. The following sections lay out various aspects of the methodology used.

3.1 Working Definition

As astrobiology and Big History as separate disciplines continue to change, a working definition is useful to define and limit the scope of this paper. Together astrobiology and Big History provide a dominant narrative mythos of modernity and modern science in the twenty-first century where astrobiology is the science of the relation of humanity to the stars and Big History starts with the big bang and continues to the future of the universe.

3.2 Hypothesis

A layperson presumes an equivalence and therefore identity between the results of two disparate cultures without consideration of their foundational values or fear of contradiction, when what instead exists are analogous homologies without presumption of identity. Having shown this, several real-world consequences can be demonstrated and it is suggested that such can be taken across and applied to the paradigms of western science in astrobiology and big history.

3.3 Multiple Viewpoints

Jainism provides the concept of *anekānta*, in which any subject or object is considered from multiple angles in all its aspects, providing multiple perspectives that together form a whole., and which has been adopted as part of the universal methodology across the Indian systems. Like the multiple branches of physics which allow the examination of a system from different perspectives—electromagnetism, statistical physics, Newtonian mechanics, special relativity, quantum mechanics and quantum field theory, chaos and complexity theory (Stevens 1995), the systems of Indian philosophy complement each other and are generally treated not as severally separate but building with and on each other. This helps to assimilate and synthesise what might seem very disparate elements and approaches. *Anekānta* is summarised in the story of the blind men and the elephant, each insisting that the elephant is a flexible hose-like trunk, a tree-like leg, or a floppy ear, or a twine-like tail. Oppenheim and Puttnam (1958–1991) also describe science as unified, each building upon the other, with biology building upon chemistry based upon fundamental physics complementing and informing each other. Anekānta is not the relative and separable truths of post-modernism: it is about multiple perspectives, corresponding to complementary descriptions and different aspects of the same "reality".

3.4 Comparison

Homologies are established using the comparative method in law, whereby a law or institutional structure is identified and compared across different cultures on the basis of a similar or identical functionality and internal relationship within the cultural structures. The comparative approach indicates homology, not an identity or an analogy. Any equivalence of function may be indirect and dependent on cultural or situational difference. Direct equivalence would only be possible where it is intended to replace the structure. The homology may not hold in the presence of new knowledge in physics or the other sciences.

3.5 Assumptions

The following assumptions have been identified in order to ensure consistency across different disciplinary domains, although other pre-suppositions and sources of possible bias may not be listed or identifiable. This should also assist in countering possible cultural and methodological prejudices inherent in the viewpoints of a single dominant culture, here assumed to be the general paradigm and history of Western science.

1. There exists an astrobiology-influenced big history in Indian cultures;
2. An analogy can be made with Western science;
3. There exist homologous structures within the two systems without presumption of equivalence or identity;
4. Global structures selected for discussion are relevant to and at the level of the socio-cultural comprehension of the layperson;
5. Simplification of concepts implies that the two systems need not agree to the smallest detail, mathematical or otherwise;
6. That there exist simple linguistic equivalences for terms in different languages.

3.6 Rigour

Methodological rigour may be compared with four recent papers accepting of dominant culture paradigms finding correlation and inspiration in European antiquity and prehistory. A recent paper (Martens and Lehmkuhl 2020) requesting comments on the arXiv pre-print server uses the consubstantiality interpretation of Roman Catholicism to interpret a parameter describing dark matter and spacetime. Another (Domokos et al. 2020) gets its inspiration from Plato's celestial solids to confirm that the Earth's basic form is a cube. A third (McConnell et al. 2020) makes teleconnections between volcanic eruption in Alaska and civil disorder in 43 BCE in the Roman Republic using several short statements made by contemporary writers. And finally, Neanderthals intuited mathematics and multi-component technologies (Hardy et al. 2020) despite having neither.

4 The Indian Cultures

Although culturally heterogeneous, the cultures of Central, East, South and South-East Asia share a common thread in Buddhism. Panikkar (2010) has shown that Buddhism, Jainism and the various forms of Hinduism all share a common cosmology and cosmogony in which the cosmographical detail does not differ at the scale examined here. In East and South-East Asia, this influence lives alongside Taoism, Confucianism and Shinto. In Central Asia with Islam, and in South and South-East Asia also with Islam, Hinduism is hegemonic or dominant. Interaction between these cultures at Nalanda[6] and other such centres of learning in the Indian sub-continent underlines the synergy and synthesis that gave rise to the six Hindu philosophies (Nyāya, the Vaiśeṣika, the Sāṃkhya, the Cārvaka (also known as the Lokāyata), the Mimāṃsa–translatable as Logic, Differentiation/atomism, Evolution, Materialism, Ritualism/Action,—and Vedānta), these being co-eval with Buddhist (Mahayana and Hinayana/Theravada) and Jain traditions. The Jain scholar Haribhadra (four/fifth century CE) in his *Sad-darśana-samuccaya* (Haribhadra (tr. Murthy) 1970) summarises the traditional Indian philosophical systems, not including the post-fifth C. Vedānta and its derivative traditions. Further, in China in the eleventh and twelfth century CE, Buddhism, Taoism and Confucianism were synthesised into neo-Confucianism (Capra 1975), now also incorporated into Chinese Communism, guiding life, policy and government in China today. The better-known Zen and Tantra Buddhism are extant in China, Tibet and Japan. Essential concepts relevant to the present discussion are from Haribhadra (tr. Murthy) (1970), Bahadur (1978) and Gupta (2012). Interested readers may wish to access Radhakrishnan's 2-volume *Indian Philosophy* (1923) or Das' 5-volume *History of Indian Philosophy* (1975 edition) for details which cannot be covered here. Henotheistic versions of these

[6] https://en.wikipedia.org/wiki/Nalanda.

philosophies with Śiva, Viṣṇu and the Mother Goddess as non-creator deities were also being propagated in parallel amongst the general population.

4.1 Non-theism

All systems, as explained by Haribhadra (tr. Murthy 1970), are considered to have been non-theistic from their inception. There is no concept of a creator God, unlike the Abrahamic religions. Although at one time considered real, the multiple deities or gods of Hinduism and Buddhism were later explained as mental constructs (*op. cit.*, p. 87). This has implications for the Anthropic principle and the possibility of life in the universe which will be discussed.

4.2 Foundations

The Nyāya and the Vaiśeṣika are considered foundational to all the systems: the former provides an epistemological basis for methods of logical and rational enquiry and argumentation from sense perception and inference (including induction and deduction), supplemented by the other systems with analogy, comparison and testimony, which last combines observation and empirical evidence with hermeneutic and expert analysis, and by reasoning from first principles and postulates. The Nyāya classifies all theories as general, particular, those of limited validity and those without empirical or other evidence. The latter is primarily a system of classification, categorisation and differentiation (or difference). Its contribution is the atomistic (as ultimate constituents) basis of matter in its absolute or ultimate stratum, which particles the Buddhists describe as the result of processual interactions. Causal perception is based on empirical experience and in all cases implies that existence is material, and that knowledge is determinate. However, knowledge may also be inferred, in which case it is indeterminate until shown to exist (or proven). This suggests an analogy with the probabilistic determinism and observer interaction of quantum-mechanics and in chaos theory, as the implied determinism otherwise would contradict the inherent pluralist principles of Jain philosophy—the *anekānta* approach of multiple perspectives. Observer interaction has been formalised in the henotheistic development of the male principle discussed below, and which forms the basis of an emergent consciousness and self-awareness in the Indian systems.

4.3 *Cosmic Evolution*

4.3.1 The Cosmos Unfolding

The origin and the evolution of the Cosmos is addressed by the Sāṃkhya system. In combination with the other systems it describes mechanisms for the combination and origin of constituent elements as well as the evolution and distribution of matter in the universe. Within the unmanifested and ultimate reality of the size-less void as described in Buddhism, there is a constant process of creation and destruction. The principle of the conservation of matter applies, as something cannot be obtained from nothing (*ex nihilo nihil fit)*. This void contains many points or nodes conceived as particles within some primary existing substance or field, which may expand into a universe. That many such points can do this implies the potential for and possible existence of many universes.

The question of why a stable substance starts to differentiate and evolve is addressed by invoking a perturbation in the equilibrium of the three fundamental properties of *prakṛti* (see below). Later considerations proposed a secondary, inanimate, immutable, passive principle as catalysing this perturbation (Vetury 1987) personified as a male deity or monistic spirit in theological systems. The unbalancing of the property triplet may be seen by the layperson as corresponding to symmetry breaking of the charge-parity-time triplet in modern physics, while the personification of the catalyst is a theological consequence of the anthropic principle (Petit 2020) similar to the Christian Trinity. A triplet also occurs in the three pairs of quarks in the standard model of physics: in Sāṃkhya, the three fundamental properties of *prakṛti* are considered to have an existence independent of their substrate and are in themselves the result or effect of interactions.

4.3.2 Cosmic Time and Distance

Time and distance are larger concepts in the Indian systems (Perrett 1999; Balslev 2009). The three initial properties will at various times balance each other and revert to a stable equilibrium (Vetury 1987, p. 54) during which a universe of unequal durations is considered uninhabitable and inimical to humans. The periods of disequilibrium are presumably when the universe becomes habitable. Note the implication of succeeding and new universes. Time re-starts with each new universe: Friedman's solutions to special and general relativity indicate that every world line has a singularity from which to define an elapsed duration of time. These divergent solutions also indicate an oscillating or recurrent universe; note the role of quantum fluctuations in birthing multiple or succeeding universes (Torretti 1999, p. 293).

The age of the universe in a single manifestation (origin to next origin) between periods of dissolution is around 8.64×10^9 years, or 4.32×10^9 years for the actual duration of the ordered universe. The orbit of the heavens is about 2.43×10^{17} km (Balslev 2009; Yano 2020). The lay perspective views factors of 2–3 or a single order of magnitude insignificant when comparing these with the numbers of modern science, an age of about 4.5×10^9 years for the Earth (and by extension inhabitation), of 13.7×10^9 years for the age of the universe, and of an estimated 23.65×10^{17} km for the circumference of the Milky Way. Whether the "orbit of the heavens" is to be interpreted as our local galaxy is open to question.[7] Theological approaches in the wider Indian literature may provide a wider discussion of the relation of deep (or geologic and cosmic) time in a manner similar to that of Anthropocene time (Chakrabarty 2018), but for which there is no space here.

4.3.3 Matter

The substance within the void from which the point or node expands into a universe is described as water (liquid, fluid) by numerous writers (Haribhadra (tr. Murthy) 1970), as did Thales (c. 620–546 BCE), a Greek philosopher: this is homologous to treating the primordial field as having fluid-like properties in the many solutions proposed to General Relativity (Torretti 1999, p. 293). Water (although it cannot be the water that we know on Earth) stands for the creative primal matter, and the fluid of twentieth century cosmological theories of spacetime, and are surely cognate with the movement upon the waters of the Judaic *Genesis* and the Sumerian creation myths, In Greek philosophy Empedocles introduced the four primordial elements of fire, air, water and earth, corresponding to the more modern energy, gas, liquid and solid (Adams 1988). Water as a liquid is necessary for life, and in particular a carbon-based biochemistry (Lunine 2005).

Prakṛti, the substance within the void, is derived from roots suggesting a primordial form. In translation denoted matter, from which derives materialism, it is particulate (atomistic in the Greek sense) and undifferentiated, stable (as in dynamic equilibrium, not static), eternal and ascribed an active female creative principle, hypothesised from the observation of transience and change. The substance is extensive in space with a tendency to action or motion. In Europe, similar notions of matter and motion became associated with the development of Galilean and Newtonian physics (Torretti 1999, Chaps. 1, 2). The original perturbation, *mahat*, shares the etymological root for motion, and is part of the word "mahatma", which breaks down as Great Soul, but better "motivating individual"; consequently, agency and structure (karma and dharma) are also considered to be extensive primordial substances, with social and ethical implications discussed below.

In combination its constituent particles have physical properties and are subject to transformations, which changeability suggests that they are divisible, insubstantial, fleeting and interdependent. Prakṛti evolves and generates more physical entities

[7]Also translated as the "orbit of the sky"—to what object or region the original term in Sanskrit refers is uncertain. For more details see Yano (2020) and Kak (1999, 2000). Kak also uses the term "radius of the universe". He further argues that Aryabhaṭa (fifth century CE) considered the speed of light to be finite and calculates a figure close to 186,000 miles/s from *purāṇic* texts.

from preceding entities; the last of which eventually give rise to the physical and chemical elements and properties that we know today. Matter (as in materialism) is considered to be the only reality for two of the systems: reality is considered to be independent of observation or perception. Earth, water, air and fire are made of atoms and therefore tangible. A layperson may perceive a similarity, thereby concluding an identity with the sequential building of various elements in the Periodic Table, perhaps even stretched in the lay imagination to nucleosynthesis. The Indian *tattva* (also *mahabhuta—gross matter)* is then seen as equivalent to modern chemical elements and is often translated as such. Oppenheim and Puttnam (1958/1991) describe several non-metaphysical stages of evolution from elementary particles to atoms, thence molecules, cells, multicellular organisms and finally the social organism, similar to the evolutionary path described by the Indian systems (Vetury 1987, p. 43).

These particles have qualitative differences, are passive and compose matter, and the matter thus formed consists of a number of combined substances or evolutes which change and evolve according to certain processual principles of structuration and differentiation. Earlier systems appear to view the particles as identical to each other, later systems add that the particles are differentiable from each other, and still later systems that they form exclusive partnerships. Coincidentally, this chronology and separation of particles appears similar to the identical, differentiable and Pauli exclusion principle particles of Boltzmann, Bose-Einstein and Fermi-Dirac statistics (Torretti 1999, Sect. 6.1). In Sāṃkhya (Bahadur 1978, p. 182), particles exist as the result of interactions and are subject to motion as a result of some unseen, impersonal, inexplicable principle (*adṛṣta*—invisible), reminiscent of the field theories of modern physics. In the standard model of modern physics, particles come into existence to mediate interactions.

4.3.4 The Cosmic Dance

Prakṛti is the potential form of the universe. When actualised, it is referred to as Śakti (or Shakti). In translation, this indicates energy, power and strength. Personified, the henotheistic form becomes the mother goddess; when coupled with time (*kāla*), she becomes Kālī (or Mahākāli), and allegorises the ravages of time (or entropy) through the cosmic cycles. The circle of life with all its events and activities are now become part of the history of the universe, or of Big History. This is the power of transformation in all manifestations, material or intangible, animate and inanimate. As the female personification of both potential and actualised energy, she is the consort of Śiva personified as passive male principle. During the dissolution of the universe, Śiva dances to excite her passions, leading to regeneration and a new universe. This metaphor of allostatic creative and destructive disequilibrium has been depicted as the Cosmic Dance(r), a sculpture of which has been presented by the Indian Government to, and which stands outside CERN in Geneva (Fig. 13.2). If astrobiology and Big History are about energy and entropy transformations, flows and transitions, then there is no better imagery available within human cultures.

Fig. 13.2 Statue of the Hindu deity Shiva as Nataraja outside CERN in Geneva; the cosmic dance represents particle physics, entropy and the dissolution of the Universe. Presented by the Indian Science Mission in 2004 (credit: Ryan Bodenstein 2017/Creative Commons; on-line version in colour)

4.4 Biological Evolution

Whereas the concept of evolution is prevalent throughout the Indian systems (Baindur 2015; Singh 1970), there appears no specificity as to evolution in biological systems. Vetury (1987, p. 19) presumes on the basis of a single phrase: "the need creates function" that the Indian systems support Lamarckian or possible epigenetic mechanisms for biological change, and not the Darwinian mechanisms of mutation and natural selection, with possible implications for anthropogenic evolution. However, although not discussed in the literature, change in an organism through the transformation of aggregates of particles may be possible, as it is in the genetic approach to Darwinian evolution. It is unlikely to include, and there is insufficient detail available, to examine this possibility. The focus in the West has moved from the larger entity (individual person, tribe or species) to the smaller molecular species (Helmreich 2009), which however retains the same differential outlook of life based on known templates.

Although the corresponding Darwinian and Lamarckian mechanisms of natural selection and environmental stimulus are not considered, the Indian systems can certainly accommodate the mechanism of mutation and possibly other mechanisms as yet unspecified, given their more general approach to evolution. Unlike the Western approach, the Indian systems include *a priori* a requirement for consciousness and awareness in their approach. In doing so, there are indications in the contemporaneous (c. eighth century CE) Vedānta and Yoga-Vāṣiṣhṭa systems of the possibility of a co-evolution of awareness and consciousness. Similar to thermodynamic approaches in which the mechanism is not specified, these are viewed as an inherent and emergent property tied to stages of increasing physical, organismic and organisational complexity (Stengers 2010; Torretti 1999; Oppenheim and Puttnam 1958/1991; Thadani 1931). This leads to the differential and somewhat hierarchical tendency to ascribe differing degrees of consciousness to inanimate objects, eco-systems and geographical features, and through the tree of life to humanity, and is likely the basis for anthropomorphic deification in the henotheistic systems (Thadani 1931). In addition, the Vedānta also originated a number of offshoots which are the now the dominant philosophies behind the orthopractic henotheisms, ranging from the monistic universal self to immanent shared selves, a plurality of selves and a transcendent self separate from the inhabitation of the universe. These latter see a teleologic spiritual nirvana, in which context the Teilhardian noosphere and the Kurzweil singularity may be understood as a collective and merged intellectualisation in the Gaian biosphere or in technological form.

4.4.1 Death and the Inhabited Universe

At death, these selves (or the constituents of these selves as there is no continuity of self-aware identity after death), which are atomistic, first transfer to the clouds and then beyond to the Moon (Deussen 1912). From there the constituent particles travel back into clouds, and pass down through rain into soil, then plants, and through food into human or other bodies to constitute the next generation. The alternative is that these constituent atoms travel further from the Moon into the Cosmos to reach the abode of the gods. If these gods are real, they live elsewhere in the universe, implying the existence of other planets. Note also that as they appeared soon after the universe came into existence, they may be more advanced culturally and technologically compared to human civilisations. Ergo, the existence of multiple planets (exo-planets) and aliens is assumed as a matter of universality and the need for coherence and consistency. This is similar to the planetary inhabitants of the various spheres of the Kabbalistic Tree of Life, and those on the planets of the solar system discussed by Fontenelle in his Plurality of Worlds (1686). Chinese cosmology has also considered the possibility of the plurality of worlds based on the idea that heaven and earth influence each other (Lunine 2005). Anaxagoras, the ancient Greek philosopher, referred to the Moon being inhabited.

4.4.2 Transhuman Diversity

Diversity of life and its unity is acknowledged at all times and is allegorised in the manifestation of the "universal form" (Bhagavad Gita, Chap. 11). All human, divine and animal life is included. Śiva's wedding procession includes many non-standard humaniform entities, often translated as ghouls, pixies, demons, goblins and the like. The anti-hero who abducts Sitā is described in translation as an evil demon: yet he obtains his powers through Śiva—his people are named "protectors, forest guardians", with access to all the amenities and benefits of worship and civilisation. Primary characters in myths and legends are monkeys, bears, squirrels, vultures, elephants, all of whom have speech and culture. The acceptance of diversity is the result of observation of life, and in its classification of the varieties of life, the Sāṃkhya includes artificial life (Bahadur 1978, p. 189) as a specific category. The mythologies and depictions also indicate an acceptance of transplants and deformity, as indicated by Ganesh, the elephant-headed god, the third eye of Śiva, and the multiply-armed deities.

An extensive analogy with Darwinian evolution (Mackenzie Brown 2012) has been suggested by various social, cultural, political and religious reformers from the nineteenth C. onwards. In this, the ten *avatars* (incarnations) of Viṣṇu perform a number of tasks for the benefit of righteousness and peripherally for humanity. The first[8] is a fish, followed by a tortoise, then a boar, a half-lion, a dwarf, a warrior, a civil and social paragon, a hedonistic politician-individualist, a psychologist, and finally "tomorrow's avatar". Ghose (also known as Sri Aurobindo, 1972), possibly following earlier reformers, interprets this as the evolution of life on land from an aquatic creature (recall Anaximander's fish), followed by stages of animal evolution. The second half indicates levels of personal, psychic, social and institutional change and evolution. The ten-predecessor trope is common to all Indian traditions and is assumed to show continuity and personal evolution.

4.5 Society, Culture, Nation

One less well-known school of thought in the Indian cultures is the school of material liberty and freedom. The systems discussed above are all foundational in

[8] I have provided indirect translated equivalents based on what I see as their characteristics to support the exposition here presented. Please refer to Wikipedia (https://en.wikipedia.org/wiki/Dashavatara) and the wider literature for a more traditional discussion.

broad outline to the henotheistic traditions in the Indian hegemonic cultures and populations. From exactly the same foundations, the Yoga-Vāṣiṣṭha school (eighth century CE or earlier) denies destiny, deity and fate, exalting personal effort and responsibility. Most astonishingly, it develops an entire social and ethical system with reference to multiple and inhabited universes among other very modern concepts. Extoling freedom and free will, it extends agency to all organic life, but most especially humans. Whereas again the detail may differ, the outline of change and evolution from the origin of the universe to the development of biological organs appears to be much closer to the narrative of modern science (Vetury 1987, pp. 16–20, 79–81). It is also highly encouraging of an intellectual and social approach to personal development and evolution, better known in the West as (Rāja, Patāñjali or Haṭha) Yoga, and which focuses on different techniques. Teleological human agency (karma) can also lead to the Nietzschean uber-mensch or a collective intellectualization in the noosphere of Teilhard de Chardin and Vernadsky (Vetury 1987, pp. 88, 91). Might it also extend to the post-human technological singularity?

4.5.1 Social Ethics

As Berthelot (1922/1938) in his *La Pensée de l'Asie et l'Astrobiologie* has shown, personal and social morality in the Indian cultures is based on astrobiology. Dharma (acting according to the laws of nature, the latter being a problematic statement in the Western paradigm) becomes a categorical imperative. The Indian systems encourage an engagement with physical reality through action. Activity as causation is often described as karma or cause and effect. Actions can have later rather than immediate effects in time–this is the temporal version of action-at-a-distance (influence on a non-contiguous entity), and such agency is inferred to have real world effects despite being a moral and intangible construct. Karma is deterministic: the future is determined by past events and their history. It is not pre-destination–there are multiple paths to be taken, but which may be constrained by circumstances. To choose is valid: the act of choosing is analogous to an external force acting to change the direction or speed of an object travelling in a straight line. The notion of "karma" is exceptionally complex and has been interpreted in the West as a form of reward and punishment. It is however more kin to agency. The fundamental idea of change through evolution or revolution is anti-fatalist, and against pre-destination. Evolution is dynamic and change can be managed and controlled: it implies an anthropogenic hegemony, with links to the Anthropocene. It acts as social constraint as well as social cooperation and may be used as a form of social credit. As reward or punishment, it may be indicative of a progressive or regressive evolution in the individual or collective group. It then performs as a restraint on social interactions and behaviour and includes non-violence and freedom of action in its orbit.

If karma is understood as agency, then it may be viewed as purposeful. A goal or result is decided and then action is taken to achieve that goal as expressed in a well-known couplet (Bhagavad Gita, II.50).[9] In Newtonian mechanics, Laplace interpreted the Hamilton-Jacobi form of the variational principle of least action as a pre-set mechanistic determinism in which the end result determines which path of least action is to be taken. This teleological determinism (Stöltzner 1994) becomes theological predestination when set in motion by God. However, the Eastern concept recognises that external forces may constrain or affect action and activity in the form of social credit, peer pressure and other human and environmental limitations, but do not determine either the nature of the activity or the goal desired. The teleology is not external: it is the individual who decides on the goal and who subsequently takes action to achieve that goal (Lipner 1997). The absence of a creator god makes the confrontation between free will and pre-destination irrelevant. An external force (or god) is just another constraint, another interaction between multiple agents. In addition, the intention of Bhagavad Gita II.50 appears more like deterministic chaos than teleological determinism. It allows different initial conditions and multiple paths depending on the desired goal, although the path once chosen is constrained and therefore determined. Further, in terms of human agency, the interconnectedness (—perhaps quantum entanglement—) of the universe suggests that harming something implies that you are harming yourself. Extended this leads to the idea of *ahimsā*—non-harm and non-violence as known in the West through the actions of Gandhi. In the modern world, this approach has implications for anthropogenic transformation and environmentalism.

4.5.2 Cultural Assimilation

Observation of change and motion leads to the idea of diversity, where each part complements other parts. This in turn leads to the idea of multiculturalism, pluralism and then federalism. However, this can also be viewed as hierarchy and status, given the inflexibility of difference and its related concepts. This is very similar to the Vulcan idea of infinite diversity in infinite combinations from Star Trek in the original series but with added differential hierarchy. It is possible that inflexibility and differential status is introduced through the idea of a transcendent God or through the notion of destiny and fate. This is also a form of teleological determinism, and the difference between the Western and Eastern cultures appears to be a creator god as dictator, governor and director in the former or the individual self as actor and agent in the latter.

When Hindus conquer or move into a new territory the inhabitants are expected and allowed to retain their own culture and institutions. Social structures (caste, etc) re-form to absorb and assimilate the foreign culture, thus assuming an immediate

[9]Unpublished essay (2003) for my M.Sc. in Scientific, Medical and Technical Translation with Translation Technology): "Having decided [on a goal], whether done well or ill, do it: for action is a means to an end" [my translation]. The couplet is problematic: over 30 published exemplars over 150 years all disagreed with each other; how a translation is affected by the translator's background, training and expectations is not easy to establish.

equivalency. Given the recognition of diversity based on observation, this embraces alien hierarchy and status. In contrast to the Western need to award legal standing to an alien entity, the inhabitants would (in theory at least) be treated as they would wish to be treated. This is an extension of the law of hospitality followed by the Indian and Arab desert cultures and bears a remarkable similarity to the metalaw proposed by Haley (1956). In principle at least, the assimilation of non-terrestrial cultures is included in this approach through a multiculturism federal in its institutional structures.

And as Geraci (2018) reports and examines, the Indian populace will readily assimilate technology into daily devotional ritual. A public performance and survey by Anab Jain (2016) reported on Indian attitudes to the ISRO Mars Orbiter Mission; miniature models being distributed as part of the performance and survey were soon found in personal and family shrines, having been deified. This is an example of reification–a social interaction, in this case a miniature model, has taken on an autonomous identity as a deity. ISRO naming of their craft is also very prosaic–not spiritual–as Mangalayaan and Chandrayaan translate as Mars vehicle and Moon vehicle, respectively. In this way, advanced technology becomes incorporated into daily life and becomes an object of worship and devotion. This underlines the continuity of Indian cultures through orthopraxy rather than orthodoxy and may be a corollary of Clarke's Third Law (Clarke 1973), whereby any advanced technology is indistinguishable from magic. It allows those cultures influenced by the Indian philosophies a much greater and wider acceptance of the STEM disciplines, which then leads to better educational opportunities and a greater acceptance of modern technologies and changes to life.

4.5.3 Nationalism

Indian or Hindu Nationalism and religious fundamentalism in Hindu cultures and politics views as one of its goals a return to a Golden Age (*Satya Yuga—the age of reality or truth*). The biopolitics of Hindu Nationalism is complicated by clan, caste and origin myths–progenitors are descended from deities and their associated planets: that is, they are the result of panspermia or alien immigration, and trace their descent from life on that extra-solar or other planet. The Indian henotheist texts attest to an antiquity of advanced civilisation of indigenous or extra-planetary origin with weaponry equivalent or superior to modern technology, including weapons of mass destruction, and self-propelling air and ground vehicles. As Olivelle (Bharati 2005, p. 271) points out "one way of effacing [new ideas and institutions] is to relate them to central concepts of the old order." In some respects this is that familiar story of UFOs and alien visitations: that ancient wisdoms in the form of alien religions and technologies started or contributed to ancient civilisations through an early form of albeit extra-planetary instead of Indo-Aryan or European colonialism. The ancient sciences are presumed to have already the results that Western science is only just discovering, with parallel universes, unity of life, evolution, and ecological guardianship among the examples cited. In this case, the neo-Hindus are not denying modern science–they are assuming antique primacy in order to create an Indo-futurism. How the ancient texts are interpreted (Kak 1999, 2000) and science is used may be subject to bias and abuse (Saini 2019).

5 Discussion

When the historical narrative from the Indian systems is laid out in a linear fashion the various elements or constituent parts of the story become obvious and seem to appear in the same order and same homologous relationships as the narrative structure put together from astrobiology and Big History. This suggests that selection bias may be negligible in the narrative and its analysis, given there are many concepts without such correspondence in the Indian systems.

5.1 Diffusion

The narrative given above is remarkably similar to that put together by modern science. Although equivalent in cultural terms, there has been no assumption of identity or appropriation across cultural boundaries. A first assumption would state that the two cultures are distinct and unconnected: then the similarities noted above would be a clear case of apophenia, or its milder cousin, pareidolia–seeing correlations where there are none, between two unconnected systems. Assuming the two cultures remained hermetically isolated from each other, parallel evolution in intellectual thought and philosophy is a possibility. However, it must be recognised that the two cultures have had contact through the millennia, through trade and travel, and in particular after the European expansion from 1500 CE onwards. Previous to that contact would have been infrequent in person, and more indirect, through the intervening Islamic and its predecessor cultures in the Middle Eastern region.

If a common origin (Seaford 2020, p. 8; Allen in Seaford 2016) is presumed for the Greek and Indian cultures, it is surprising how the Indian versions extant in the first millennium BCE appear closer to the concepts of modern science after 1600 CE, these latter having moved further away from their supposed Greek antecedents. The similarities may be the result of common descent from a common culture and traditions which gave rise to both Western science and the Indian philosophies. This would imply a continuity of early, antique concepts, and requires constant renewal, suggesting that nothing is original, just a re-interpretation of old ideas in applying them to new knowledge. This is most likely if the hypothesis[10] of a

[10]Variously known as the Indo-Aryan, Indo-European, or Aryan invasion theory, it describes a common ancestor on philological grounds for a number of cultures whose languages are related. The hypothesis is particularly controversial amongst Indian nationalists. A wide literature on the subject is available.

common group ancestor for the Graeco-Roman and Indo-Iranian cultures is considered to be correct. And since the interconnectedness of human societies is a given, it is difficult to exclude the hybridisation of ideas as a result of contact through trade, commerce, travel, translations and cultural transference through migration. There may have been a vast exchange of ideas and cultural texts by and through oral transmission. The history of this exchange is too tangled to come to any firm conclusion, and it cannot be said that any side has primacy in these ideas. What is certain is that the exchange of ideas has led us to the marvellous connected webs of knowledge now being expressed in astrobiology and big history.

The synthesis given above is based on the work by Haribhadra (c. 459–529 CE). As such, unless we allow a time travelling pre-plagiarist (see footnote 12), it is likely that any exchange of ideas must have been from the Indian cultures towards Europe. It is worth recalling that this is the same culture that gave rise to the zero and a useful notational and positional placement numerical system and symbols. Laplace (quoted by O'Connor and Robertson 2000) expressed an opinion on these culture wars:

> The ingenious method of . . . using a set of ten symbols . . . emerged in India. . . . it was beyond the two greatest men of Antiquity, Archimedes and Apollonius.

The Hindu-Arabic numeral system was developed to address the needs of Indian cosmology (Plofker 2009). This led, among other achievements in the Indian cultures to Aryabhata (476–550 CE) describing a rotational, spherical Earth, the mechanism for eclipses and a comprehensive theory of heliocentrism. His successor Brahmagupta (598–668 CE) advanced the idea that all bodies are attracted by the Earth–an early description of gravitation (Subbarayappa and Sarma 1985). The numerals were introduced to Europe through Spain by the Arabs, publicized in c. 1202 by Fibonacci, with formal and full widespread adoption only around 1500 in time for the European expansion, the Renaissance and the birth of physics. Torretti (1999, p. 430) points out that "[m]anners of thinking are born and grow contingently throughout the course of history. Alternative physics could arise elsewhere in the universe, or issue from an unorthodox deviation of ours (Cushing 1994). After several generations and deviations, they may become mutually incomprehensible even though they share the same roots."

5.2 Alternative Frameworks

The narrative paradigm that Indian cultures form does not in and of itself contradict any observations and models in science, as it is a meta-approach, a narrative creation myth for the modern world, albeit not dominated by the Western paradigm. A conceptual framework or frameworks for science may be no more than a social construction (Ben-Ari 2011), and there exist many formal representations of such frameworks. Apart from the well-known Copenhagen and Bohmian interpretations of quantum mechanics, there are the newer forms of quantum logic and the many worlds interpretation by Everett (Torretti 1999). Cortês and Smolin (2014) are developing a new framework for quantum mechanics using Energetic Causal Sets. Darwin's *Origin of Species* has become the new evolutionary synthesis (Smocovitis 2020). Mass, particles, space and time have been reconfigured into density distributions, fields, excitations, and geometric spacetime as Torretti (1999) documents in his *The Philosophy of Physics*. When looking for alternative theories and interpretations of science, one finds many examples: string theory has over 300 versions, loop quantum gravity, bouncing universe, oscillating big bang, multiverse and branes, bubble universes, space-time from quantum entanglement instead of mass, the Einstein-aether theory which seeks to explain dark matter and dark energy, with variations, and so on. All these seek to explain the same data from the same observations. These frameworks are further re-interpreted for the lay person (or non-scientist) through the optics of various literary and critical theory perspectives—postmodernism, structuralism and post-structuralism, post-colonial, decolonial, feminist and so on. These formal and informal interpretations of science and its theories form a mythology of science influencing the non-scientist as lay-person. The social impact on the layperson is not limited or one-way: the non-scientist also influences the acceptance or otherwise of a scientific theory and can input traditional expectations and myths into the framework to ease a wider understanding of a difficult subject. In this sense, myths may be re-interpreted as scientific allegory, as mentioned above in the case of the Kaballah, or hybridised with tribal practices.

Mathematisation is no guarantee of correctness; wave mechanics and matrix mechanics are built from different conceptual foundations yet both lead to the same results. The results of quantum mechanics and field theories in general relativity require the use of classical mechanical approximations for their predictions and application. Special relativity is valid at all speeds up to that of light and includes Newtonian mechanics as a limiting approximation. Einstein introduced universal principles by analogy from the different domain of classical thermodynamics which "account for a vast and ubiquitous class of phenomena, without making any assumptions about the underlying deeper structure" (Torretti 1999, Sect. 4.3.2, and p. 253), an approach possibly applicable to interpreting the narrative given above. Lagrange, Hamilton and Jacobi provided new insightful reformulations of classical mechanics that hastened the advent of quantum theory; by formulating the same thing in different ways more knowledge is obtained, not a new theory but a new framework in which to see old theories and potentially new ones. Torretti (1999) has gathered a useful set of opinions from leading mathematicians, physicists and philosophers. Thus Hilbert: "any theory is the scaffolding or schema of concepts, together with the mutual relations, and the basic elements [of which] can be conceived in any way you wish". Opposed to which is a physical theory viewed as an axiomatic mathematical system wherein are meaningful statements interpreted or applied to reality (which links together proofs, applicable to a limited domain within some validity or range). Both approaches require corroboration by evidence, the former being empirical and data driven, the latter developing from first principles through hypothesis and experiment (Torretti 1999, p. 409). Again: "a given stock of empirical information can be approximated by an infinite number of different theories" (*op. cit.,* p. 430). And we have no idea where concepts originate: "… the fictional character of foundations (Grundlagen) was made perfectly evident by the fact that two essentially different foundations can be exhibited, both of which amply agree with experience …" (Einstein 1933, p. 182). Physical law as described by theory is approximate and valid only within its specified range. But a physicist acts as though there is an underlying reality behind the theory which unifies the approach. However, the physicist can only choose to verify, modify or make more precise one hypothesis from an ensemble of hypotheses—leaving the theoretician freedom to open up new avenues. There is no necessity to accept theory which can be corrected by invoking error or new phenomena. Nor is an underlying unity necessary. But any approach must be internally consistent and consistent with the ensemble of hypotheses, according to Torretti's account of Duhem (*op. cit.,* Sect. 4.4.4).

In overlapping science with society, given that myth may be read as allegory, this type of reading is often extended to science. This latter then gives rise to partial applications in other domains—the use of quantum mechanics and its observer affecting measurement may be used as a postmodern basis for the discussion of subjectivity in literature or social interaction, or chaos theory applied to political decisions and policy. In this way, science enters, affects and structures social behaviours and beliefs. Thus, creation and other myths or legends in many cultures are read as a narrative of modernity and modern science despite the prevalence of glaring contradictions and anachronisms (Wright 2013, Chap. 3). There can be many examples of this, of course, as many as there are cultures amongst the many and diverse human populations on Earth. And once humanity leaves Earth for outer space, there will be even more. As we examine astrobiology in the context of Big History, it should be borne in mind that previous generations (especially nineteenth century European scientists) have assumed the completeness of their understanding of science as well their exactitude and precision in representing reality. Indeed, the model or conception is often taken to be the reality despite our limitations of knowledge. Yet new science always comes along, needing to be shoe-horned into our approximations of reality. Could the ideas of the Indian cultures presented above be a new or different basis for interpreting Western science? This would perhaps require ensuring the testability or falsifiability of these approaches (Bharati 2005, p. 217, note 138 referencing Potter 1991, and note 139) and becomes a much larger endeavour than can be entered into here.

Similarly, does interpreting or translating scientific concepts into the arts and humanities introduce a new form of symbolism that obscures the science? As Torretti (1999) has discussed, the insertion of theology through the concept of a Christian creator god into Greek notions of matter in Aristotle's physics introduced new constraints. However, later scientists did away with the theism so implicated, and conceived matter in a different way, as a singularity or an interaction within a field. As ancient Greek and indeed Enlightenment century theologies and concepts are questioned, renewed, or pushed aside, it is essential to ask whether a new narrative (or origin myth) based on science is necessary for non-scientists' consumption. Previous attempts at this have remained Eurocentric and Christocentric: replacement narrative mythologies remain creationist, with a creator God retaining predestination through a secularised (or supposedly de-theologised) extreme determinism. However, there are existing narratives that can assimilate, integrate and extrapolate; science fiction is one such approach, and the current work attempts another–this latter continues a secular mythology with spiritual elements if required, but without theological or religious morality as an imperative. In this, it is suggested that the Indian cultures provide a comprehensive paradigm consistent with modern science and with the interplay of astrobiology and Big History. Furthermore, the Indian cultures are primarily a way of life rather than theological doctrines constrained by belief. Therefore, a much more cogent argument for continuity can be made regarding the use of a framework from Indian philosophy using Śankara's eighth century pre-plagiarism[11] of the eighteenth century Immanuel Kant, and Duperron's recognition that Kant and the Upanishads[12] have much in common (Chandrasekharayya 2006, p. 170). Thus, the systems of Indian cultures can be taken as the basis for constructing a new narrative regarding astrobiology and Big History without fear of contradicting later developments in physics or its Kantian interpretation. In a similar vein, in *The Holistic Inspirations of Physics* (1999), Dusek asks the extent to which classical electromagnetic field theories are a product of non-mechanistic, organic and holistic philosophies and frameworks and of Chinese traditional thought. The discipline of linguistics too was vastly enriched by the Sanskritist studies of Jones and Burke in late eighteenth century; while Nāgarjūna's discussion on signs must have contributed to Saussure's development of semiotics, given the latter's position teaching oriental languages at the College de Paris in the early twentieth century.

5.3 *Ethno-cosmographies*

As Ayesha Keshani of the Sarawak Museum in Borneo points out (personal communication), ethnography and natural history are considered separate but are actually mixed. Ethno-cosmologies are a way of structuring the experience of the world. In the modern world the past is seen as unscientific and superstitious as well as anti-reductionist, which is itself somewhat ironically a reductionist view. In contrast to this consider Torretti on Mach: "Scientific knowledge is concerned with the connection of phenomena. Whatever we might make out as standing behind phenomena "exists only in our understanding and has for us just the value of an aid to memory or formula, whose form, being arbitrary and indifferent, can very easily change with our *cultural standpoint*" [my emphasis] (Mach 1872/1909, p. 25). We are therefore

[11]Churchill (1996, p. 287) quotes Durant: [Śankara (c. 700–750 CE) is a] "pre-plagiarist of Kant" [1724–1804]. Apparently Durant was implying that Kant could never have predicated his philosophy on the reading of Asian texts despite Śankara having lived over a millennium before Kant.

[12]Anquetil DuPerron (1801) published what purported to be a translation of the Upanishads in Latin.

free to devise transphenomenal objects in any way we think useful for connecting the phenomena. We are under no constraint to impose on them the familiar conditions of sensory experience“ (Torretti 1999, p. 238). The present is modern, scientific and reductionist, but when deeper local knowledge is included it can and does become spiritual, even holistic. Other knowledge and other sciences add to and alter or “other” our experience of the world when inclusive of indigenous experiences and understanding, as opposed to (Western) science. Consider the Copernican principle in which the position of the observer is not privileged. When applied to the universe, it becomes a universal principle; applied to culture, it becomes pluralism or multiculturalism. Compare this with the observer in quantum mechanics, or with the participant observer in anthropology, whose very interaction with the system being observed serves to change the observation. The recognition that one’s perspective is local and not universal underlines the irony of calling it the Cosmological Principle, given that cosmological implies a universal application. It is this indeed this that the Jains call *anekānta*, a principle of multiple views and perspectives. The Chinese, as with the European cultures, consider themselves and their land and culture to be at the centre of the universe in political and social reality or metaphorically geo-centred as the Middle Kingdom. However, when the human and Earth is removed from the centre of the universe, neo-Copernican principles may be seen as decentring the universe—and note that modern science does not allow a centre to the universe in any case. However, this metaphorical centre, personal, cultural, terrestrial or solar is a matter of altering perspectives, of multiple perspectives which are all equivalent, plural and valid. Again, Torretti asks how we can tell that “our concepts fit the facts that we intend to grasp by means of them? How do you evaluate the probability that a law of nature is “true to reality” (Torretti 1999, p. 437)? To this the Jains respond—*anekānta*.

6 Conclusion

Social impact depends on reception and on perception of results by a population and not on understanding methodology or methods. The creation of an origin myth by interpreting data through social and scientific consensus regarding its significance is then seen as an objective narrative of social and material conditions: this reification of astrobiology and big history then becomes a mode of exchange and communication affecting social interaction. Uncritical acceptance by non-scientists in the West is common: killer apes, climate change or UFOs are some real and unreal examples. The simplification is taken as identity with pre-existing knowledge. To the layperson, it is the approximate result that matters, not the method: scientists (and academics) focus on method and personality. At the level of the layperson, the tendency of many cultures, and Hinduism in particular, is to abstract a statement or concept from its context in order to support some position or perspective. This is their confirmation bias: they see the results as a confirmation or vindication of their beliefs in the superiority of their ancient world and of their ancestors’ knowledge.

They do not care how the results are obtained–whether through modern science, quasi-science, pseudo-science or no science. They see the result and see confirmation. However, and more importantly, the adoption or re-invention of such an existing Weltanschauung minimises the shock of adopting new technologies, allows faster assimilation of differing perspectives and novel cultural transplants, provides continuity to the culture and the beliefs of the individual, and is applicable to new developments in the future.

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Chapter 14
"Unfathomable, Bottomless, Very Deep": Waterworld Imaginaries

Rachel Hill

Abstract Waterworlds—that is, astronomical bodies which contain large volumes of water—are increasingly hypothesised to course within our solar system and throughout exoplanetary systems. This chapter makes the case for how "planetary imaginaries" (Messeri, Placing outer space: an earthly ethnography of other worlds. Duke University Press, Durham, 2016) are increasingly shaped and freighted with this liquid promise. The move towards flooded, fluvial and oceanic planets necessitates other ways of conceptualising planetary and cosmic scales, as multiscular magnitudes meeting in a watery interface. If we accept that the cosmic and the oceanic are bound together in their unboundedness, then it is important to interrogate how oceanic spatialities are constructed and pelagic space is conceptualised. Rather than a site of colonial foreclosure, how does a cosmic axis engender an interrogation of what the oceanic portends? Moreover, how do the ways in which the cosmos is figured have traction upon how the Earth is configured, necessitating a more cosmic perspective to be integrated into our worldviews? To address these questions, waterworld imaginaries, astrobiological hypotheses and the blue humanities are brought into a mutually informing matrix, crosscurrents which are tempestuously played out across this chapter's many meandering tributaries. A navigation of the extra-, inter-, and intra-planetary ecopoetics of waterworlds results.

Li Zeng describing waterworlds, quoted in Dvorsky (2019).

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1 Introduction

Tides are turning in the cosmos. Moving from parched or gas-swirling planets, our solar system is increasingly captured as awash in icy spheres, watery worlds which are anticipated to contain saturated subsurface ecospheres, and perhaps even life. Spiralling outwards, recent discoveries and models in exoplanetary studies hypothesise that our galaxy teems with waterworlds and liquid planets. Closer to home, space-based images of Earth have resulted in reconceptualisations of the planet as a fragile terraqueous orb, balanced within an inky beyond. The abundance of anticipated waterworlds—astronomical bodies such as moons and planets harbouring large fluid volumes—begin to recalibrate how planets are conceptualised, and forge new interrelations across the cosmical depths. This mounting plenitude of liquid leads planets to be mercurially poised and slipping between two polarities: recognisable and graspable on the one hand, unknowable and alien on the other. Scientific images thus modulate how cosmic bodies are delineated and understood within society at large, with water, in its lack or abundance, becoming the primary index through which "planetary imaginaries" (Messeri 2016) are calibrated. In other words, the way we image informs, but also reflects, how we imagine.[1]

As dominant imaginaries of planets shift from arid and d(r)ying horizons (of Mars et al.) to oceanic depths, so too are representations of alien alterity redefined. Waterworld images, and the imaginaries they tow in their wake, are accompanied by a deluge in anticipated aquatic life. Indeed, the preponderance of hypothesised planetary (exo)oceans are of immense focus for astrobiology, with terrestrial oceans becoming a blueprint for how extraterrestrial ecospheres and alien life are conceptualised. Premised on terrestrial precedents, water is positioned as the key tributary to evaluate the potential for life. The apparent ubiquity of waterworlds has thus unleashed a new cascade of hope for finding extraterrestrial life. The enticing promise of inhabited waterworlds has also led to a surge in aquatic aliens in popular culture, demonstrating that how planets are predominantly imag(in)ed has massive traction upon how extraterrestrial life is envisioned. Expected to reside across this similarity of waterworlds, life becomes a vector binding planets into closer proximity. Through the entanglements of liquid and life, waterworld imaginaries enact sidereal folds: rather than discrete objects separated by incomprehensible distance, planets increasingly become (and contain) multiscalar bodies enmeshed within marine resonances, reaching across interplanetary and interstellar space. As NASA's virtual *Ocean Worlds* platform states:

[1]The chapter uses the term 'waterworlds' to specify investigation into planets and moons which are anticipated to hold global scale volumes of water—this is in contrast to ocean worlds which more generally defined by fluid volumes of different compositions—such as Io's hypothesised lava oceans. Non-water ocean worlds demonstrate the flexibility with which the oceanic is thought and reconfigured through a cosmic axis.

> The story of oceans is the story of life. Oceans define our home planet, covering the majority of Earth's surface and driving the water cycle that dominates our land and atmosphere. But more profound still, the story of our oceans envelops our home in a far larger context that reaches deep into the universe and places us in a rich family of ocean worlds that span our solar system and beyond (NASA Ocean Worlds).

Shifting beyond bounded planetary spheres, waterworlds, with their indeterminate surfaces, unquantified distributions and frothy atmospheres, are ensconced within a cosmos which itself has long been conceptualised through an oceanic lens. Within the cosmologies of multiple cultures, the cosmos is configured as a great pelagic expanse. The paradigmatic shift towards waterworlds not only modulates how planetary scales are imagined, but also alters the form of this cosmos-as-ocean, what I will call the "cosmic-oceanic." Telescoping out from the worldview, as planetary imaginaries are increasingly freighted with the multiple valences of watery space, so too are more unbounded, cosmic-oceanic "cosmoviews" (Messeri 2016) necessitated. Water molecules are fused through the combustive dynamics of nebular forges: hence accompanying the cosmic-oceanic is the awareness that "the origins of our oceans are in the stars" (NASA Ocean Worlds). How then is the oceanic, the planetary and the cosmical reconfigured through the nexus of the waterworld imaginary? In order to conceptualise these interacting magnitudes, the following will bring work from the oceanic turn and the "blue humanities" (Mentz 2015) into conversation with (exo)planetary waterworlds and the cosmic-oceanic.

Facilitating forms of mastery, nationhood and commerce, while materialising the immeasurable, ahistorical and incomprehensible, the oceanic is perhaps the greatest of paradoxes. The oceanic anchors forms of control, just as it gives them the slip. To think through the importance and implications of waterworlds, the historicity of the oceanic must be attended to. Reorienting the marine away from the maritime traditions of European colonialism—which currently still pervade the cosmic-oceanic—the following will deploy water-centric critiques such as Barbadian poet-historian Kamau Brathwaite's decolonial "tidalectics" (Brathwaite 1981). Rather than reproduce the supposed solidity and dialectics of land-based epistemologies, tidalectics (and the oceanic turn more generally) proposes an ontology based on navigating flux and flow. Relocating emphasis from projected solidity to boundary-defying-permeability leads to the blurring of land by seas, and the merging planet with cosmos. Through the blue humanities and tidalectical analysis, this chapter will both situate waterworlds within configurations of the oceanic, whilst dredging up their destabilising potential. Conjured within these ruptures and convergences, the following will explore the extra-, inter- and intra-planetary ecopoetics of waterworlds.

2 Planetary Imaginaries

> The imagination is not, as its etymology suggests, the faculty for forming images of reality; it is the faculty for forming images which go beyond reality, which sing reality . . . the imagination invents more than objects and dramas—it invents a new life, a new spirit; it opens eyes which hold new types of visions. (Bachelard 1999, p. 16)

Imagination is crucial to any scientific endeavour. Indeed, planetary scales cannot be thought without processes of the imagination. These processes enable inhuman magnitudes to be formattable within thinkable scales: imagination is a connective tissue between here and the cosmic elsewhere. Extrapolating life as it is lived on terrestrial grounds and projecting it into cosmic unknowns, imagination catapults thoughts of extraterrestrial inhabitation and spaceflight into orbital trajectories. Imagination becomes rooted to matter, finding new routes for matter to take. The imaginaries accruing around astronomical bodies—and the technical objects which chart them—are crucial to how the cosmos is perceived and conceived.

As Walter McDougall has outlined in his encyclopedic treatise on the Cold War space race, it was the imaginaries or "dream of spaceflight," conveyed through the science fictions of Jules Verne and H. G. Wells, which "inspired the great pioneers of modern rocketry" (McDougall 1985, p. 20). Viewing the Earth from atmospheric altitudes, the flight of early rockets reinforced, but also modulated, the worldviews they emerged from. Thus, planetary and cosmic scales are encountered through the interlocking vectors of collective imaginaries, space science, and technological infrastructure. These social and technical interlocutors reflect, forge and mediate how planets are encountered, sculpting new types of vision which dictate how worlds can and should be inhabited. Here, it is important to distinguish between planet and world: planet is a physical reality, a multiplicity of known and unknowable vectors. World is an ontological category, that which emerges between subject (s) and planet. Imagination is the interface which arbitrates between planet and subject, resulting in the formation of world. How then do imaginaries sing planetary reality through the shimmering parameters of world?

H. G. Wells' novel *First Men in the Moon* (1901) speculatively outlines how other worlds—and other forms of world—can be experienced through new modes of technical mobility and vision. On the first crewed journey to our lunar neighbour, Wells' explorers encounter a surface which rapidly oscillates between labyrinthine verdance and devastated desiccation, in alignment with the Sun's rise and set. Below the fluctuations of this familiar yet strange surface dwell an ancient species of extraterrestrials, named the Selenites. Calibrated to their extreme environment of excess and deprivation, Selenite physiology is a strange fusion of tentacular protrusion and insectile exoskeleton, hybrids webbing the diurnally wet and nocturnally dry lunar ecology into one alien body. Extraterrestrial botanicals and subterranean civilisations, with their strange resemblances to terrestrial forms, turn lunar unknowns into comprehensible places. The translation of these cosmic unknowns into the existential parameters of a world are catalysed through 'discovery' and exploration. But this translation is not unidirectional. The increasing readability of lunar conditions within terrestrial epistemologies (more specifically the world of European modernity and its extractive colonial refrains), are counterbalanced by an unmooring of the main protagonist's subjectivity. As the character Bedford states:

> Do you know I had an idea that really I was something quite outside not only the world, but all worlds, and out of space and time, and that this poor Bedford was just a peephole through which I looked at life (Wells 1901).

Wells' lunar imaginary is defined by a chiasmus whereby, as the cosmic becomes known, so too are the supposed knowns of western subjectivity untethered from "all worlds," and rendered alien to itself. The worlding of cosmic elsewheres leads to the unworlding of that which was previously thought secured and accepted. A corollary to this estranging revelation is an awareness that life is only narrowly understood through the occulting "peephole" of an increasingly unstable subject. As worlds flicker in cycles of (in)comprehensibility, so too does the life they hold fluctuate. In turn, these worlds are sent aquiver by the amorphousness through which forms of life and their modes of inhabitation are envisaged. New worlds are thus seen through a camera obscura where cosmic unknowns become visible but inverted, a flipping which sets settled reality askew.

Jules Verne, as another great proselytiser for the cause of science, similarly imagined inhuman spatialities as livable, but only through the estranging of the habitual. *Twenty Thousand Leagues Under the Sea* (1869) follows the voyages of the Nautilus, a submarine which (as with Wells' spaceflight and Moon landing) Verne formulated long before this aquatic mode of technology was a reality. Again, as seen in Wells, inhabitations of these alien spatialities provide access to planetary scales of thought, and necessitate new ways of worlding. Unlike Wells' lunar escapades, however, here the planetary is arrived at through a dive into its depths. As Captain Nemo states:

> The sea is everything. It covers seven-tenths of the terrestrial globe [...] It is an immense desert, where man is never lonely, for he feels life stirring on all sides. The sea is only the embodiment of a supernatural and wonderful existence. It is nothing but love and emotion; it is the 'Living Infinite' (Verne 1869).

A sea dominated globe: here Verne articulates how the Earth came to be understood and imagined not only on planetary scales, but more specifically as a waterworld. Earth as a waterworld containing a "Living Infinite" demonstrates some of the ways in which the globe, and its ordering of terrestrial finitude, is surpassed by the folded infinities of oceanic volume. As an embryonic waterworld imaginary, the globe for Verne is rethought from the amorphousness of water, rather than the (illusory) stability of land. Nemo continues:

> The globe began with sea, so to speak; and who knows if it will not end with it? [...] Upon its surface men can still exercise unjust laws, fight, tear one another to pieces, and be carried away with terrestrial horrors. But at thirty feet below its level, their reign ceases, their influence is quenched, and their power disappears [...] There I am free! (Ibid).

Nemo contrasts the (ostensibly) masterable horizontal surfaces of the ocean with the freedom of its untamable depths, or as philosopher and poet Édouard Glissant has observed, "beneath the fantasy of domination [...] the really livable world" (Glissant 2010, p. 28). As gestured to here, many literary and maritime traditions reinforce "a *transoceanic* imaginary, positioning the sea as a stage for human history; a narrative of flat surfaces rather than immersions" (DeLoughrey 2017). Reduced to the horizontal spatiality of a surface traversed and ruled, the oceanic is frequently embedded within a land-based worldview of stability, through which nation-building, imperial commerce and colonial violence are assured and insured. As Christopher L. Connery states, "the ocean [...] is capital's favoured myth-element" (1994). Meanwhile Paul Gilroy's *The Black Atlantic* (1993) traces how the transatlantic slave trade hinged upon the goverance and territorialisation of oceanic surface. As a site and facilitator of capitalist extraction, accumulation and enslavement, the oceanic has been utilised and formatted within the coordinates of place in land-based forms of world building and control. Emblematic of the "powerful sedentarisms in our thinking" (Malkki 1992), the imposition of landmass perspectivalism upon the oceanic, where watery volumes are construed as a vast emptiness contrasting with the populated land, facilitates the transmutation of the wavering surface into a place of restraint and coercion: a colonial frontier. Nemo's oceanic infinitudes resist, but are tempered by, the territorialisations and trade routes which historically condition, and still striate, the surface under which he resides. And yet, despite such attempts to attenuate and curtail its alterity, the oceanic remains ultimately unassailable. Central to the imposition of control yet uncontrollable: just as the oceanic facilitates modes of commerce and capture, so too does it flow back in unanticipated vectors, eroding the expansions it enables.

Rather than a neutral surface ideally primed for the projection of a contiguous empire, Nemo's summoning and inhabitation of the deep emphasises the destabilising potential of oceanic depth. Enacting what Peters and Steinberg (2015) have elsewhere observed, through his watery engulfments, Nemo is "challenging the horizontalism inherent in such approaches by opening a vertical world of volume". Plunging into watery submergences and metamorphics (re)opens the entrenched and weather-worn "terracentrism" (Rediker 2014) endorsed by surface modalities of control. The mobilisation of such a "'wet ontology' can reinvigorate, redirect and reshape debates that are all too often restricted by terrestrial limits" (Peters and Steinberg 2015). The oceanic is instead encountered in its immanence and responsivity, an assemblage which pulls the fixed and grounded into the infinite mobilities and multiplicities of the volumetric. The oceanic thus enables us "to derive new forms of relatedness" (Ibid.). Brathwaite's postcolonial concept of tidalectics is instructive here. A pun which seeks to upend and replace the dialectical preoccupation with fixity rooted in land-based epistemologies, tidalectics instead privileges fluidity, that which is provisional, amorphous and all-encompassing, to envision alternative means of navigating and being in the world. Overcoming the false structures and stability of horizontal spatialisation, tidalectics, with its environmental sensitisation to the myriad atmospheric forces and subsurface speeds, could best be described as deeply volumetric. Not merely an abstraction instrumentalised for escalating forms of control, within these depths the ocean is a volumetric spatiality which is

> Fundamentally a space of dispersion, conjunction, distribution, contingency, heterogeneity, and of intersecting and stratified lines and images—in short, a field of strategic possibilities in which the Oceanic order holds all together in a common but highly fluid space (Blum 2010, quoting William Boelhower).

Within this contradictory space of dispersion and conjunction, life becomes reconceived as consummate with ever-greater immensities. Nemo's oceanic perspective, configured as planetary-spanning volumes teeming with life, simultaneously entangles and juxtaposes forms of alterity—as represented by comparisons to perennially shifting deserts, infinity and the supernatural—with the known world of globes, community and emotion. The increasing apprehendibility of planetary scales and their beyonds, as arrived at through speculative submarine technologies, also engender new ways of perceiving life. Outside the ordering of commercial quantification or land-based taxonomies, these new understandings of life, as an oceanically vast "stirring on all sides" (Verne 1869), in turn begins to shift how planetary scales are comprehended. Beyond colonial conditioning, the oceanic is a matrix through which life and the planet are imagined as contiguous, mutually modulating and modifying in "a highly fluid space" (Blum 2010).

Both Wells and Verne traverse alien spatialities through speculative technologies, demonstrating how such mobilities enable and necessitate planetary-scale thought. For McDougall's future engineers, turn of the twentieth century science fiction transformed the alterities existing beyond Earth-bound skies and within oceanic vicissitudes, into a space that could be traversed and a place which could be inhabited. Envisioning the technologies which would render these strange cosmic-oceanic spatialities inhabitable, Wells and Verne also posited new ways in which humankind could express itself within not only planetary but also exponentially growing magnitudes. In other words, in other worlds, Wells and Verne provided the imaginary apparatus through which alien spatialities could be brought into scales concordant with human modes of inhabitation. Nonetheless, the emplacing of these cosmic-oceanic orders agitate and displace the stability of the norms they are predicated upon.

In her ethnography of exoplanetary studies entitled *Placing Outer Space*, anthropologist Lisa Messari (2016) makes a powerful case for how planetary scientists consolidate upon (and further feed into) particular imaginaries through narrating other worlds as concrete places. As she contends (in a passage which resonates with Nemo's oceanic mediations):

> To claim that the infinite field of stars is not an invitation to loneliness but a prompt for feeling the pull of cosmic companionship requires a powerful and pervasive understanding of these planets as worlds and places that relate to our own—that invite being (Messeri 2016, p. 2).

Exoplanetary studies then are never solely about the detection of other astronomical bodies, but are intimately tied to how we imagine worlds. Placemaking practices play a definitional role in what Messeri has termed "planetary imaginaries," through which the strangeness of cosmic phenomena and magnitudes are not only made commensurate with human scales of perception, but are increasingly embedded within modes of being. Echoing Nemo's description of the sea as a realm in which "man never feels lonely," the invitation to being conjured by charting alien spatialities is made available through the extension of terrestrial worldviews. As Messeri states, "extraterrestrial placemaking grounds knowledge of other planets in familiar contexts" (ibid). Formatting cosmic alterity into the trifecta of world, place and being, maps interstellar distance into known coordinates. From science fiction to exoplanetary studies, the sculpting of cosmic placedness is primarily enacted through the twinning metrics of visibility and habitability, where alienness (and alien life) are similarly folded into and rerouted through terrestrial analogues. The interaction between science and its fictions forms an imaginary-matrix through which the inhuman realms of distant astronomical and oceanic bodies become orientated through scientific methodology, and measured within a contemporary calculus of world.

Images from interplanetary probes such as the *Mariner, Viking* and *Cassini-Huygens* missions, capture the concrete characteristics of distant bodies, thereby relocating abstract space into recognisable terrains. Scientific images and visualisations thus become a very literal form of world-building, which not only impacts on the practice of planetary science, but also shapes societal expectations around what a planet can be. Planetary imaginaries are shaped by, and dictate, the forms of life anticipated to reside within them, as demonstrated both within contemporary astrobiological research and the many representations of alien alterity found in science fiction. Planetary knowns, like Wells' ill-fated protagonist, are fractured by exoplanetary difference. Placemaking then is always alien-making also.

Messeri's planetary imaginaries, with her dialectic of known and unknown, are embedded within, and rest upon, a land-based ground. This is not surprising. Prevalent understandings of planets are derived from decades of probe images of Mars, Mercury and the Moon, with their cratered surfaces and dry regoliths, or the impenetrable twists of gas giants. The landscapes of such dried and desiccated planets serve to reinforce, and seem to attest to, the static nature of land-based fixity. Contingent on the planar, the fabrications and designations of placedness are quickly dislodged once filtered through the volumetric intensities of water. As Elizabeth DeLoughrey (2017) has outlined:

> Unlike terrestrial space—where one might memorialise a space into place—the perpetual circulation of ocean currents means that the sea dissolves phenomenological experience and diffracts the accumulation of narrative.

Titanic tidal forces unsettle and fold the apparent stability of land-based ontologies into aquatic gestations. With their dissolving circulations, current paradigmatic shifts towards waterworlds trouble and expose the terrestrially conditioned presuppositions of previous planetary imaginaries. As DeLoughrey makes clear, the depths, submersions and vicissitudes of the oceanic resist the reductions of horizontal curtailment, unmooring phenomenological delineations of place. Building on Stefanie Hessler's tidalectical formulation of water as a nexus which "allows us to think of hybridity, cross-cultural syncretism, incompleteness, and fragmentation" (Hessler 2017), waterworlds necessitate the thinking of the planetary as an ever-shifting multiplicity of vectors, textures, speeds. Confluence and discontinuity: the wavering diffractions of the oceanic propagates and forestalls the generation of new networks. In a contemporary moment where the planetary is constructed through a polyvariant chorus of exoplanetary simulation, science fiction and hydrodynamic processes, an awareness of oceanic realities sings planetary imaginaries anew.

3 Interplanetary Probes and Mars

Our solar system is predicted to harbour multiple waterworlds, with subsurface oceans thought to flow on the moons Enceladus, Europa, Ganymede, Callisto and Titan, as well as Pluto. Above such extraterrestrial depths lies Titan’s surface, speckled by rivers, lakes and seas of liquid methane. Rolling from the exsiccated towards the aqueous: images captured by space probe missions such as *Voyager, Galileo* and *Cassini* have been key in exposing the mounting volumes of these hidden oceans, yielding data which has substantially added to the tidal turn in contemporary planetary imaginaries. But rather than a new phenomenon, there has always been a resilient correlation between the visual cultures of planets and the contemporaneous imaginaries they conjure.

At the turn of the twentieth century Mars was the locus of intense interest and speculation, due in large part to Percival Lowell’s images ostensibly depicting Martian irrigation canals. Canals or “canali” were first postulated by Italian astronomer Giovanni Schiaparelli in 1877 as he squinted through the blur of his low-resolution telescope. Lowell’s imagination subsequently sharpened these fuzzy features into the shock discovery of alien artifice: speculative canals were transformed into incontestable proof of ancient engineering spidering across the planet. Extrapolating from humankind’s agrarian histories, Lowell’s book *Mars* (1895) postulated that these irrigation technologies were created to siphon off water from the Martian ice caps in order to combat an accelerating planetary drought. The transmutation of Schiaparelli’s optical illusions into Lowell’s alien techno-phantoms had massive implications for planetary imaginaries of the time. Mars became romantically reconfigured as a failed waterworld, a former cradle of civilisational flourishing now in retrograde. Before the advent of space probe photography, Lowell’s planetary images catalysed a narratological trajectory of past sophistication, present ruination and even possible futural renewal, that clearly demonstrates how planetary imaginaries not only encompass alien spatialities but also multiple temporalities.

The romantic planetary imaginary of an imperilled Martian civilisation of great but decaying technical skill shaped one of the most iconic representations of non-humanoid alien life, that of the Martians in Wells’ *The War of the Worlds* (1898). Wells cited Schiaparelli’s work as evidence that his aliens were not as outlandish or fantastical as they may at first seem. Stephen Dick has gone on to state; “it was no accident that Wells’ invaders came from the Mars of Percival Lowell, whose Martian canal controversy had by now reached England” (Dick 1998, p. 113). Wells’ Martians thus herald from a cooling site of former watery abundance now in collapse: a decaying waterworld.

Concordant with the planetary imaginary of Mars as a once verdant world subsiding into deep environmental decline beyond technological amelioration, is a relict mode of mechanico-cephalopodic alien alterity. Endangered hydro-technical origins become instantiated in a Martian physiology defined by octopoid malleability and a nefarious mechanical tentacularity. Dowsing for inspiration, it is perhaps unsurprising that cephalopods, as tool-using (Amodio et al. 2019) Earthlings defined by their strange morphologies, became a source from which to extrapolate an equivalent cosmic strangeness. What is made clear from Wells' example is that ostensibly cutting-edge scientific images of Mars not only shape planetary imaginaries, but also have a concomitant role in determining the form in which alien life is conceptualised. There are of course other constitutive factors leading to how and why alien alterity is represented. That being said, planetary imaginaries, and the scientific images they subtend, do nonetheless have massive traction on how alien life is constructed and anticipated.

Further evidence for the purchase planetary imaginaries have upon how (alien) life is conceptualised is found in the *Mariner* missions. Dethroning Lowell's apocryphal canals, in 1965 *Mariner 4* beamed back images of Mars as cratered and desiccated, more inhospitable and inanical to life than had previously been imagined. Rather than providing any hoped for watery intrigue, "the extreme lunarlike features shocked even the scientific teams overseeing the mission" (McCurdy 2011, p. 122–3). A refusal to let go of the dream of an aqueously inhabited Mars prompted subsequent Mariner missions. In anticipation of *Mariner 9*s arrival at Mars, a quorum of scientists and science fiction writers was convened to debate Mars as geophysical reality and as "inexhaustible metaphor," asking:

> Is Mars a brother of Earth as was generally believed before the first *Mariners* in 1965 and 1969? Or is it nothing more than a cousin of the Moon, as the results of the early *Mariners* seemed to indicate? Or can it be a member of an as yet unknown family? (Bradbury et al. 1973, p. 3).

These musings and hopes for a new expression of cosmic companionship, to be shaped through evidence of a Martian waterworld, were further flouted by *Mariner 9*'s images of a primordial Mars bereft of life. And yet, *Mariner 9* also returned the first images of ancient Martian river valleys, providing evidence that Mars may indeed have *once* been a waterworld, but no longer. Former romantic narratives of civilisational sophistication and "Earthlike" dreams of a Martian waterworld were thus thrown into an alienating planetary corrosion. The ineluctability of the planet's endlessly cracked surfaces catalysed representations of non-humanoid alien life to shift dramatically in the 1970s to a preponderance of the insectile**.** Still clearly in the lineage of Wells' predatory semi-mechanical alien life, iconic alien representations from the 70s are defined by the exoskeletonal armour and proboscis weaponry of insectile life, as seen in the egg-laying arthropodic Xenomorphs of the *Alien* franchise. Although published in 1985, *Ender's Game* was based on a short story first published in 1977, featuring an alien race called 'Formics' (latin for Ant) but referred to throughout with the pejorative "buggers." Once again planetary imaginaries, here relocated to parched and shrivelled lands, dictate how alien life is subsequently imagined.

Spacecraft images of desiccated worlds were all the more stark for emerging at the same time as *Earthrise* (1968) and *Blue Marble* (1972). For many, the *Blue Marble* has become the planetary ur-icon for waterworlds, cementing narratives of fragility and grounding ecological discourse, although others dispute this legacy (e.g., Spier 2019). With mounting evidence that Mars is a failed waterworld (Dickeson et al. 2020), the similarities and divergences with the current Earth of ecological collapse become even more fraught. With its hydrodynamic escape and evanescence, the collapse of Mars' liquid vitality is a warning. Ghostly Martian oceans lurk and beckon blue marbles: the haunting of extraterrestrial might-have-beens become a potential foretelling of what terrestrially-might-be. From parched Martians to desiccated *Mariner* images, the repeated droughts, neeps and springs of Mars across time cumulatively demonstrate the vibrant plasticity through which planetary imaginaries meander.

4 Exoplanetary Waterworlds and the Extraterrestrial Earth

Out of the desiccated imaginaries of *Mariners'* Mars images, a more amphibious, aquatic and overall oceanic imaginary is now (re)emerging and gaining ground. Bringing us into the present, the *Cassini-Huygens* probe has catalysed a new revolution in the shape of planetary imaginaries, and the forms of alien life expected to reside therein. *Cassini,* which recorded data within the Saturnian system from 2004 to 2017, caused a sensation when it returned images of cryovolcanic plumes on Enceladus**,** providing the strongest evidence yet for an extraterrestrial subsurface ocean. This global ocean is expected to be warm and salty, and potentially hospitable for life (as we currently understand it). Concurrently, images of a lake-strewn and fluvial Titan confirmed Saturn's largest satellite to be the first non-terrestrial place in the solar system known to host surface liquid (of methane and ethane). Where once planetary imaginaries were determined by images of the cratered worlds of Mars, Mercury and the Moon, *Cassini's* images are instead saturated in liquid promise. Recent work in exoplanetary studies further reinforce and launch this aquatic imaginary into the stelliferous depths.

A recent paper by Li Zeng et al. (2019) hypotheses that sub-Neptunian exoplanets, found in abundance across the Milky Way (anticipated to be about 35% of those so far discovered), and commonly thought to be gaseous, are more likely to be vast waterworlds. Zeng and his team used the Monte Carlo method to run simulations of protoplanetary disks, speculatively charting planetary evolution and solar systemic development. Through this process it was determined that sub-Neptunian planets are probabilistically composed of 50% water on average (whereas the Earth's total mass is estimated to be 0.2% water). From core to surface, these exoplanetary waterworlds are defined as much by their alienating amorphousness, as by their potential familiarity to Earth-like conditions. As Zeng et al. state, exoplanetary waterworlds "may or may not have a well-defined surface [...and] could be fluid all the way down—all the way down, to great depth" (2020). These depths could be within the order of hundreds of kilometers (in contrast the Mariana Trench, as the deepest point on Earth, which is about 11 km). Through such simulations, exo-waterworlds become extreme examples of what has elsewhere been ascribed to the "three-dimensional and turbulent materiality" of the (terrestrial) oceanic (Peters and Steinberg 2015). Outside of Earth's biospherically bounded parameters, or the cryospheric seals of Saturnian and Jovian moons, the indeterminate surface and atmospheric escape of some exoplanets depart from a conventional notion of surface all together. These fluctuating waterworld morphologies expand the variety of forms planets can be expected to take, and estranges how water has habitually been understood. On the constitution and distribution of exowater, Zeng et al. write:

> This is water, but not as commonly found here on Earth [. . . exo-waterworlds] surface temperature is expected to be in the 200–500 °C range. Their surface may be shrouded in a water-vapor-dominated atmosphere, with a liquid water layer underneath. Moving deeper, one would expect to find this water transforms into high-pressure ices before we reach the solid rocky core (Zeng 2018).

Speculation, extrapolation and modelisation collide in exowaterworlds; emerging from these simulations are extraterrestrial iterations of the oceanic. The interior structure of these waterworlds are expected to be deeply strange, replete with exotic material such as superionic ice (Zeng et al. 2019). Hypothesised to be hot, black, and four times heavier than terrestrial ices, superionic ice has only recently been artificially created on Earth in labs. And yet, due to its anticipated importance in the planetary formation and composition of waterworlds, superionic ice is now thought to be the most abundant form of ice in the universe (Sokol 2019). The expected pervasiveness of superionic ice attests to the extreme alien possibilities of H_2O, far outside terrestrial experiences and manifestations. Models of waterworlds also include "steam, liquid, superfluid, high-pressure ices and plasma phases" (Zeng et al. 2019) of water, oscillating compositions which pull out and make apparent the alien potentialities of water. The alien abundance and flexibility of waterworlds, far beyond Earthly or even ice-moon manifestations, transform the most definitional terrestrial component into something increasingly strange and estranging.

From subsurface to solar systemic scales: the alien flexibility of exo-waterworlds enacts myriad weirdings to planetary parameters. With a radius between that of Earth and Neptune, these galactically populous planets are not found within the architecture of our solar system, rendering them both common and unusual. Conversely, the lack of Sub-Neptunian planets adds to the probability that the structure of our solar system is itself an oddity. Sub-Neptunian waterworlds, with their potentially indiscernible surfaces and feathering atmospheres, their internal percolations of exotic materials and their galactic plenitude, are not only made (somewhat) knowable through extrapolations from Earth’s position as a waterworld. The broadening of what a waterworld comprises leads to the destandardisation of the Earth. This analogical (dis)placement of planets has long structured planetary science and imaginaries. As Robert Markley has observed in *Dying Planet: Mars in Science and Imagination*:

> Over time, such analogies have reflected changing conceptions of both worlds: while Mars has been perceived through the lenses of terrestrial sciences, the study of the red planet has shaped, and continues to shape, humankind’s understanding of Earth (Markley 2005, p. 1).

Similar to Markley’s Mars-Earth matrix, work on exoplanetary oceanography brings terrestrial and extraterrestrial oceans into greater correspondence, alignments and resonances which affect how both oceans, and the life they contain, are understood. Thus, Earth and its Earthlings are not only extrapolated as analogues through which extraterrestrial life can be conceptualised: simultaneously Earth is remediated through the burgeoning potentialities of alien ecospheres. In line with Messeri’s planetary imaginaries, the continuing emergence of compelling cosmic difference begins to unmake understandings of terrestrial conditions, exposing their solidity as more provisional than previously supposed. Exoplanetary waterworlds problematise the position of Earth as the superlative form of liquid planet. But beyond Messeri’s and Markley’s dialectics of place and unplace, the expanding cohort of waterworlds filters and reels in transversal currents, leading to a tidalectical multiplication of diffractive difference. This prismatic spectrum of waters

> endorse the perspective of a world of flows, connections, liquidities, and becomings, but also [. . .] propose a means by which the sea’s material and phenomenological distinctiveness can facilitate the reimagining and reenlivening of a world ever on the move. (Peters and Steinberg 2015).

Taking the volumetric vibrancy of terrestrial waters and applying it to the theorisation of alien waterworlds effectuates tectonic shifts in how the Earth itself is conceptualised, whilst potentialising exoplanets as endless oceanic becomings. The increasing engulfments of exoplanetary water demonstrates that to talk of world, one must parley with worlds. To think with the potentialities of the hydrological, one must contend with interstellar multitudes of water. The transmutation of sidereal unknowns into terrestrial legibility simultaneously unmakes the Earthly, leading to what Stephan Helmreich has called the “extraterrestrialisation of the Earth” (Helmreich 2012). Rather than structured by the dichotomised poles of place and unplace, the unexpected sinuosities, gigantic circulations and wild turbulences of waterworlds demand a gradient wherein the known and strange are understood to interpenetrate continuously and coexist in multiscalar forms, across the multiple manifestations of water.

Meanwhile, as the havoc of climate collapse plays itself out in sea level rises and deep-sea desertifications, the Earth is increasingly rendered alien from within. As the cryosphere sinks into a watery demise, hydrospheric volumes gain ground: gnawing coastlines, submerging littoral zones and swallowing islands. Currently, the extraterrestrialisation of the Earth is also Earth’s ex-terrestrialisation. Unlike the prevailing dearth defining the dried horizontal landscapes of a lost Martian waterworld, here the deepening of water comes as an unwelcome surfeit, an unwieldy excess. Below the beating of this tidal persistence, the depths are rapidly depopulating, undermining the assumed boundlessness of oceanic plenitude. These aquatic gains, both creeping and dramatic, materialise and make apprehendable planetary scales of oceanic action.

Exo-waterworlds problematise understandings of large bodies of water, adding new exotics to their eternal flows. Once refracted and streamed through hot superionic ice-beds, beyond 100 km depths and the speculative rhythms of fizzing exowaves, our world of shallow oceans becomes yet more estranged. Whirling admixtures, unruly and alien oceanics converge, necessitating the renewed question: what is an ocean? Alice Te Punga Somerville (2017) has elucidated on the multiscalar production and operations of oceanic imaginaries, as imbrications of discursive, scientific, affective and hyptic elements:

> We produce ocean through names, anthologies, maps, reading lists, bookshop sleeves, blog posts, festivals, activist networks, scientific research, creative exchanges, genealogies. We also produce oceans by tracing their effects: weather patterns, coastal erosion, tsunamis, garbage patches, schools of fish, tides (Somerville 2017).

A mesh of material and symbolic orders, here Somerville captures the polymorphous ways in which we ocean, we world, we cosmos. Familiar and unfamiliar unite when we understand the Earth as one waterworld among many, rerendering its watery clashes as eternal folds in “a spherical voluminous realm of matter” (Peters and Steinberg 2015) across space. Although Peters and Steinberg are here talking about the mercurial tempest which storms within terrestrial oceans, they could just as easily be formulating the perculations and becomings expected to be endemic to many exowaterworlds. Amorphous and alien, these cosmically expanded waterways necessitate the rethinking of what a world is, and what it could be. The (exo)oceanic unleashes waves towards us. A beckoning. We are already in the water, within the waves.

5 Extraterrestrial Earthlings

Adding to this strange weight of sidereal water, in her Keynote Lecture at the Goldschmidt Geochemistry Congress in August of 2019, Dr. Stephanie Olson presented models indicating that “some exoplanets with favourable ocean circulation patterns could be better suited to support life that is more abundant or more active than life on Earth” (Olson 2019). This anticipated “superhabitability” signals a density of inhabitation which could far outstrip and surpass current forms. Superhabitability thus relegates Earth from its default position as the superlative measure for vibrant, life-nurturing ecospheres. This counterintuitive flipping of what signifies a habitable planet means the primary component determining “Earth-like” conditions is increasingly untethered and decoupled from Earthly coordinates.

Astrobiological searches extrapolated from terrestrial analogues could be unknowingly predicated upon a diminished notion of life and habitat. As Olson goes on to state, “a further implication is that Earth might not be optimally habitable” (ibid). Yet again, the modelisation of exoplanetary conditions effectuates a weirding, whereby the presupposed applicability of Earthly conditions for the purposes of extrapolation are problematised from the axis of outer space. Indeed, astrobiology potentially surpasses the Earth-based lifeforms it is premised upon, turning back to decenter Earth’s position as the template dictating the viability of other living worlds. Where Mars and Venus are seen as possible variants for collapsed Earth-like biospheric waterworlds, acting as an index of negative, redundant or peripheral habitability, on the other extreme, the overflowing liquid potentialities of waterworlds speculatively replaces Earth as the home of optimum habitability.

On the speculative abundance of exo-oceanography, assistant professor of geophysical sciences Edwin Kite contends; “this really pushes back against the idea you need an Earth clone—that is, a planet with some land and a shallow ocean” (Kite 2018). Anticipations of oceanic extraterrestrial life not only problematizes the ascription of Earth-like as a valid measure for the plausibility of inhabitation: extraterrestrial life is also hypothesized to be a crucial means through which the (exo)planetary can be ascertained and understood. Commenting on the importance of waterworlds as a site for the observation of biosignatures, Chris Reinhard has stated: “we expect oceans to be important in regulating some of the most compelling remotely detectable signs of life on habitable worlds” (Reinhard 2019). Broadcasting themselves across interstellar distance, conflations of the oceanic with biological fecundity are thus astrolised and endure.

The escalating prevalence waterworld imaginaries, with their variously (super)-habitable circulations and horrendous hydrological floods, (re)emerges during times of acute ecological precarity. External cosmic relegations of Earth’s geological composition as not only creating, but also curtailing, the propagation of life, are met by the internal jeopardisations of the anthropocene. For a more complete understanding of Earthly inhabitation to be formulated, predicted species decline must be supplemented by the current scales of biodiversity loss which have already become naturalised and opaque. Professor Callum Roberts’ *The Unnatural History of the Sea* (2009) interrogates how historical levels of aquatic habitability far outstrip the levels they are retrospectively expected to have held. The contemporary levels of oceanic inhibition to which we are accustomed, thus commence from a position of forgotten former abundance. This previous plenitude becomes obscured by the naturalisation of present lack, to become the standard measure for the levels of inhabitation the Earth can produce and maintain. Cosmic planetary contrasts, current foretellings of ecological collapse and historical lost abundance form a deceiving concatenation. As the interaction of cosmic externalities and anthropocenic internalities render Earth as ever-less habitable, it is increasingly difficult to give a full account of what an inhabited Earth really could, and has, entailed.

The escalating ubiquity of both predicted waterworld superhabitats and Earth's flooding decline, are reflected in a popular culture increasingly frequented by cephalopodic intelligence and tentacular aliens. Popular science books such as Peter Godfrey-Smith's *Other Minds* (2017) and Sy Montgomery's *The Soul of an Octopus* (2016), are testaments to the wide-spread and escalating interest in cephalopods and their ilk. But perhaps the most evident example of how this couplet of waterworld imaginary and aquatic/cephalopodic models have come to dominate representations of alien alterity in the twenty-first century can be found in science fiction.

Discarding conventional human-alien animosity, many contemporary science fictions incorporate thriving waterworld imaginaries which focus on multispecies alliances. In Sayuri Ueda's *The Cage of Zeus* (2011), multicellular life under Europa's cryosphere elicits forms of kinship with human characters. Decentring the prioritisation of human needs, one of Ueda's characters even states "those tiny lives were as sacred as the gods themselves, and we far paled in comparison" (Ueda 2011, p. 217). Similarly, the cephalopodic aliens of Denis Villeneuve's film *Arrival* (2016) necessitate forms of rescue and collaboration enabled through shifts in human ontology. Early in Adrian Tchaikovsky's *Children of Ruin,* the ultimate insufficiency of anthropomorphic reasoning when encountering alien alterity is indicated as "something pale moved in the air and the human eye tried to recast it as a bird, a machine" (Tchaikovsky 2019, p. 15). The novel then unfolds to become a sophisticated interrogation of how massively divergent forms of being—cephalopodic, arachnidian and human—can meet, but only through mutual multispecies modulations. A common theme coursing throughout these science fiction waterworld imaginaries is humankind's responsibility for species protection, environmental conservation and the potential for communication with cephalopodic kin. In this context science fiction becomes a means of metamodelling how ethical encounters with both alien and terrestrial life could manifest, through the development of new collective forms of inhabitation.

6 What's in a Waterworld? Towards the Cosmic-Oceanic

Where once desiccated worlds imparted a stripped aesthetic of prevailing exhaustion, geological quiescence or a sense of slow inward collapse, the increasing preponderance of waterworlds is defined by a dynamic metastability, or a meandering, spilling outwards. A dramatic visualisation of this more networked cosmos is found in Enceladus, which vents its contents to form and replenish Saturn's E-ring. The Enceladean oceanic is composed of a rhythmic weaving of water, circulations which blast matter from deep subsurface interiors, out to rotate in circum-Saturnian orbits, before relanding on the moon, to become once again its temporary, moulting ground. A surface waiting to become the depth it tentatively encloses. Such watery migrations highlight the role supercritical fluids play in destabilising solid notions of surface and blurring the presupposed parameters of the planetary. A passage from Anna Ryan (2012) reflecting on the restlessness of terrestrial seascapes seems appropriate when trying to think through the reality and poetics of Enceladus' cryovolcanic iteration of waterworld imaginary:

> The spatial configuration of surface and depth are in constant flux, with one becoming the other in continual intensity of motion. Depth rises into surface, only to be returned below once again. Surface is submerged, becoming depth in a regular oscillation [. . .] the physical natures of their separate materialities and movements come together as a palpable, and particular, intensity of place (Ryan 2012, p. 1).

The focus on endless becoming, where surfaces are transient and mobile, rather than exemplifying the persistent stability of land, provide a model for how waterworlds configure the relationship between planetary bodies and outer space differently. The mounting analogies of speculatively comparable environments reinforce liquid resonances across space, collapsing distance into oceanic forms of restless place. Helmreich mobilises Foucault's notion of heterotopic space through which to conceptualise oceanic volumes as a "heterogeneous space" (Helmreich 2009), which overlaps and exceeds conventional delineations of sea and land. Understood thus, the oceanic becomes about the propagation of continuities which capsize conventional understandings of planetary delimitation. Planets as interpellated within the former planetary imaginary of dry worlds remain a discrete mode within a networked metasystem. As Messeri (2016) has claimed:

> Planetary places are populating the pale blue dot cosmology as Earth becomes part of a vast interplanetary network... The act of placing outer space puts forward not a particular worldview but a cosmoview . . . knowing our place in the universe is knowing the planetary network in which Earth exists (Messeri 2016, p. 22).

Here Earth remains a discrete sphere or node within a network of astronomical bodies. Once the metastable flows of waterworlds are brought within this network, however, former planetary discreteness is called into question. Commenting on how more aquatic cosmoviews emerge with the popularisation of iconic images of Earth taken from space (such as the oceanic *Blue Marble*), Helmreich states: "post-cold war environmentalism balloons up to include the entire solar-system, with planets akin to islands in a macrocosmic sea" (Helmreich 2009). Rather than a new phenomena, outer space has long been interpreted through an oceanic lens, with the Earth and other astronomical phenomena framed as islands, moments of reprieve within a roiling cosmos.[2] However, here Helmreich outlines how the cosmos has

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[2]It is far beyond the scope of this paper to give a sufficient overview of the myriad ways in which the cosmos has long been conceptualised as oceanic, where astronomical bodies are recast as islands. Some of the few amongst the teeming many: Mesopotamian maps of Earth as a disk situated within a cosmic ocean to biblical depictions of an island-Earth afloat amongst the cosmic waves. From Giotto's ceilings with their depictions of the heavens as saturated in the cerulean of lapis lazuli, to Dante's Paradiso where "every nature moves across the tide of the great sea of being to its own port" (Dante 2003), theological conceptualisations of an ultimate reality beyond the terrestrial realm are overwhelmingly oceanic. Gesturing towards the poetics of both oceanic and cosmic infinities, essayist Joseph Addison (1672–1719) encouraged others to "consider the fixt Stars as so many vast Oceans of Flame [. . .] sunk farther in those unfathomable Depths of Ether" (Addison 1712). Elaborating on this propensity towards an accompanying archipelagic imaginary within the

been explicitly "environmentalised" in alignment with the ecological and governmental discourses subtending images of Earth—demonstrating the interrelations between planetary imaginaries and the cosmos they inhabit.[3] Accompanying these super-planetary hydrological cycles, configurations of life remain key to the operations and propagation of the cosmic-oceanic.

For Arthur C. Clarke, humankind never left the ocean. Across his cosmically orientated opus, epidermal layers are a proto-spacesuit enabling humankind, as an elementally hydrological creature, to inhabit land temporarily. Accessed through these oceanic skinsuits, land-based existence is a momentary pause between two watery volumes, "a brief resting place between the sea of salt and the sea of stars" (Clarke 1999, p. 216). In other words, we carry the sea we leave within us. If, as Helmreich contends, "the alien [microbe] is a channel of exchange between the oceanic and the human" (Helmreich 2009, p. xi) then for Clarke the human is a channel between the ocean and the cosmos. This terrestrialisation of oceanic life as enlarging, rather than departing, aquatic dimensions has been theorised by evolutionary scientists Mark and Dianna McMenamin as the "Hypersea" (McMenamin and McMenamin 1994). Rather than individuated lifeforms bound to land, life is a contiguous component of the Hypersea, an "interconnected system of terrestrial life that has extended the sea and taken it along for the ride" (Neimanis 2017, p. 123). As such, Earthlings are "conduits of Hypersea" (ibid). According to poet Rita Wong, the ocean

> is formidable & humble, far away & intimate, outside and inside, all at once [. . .] hypersea is a story of how we rearrange our oceanic selves on land. We are liquid matrix, streaming & recombining through ingesting one another (Wong 2015, p. 10–1).

Wong charts the fluid dynamics of the oceanic as enveloping the polarities of interiority and exteriority, where waves become folded into Earthling physiologies, emphasising interspecies intra-relationality. As Astrida Neimanis remarks, through water, "we experience ourselves less as isolated entities and more as oceanic eddies [. . .] The space between ourselves and others is at once as distant as the primeval [or exoplanetary] sea, yet also closer than our own skin" (Neimanis 2012, p. 85). Water is a transversal means of understanding how bodies—from the micrological to the astronomical—reach multiscalar coherence, and cohere.

To return to Clarke, his iteration of the hypersea dictates that departure from the sea is always about unearthing new ways of returning to it. Clarke's opus resonates with the aesthetics and "cosmoviews" of the cosmic-oceanic, as for him spaceflight and space exploration are the manifestation for humankind's predestined oceanic

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cosmic-oceanic—and contrary to prevailing logic of the time—Immanuel Kant was an early proponent of the cosmic model which posited that nebulae were separate galaxies known as island universes (Kant 1981). Worldviews have long incorporated the cosmic-oceanic within its planetary island-ontology. Long before scientific and photographic evidence of Earth as a terraqueous sphere became commonplace, across multiple cosmologies and historical trajectories through to the present, the collocation of the oceanic and the cosmic pervades.

[3]For more on the environmentalisation of outer space see Janet Olson (2018).

return. Ever-greater plunges into the sidereal expanse are thus deeper dives into our aquatic home. Rather than construe departure from Earth's gravity well as a planetary-escaping velocity, Clarke's prognostications regarding human inhabitations of outer space are instead about the realisation of planetary potential through the astrolisation of the Hypersea. The Hypersea not only submerges land through the propagation of life, but speculatively could also forge further continuities between planet and cosmos. The interaction between waterworld planetary conditions and the life it seeds thus creates vectors of flourishing which continue to connect and strengthen the interrelations between terrestrial and cosmic modes of the oceanic. As existential folds, spacefaring humans engineer new transplanetary symbioses between waterworlds and the cosmic-oceanic. Once applied to the space environment, this new order of tidalectics becomes a means of reimagining human and more-than-human relationships as based on mutual reflexivity and flux, both on Earth and within larger cosmic dimensions.

7 Conclusion

> If the imaginary carries us from thinking about this world to thinking about the universe, we can conceive that aesthetics, by means of which we make our imaginary concrete, with the opposite intention, always brings us back from the infinities of the universe to the definable poetics of our world. This is the world from which all norms are eliminated, and also it is this world that serves as our inspiration to approach the reality of our time and our place (Glissant 2010, p. 203).

The planetary imaginaries of waterworlds, as they wander from deep planetary interiors to the vastest of sidereal scales, from world to universe, necessitates the development of extra-, inter- and intra-planetary ecopoetics. With a renewed gaze, these ecopoetics highlight how fluctuating cosmic perspectives are in constant dialogue with our understanding of world. This gaze crafts orders of world which span and incorporate the oceanic, the planetary and the cosmic. Worldviews are thus increasingly formed by the viewing of multiple worlds. These worlds of water adorn planets which spin in a perpetual dance with the known and unknown, the knowable and the unknowable. The accompanying cosmically expanded mode of poetics enables us to re-encounter the Earth, serving as new inspirations for which to approach reality and, now caught within cosmically scaled waves, from which to sing planetary reality anew. In turn, cosmic magnitudes collapse into aquatic correspondence.

From surveying a variety of waterworld imaginaries it is clear that the oceanic is as much earthly as it is cosmological, forming an indissoluble bond between the planetary and the interplanetary. Flowing back once more, the increasing awareness of Earth as suspended within an expanded tidal system of cosmic aquatics necessitates a corresponding shift in world(s)views to renewed cosmoviews. Unravelling astronomical bodies and visions of astrolised Hyperseas are expressions of the cosmic-oceanic's transplanetary ecologies, ecologies which necessitate tidalectical cosmoviews of world. Cosmo-ecopoetics enable the reconceptualisation of not only the Earth, now suspended within the flows of multiple worlds and scales, but also call for modulations in how Life is encountered, understood and calibrated. Unbounded from land-based modes of thinking, Life beats within the rhythmic fluidity of water, the incessant swelling and receding of the tides.

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Chapter 15
Astrobiology and the Outer Limits of Human Ethics

Tony Milligan

Abstract When it comes to the discovery of microbial life elsewhere in the Solar System, there is a widely shared intuition that such life ought to be protected. While we might explain this in terms of protection for the purposes of science, there are at least some indications that our motivations for protection reach further, toward some notion of intrinsic value. A problem here is that we tend to discount any such notion in relation to terrestrial microbes, giving rise to what we may call a 'similarity problem.' This chapter will aim to dissolve the problem by presenting a picture of what it is that talk about intrinsic value does. The argument is that it tracks our reasons for action (and for other responses) and not a peculiar, figurative, sort of inner gold. On the latter, more problematic, approach it makes sense to say that all value bearers are equal and that treating them differently is some manner of bias. On the proposed approach, based around reasons for action, it is clear that our reasons for action (and hence, what 'intrinsic value' talk does) is situationally sensitive. Put simply, our reasons for action shift and change with context, and should be expected to vary in any comparison between terrestrial microbes and microbes discovered elsewhere.

1 Thinking from an Ethical Point of View

It is perfectly possible to comment informatively upon the ethical dimensions of astrobiology without entering into any deep discussion about methodology or about the ultimate standing of ethical discourse. We may do so without taking positions on how ethics works, and whether or not there are ethical facts or moral properties, or about how such properties might relate to the regular natural properties considered by science. Most of the time, it makes sense to keep a certain distance between these

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things. Similarly, no one needs to reflect upon the laws of thermodynamics in order to change a light bulb. Even for applied ethicists, the ultimate standing of ethics as a discipline is rarely part of the day job. However, what is said in the day job has to be at least consistent with a plausible, non-arbitrary, account of ultimate standing. And there are occasions when it may be useful to stray a little into the territories of methodology (how best to carry out the work of ethics) and metaethics (what ethics is ultimately about). Occasions when a previously useful way of stating matters can mislead. For example, when ethical discourse is extended into new areas, such as the ethical standing of microbial life, we may find that our existing imagery, metaphors and formulations make it difficult to acknowledge something obvious or otherwise difficult to ignore. This is not, of course, a problem which is unique to ethics: the terminology of black holes would be problematic if we took it literally, the terminology of dark energy may be useful, but perhaps more useful for some purposes than for others. I want to suggest that there is a problem of this sort with certain aspects of our ethical talk about 'intrinsic value,' (hereafter, just 'value'), and about whether or not such value has any bearing upon our thinking about microbial life. In what follows, I will try to demythologize this kind of talk, so that we can bring our ethical commitments in line with our likely response to the discovery of life elsewhere.

In short, I want to accept that an appeal to intrinsic value will help us to make sense of our apparently inconsistent attitudes towards microbial life and its discovery elsewhere. The concept has important work to perform. However, it will be more useful, and less likely to mislead, if situated within an undemanding view of ethics. Undemanding, in both a practical and ontological sense (a sense which deals with claims about 'what exists'). That is to say, it is best to avoid a strange, but tempting, view of what value talk is all about. My primary concern will not, then, be with reviewing the familiar arguments for and against microbes having value, although some mention of these will be made (Schweitzer 1987; Wilson 1984; Cockell and Jones 2009; Milligan 2015). Rather, the primary concern will be with making sense of what we are doing when we think about microbes *from an ethical point of view*. Having a grasp of this is not the same as giving a yes or no answer to 'Do microbes have value?' (Again, I would answer 'yes,' but my aim here is to say something else.)

The view of ethics that is presupposed, and at work, is as follows. Ethics is born within creaturely practices, and most obviously within human practices. It cannot be found elsewhere, outside of these practices, or in the sheer nature of things in themselves. And so, when we speak of the inherent value of humans and animals, or rocks and trees, or moss and microbes, what sits at the bottom of such talk is our having *reasons for action and response*, and practices (such as practices of justification) within which these reasons arise. Some of the practices run more deeply within our humanity than others. Some are more open to shifts and changes. We may be tricked by language, habit and expectations into thinking otherwise, but ultimately this is all there is. It is also all that we need in order to talk about issues of ethics in an orderly, motivating and disciplined/suitably constrained way. And while someone in the grip of a special theory of intrinsic value, one which treats it as an inner possession akin to hidden gold, may feel disappointed by this idea, and long for something else, such as a sanction given by the universe itself, my own thought is: 'Who could ask for anything more?' This approach gives us all that we need: motivation to act and respond, a manageable stability in our judgements about the world, and an acknowledgment that our reasons for action and response can be fully robust. To need more than that, to need some broader and human-independent sanction from the universe, is to need too much.

2 The Microbial Similarity Problem

The situating of our ethical deliberations about microbes within this ontologically undemanding approach towards ethics will draw upon a thought experiment (strictly, a cluster of thought experiments, but one does the main scenario-setting work). Imagine the discovery of microbial life elsewhere in the Solar System, somewhere below the surface of Mars, or in the clouds of Venus, or even in the immense ocean of Enceladus, sitting somewhere beneath the surface ice. We (or at least most of us) accept the discovery as a momentous event, but the biochemistry of the discovered life is familiar. It may have no exact counterpart on Earth, but it fits within our existing understanding of life's likely range. While we are satisfied that it is the result of a second genesis, rather than direct transfer across space, its similarity to terrestrial microbes may lead us to wonder about whether this discovered life has emerged because of the peculiar local conditions within the Solar System, rather than as a result of life's abundance elsewhere given routinely present conditions of planetary habitability.

The discovery is momentous, but perhaps it is not quite all that we may have hoped. It is no game changing alien Burgess Shale, full of strange and unfamiliar forms of life, on the more classification-shifting interpretation of the latter (Gould 1988) rather than the strong continuity view (Conway Morris 1998). In fact, we may learn a great deal less about life than we have learned from the Burgess Shale, or from extremophile life associated with hydrothermal vents and with other hard to access places. The discovery may help us to comment a little more on the Drake equation, i.e., to talk a little more plausibly about the odds that intelligent life may exist somewhere else, but we still do not really know. The discovery is, again, consistent with the emergence of life being only a local anomaly. Perhaps a one-place-only anomaly, at the level of the Solar System. Something that we are no closer to replicating under laboratory conditions.

From an ethical point of view, the similarity of terrestrial microbes and the life which is discovered in our thought experiment may seem to pose a problem: we are unlikely to treat the discovered life in the same way that we treat comparable microbial life here, on Earth. But our differing responses cannot be grounded in the kind of biochemical or structural difference that we might like to be able to point to and say 'this is what matters more than that.' From a protection point of view, it may even be difficult to explain exactly what it is that we are trying to protect, and why we would be doing so. We could play safe, and appeal strictly to the special protection of the discovered life for the sake of scientific investigation, and for no other reason. But this is unlikely to exhaust our actual motives. Our justifications and our motivations would then be in danger of falling apart from one another, and this is a division that we usually try to limit, even though it cannot be entirely avoided. And if we were convinced that we had uncovered all there was to know about the microbes, many of us would still not be content to have them destroyed or removed *en masse* from their original location, holding back only some samples as a precaution against future, improved, scientific techniques.

Those of us who would be reluctant to endorse such destruction might not share Carl Sagan's view that Mars would belong to the Martians, even microbial Martians, if there happened to be any (Sagan 1980). But we might sympathize with, and join in with, protests about destruction or removal as wanton harm. Perhaps we would still not say that the microbes *own* the planet they are on, and this need not be a result of uncertainty about where to send the title deed. After all, some animals might be seen as the owners of a piece of land, under imaginable legal systems which seek to limit human expansion for ecological reasons. Nonetheless, even without ownership, we could still appreciate a sense in which the discovered microbes would not simply be *on* a planet (or a moon), but would *belong* to the place, and so should not be removed from it without good reason. We would have duties in relation to them, even if we could make little sense of their having rights. We could, of course, borrow the language of rights, or extend it, at the expense of a little awkwardness. And something similar has been done in the case of rivers (Boyd 2017). But with or without rights talk, their wanton removal might still seem to involve wrongdoing of some sort.

As the microbes in the scenario (which many of us would want to protect) bear a striking biological similarly to microbes on the Earth (which we do not ordinarily protect), the described situation will still seem a little odd. Perhaps even a little unfair. Nor need we indulge in anthropomorphic flights of fancy or imagine a difficult conversation with disadvantaged microbes in which we are called upon to justify our apparent bias. However, even if we were satisfied that our mixed attitudes towards microbes and their protection did not stem from anthropomorphism or, better still, from the wrong kind of anthropomorphism (rather than a more helpful kind), the difference in response might still seem to be odd. Something that warrants comment because it may help us to make sense of how our attitudes are shaped and justified. More specifically, what seems clear is that the apparent inconsistency between our attitudes in the thought experiment, and in regular life, has something to do with situational factors, and not biochemical structure. (Although without the structure of life, the problem would not arise.) What seems to underly the difference in attitudes is an obvious consideration: the fact that the discovered microbes are the only indigenous life that we would ever have found elsewhere, the only life which we would know has emerged elsewhere. Yet there is a kind of thinking about value which may make this consideration hard to place at the centre of our understanding of ethical response. It is this kind of thinking that I am trying to challenge precisely because it can block us from saying what seems obvious, but does not fit well within a favoured story about ethics and intrinsic value.

My thought is that the considerations, the reasons for special concern, which have just been mentioned really do go to the heart of the matter. And we can reinforce the point by flagging up a range of scenarios in which we would again think of discovered microbes and terrestrial microbes in significantly different ways, now favouring one, now favouring the other, but in each case using value talk to make sense of our responses without claiming that differences in biochemistry are doing the work. For example, if we were faced with a scenario in which all life on Earth was predictably going to die out, with the exception of terrestrial microbes, we might then see such microbes as more important than the discovered microbes, and certainly as a better option than no life at all. Such an attitude would again be driven by situational factors, and not by an appeal to anything like biological structure.

Consider a further scenario, already present in the literature on astrobiology and ethics (Milligan 2016). Again, involving structurally similar terrestrial microbes and microbes from elsewhere (again, Mars, Venus, or Enceladus may serve as a convenient source location). This thought experiment is an extension of the extinction scenario just considered, and again it weights our ethical response towards the terrestrial microbes rather than discovered microbes. Let us imagine that we have a reliable technology for planetary seeding. One which is capable of detecting and avoiding any threat to *in situ* life when attempting to initiate a process of genesis. To the best of our knowledge, it is unlikely to kill off life elsewhere. For various good reasons we may think of the technology as reliable. Or, perhaps, we are not convinced about safety, but people in key decision-making positions are convinced. They believe that seeding could support life's extension rather than supporting a well-intentioned bioweapon. (We are Prometheus, and not a complacent Zeus.) Perhaps, we raise some objections about the risks and the difficulties of finding life even in a desert where life may be abundant, yet we cannot ultimately convince our decision-makers about this same danger. The decision is then taken to send and try to seed.

Which microbes should we send? We may want to say 'none,' and even do so, but in this scenario we can only influence the process and not stop it. Some of us will not want to lend any further legitimacy to the process, but some of us will have a fallback position and be ready to offer advice, or at least an opinion. If microbes are to be sent, there is a clear case for sending some of the microbes that we have found elsewhere, or their laboratory successors. They have a proven track record of survival under relevant conditions of adversity, without the lush advantages of Earth. This might give them an edge for strictly instrumental reasons. However, some of us might then raise a point whose significance is hard to evaluate: we do not share the same kind of common history with the microbes from elsewhere that we share with the terrestrially sourced microbes. If we want something of life here on Earth to survive after this planet has become uninhabitable, and once the Solar System has become unfavourable to life, then sending out microbial life which is from the Earth may be all that is available to us. This may be our ultimate legacy. Interstellar travel for humans (or our successors) may remain theoretically possible, while always being something of a long shot - much less likely to success than seeding. Its emergence as a practical option cannot be relied upon. At some future and distant time, seeding is all the legacy that we may ever have.

Whatever is eventually decided, my point here is that an appeal to common origins belongs within the deliberations, as one among many different considerations. It is not decisive, but it would be a proper part of the discussion. Yet it leans towards favouring the survival of terrestrial microbes, rather than the microbes discovered elsewhere. Again, it looks like there is nothing which is strictly intrinsic to either set of microbes, in the sense of something to do with their biological composition or structure, which is driving our deliberations about their relative ethical importance, yet the deliberations themselves are not arbitrary. They look like a local example of precisely the kind of deliberations that we ordinarily engage in when we think of humanity, our future, and our legacy, from an ethical point of view. However, there are different ways of thinking about things from such a point of view, some of which can accommodate problems of this sort more readily than others.

3 A Story About Ethics

There are at least two obvious and tempting ways to respond to the microbial similarity problem by 'fell swoop,' i.e., by looking to a general consideration or principle which will settle matters. On the one hand, we may say that only sentient life matters, therefore microbial life has no moral standing and we are only imagining that it does. We are tricked, perhaps, by anthropomorphic delusions. On the other hand, we may embrace something like a valuing of all life, or (in Albert Schweitzer's terms) a sense of 'reverence' for all life (Schweitzer 1987). And the important point is not the quasi-religious overtones of the formulation, but its overtones of equality. In which case, ethics should be geared to thinking of microbial life here in the way that we think of the discovered life. And this would be rather difficult, excessively demanding, an idea we may reflect upon but cannot actually live by.

But we will only be drawn to these kinds of fell-swoop move if we have a conception of what ethics is, and what ethics does, that leans heavily upon the idea of a generalized theory. We will then be continuing a pattern, or extending a series. Yet we need not think of ethics in this way. Consider two conceptions of ethics. In the first, we apply a generalized theory, with references to the great historical tradition: to Kant, or Mill, or perhaps to Aristotle (Cleland and Wilson 2013). The theory specifies various overall principles and it indicates when something is of ultimate value, and why it is of ultimate value. There is no attempt to drill down much further, into the concept of value, but a correlation is drawn between having value (alternatively 'moral standing') and something such as happiness, or rational autonomy, or human flourishing. A set of principles is based around this view of what matters, and these principles are portable. They carry over and can be extended from familiar cases to unfamiliar ones. The principles are also comprehensive, in the sense of

Table 15.1 Focusing upon a Generalized Theory

We should maximize…	We have a duty to…	Human character…
…our human presence	…back up the biosphere	…includes wanderlust
…the survival potential of humanity	…take ecologically damaging production off-world	…will be improved 'in a new place'
…the presence of life	…terraform other worlds	…needs a grand vision

being applicable more or less everywhere. These two features make sense of the idea that the theory is generalized.

The second conception of ethics is one in which we take a more pragmatic and situational approach. Principles may still be part of this approach, but they are no more basic or foundational than a range of other considerations. Instead, they are hints, clues, and reminders, and sometimes they are pedagogic tools for teaching. A convenient shorthand helping us to keep various important things in mind. This second conception of ethics aims at more of an 'all things considered' judgement, and the importance of any given consideration may vary with the situation at hand. In situation S_1, consideration c may matter more than it does in S_2. Figuratively: sometimes, the difficulty of climbing a mountain is a reason to take another route, but sometimes it is a reason to climb the mountain. Reasons are situationally sensitive. Something can tend to be important, and even important in much the same way from case to case, but importance and degree of importance is not fully fixed in a way which is independent of situations. Any general principle will only apply *up to a point* or *to some extent.* The thought is not that what matters can have its importance outweighed, but that its importance itself is not the same from case to case.

If we adhere to the first conception of ethics, then we are likely to draw upon one or more generalized ethical theory of the following sort: *Consequentialism*, the view that we should act in ways which maximize outcomes; *Deontology*, the view that we should act in line with rights and duties, not outcomes; or *Virtue Ethics*, the view that actions should be shaped by good character. These are nuanced theories, and the brief summaries do not do them full justice, but they give enough of an idea of the distinct focus of each. Deliberation will then typically involve considerations of the sort identified in Table 15.1, or something of much the same sort.

The first column is consequentialist, the second deontological, and the third is virtue ethical. Structurally, the approaches have a similarity, although they differ in their rival accounts of exactly which principles are legitimate or most important. There is an elegance and economy to such an approach. In each case, the preferred theory will be action guiding. It will not leave us in any great confusion about what is to be done. Suitably nuanced versions of each may also be able to accommodate more or less the same ethical intuitions as the others, albeit under different descriptions. Virtuous agents worry about consequences of actions, duties include duties to try to be a certain kind of agent, and consequentialists can recognize the usefulness of good character and systems of rights. The conceptual repertoires appealed to may be a little different in each case, but similar points can be drawn out, with differences of emphasis.

There is, however, a downside. The clear action-guidingness of such approaches is purchased at a price. There is a risk that the theories in question may oversimplify the range of things that ultimately matter to humans, in favour of some more limited but easily manageable sub-set. Perhaps, in extremis, the reduction is to some single central consideration (consequences, duty, character) which alone is taken ultimately to matter. Other considerations are then factored in, but in a way which makes them second rate, important only indirectly, by proxy. If, for example, we are trying to maximize human presence, or the presence of sentient life, then we will care for hills, rivers and forests only as carriers and not in their own right. If we have a duty concerning ecosystems or biospheres, the landscape and integrity of barren, 'lifeless' places such as other planets may seem to be something that we can easily override (McKay 1990; Midgley 1983). Once the range of things which are ultimately valued is simplified, counter-intuitive conclusions can easily be reached. We might even begin to think, as Werner Von Braun claimed to do, that the extension of life to space is more important than absolutely anything else, in which case the use of slave labour at launch sites, or group hangings to keep the schedule on track would seem justified. The cold equations might tell us that this is better, more in keeping with our manifest destiny, than failure to develop rockets. Or, without any such lapse into brutality, we might do what David Duemler's early text on space ethics *Bringing Life to the Stars* (1993) did, and apply a generalized consequentialist theory in which the extent of sentient life is the goal and the measure of all things, both motivation and justification for our actions in space. This is a more ennobling vision, but the justification process remains strictly consequentialist and similarly vulnerable to reductive explanations which pull away from our familiar moral psychology. And hence, from a sense that the ethic on offer would be liveable for an entire society (of a familiar sort, where nothing has gone badly wrong).

It is difficult imagining an emerging discipline such as space ethics without provisional statements of this sort, which look a lot like the application of a pre-set theory to a new topic rather than anything like dialogue and 'all things considered' deliberation. Yet no matter what complimentary things we may say about such early and provisional approaches, people do not think in the way that such approaches presume and require. The range of things that matter to us is always much larger than a generalized theory allows. Oversimplification also feeds into intractable disagreement, as agents who value different things go head to head in support of the one big consideration at the foundation of their approach. Given disagreement of this sort, such theories cannot directly underpin space policy and law within democratic societies where multiple things are valued. If we are aiming for anything like democratic consensus, they are of limited usefulness. Another way to put the same point would be to say that ethicists sometimes apply generalized theories, for limited purposes, but space agencies do not. While all space agencies take ethical considerations into account, none is in the business of rolling out a generalized theory of ethics of the kind set out in Table 15.1. Space agencies are strong on emphasizing inclusion, tackling risk, and on the justification of expenditure on space. NASA is

Table 15.2 A more piecemeal approach to ethics

Focus upon particularity	Include standing considerations	Sustain cohesion of approach
Precedents and exemplars	Hints, clues, and reminders	Identifying tensions
Engaging in thought experiments	Guidelines	Maintaining coherence
Prioritizing one case over another	Norms and principles	Making sense of which tensions are the ones we live with, and which lead to radical incoherence

also particularly strong on data disclosure as an ethical commitment. (Something for which anyone who works on climate change is duly grateful.) Its data sets become available, and this is bound up with ethical commitments concerning the dissemination of knowledge and NASA's broader societal role. But NASA is still not applying a generalized theory of consequentialism, deontology, or virtue ethics. It is answerable to the US government and to international law, and that is a rather different kind of answerability.

The role of ethics in actual space-related activities, shaped by space agencies and by agents of other sorts, tends to be in line with the second (far more pragmatic and situational) understanding of ethics. On the latter, generalized ethical theories do not function in the same way as general theories within the sciences. They are not something that we readily 'apply' in the same sense. Instead, they sit much further in the background. They have various roles to play, and we might draw upon them when we deliberate about our human future and the role of space within it, but the focus of ethics in space is often upon something more pragmatic and less laden with deep philosophical assumptions. For a large class of cases, ethical deliberation concerning space involves something closer to the considerations in set out Table 15.2.

The opening thought experiments could be brought into line with either of the conceptions of ethics in Table 15.1 or Table 15.2, but the ways in which the thought experiments are set out favours the second conception. And, it does so deliberately. The thought experiments are not geared to be neutral, but already weighted towards a particular way of seeing things. There is, for example, no search for a single trumping consideration such as biological structure and its complexity. Multiple key factors are left in play, and the thought experiments are themselves suggestive rather than conclusive.

Further examples of ethical deliberation about space which are more in line with this Table 15.2, open ended and pragmatic, approach include Arnould (2011) which draws upon a familiar shared myth of Icarus to help shed light upon ethical problems in space; Milligan (2015) which explicitly embraces a normative pluralism; Schwartz (2020) which thinks about the specific place of science in relation to multiple offered justifications for space exploration, without lapsing into consequentialism; and Pinkus et al. (1997) which shows the place of ethical considerations within nuanced situational descriptions of Space Shuttle engineering. In the final text on this list, principles are, from time to time, brought into play, but overall the ethical insight about their place and limits is in the detail. Ethics, on this second approach is at times less reassuring than it is on the first approach, when it comes to providing answers to difficult questions. Often, there will be no readily understandable single consideration of value and importance which guarantees that our all things considered deliberation ends up on the right path. Straying remains possible. Indeed, there may be no single right path, but several options which will take us in different directions. John Bunyan would not approve, but ethics of this sort is not a pilgrim's progress. The approach is, however, 'disciplined,' in a different respect. It may not always guarantee clear and correct action guidance, rather than broader kinds of insight, but the approach makes it harder to diverge from our best understandings of practical wisdom. If a conclusion is counter-intuitive, it need not be wrong, but its counter-intuitive nature will give us a reason to revisit our deliberations even if they do conform to some background principle. The second type of approach towards ethics is better placed to acknowledge this, rather than driving conclusions in counter-intuitive ways, irrespective of a growing sense that something has gone badly wrong with our ways of thinking about whatever problem is at hand. Here, we may think of absurd conclusions such as the idea that discovered microbial life has *the same* intrinsic value as we do, because all value is binary (we have it or don't), and all life has the same value; or the idea that discovered life has no more value than the microbes accumulating in our domestic plumbing systems; or the idea that unblocking a drain is genocide. When we get into this territory, something has gone badly wrong, the pathway is not a plausible or helpful one. This is not *what ethics is for*, or not *what it does well*, on our best available conceptions of the roles that ethics can play within our lives.

Practicality and conformity to practical wisdom is secured, or bought, in a Table 15.2 approach, at the expense of setting aside the appeal of a more architectonic (in Kant's terms), or comprehensive and systematic theory. We may then worry about whether or not it is sufficiently ambitious compared to generalized ethical theories which might, after all, extend into a grand unifying account of all ethics on Earth and in space. Yet here we may also reflect upon the important role that standing considerations retain in the second approach to ethics. And upon the experience of multiple research fields in which the emergence of the larger insights of 'big theory' is often driven by lower level analysis, the recognition of anomalies and liminal issues, as well as the steady accumulation of outliers. Normal ethics may still not be normal science, but it can still be akin to normal science in this respect, and both may lead at some point to a larger change in the ways that we see things, larger changes in the stories that we are able to work with and tell.

4 Two Ways to Understand Value Talk

As indicated above, generalized theories of the sort which are in play in Table 15.1, do not claim to drill down to any depth into the metaphysical underpinnings of ethics, although we may sometimes imagine that they do so. In formal terms, they stick to normative and applied ethics and avoid the more abstract territory of metaethics. When we lose sight of this, as ethicists often do, we may begin to think of their value talk in ways which are problematic, in ways which (following the opening summary of this paper) treat intrinsic value as if it was a kind of inner gold, invisible to science but there inside each of us, and associated exclusively with some other property of a more observable sort. This is a harmless enough way of thinking when humans alone are under consideration, and matches well with the idea that each human has a unique importance and is, at some level, just as important as every other human. This is an idea which is likely to be at the heart of every ethic which is politically viable under conditions similar to those of liberal democracy. However, it becomes more problematic when we extend consideration beyond humans, at which point we may say 'sentience' is the key rather than 'autonomous rational agency' (Singer 1974; Regan 2004). And the latter in turn becomes problematic when we move beyond animals, and even beyond living organisms. The idea that inherent value is not simply possessed as an inner property, but *equally* possessed as an inner property, then leads us to some very strange places, and into ethical constraints which may be excessive: bees become as valuable as babies, or else entirely lacking in value; an individual ant ends up with more value than an entire eco-system, because value is the property of individual creatures and only of individual creatures. And once they have it, they are the most important thing of all. (Or, rather, instances of the *only* important sort of thing.)

The previous section begins to shift our understanding of value talk in ways which will help us to avoid moves of this sort, respond to the charge of excess, and give us a direct pathway to dealing with the microbial similarity problem, i.e., the apparent inconsistencies in our attitudes when dealing with discovered microbial life which is biochemically or structurally much the same as terrestrial microbial life. To develop the position further, I will draw a contrast between two large types of approach to intrinsic value and to value talk. What is at stake here is not individual theories, but broader *types of approach*. And I shall not seek to present them in an entirely neutral way. My aim is not a detailed contrast, but rather the articulation of a single point: that value talk is best thought of as a matter of reasons rather than properties (even though an appeal to a particular kind of property can sometimes function as a reason). The contrast is, of course, a simplification, but it serves to draw our attention to something that we might otherwise fail to see.

On the one hand, there are approaches which remain heavily influenced by an exclusive focus upon individuals and their properties. Having intrinsic value is then much the same as having brown hair or hazel eyes. True, value itself is not something that we can simply point to, but it supervenes in some way upon physical properties, it sits on top of them. In a language which has long been banished from

Table 15.3 Two ways to understand value-talk

Approach	Conception of intrinsic value
Valuer-independent approaches	Value is a hidden property of value-bearers, thought of independently from valuing agents
Appeal to reasons for action and response	Value is relational, talk about it is a way of saying that agents have certain kinds of reasons for action and response

science, it is akin to an emergent property. Intrinsic value is, figuratively, inner gold. This is what we might refer to as a 'valuer-independent' approach. The second type of approach avoids any sense of moral alchemy by treating value talk, or at least value talk of the most informative sort, as a convenient way to track the considerations which have been focused upon above, i.e., *reasons for action and response*. More specifically, it tracks non-instrumental reasons for action and response. For convenience, I will refer mostly to reasons for action rather than for assertion, or for emotional response, but will do so as a way of capturing all these things (and other things for which we can have reasons). Table 15.3 captures the contrast.

On this second approach, there is no special, hidden, inner gold, but neither is ethics merely subjective, or a projection of desires, or a convenient fiction. Rather, ethics is allowed to draw upon something that we recognize and acknowledge daily, and in multiple ways. While there are familiar ways of acting which may be arational (i.e., without any reason), most of the time we have reasons for action. And these reasons presuppose that we value various things in their own right. As a point about moral psychology, our reasons for action cannot all be instrumental, because instrumental reasons presuppose something else that we are attempting to bring about or are committed to. To press matters a little further, and think in turn about reasons, they are considerations which play a role in the motivation of action and in our practices of justification. When we are asked 'Why did you do that?' we can answer 'Because of x,' and this is what a normal practice of justification looks like.

Thought of in this way, we are much less likely to imagine that value talk must track just one special thing such as self-awareness, autonomous rational agency, sentience, or even the fact that something is an example of life rather than non-life. Justifications for action can, obviously, vary. They do not always end up appealing to the same bottom line or foundational consideration. In relation to one another, we have multiple reasons for acting. Literature can sometimes help us to understand what these are: they may point to rational agency or sentience, but they may just as readily point to the vulnerability of others, or to the way that they suffer just as we do, experience joy as we do, laugh when tickled, bleed when pricked and, when wronged, long for revenge. The reasons that we can offer are utterly familiar, yet not identical from case to case. Whenever a reason has been given, more may always be said, but practices of justification do have to end somewhere, although not always in the same place. This is a completely general point about justification and the giving of reasons as they figure within our lives. It applies not just to ethics, but to any kind of practice of justification. When presented with a mathematical proof, we may ask why mathematics has just the rules that it does. When presented with a derivation of the rules, we may ask why the conclusion follows from what has been shown, and so on. Often, a further justification can help. But we do not, in our adult lives, get caught up in the game of endlessly asking ‘why?’ when something has already been more than adequately justified, even if the possibility of doing so remains open long after we are satisfied that enough has been said.

This is a much more recognizable picture of what is going on when we make value attributions and engage in value talk. It borrows a little from Wittgenstein’s river-bed metaphor: there may always be something solid underfoot, but it shifts and changes from case to case (Wittgenstein 1975). The approach performs several roles simultaneously: it demythologizes value talk so that we have no need to treat it as a claim about mysterious inner gold; it allows us to make sense of the indispensable character of value attributions, given that something would always need to play much the same role; and it captures the simple and well-placed intuition that many people across the sciences have: *ultimately, there can be no value without valuers*. Accepting this well-placed intuition also does not require us to add a further row to the table, one in which value talk is treated simply as convenient fiction. Reasons for action and response do the required work, without bringing in counter-intuitive ideas about morality being in some way arbitrary or subjective, or the idea that there is nothing *really* wrong with recreationally killing strangers, impaling infants, and dropping bombs upon weddings. Two important intuitions are thereby upheld: the intuition just mentioned, that talk about value is best understood in relation to valuers, and that humans and other creatures really do have value and may even be thought of as unique and irreplaceable. That is to say, we may have good reasons for regarding them in this way.

Where we take matters from here depends upon what kind of metaphors and imagery we are comfortable with, and think of as most informative or least likely to mislead. Of the metaphors and imagery which capture a sense that our responsiveness is always part of the story about ethics, I happen to favour metaphors of seeing, and of ‘moral vision’ (Blum 1994; McDowell 2001) rather than those of construction (Korsgaard 1996) or projection (Blackburn 1998). They seem better at capturing the robust nature of our reasons for acting when we act as moral agents. They may also be better at *recognizing* or *acknowledging* that we often have good reasons to do one thing and not to do another, and that these reasons are of a sort that other agents may share or at least appreciate. How far we press the story in this direction is an open question. I know where I stand, more or less, but other options may capture the same ideas and our differing vocabularies may later turn out to be equivalent, in suitably qualified versions of each approach. If we like the language of properties, then we may even hold onto it in a more demythologized form, by representing certain actions and events as having dispositional properties, i.e., they tend to generate certain kinds of responses in suitably socialized agents, and such agents are (in turn) disposed to respond in the relevant ways. They are sensitive to the salient reasons for actions and response, while others might not be. And those agents who cannot grasp various familiar reasons for action at all are not just deficient in various important respects, but dangerous. What we want to say about the robustness of our reasons can be captured in this way, or in broadly similar terms, with value talk making sense in relation to valuers, rather than understood as something which may be thought of as valuer-independent.

5 Conclusion

But if this is all there is to value talk, then why do we not always and directly talk about reasons for action and response, instead of talking about intrinsic value? Or why do we not opt (as some people have suggested) for talk about 'relational value' instead (Chan et al. 2016)? Why do we risk the confusion? The answer to this concerns the differences, alluded to at the start, between metaethics and ethics of the more familiar sort. Talk about 'reasons for action' may sometimes be a better way to make sense of things at the level of philosophical clarity and precision, but talk about 'intrinsic value' is far better at capturing the affective and motivating side of our individual experience, the phenomenology of *what it is like* to care about something *for its own sake*, and to have reasons for doing so which fit within the practices of justification which we come to share. There are multiple ways of speaking about almost everything, and practices work best when we are able to shift between them. Brain surgeons do not operate upon humour, and lovers do not invite one another to engage in coitus. To say that we have reasons for action which involve saving rainforests and slowing permafrost thaw, is fine in some contexts, but it can miss the motivational force of speaking about the intrinsic value of places and fellow creatures. Neither way of addressing matters belongs everywhere.

There is a good deal of explanatory machinery here, but the work that it does is important in the case of the microbial similarity problem. In a sense, it dissolves the problem. When we think of value talk in terms of reasons for action and response, we can readily recognize that there is no good reason to assume that value is binary rather than situationally sensitive. Or, in simpler terms, there is no good reason to assume that 'all value bearers are equal' and that their equal value can somehow be specified independently of the context in which we encounter them. There are certain special human contexts, such as those of politics and law, in which we really do have stable reasons to treat various kinds of beings (such as ourselves) equally, but the special contexts are not all contexts. Outside of their limits, our reasons for action in relation to different people, creatures, life-forms, places and things, will often differ. Trade-offs can hardly be avoided, and the need to prioritize cannot be replaced by the fiction of always having exactly the same reasons to act, in relation to all beings and all things whose moral standing we accept.

On this approach, fears that inherent value attributions will yield wildly impractical consequences, because all value bearers will end up being treated equally (frogs and philanthropists, microbes from *here* and microbes from *there*) are misplaced. Saying that a microbial colony on Mars would have intrinsic value, is simply *not* the same as saying that 'here is something which would have the same value as a human community,' or claiming that it would have the same rights as an individual human.

It merely entails the claim that some of our reasons for action in relation to such discovered life would not be strictly instrumental.

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Chapter 16
Big History and the Significance of the 1969–1972 Apollo Lunar Landings

Nick Spall

Abstract Putting Apollo in the 'big historical' perspective of human evolution over approx. 2.5 million years, it can be seen that the success of NASA's human lunar landing programme at the end of the 1960s signified a key "marker" of the level of technological progress achieved during the last 12,000 years. This achievement, it is considered, represents the commencement of a new stage of the human evolutionary path. Although born out of the planet-wide social and economic conflict of the Cold War, it is also argued that the Apollo programme bought a heightened level of environmental awareness and a global cultural identity. The US/NASA success may also have accelerated the eventual collapse of Soviet Union, as part of short-term geo-political history, post WW2. In addition, there were environmental consequences, with humanity seeing the Earth as a vulnerable "oasis" in the Cosmos, effectively existing as a "spaceship" in a hostile Universe. Approximately 650 million people watched Apollo 11's Moon-landing success and, despite the short-term national competition at its birth, it showed in an inspiring and heroic way that humanity can achieve extraordinary goals. It is contended that the 'gifts of Apollo', including its many technological, scientific and inspirational legacies, have left humanity in a more positive state than it would have been otherwise. It is argued that humankind is now better equipped to expand across the Solar System and eventually the Galaxy, entering a new stage of evolution as a space-faring species.

1 An Evolutionary Step Forward

Over 50 years have passed since Neil Armstrong stepped onto the lunar surface on July 21st 1969 and after half a century we should now have a clearer understanding of just what Apollo achieved in historical terms, for both the short and longer term.

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Armstrong's words referring to a "giant leap for mankind" had resonance and meaning. But did the Apollo events really signify a key turning point or marker in "Big History"?

The Apollo programme occurred during a compressed period of dramatic social and cultural change. The 1960s saw the turmoil of US race riots, the Vietnam War protest movement, the assassinations of President John Kennedy, Martin Luther King and the Democratic Party's Robert Kennedy, all shaking the establishment and combining with demands for worldwide social change and freedom of expression. The late 1960s "Woodstock generation" arose during the same time as Cold War political and economic confrontations, with the USA locked into a major war in Indo China. The achievements of human spaceflight were therefore viewed against a seemingly more important backdrop of world instability and US self-doubt. From this era, half a century on, the philosophical, political, economic, technological, cultural and environmental impacts of Apollo can be assessed more clearly.

To many in the media and academic world at the time, particularly those not attuned to the technological revolution that was accelerating through the mid-1960s, early space travel appeared of little historic consequence. Despite the stunning progress in aviation and rocketry development that followed World War 2, the prospect of humankind spreading out across the Solar System following the Apollo Moon landings did not seem to then influence mainstream historical thought or analysis.

Much as Stephen Hawking and Leonard Mlodinow (2010, p. 5) believed that philosophers have failed to properly consider and catch-up with the results of particle physics and cosmology research from recent years, with its detailed explanations of how the Universe came into being, so it might be said that historians during the "Space Race" of the 1960s were unprepared to appreciate the impact of the Moon landings on the world and its future history.

As an example of this sceptical attitude, on the night of the Apollo 11 lunar landing, July 20th 1969, the renowned British historian and author A.J.P. Taylor responded as a guest on David Frost's ITV television coverage programme saying that he did not believe that a successful landing on the Moon could have any possible impact on human history or people's lives—meanwhile, science-fiction author Ray Bradbury walked out of the show, believing that the coverage was not taking the whole historic event seriously (see Billington 1969; Wikipedia 2020). They, and an estimated 650 million people, about one fifth of the Earth's population at the time, were about to watch the ghostly TV pictures of Armstrong and Aldrin stepping out of the Eagle lunar module—science fiction was becoming reality a mere 66 years after the Wright brothers had first mastered powered flight.

In terms of humanity's daily lives, one can see a little of what Taylor was getting at. Aside from the thrill and pride it gave individuals across the world, no man or woman in the street was going to fly to the Moon the next day. The daily grind of working for a living would continue, taxes would need to be paid, the fear of a nuclear holocaust would still be present and those in the Third World would still be struggling to find enough food to live—life in 1969 would carry on "as previously." What Taylor and other sceptical observers would not take on-board at that time is properly considering the first landing on the Moon as a key "marker" and turning point of the progress of human development. This should be seen in wider "evolutionary" terms.

Once Armstrong had set foot on the Sea of Tranquillity, in symbolic terms mankind would never be the same again.

2 Evolution and Apollo

The concept of humanity one day spreading-out across the Solar System and indeed the Cosmos beyond, had been explored in the writings of space "seers" and futurists such as Konstantin Tsiolkovsky (1903), HG Wells (1933), Olaf Stapledon (1930) and Arthur C. Clarke (1962).

Human evolution has been dependent on a highly successful and adaptable morphology. Unlike cetacean, avian, mollusc and reptile species that are limited by their environments and brain-size constraints, human morphology appears as very appropriate for the development of intelligence, conceptualisation and tool usage in an Earth-like environment, as contended by Robert Bieri (1964). This is not to say that, given the right environment, octopus evolution might not develop further in surprisingly advanced ways; Olivia Judson (2016) has vividly described that creature's relative intelligence level in this regard.

Based on its successful morphological start, the evolutionary premise of the development of human "Big History" follows a general line of a "transcendence" through several stages of development.

Emerging from its African origins with over 2.5 million years of evolution, Homo sapiens achieved an initial stage of relatively sophisticated intelligence 50,000 years ago, where the Upper Palaeolithic late stone age peoples could refine basic tool-usage, master fire and hunt wild animals effectively. Socialisation and storytelling became most important at this starting point of the Holocene era, as contended by Yuval Harari (2014).

The next phase of a relatively advanced human development can be considered as controlled agriculture, which was established approximately 12,000 years ago—civilisations became possible, initially in the Middle Eastern "fertile crescent," as identified by Gordon Childe (1942).

Humanity's more recent technical development story can be considered as the human industrialisation era, modestly commencing during the sixteenth century Renaissance and then dramatically gathering pace during the full eighteenth century industrial revolution, as described by Childe (1942). Metal technologies were mastered, land explorers such as Marco Polo and seafarers Columbus, de Gama and Cook explored the planet and flying machines eventually conquered the air. Practical rocketry was established by the mid-1940s and orbital space accessed. By 1957, the success of Sputnik had shaken the world and the USSR's Yuri Gagarin's 1961 flight into orbit set the scene for a "race" to the Moon.

It is worth noting that a potential future post-industrial technical evolutionary level is on its way—this will most likely involve sophisticated artificial intelligence, AI, and possibly the eventual machine-human "Cyborg" evolution. This was forecast by Clarke (1962) in the early 1960s, amongst other evolutionary possibilities.

The successful Apollo 11 Moon landing has to therefore be seen against a wider evolutionary context, signifying a new level of technical and organisational development of humanity.

Tsiolkovsky's famous quote (NASA 2010) "The Earth is the cradle of humanity, but one cannot live in the cradle forever," describes the core driver for the dramatic exploration impulse inherent in human society. This gained momentum from the fifteenth century onwards. By the twentieth century post 1945, the technology to go beyond the Earth became realistic.

US President Kennedy's 25th May 1961 speech to the US Congress putting forward the challenge to America to "choose to go to the Moon," noted that the lunar journey would "in many ways hold the key to our future on Earth." After the initial Apollo successes, NASA's lunar exploration programme was subsequently cut short by President Nixon, with Apollo's 18, 19 and 20 being cancelled and Von Braun's hopes of crewed Mars flights during the 1980s never being realised (see Turnill 2002).

However, Apollo had succeeded in its wider goal. The future long-term exploration of the Moon, the potential colonisation of Mars, and the expansion of humanity as a spacefaring species was now considered a more practical possibility. Clarke (1962) took the long view and considered that in the long span of history, a "Golden Age" of space travel awaited humanity.

3 The "Space Race" Is Won

Taking into account shorter-term history, beating the USSR to the Moon was obviously a key geopolitical ambition of President Kennedy's in 1961—Logsdon (2010). Although a somewhat pragmatic Kennedy would later suggest a possible collaboration with the Soviet Union to reach the Moon jointly, from his Sept. 1963 speech to the UN General Assembly, it is arguable that the original desire of the US administration to show that western capitalism could prevail over state socialism was a huge test and a key message to the world. In this respect, history does indicate that the USA succeeded with this by 1969 as a result of Apollo.

The background context to the preparation for the Apollo Moon landings is one of apparent US international failure to beat Soviet communism. The Bay of Pigs invasion disaster in Cuba in 1961, the Vietnam war escalation from 1963, the threat of the Warsaw Pact and the Berlin Wall division, plus of course the USSR's space successes of Sputnik, Lunik,Vostok and Voskhod missions, all pointed to an uncertainty that free market economies could achieve such difficult and technically challenging undertakings on a global scale like a human Moon landing when compared with State-led command economies.

In the end, the race to the Moon was "won" by US capitalism and corporate industrial organisation. Kennedy had called this process "a battle between freedom and tyranny" in his May 1961 Moon-shot proposal speech to the Joint Sessions of Congress (see Space.com 2011). The reality, of course, was that the USA was able to beat the Soviet Union via a deep funding commitment and focussed organisation. At its maximum in 1966, the USA federal budget allocated 4.4% of its total to the Apollo programme (Levine 1983). Currently in 2020 the figure is only 0.5% for NASA state funding.

The USSR is thought to have spent only 50% of the NASA budget, covering its Vostok, Voskhod, Soyuz 7-KL3, LOK/LK lunar lander projects and the N1/L3 launcher testing (Siddiqi 2003). Despite the firm commitment made via the Soviet Communist Party's Central Committee Command 655-268 on Aug. 3rd, 1964, requiring circumlunar flights by 1967 and a lunar landing by 1968, the USSR could not reach the Moon with its cosmonauts. The un-crewed circumlunar Zond 4 and 6 missions failed, and the massive but underfunded N1 Soviet Moon rocket exploded four times, eventually being cancelled altogether.

As a part face-saving measure, in July 1969 the USSR attempted to land the un-crewed Luna 15 soil-return probe on the Moon, just as Armstrong and Aldrin were completing their walk on the Sea of Tranquillity. The Soviet mission failed. Apollo 11 had won the "Moon race" and strong US technical and international prestige was established—this echoed right through to the end of the Cold War in 1991.

4 Contribution to the Ending of the Cold War

It is arguable that the success of the 1969–1972 NASA Moon landings helped shift the international balance of power to the US from the 1970s. It is also possible to suggest that Apollo's success helped lead to the downfall of Soviet Union in 1991, with the relatively peaceful revolutions across Eastern Europe occurring from 1989 and the previous period of *glasnost* "openness" and *perestroika* "restructuring" associated with the Soviet leader Mikhail Gorbachev being established by the late 1980s (see Launius 2019).

The geo-political context of the fall of the USSR was arguably the gradual collapse of its command economy bought on by huge military spending during the 1970–1980s and failure in the 1979 Soviet occupation of Afghanistan (Reuveny and Prakash 1999). But the seeds of the USSR's dissolution may also stem from US prestige and the apparent success of free market approaches, the boosting of hi-tech industries, increased western living standards and world confidence in the strength and capability of US "know how," as exemplified in Apollo. This was all occurring despite international political and military failures of the USA's such as the Vietnam war by 1975 and the humiliation of the Tehran hostage crisis in 1980.

It can be argued that the success of Apollo 11 gave the USA and indeed the West a renewed confidence. It became a key exemplar of the power of capitalism, fulfilling

Kennedy's "free world" space achievement ambitions as apparent proof that the western democracy economies were the most potent and successful for the planet.

Apollo 8 astronaut Frank Borman (2018) described his part in the Apollo Moon programme as: "I was there to participate in the Cold War battle with the Soviets" This sounds somewhat sweeping as an assessment of a huge space exploration achievement, but there is some truth in the concept that the two sides were effectively fighting a war "without casualties"—a failure of the Apollo programme to land successfully on the Moon before the USSR could have had resounding geopolitical and historic consequences.

5 Science Discoveries of Apollo

Whilst initially modest, with an initial return of 22 kg of lunar rocks and the establishment of three surface experiments, the science results from the Apollo 11 mission on its own in 1969 were the precursor to more intense exploration activities of Apollo's 12, 14, 15, 16 and 17. These missions would rewrite the story of the Moon (e.g., Heiken et al. 1991; Crawford 2012).

The six landing missions had secured 382 kg of Moon rock by 1972, with NASA distributing this across the world's research labs. Geologist Harrison Schmitt had explored the Taurus Littrow region with Gene Cernan during the Apollo 17 mission, deeper core tube samples had been taken to 3 m and more complex experiments set-up. As noted by Crawford (2004), Apollo 17 was a highly successful conclusion to the Apollo mission series, providing intense lunar exploration science. The crew travelled 35 km in their lunar rover during their 3 day stay—interestingly, it would take 14 years for the Spirit rover to travel this distance on Mars.

It was concluded from the samples and experiments that the Moon has evolved over its 4.6 Gyr lifetime, with its surface having been initially molten, solidified, and impacted by asteroids and meteorites. Samples older than any on Earth were collected. Lunar cratering became better understood and the history of the Earth's, Mars, Venus and Mercury cratering rates more clearly clarified. The Moon was found to be devoid of evidence of life, past or present. Lunar basins were identified as coming from impacts, with lava filling them 3.2–3.6 Gyr ago. It was found that the Sun's radiation effects implanted elements in the surface material from 4 bn years ago and an ancient lunar magnetic field may have once existed.

Thus, the 3-year programme of Apollo landings was dramatic in its science output, dwarfing the Soviet robotic mission results of that period which had bought back only about 320 g of lunar soil via three Luna sample return missions (Heiken et al. 1991).

6 Technological Acceleration and Economic Change

Technological progress during the 1960s did appear to have received a firm boost emanating from the rapidly developing aerospace industries and from the Apollo programme in particular. The technical "fall-out" from this is considered by most observers as beneficial for the US economy and for worldwide technical innovation.

It can be argued that President Kennedy's challenge for the USA to land a man on the Moon before the 1960s decade ended was in-part based on a desire for a "Keynesian" approach to public spending—from it, skilled employment and technology research would be boosted, spin-offs provided and the whole "trickle-down" process of technical innovation improving everyday lives and living standards would flow.

The prime motivation for the "Moon Race" at the time was essentially a political one—the goal was to be seen to beat the Soviet Union. However, Kennedy and Vice President Lyndon Johnson must have been keenly aware that Congressional support for the Apollo programme would relate back to establishing US technological prowess, the superiority of free-market economics over USSR state control and the inevitable technical "spin-offs" that would occur. Kennedy's "We choose to go to the Moon" speech of 1961 referred to rocket technologies and materials that at the time did not even exist and recognised the challenges to US innovation and industrialisation.

The significant technological progress that occurred at a relatively fast rate post-1961 can be considered as aligning with the Apollo programme years, normally regarded as 1961–1972. NASA maintains that over 6300 actual inventions came out of the 1960s Apollo moon programme—many of these went on to have direct and indirect everyday applications as "spin-offs" (NASA 2004).

We are familiar with the arguments and claims for many of the space programme spin-offs: these include, battery-less power tools (first created by Black and Decker for NASA in 1964), cordless vacuum cleaners, memory-foam beds, shock-absorbing material for trainers, freeze-dried food, fuel cells, solar PV panels, smoke detectors, fire-proof clothing garments, water purifiers, telemetry heart monitors, protective heat proof coatings, light-weight fabrics (famously used to cover Houston's Reliant Stadium), computer joysticks, scratch-resistant lenses, ear thermometers, CAT scanners, kidney dialysis equipment and quartz-clocks.

As part of the history of technological change, Apollo arguably accelerated emerging technology innovations.

7 The Computer Revolution

A key historic "gift of Apollo" that has been identified by Carl Sagan (Sagan 1994) and analysed by space historian and film-maker Chris Riley (2015), covers the powerful accelerator effect that the project had on computers and information technology. This process would kick-start the subsequent rapid evolution of small and relatively powerful computers for everyday use.

Riley records the story of how NASA, within only weeks of Kennedy's 1961 Moon programme speech, approached young Massachusetts Institute of Technology (MIT) PhD-level academics to seek the answers to safely navigating the Apollo spacecraft across cislunar space. It was quickly concluded that a new approach was needed whereby a small light-weight computer would be developed to fit into the Apollo Command and Lunar Modules, linked to a sophisticated fly-by-wire systems. The computer would need to use reliable integrated circuits which were just coming out of the early microelectronics industry. NASA placed an order for one million of them from the Fairchild Semi-Conductors company—within a few years, this financial kick-start to the industry prompted two Fairchild employees to leave and form the "Intel" company in 1969.

Advancing this emerging technology by at least 10 years beyond its expected development stage, the Apollo programme's navigational requirements resulted in fast-track computer evolution and miniaturisation. From this commercialisation of micro-circuitry, pocket calculators arrived in the early 1970s, affordable home computers in the 1980s, and the internet and world-wide-web emerged from Tim Berners Lee's pioneering initiatives by the 1990s—now the planet's smart-phone, video streaming, i-pad culture and resulting social network revolution has arrived.

Following the Apollo programme's technological acceleration therefore, it is apparent that the world has rapidly shrunk. The 1960s concept of Marshall McLuhan's (1962) "Global Village" has now effectively occurred. Instant news communication comes from across continents, via smartphones and tablet video feeds and "Dan Dare" style communicators from the science fiction of the 1950s are with us ahead of time—all in part thanks to the technological "gift" from Apollo.

8 History and Value for Money

In historic terms, some would question the financial worth of Apollo and whether the public money could have been better spent elsewhere, achieving the same beneficial results (see New Scientist 2019). Many proponents of space exploration's public financial investment, particularly covering human spaceflight, often quote the technology benefits as paying back the actual cost. It has been claimed that the US taxpayer got back many times the outlay in terms of tax dollars invested from hi-tech employment stimulation and technology boosts to the US economy (e.g., NASA 2018; Benaroya 2018).

During the mid-1960s over 400,000 people were working on Apollo, including NASA employees, contractor management and factory employees and science academic staff across the USA and abroad, with the resulting economic multiplier effect forthcoming (Levine 1983).

Historically, Apollo's beneficial value for money argument therefore appears positive.

9 STEM Inspiration and Space Adventure

The “Apollo effect” of the late 1960s stimulated academic interest in science and technology and “STEM” subjects became more appealing to graduates. A three-fold increase in science and engineering topic PhD’s occurred across the USA during that period—Benaroya (2018).

Technical innovators like Jeff Bezos of Amazon were inspired by the Apollo period to develop technology-linked businesses. Paul Allen and Bill Gates flourished in the Californian “Silicon Valley” hi-tech world that had close links with NASA and the aerospace industries.

Space enthusiasts of that generation, Sir Richard Branson (2011) and later Elon Musk, were also inspired by the adventure of the 1969 Moon landing, starting their own private spaceflight companies. Musk’s Space X company has achieved the extraordinary, with the highly successful part-reusable Falcon launcher undercutting other conventional rockets and now the Crew Dragon human spaceflight capability emerging.

Phrases used to cover this generation of space entrepreneur’s attitudes have included “children of Apollo” and, later, “orphans of Apollo.”

The Apollo effect would challenge many individuals to become astronauts. UK-born Michael Foale, Piers Sellers and Nicholas Patrick all referred to the Apollo inspirational impact to fire their own careers with NASA. More recently, UK/ESA astronaut’s “Principia” mission to the ISS in 2015/2016 sought to create its own “Apollo effect” in UK schools, by inspiring children to take-up STEM science and engineering topics.

A generation of space scientists would emerge as a legacy of the Apollo years, covering not just lunar science, but wider astronomy and cosmology areas.

10 Environmental Legacy

Early images of the crescent Earth floating above the Moon were sent back from NASA’s robotic Lunar Orbiter 1 in August 1966, but it was not until the 70 mm Hasselblad camera’s coloured “Earthrise” photo was taken by Apollo 8 crew member William Anders in Dec. 1968 that the world fully appreciated the potency of seeing planet Earth from 250,000 miles away.

Images of the Earth from low orbit are impressive enough and astronauts speak of the “overview effect” that extended spaceflights provide, as described by Frank White (1987). From 400 km, the full potency of seeing the beauty of the planet without evident boundaries across its surface can affect an individual’s perception of human existence and meaning. But lunar distances that applied to the Apollo missions truly conveyed the isolation, fragility and beauty that “oasis” Earth possesses against the blackness of space.

Astronaut William Anders famously stated from the Apollo 8 mission that: “We came all this way to explore the Moon and the most important thing is that we discovered the Earth” (Museum of Flight 2008). Crew-mate Jim Lovell said of space and the planet: “The vast loneliness is awe-inspiring, and it makes you realise just what you have back there on Earth” (National Geographic 2018). Neil Armstrong himself noted the “oasis” appearance and how he could blot-out the Earth just with one spacesuit gloved finger from the lunar surface (Hansen 2005).

When the last of the nine Apollo lunar voyages had been completed in 1972, the world was used to seeing extraordinary images of the Earth taken from lunar distances by the Apollo astronauts. The planet, with its colour and obvious atmosphere, strongly contrasts with the sterile “desolation” of the Moon. Apollo 17’s full Earth “Blue Marble” image taken by Harrison Schmitt in 1972, is now used in countless biology books and by the United Nations as the inspirational image for the work of UNESCO.

Historically, Apollo can be seen as providing a “mobilising effect,” stimulating the environmental movement. Friends of the Earth was formed in 1969, Greenpeace in 1971 and by 1972 the “Club of Rome” academic environmental group had issued its “Limits to Growth” warning of pollution dangers and resource depletion across the planet. James Lovelock produced his “Gaia” hypotheses in the late 1960s and the 1968 “Whole Earth Catalogue” of Stewart Brand made use of the iconic “Earthrise” images. Buckminster Fuller referred to the planet as being “Spaceship Earth” from 1968 onwards.

Spier (2019) takes a more cautious view of how significant, or immediate, this impact really was—perhaps in the longer-term history of say another 50 years the historic consequences will be more clearly understood.

Arguably, a key environmental message from the success of Apollo is, of course, essentially that mankind can achieve almost anything if resources and international commitment exists. Thanks to the space programme and its Earth observation work data, it can be argued that humanity is now more acutely aware of the dangers of climate change and global warming. The world has tackled ozone depletion internationally via CFC controls and monitors their depletion level from space. The Kyoto Protocol shows that some level of direct action is possible across international boundaries and, whilst the future is still uncertain, climate change is now at the forefront of debate and early attempts at finding solutions.

11 Philosophical Consequences in History

The appreciation of the view of the Earth from the Moon has also arguably altered our perception of the trajectory of human evolution.

If Apollo marks the start of a future stage for humanity, its message to many is a philosophical one, as well as technical and scientific. It is arguable that the Apollo 8 readings from the Book of Genesis in lunar orbit in Dec. 1968 resonated around the world because the message was a common one to three of the planet’s great religions. Apollo astronaut Frank Borman referred to the “Good Earth” in his Christmas 1968 transmission from the Moon.

Although fascinating and challenging as a world to explore, the Moon is clearly sterile in all the Apollo images. By contrast, humanity appreciates now that the Earth combines life and consciousness—so far as we know at present, this is unique across the Solar System, possibly in the wider Galaxy and this must be seen as a hugely significant philosophical standpoint.

For many, Apollo’s historic impact is a very wide and diffuse one. The unauthorised trans-lunar ESP experiment and personal spiritual awareness “epiphany” experiences of Apollo 14 astronaut Edgar Mitchell in 1971 highlighted what many were seeking from Moon voyage messages, in the form of a quasi-religious experience (Mitchell 2014).

Buzz Aldrin famously took Mass on the lunar surface in 1969 (Aldrin 2009, p. 26). Although such spiritual and religious awareness remains outside science, the fact that it occurred at all reveals the richness of the Apollo programme’s human story, indicating that there can still be a place for human spirituality in the hi-tech world of lunar exploration.

The Apollo 11 Moon landing fired emotions from observers as well as from participants. Clarke told the BBC space correspondent Reg Turnill (2002) at the launch that “I cried for the first time in 40 years.”

12 Cultural Historic Impacts

Whilst the dramatic ambition of landing on the Moon seemed extraordinary during the mid-1960s, arguably the Apollo culture of NASA at the time could appear relatively unemotional and uninspiring Before the 1970 Apollo 13 mission drama, flying to the Moon was beginning to look too easy—spacecraft commander Jim Lovell said of the mission: “People were getting bored. The publicity for Apollo 13 you could find on the weather page of the newspaper, that was it” (Hollingham 2017). At the time, NASA appeared to discourage any suggestion of real danger or hazards for the Moon landings.

In recent years however documentary films like “Shadow of the Moon” (2007) have allowed the Apollo astronauts to be more open. Alan Bean of Apollo 12 explained in the movie his real fears during his space mission—that openness to the dangers of space travel makes the success of the landings seem all the more impressive.

The heavy $160 bn (2016 values) cost of Apollo could, according to many at the time, have been used to tackle poverty and disease, plus wider US social and urban deprivation. In the 2018 movie “First Man,” director Damien Chazelle showed this possible negative attitude to Apollo, where many questioned the cost; poet Gil Scott-Heron wrote “Whitey on the Moon” as a searing indictment of the project at that time (Rao 2018).

Today, arguably "space" is considered as a more popular mainstream cultural topic, embedded in international consciousness. An historic consequence of Apollo was to give humanity a collective "we did it" attitude to achieving an extraordinary goal.

13 Management Inspiration

Following the image of competence and systems success that NASA and the Apollo crews dealt with the unexpected during the nine voyages to the Moon, many subsequent technical management courses now focus on the organisational inspiration that the Apollo programme provided. The phrase "failure is not an option," attributed to Apollo's Chief Flight Director Gene Kranz and the title of his autobiography (Kranz 2000), has become a buzzword in project management terms.

The story of the Apollo 11 suffering its "1201" and "1202" computer overload alarms during the lunar landing sequence, all addressed very quickly by mission engineers Jack Garman and Steve Bales at Houston, are now regularly used as examples of coping with crisis management problems as part of well-organised teams and management structures.

The historic lessons and legacy from NASA's practical handling of the Apollo missions are therefore powerful. Across the world, dynamic management-thinking is often referred to now, following the line of "if we can put men on the Moon, surely we can learn from the way NASA did it."

14 The Human Endeavour of Apollo

It appears that President Kennedy understood the human challenge of landing on the Moon during his famous speech at Rice Stadium in Houston on Sept. 12th 1962—it was intended to galvanise the US public and commit billions of dollars. He described Apollo as a project that needed undertaking, saying: "We choose to go to the Moon and do the other things not because they are easy, but because they are hard."

Kennedy then described Apollo as: "The greatest adventure on which mankind has embarked," reaching into the powerful human psyche's desire to explore, particularly the American "settler ethos" which valued perseverance and determination. He quoted George Mallory's "because it is there" apocryphal words, which once explained the reason for climbing Mt. Everest. Kennedy also noted the practical geo-political point of going to the Moon ahead of the Soviet Union.

David Baker (2019), who was working with NASA during the Apollo era, noted the enormity of what was achieved in terms of its adventure and the human spirit. He considers that it was the most audacious of human endeavours, but also that it was about people.

In historic terms the philosophy of the Apollo approach and the human desire to explore relates to the deep-seated human spaceflight urge that fires many of the world's space communities. UK astronaut Tim Peake and his 2015/2016 Principia mission to the ISS represented that national desire, in the same way that Apollo did for the USA. Governments respond to the apparent public need for "exploration" beyond the confines of the Earth—echoing Tsiolkovsky, actor and space enthusiast Brian Blessed described this urge to a British Interplanetary Society (BIS) audience (Nov. 2017) by saying that his gut-feeling had always been that: "We don't just belong *here*!"

15 International Cooperation

By 1963, Kennedy would be considering a joint lunar mission approach to the USSR as a means of creating a geopolitical détente between the superpowers (Logsdon 2010). Perhaps daunted by the heavy emerging Apollo cost to the US, he was also seeking ways to end Cold War tensions. In the event of course, President Johnson continued US commitment and NASA came first in the "Moon Race."

In historic terms there is a profound "international" message from Apollo. In 1969, over a fifth of the world's population, approximately 650 million, watched the Apollo 11 landing on TV. The pride of the USA was at the core of this success, but it did link the world together—humanity appeared united as one. NASA employed international scientists and engineers in the Apollo programme and positive public recognition of the achievement stemmed from its use of the phrase "We came in peace for *all mankind*," which was engraved on the Apollo 11 Lunar Module Descent Stage landing leg and left on the surface at the Sea of Tranquillity landing site.

An international recognition and a sense of "we did it" must therefore be another positive historic legacy of Apollo. International space projects such as the 17-nation International Space Station (ISS) and the planned 5-nation Lunar Gateway station are current, and human Mars exploration will most likely follow this international approach for the 2030s and beyond.

16 Apollo Space Heroes for History

A further cultural outcome of the Apollo programme has been the way that the media now recognises more solidly the achievements of the Moon landing astronauts as "heroic" human beings (Turnill 2002). This clearly occurred for the Apollo crews and the NASA support teams—as a result of the "Apollo 13" movie for example, astronauts like Jim Lovell, Jack Swigert and Fred Haise have become established in popular culture.

The then unsung female NASA technical staff from the Apollo era, including figures like Katherine Johnson, Margaret Hamilton of MIT and Frances "Poppy" Northcutt, plus the endurance of Apollo astronaut's wives as described in books like Andrew Smith's "Moondust" (2009) and Fred Hansen's "First Man" (2005), have also now become significant following the half century historical perspective of the Apollo years.

History promotes heroes and the strong positive features of the late Neil Armstrong, the "reluctant hero" of Apollo, are only just being given appropriate recognition. Armstrong was of course determined to stay out of the limelight of media attention, as he considered the Apollo success was down to the NASA support teams and the 400,000 industrial employees, engineers and scientists who made the success possible (e.g. Hansen 2005; Smith 2009).

Smith's "Moondust" book describes the efforts that Armstrong made to avoid endless interviews and autograph signings. However, many consider in retrospect that his well-considered "one small step" first words on the Moon, his conduct on the post-mission world tour, the modesty he showed over the lack of photos of himself on the lunar surface—only five exist—and his support for the USA's human spaceflight ambitions over many years, must make his life and inspirational achievement a key legacy from Apollo.

In the 2007 movie "In the Shadow of the Moon," directed by David Sington and Chris Riley, Apollo 12 astronaut Alan Bean said of Armstrong: "I cannot think of one negative of Neil Armstrong. That's a tough role" Apollo 11's Mike Collins (2012) stated: "He never showed a trace of arrogance and he had plenty to be arrogant about. . . . He was the best and I shall miss him terribly." Norman Mailer, author of "Of a Fire on the Moon" (1970), noted how Armstrong stood out in the group of astronauts as being "someone quite special."

As an Apollo "heroic" legacy, it should be recognised that Armstrong stepped-out onto the Moon 50 years ago in an essentially open and media-transparent way. NASA achieved the landings without secrecy, being prepared to take the consequences of failure and operating in the context of a relatively free society and culture.

17 Conclusions and the Future

Fifty years on from Apollo, the international ambition to press ahead with the exploration of the Solar System appears solid and undiminished.

NASA was instructed by President Trump's 2017 "Space Policy Directive One" to return to the Moon via Project Artemis, allowing the first woman and next man to step onto the lunar surface by the mid-2020s.The intention is to maintain a future lunar presence via a semi-permanent international Moon base and orbiting Lunar Gateway station. An eventual human journey to Mars is intended to occur in the mid 2030–2040s via a proposed "Global Exploration Roadmap" established by international space agencies (ISECG 2018); Europe's ESA and Japan's JAXA are generally supportive of US/NASA lunar and Mars ambitions.

The nine successful lunar missions of Apollo are continuing to be inspirational and these will be followed by future long-duration deep-space missions. Astronauts are now able to comfortably achieve at least 12-month flights in microgravity conditions on the International Space Station (ISS), without apparent permanent health-impact consequences (Whiteley and Spall 2014), though it may prove to be that for future long-duration space voyages across the Solar System, astronauts will require artificial gravity and enhanced radiation protection to safely endure deep-space missions.

The desire to provide alternative "lifeboat" colonies beyond Earth, giving an insurance-policy for future human existence, is now a powerful motivator for future interplanetary travel directions post-Apollo. Potential extinction threats such as major asteroid impacts and devastating world pandemics will always be present—Stephen Hawking (2010) firmly maintained the need for off-Earth colonies, with Elon Musk (2018) considering this to be a key-driver for his personal investment in Space X and long-term projects such as the "Starship" reusable spacecraft.

It is inevitably Clarke (1999) who clearly sets out the long-term future history of the exploration of the Solar System post Apollo, with an emphasis on humanity's evolutionary path:

"As our engineering skills improve, our species will spread across the Solar System, as once it spread across the face of this planet. First the Moon and Mars, then the asteroid belt, then the moons of the gas giants, Jupiter and Saturn—some so large that they are planets in their own right. And it may not be a very long run, in terms of history; after all, Columbus is barely 500 years behind us!"

For the long-term future, thoughts are already turning to interstellar travel across the Galaxy, with the human species expanding out across star-system paths to eventually explore and colonise Earth-like exoplanets. This expansion process that Tsiolkovsky, Wells, Stapledon and Clarke envisaged, also has the ambition of seeking out life elsewhere.

Technically, emotionally, physically and philosophically therefore, thanks to the achievements and consequences of Apollo, humans are now better equipped to explore the Cosmos. In "Big History" terms, it is argued here that 1969–1972 did mark a key turning point where homo sapiens can be seen to have entered a new phase in its evolutionary development, becoming a "space-faring species" for the longer term.

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Chapter 17
Towards a Planetary Polity: The Formation of Global Identity and State Structures

Andreas Bummel

Abstract This article looks into the interconnection between the development of a global identity and a planetary polity from a long-term view. It is argued that global political integration is facing special conceptual challenges compared to the historic dynamics of social evolution. The article explores obstacles and catalysts for the formation of a world state. Critical global challenges put notions of national sovereignty into question. Images of Earth from space represent a new cosmic perspective. Questions touched upon include what defines a nation and its people? How is individual and collective identity constituted? On what principles would a global polity need to be based on from a planetary view?

1 Introduction

The social evolution of the human species can be summarized as a continual coming together and breaking apart of social units. Oscillating between cooperation and rivalry they competed since the dawn of history for resources and dominance. Within those units, rules evolved to make living together as free of conflict as possible, albeit hand in hand with the formation of hierarchical social strata and a ruling class at the top that controlled the use of force and determined the distribution of resources to a large degree. The predominant attitude towards outside units was one of mistrust and competition. In the course of population growth, technological progress and productivity gains, these units tended to become ever larger in terms of population numbers and territorial reach and their interconnections ever closer.

In the long run, the total number of autonomous units has been decreasing. Around 1500 BCE, with an estimated world population of 50 million, there were perhaps 600,000 such units (Carneiro 2004). Today the world population is estimated to have reached 7.8 billion and there are around 200 states and territories. At

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first glance, the continued existence of micro-states and the increase in the total number of states in the second half of the twentieth century may seem to contradict a trend of integration in recent times.[1] Nonetheless, all these units are embedded in a complex web of interdependence in all areas that blurs their boundaries. They rely on transborder interaction and systems to sustain their functioning and are under constant influence of externalities outside their control, global carbon emissions and the impact of global warming being important examples.[2] A multitude of other entities has become more and more important in this process, for instance intergovernmental and supranational organizations at different levels and multinational corporations, in particular in the financial sector.

Today's nation-states thus do not represent a useful yardstick to measure the number of autonomous units. Instead, they should be recognized as dynamic elements in an ongoing process of global state formation that Elias (2000) traced back to feudal times.[3] By now, we are dealing with the emergence of one world system that is integrating with different speeds in different areas. Arguably, the number of autonomous units in the world has reached zero. Since there is no planetary polity either, for Zhao (2019) the world thus resembles a failed state. The fact that the global legal and political order is still based on separate states that mutually recognize each other's nominal sovereignty is a major source of tension and dysfunction. There is an ever more critical scale mismatch between global public goods that need to be managed and the limited institutions available to do so. This is in conflict with a cultural recognition of interdependence which is best symbolized by a cosmic perspective and a sense of global citizenship. This situation can be interpreted as a manifestation of a cultural lag as described by Ogburn (1957). According to this theory, every society requires time to implement changes needed to deal with new technologies, so there is a lag between technological advancement and social adaptation. This lag, though, may entail major risks and negative impacts due to lack of effective mitigation or regulation.[4] At the global scale, there seem to be particular dynamics at play that exacerbate this issue.

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[1]Over 100 states have a population size of less than ten million each, jointly representing less than 5% of the world's total. This includes around 40 micro-states with a combined population size of only about 12 million or 0.2% of the total.

[2]In the area of global goods, such as the atmosphere or the oceans, the 'tragedy of the commons' remains an appropriate conceptual framework that explains overuse, cf. (Leinen and Bummel 2018, p. 135ff).

[3]This process of global state formation is a main theme in Leinen and Bummel (2018).

[4]The lack of adjustment to the danger of nuclear arms was one of the examples mentioned by Ogburn (1957, p. 174).

2 Force Is No Option

First of all, the emergence of larger social units historically often was achieved by one unit subjugating others. However, the socio-political dynamic of development fortunately has been undergoing a fundamental change which increasingly excludes the use of force. In general terms, Pinker (2011) has gathered interesting data on the decline of violence over long time spans. Spencer (1897) already pointed out that wars of conquest had outlived their day as a means of bringing about lasting integration as this was incompatible with the human urge for emancipation. Sooner or later, such units fall apart "when the coercive power which holds them together fails" and even if they could be held together, "would not form harmoniously-working wholes" (p. 664). According to Welzel (2013) there is a universal human desire for an existence free from domination, and emancipative values continue to gather momentum from a long-term perspective.

Nevertheless, wars of conquest continued to be pursued. Territorial conflicts played a significant role in the outbreak of the First World War, and the Second World War was conducted by Nazi Germany as a war of annihilation and conquest. As Graber (2004) noted, the outcome of both these wars was an increase, not a decrease, in the total number of states. The prohibition against the use of force in Article 2, Paragraph 4 of the UN Charter documents the fact that in international law the use of force is no longer acceptable between states even if in reality geopolitical tensions and the threat of violence persist.[5] Still, the nuclear armament at the disposal of some states means that the consolidation of the system of states into a single worldwide unit by the exercise or threat of military force by a hegemonic power is impossible in practical terms. A nuclear Third World War would destroy modern global civilization. This is not to say that a nuclear war scenario can be excluded. A conflict can spiral out of control or it might be triggered otherwise intentionally or by accident. This is one of the major risks of our time. The process of global state formation, however, cannot be driven by force.

The example of European integration shows that there is another option. In this case, states gradually, peacefully and voluntarily have been building a joint new higher-level unit that takes over some of their powers. Nonetheless, it should not be ignored that historically this process was to no small part driven by the recognition of a common external threat posed by the Soviet Union and the Eastern bloc. At the time, the emergence of the European communities was strongly supported by the United States for this reason. At the global scale, no such external threat exists.

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[5]Global military expenditure rose to US$ 1917 billion in 2019 or 2.2% of global GDP (SIPRI 2020).

3 There Is No "Them"

The relevance of external units in the consolidation of other units at a higher level of integration plays a key role in patterns described for human social evolution. This is the case in a general "growth sequence" suggested by Adams (1975) that consists of three stages named identity, coordination and centralization.

First, a number of individuals or other preexisting units identify each other as having similarities in some way. The key for this identity formation according to Adams fundamentally is a binary differentiation of some set of "we" from some set of "other" (p. 210). Thus, there usually is a separate external unit or group of some kind to distinguish from.

It should be noted that those distinctions can be completely socially constructed.[6] At a more fundamental level, anthropologists have been exploring a "universal pattern" common to all cultures (Wissler 1923, Chap. 5), stating that cultural differences in behaviour and outlook are almost entirely a product of habit formation and learning at a mass scale (Murdock 1969, Chap. 7). They identified the "psychic unity of humankind" (Bastian 1900, p. 10; Köpping 2005, p. 175) according to which the psychological equipment of all people is basically alike. Nonetheless, in a study on human universals, Brown (1991, p. 6) remarked that even many anthropologists deny similarities shared by all humans "because *everybody* likes to hear that 'they' are different from 'us'" (emphasis in the original).

Back to Adams, in the second stage, once the component parts of the new "we" start collaborating, a so-called coordinated unit emerges. The crucial feature of this pattern outlined by Adams lies in the circumstance that the centralization of one unit, that goes along with the creation of hierarchies, usually occurs as part of the coordination of that unit with other units. This means that coordination of a unit with other units at the next level is a precondition for centralization of this unit at the previous one. In other words, if there are no units to coordinate with at a next level, centralization is unlikely to occur. As Adams points out, a "unit centralizes as a response to external pressure, and in human societies the only continuing pressure is that exerted by other societies. This pressure from other societies demands external coordination, at the same time that it attempts internal centralization" (1975, p. 211).

Based on this model it could be concluded that at the level of the entire human species, at the maximal level of social organization, the emergence of a centralized integrated unit is impossible because there are no known external units beyond humanity to coordinate with which would put a process of centralization in motion. Indeed, according to Adams, humanity for this reason "can never be politically unified" and the top structurally will always "remain multiple" (p. 304). This issue was touched on by Ronald Reagan (1987) when the US President noted that "some alien threat from outside this world" may be needed for humanity to overcome its internal antagonisms and recognize its common bonds. Achieving a collective

[6] On the social construction of race, for instance, see Smedley and Smedley (2005).

identity and unit centralization at the global scale despite the absence of the "other" seems to represent a unique challenge in human social evolution.

4 The Formation of a Global Collective Identity

At the level of individual identity formation, it is widely accepted that this crucially depends on "dialogical relations with others" as Taylor put it (1994, p. 34). Whether an external "other" is an absolute necessity for the formation of group identity and thus for a dynamic of centralization to come into motion at the level of humanity as a whole, however, has been contested. Why should cultural learning and adjustment not be possible at this level, too?

It has been argued that what may be true for individual identity formation does not necessarily apply equally to collective identity formation (Abizadeh 2005). Unlike an individual, a collective can constitute itself through recognition by its individual component parts. Recognition by and relations with another external unit empirically may be the usual case but in theory this does not constitute an absolute precondition. In terms of a world state the whole and the component parts would have their own subjectivities that are not identical and would constrain each other's behaviour (Wendt 2003). An internal differentiation of this kind would allow each part "to recognize the Other, while incorporating that Other within its own definition of Self" (ibid., p. 527). Conceptually, no external unit would be needed.

In addition, for territorial states a spatial boundary is a fundamental element that divides between a set of "us" and "them." By definition, a spatial "other" would not be available to facilitate the formation of a world state. The absence of spatial differentiation functionally could be substituted by a temporal self-differentiation between past and present identities (Wendt 2003; Abizadeh 2005). As Wendt explains, Germany, for instance, draws part of its identity today from the demarcation separating it from the Nazi regime and its crimes. A determination to build an emancipative global order that no longer tolerates and enables war, genocide, ecocide, oppression, racism and misery as in the past thus may be a crucial formative element of a collective global identity. In this process, in some way humanity's own collective shadow self may represent the "other."

Culturally, the experience of seeing the planet as an integral fragile entity, from the outside, is one of epochal significance for the emergence of a global identity. The latter could be defined as a notion of belonging to the whole world that goes along with a feeling of solidarity with all humankind and of responsibility for all life on the planet. For this reason, images of the Earth from space are among the most influential and important photographs ever taken.[7] TV coverage of the Moon landing in 1969 was followed by hundreds of millions of people, who were confronted with an outside perspective on the planet. The picture of the Earth in its totality is without

[7]E.g., 'Earthrise' (Apollo 8, 24 Dec. 1968) and 'Blue Marble' (Apollo 17, 7 Dec. 1972).

question *the* symbol of our age and a rising alarm over climate change, animal extinction, biodiversity loss and other anthropogenic environmental harm. Satellite images from Earth and footage from the International Space Station by now are commonplace and contribute among a broader population to what White (2014) called an "Overview Effect."

The promotion of global citizenship education by UNESCO, which was later taken up by the UN as part of the Agenda 2030,[8] shows that there is a serious effort to embed civic learning on global issues and from a global perspective in curricula across the world. No doubt this has the potential to strongly contribute to the emergence of a global identity. This includes the possibility of developing a common narrative, as the new field of Big History attempts to do (cf. Leinen and Bummel 2018, pp. 359ff).

5 State Formation and Global Citizenship

The development of institutions and the emergence of identity are reciprocal processes. In the process of state formation this is well documented. Historical research recognizes more and more that the creation of nation-states was not necessarily a result of bottom-up mass mobilization as popularized myths would have it, but rather of intentional projects driven by elites from the top (Osterhammel 2003). The creation of state institutions often was the beginning and most important instrument in the construction of national identities which previously as such did not exist.

The homogenous "nation-state" is more fiction than reality. Most of the world's states are unquestionably multicultural and have large minorities. Modern societies are increasingly complex and diverse. Extensive DNA research confirms that populations had been "moving and mixing" all the time. The idea that present-day people directly descend in some way from people who always lived in the same area is "wrong almost everywhere" (Gabbatiss 2018; Mathieson et al. 2018). To call nationality and nationalism "cultural artefacts," as Anderson (2006) did, is very appropriate.

France and Great Britain are examples used to illustrate that it was primarily the state which created a symbolic framework supporting the development of a strong national identity (Zürn and Walter-Drop 2011, p. 265). Ethnic, linguistic or religious criteria as common bonds were secondary at early points in the process (Hobsbawm 1992, p. 20). Over time, programmes of education were put together to spread a national narrative and a national language that initially was usually only spoken by a minority among the population. Even in the Third Republic in 1863, French was still a foreign language for half the citizens (Weber 1976, p. 70).

From this perspective, the successive creation of a world state could be pursued as an elite-driven project that does not necessarily rely on a predominant global identity

[8]Sustainable Development Goal 4.7 and Indicator 12.8.1.

among the world population at first, and the vast diversity of human civilization would be no hindrance either as existing heterogeneous nation-states and the history of their formation suggests. However, a strong will on the part of a transnational elite would then be required. At this point there are no signs that such a will exists. Quite the contrary, a majority of the elites seems to regard the idea of a global authority not only as something difficult to bring about but as something that itself is not desirable (cf. Leinen and Bummel 2018, p. 306ff). Arguably, a world system divided into 200 nominally sovereign units that can be played against each other provide transnational corporations and their owners massive leeway compared with a world government that potentially can establish and enforce universal rules if need be, for instance in the field of taxation. This certainly does not preclude the possibility that individuals who belong to the elite, for instance due to their net worth, develop a planetary perspective and decide to support efforts of global political integration. At some point this may become a rational choice from a self-interest perspective, too, as potential limitations imposed by a world government may be preferable to an eventual global system breakdown and its consequences. In any case, institutional inertia and a tendency towards self-preservation for its own sake at the level of national governments should not be underestimated. To a large extent it still holds true what Reves (1946, p. 259) pointed out long ago: "The representatives of the sovereign nation-states are incapable of acting and thinking otherwise than according to their nation-centric conceptions."

On the other hand, many national constitutions permit the transfer of sovereign rights to international organizations so this possibility was often anticipated by their creators and may be useful in the future.[9] In fact, membership in the UN means to accept the binding nature under international law of decisions taken by the Security Council under Chapter VII of the UN Charter, which to a degree already represents a transfer of sovereignty that states have accepted. In this context, the UN and its symbolism can play a key role in global identity formation (Fromm 2010, pp. 87ff). Global elections to a parliamentary body at the UN would be a monumental milestone in this regard. For the first time, all people would be bound together as global citizens in selecting joint planetary representatives.

At this point it should be noted that the term of global citizenship is being used in many different ways (Reysen and Katzarska-Miller 2018). In connection with the current transformative phase of global state formation, global citizenship can be seen as an emerging legal concept. It is an expression of a nascent global state order that individuals are more and more accepted as subjects under international law who enjoy certain rights and responsibilities (Peters 2016). At this stage, however, there may be global citizenship to a degree but there is no global state. This, too, can be interpreted as an element of the cultural lag described above. A full realization of global citizenship will require that this contradiction is resolved through the

[9] Baratta (2004 p. 255) lists 40 constitutions from Europe, Latin America, Africa and Asia where this is the case.

formation of a planetary polity and a global demos. In a sovereign states system, one cannot formally be a global citizen (Cabrera 2010, p. 73).

From a conceptual perspective, it is crucial to recognize that a global demos is the outcome and not a precondition of global state formation. By the definition suggested here, a demos is the populace of a given state unit.[10] A demos is never externally given, but always the result of political institutions (Zürn and Walter-Drop 2011, p. 265). It arises out of a political act, namely the founding of the state in question and its membership is legally defined by citizenship of that state. A demos does not exist ahead of a unit's creation. Whether or not there is a predominant common identity at that point, and whether or not that is relevant, are different questions. This applies just as much to a world state as to territorial states. Nonetheless, there is an important difference. In the case of a world state, the definition of who is entitled to global citizenship and thus part of the demos is straightforward: it is all human beings. There is no differentiation between some "we" and "them."

6 Layers of Identity

Individual identity emerges over time from an increasing number of layers of self-perception and identification based on innumerable criteria such as descent, family and kinship, ethnicity, gender, sexual orientation, social status, national citizenship, faith and religion, education and profession, political and ethical worldviews, or special interests that are interrelated and of varying degrees of significance. As Simmel (2009) pointed out over a century ago, each individual, starting with the accident of birth, develops more and more relationships and in the process identity is formed in the "intersection of social circles" the individual associates with (Chap. 6). The social groups to which the individual belongs or affiliates with establish "a system of coordinates" that is more and more unique (p. 371f). The individual importance of such layers or circles is a key factor that determines the degree of a person's loyalty and solidarity—or hostility—towards others individually and collectively.

Historically, the belonging to a particular nation-state has become an extraordinarily strong layer of identity for many people up to a degree that under circumstances they would be ready to kill and die "for their nation". As noted by Scheuerman (2011, p. 43), the construction of such dominant national identities allowed elites "to call on common people to fight against social peers—sometimes living just across the border—chiefly because they saw themselves as French, for example, rather than Dutch or German."

[10] Recently, Koenig-Archibugi (2020) discussed five approaches to defining the demos in the field of political theory. It is beyond the scope of this piece to enter into this debate.

The extreme case can be called exclusive nationalism.[11] Exclusive nationalism can go along with the formation of an in-group morality that removes everybody else outside the group from the circle of empathic consideration and solidarity. Usually it will be both outwards and inwards oriented, excluding not only foreigners but also minority groups inside a given country itself.

National identity and belonging, however, can have an inclusive character that is not determined by a xenophobic "us" and "them" hostility. The concept of inclusive nationalism that embraces and takes pride in a nation's diversity can draw on an influential essay of Ernest Renan (1992) who emphasized that a modern nation is neither constituted by race, language or religion, not even by geography or common interests, but by a conscious decision of its citizens of belonging together in solidarity and their readiness to making sacrifices in the interest of the common good.

For sure, national identity is not mutually exclusive to other layers of individual identity that relate to the local, regional or global level. In particular, surveys across the world indicate that there already is a sense of global identity among populations that a global state formation process can build upon.

In one such survey respondents in eight countries were informed that "global citizenship is the rights, responsibilities and duties that come with being part of the world" and then were asked whether they would consider themselves a global citizen in addition to a citizen of their country. In all countries a large majority of respondents affirmed this statement, on average 75% (ComRes 2017). In another survey in 18 countries, respondents were asked whether they see themselves *more* as a global citizen than a citizen of their country. In ten countries, a majority agreed (GlobeScan 2016). The broadest dataset in this field is probably provided by the fifth and sixth waves of the World Values Survey which covered 48 countries from 2005 to 2009 and 60 from 2010 to 2014 respectively. In both cases, on average more than 70% of respondents agreed with the statement that they see themselves as "a world citizen" (Inglehart et al. 2014a, b).

In another item of the survey ComRes (2017) respondents were informed that "a supranational organization places global interests above that of nation-states" and then were asked whether they think "a new supranational organization should be created to make enforceable global decisions to address global risks." Again, a large majority in all countries affirmed this statement, on average 71% whereas only 21% disagreed.

Since the European Union is the most advanced supranational unit at this time, it is interesting to note that the annual Eurobarometer surveys across EU member states indicate that trust of respondents in the EU is regularly higher than that placed in national governments and a clear majority of the population across member states identify as EU citizens.[12]

[11] On inclusive and exclusive nationalism, see also Dowds and Young (1996).

[12] In the Spring 2019 edition, for instance, trust in the European Union stood at 44% whereas trust in national governments at 34% (European Commission 2019).

7 A Case for World Federalism

According to the above "growth sequence," the emergence of a new unit occurs in a process of centralization once this unit has the power to make decisions for a number of other units (Adams 1975, p. 214). This not only puts the new unit into a stronger position in its interaction with outside units. Insofar the original units are not absorbed, an internal hierarchical relationship comes about that allows the new unit to manage complexity more efficiently. In fact, empirically, the history of biological evolution shows that hierarchies developed as a natural way of governing complex systems as they greatly simplify their behaviour (Simon 1962, p. 481f).

In the case of human societies, this process addresses a fundamental issue, as mastering problems and managing more energy inevitably involves an increase in socio-political complexity such as a cumulative expansion of bureaucracy, organizational structures and social differentiation (Tainter 1988). The economic benefits that accompany this growth in complexity steadily decrease and beyond a certain point they can tip over into the negative. According to Tainter (ibid., 118ff) a collapse to less complex stages is inevitable in this phase unless new sources of productivity growth can be tapped. Integration at a higher level is a way to achieve this.

The international system based on nominally sovereign separate units is marked by high fragmentation unmitigated by any overarching global hierarchy, harmonization, governance or coordination. This also broadly applies to the United Nations with its dozens of programmes, specialised agencies, commissions, secretariats, funds and other "entities." As Weiss (2009) noted, it would be difficult to imagine "a better design for futile complexity."

The emergence of a coherent planetary polity with centralized decision-making power has the potential to contribute massively to a reduction in complexity and to lower transaction and opportunity costs. A loss in individual sovereignty on the part of states would by far be outweighed by the positive effects of an equivalent gain in shared sovereignty at the global level. One example for opportunity costs that also impacts the productive capacity of societies across the world is the immense expenditure on the military and on armaments which arises from the absence of an effective system of collective security and the security dilemma, among other things.[13] Under the current system, it is hard to imagine that the goal of general and complete disarmament can ever be achieved.[14] The overall benefits of effective global action on climate change or in the area of taxation are two other obvious cases that can be made.

Nonetheless, in human societies it can be observed that higher level units can be oppressive towards lower level component units. This is the case if integration has come about by force in the first place (which was excluded above as a possibility at the global scale) but it can also happen later, for instance if a central unit comes

[13]On the security dilemma, see Herz (1950).

[14]On this goal see UN (1978).

under totalitarian political control. Eisler (1988, p. 205) suggested to distinguish between domination and actualization hierarchies. While the former term describes hierarchies based on force, the latter describes such in which all component units play an organic role in maximizing their own and the whole's potentials. This brings us to another conceptual consideration: the creation of a planetary actualization hierarchy may only be successful if the component parts themselves are actualization hierarchies, too. It is hard to imagine that a state unit under control of an autocratic government would be able and willing to participate in supranational integration and actually give away power. Even so, this would most likely create ongoing tensions and conflicts at the levels of decision-making, implementation, principles and identity, among others. The European integration project, for instance, was exclusively driven by states under democratic government. Considering an "international federal government" for the time after the Second World War, a team at the US State Department came to the conclusion that this was not doable with the Soviet Union "even if it were theoretically desirable" (Baratta 2004, p. 97). The biggest obstacle obviously was the totalitarian character of the Soviet Union at the time. In fact, recent research suggests that authoritarian states are much less likely to engage in publicly reported treaty-making compared to democracies and as a general rule do not participate in the international legal order to the same degree (Ginsburg 2020). In addition, authoritarian government contradicts the notion of citizenship per se as the latter implies political and civil rights. The realization of democracy and human rights at the level of today's nation-state units seems to be a key precondition for a full development of a planetary polity based on emancipative values. National and global democracy are thus closely interlinked.

The starting point in thinking about the features of a planetary polity is to recognize that there are component parts it will emanate from, namely today's individual state units which control taxation, redistribution, law enforcement and military power, among other things. In principle, these units, with the exception of failed states perhaps, are in a position of setting the framework for all others in their territory, including multinational corporations for instance. These state units would need to be bound by decision-making taken at the level of the planetary unit. This implies a transformation from today's system of international law to a system of world law (Bummel 2014). This also means that the component parts need to be included in the centralized decision-making process as otherwise they will hardly agree to transfer any of their power and help implement global decisions. However, as long as single component units are in a position to block decisions or to opt out of any of them unilaterally, no real transfer of power has taken place. What is needed instead is a fair system of qualified majority decision-making that takes into account minority interests. Finally, for a planetary polity to qualify as an actualization hierarchy, it would need to provide its component parts sufficient leeway to deal with affairs on their own that do not affect the whole. Ultimately this entails a federal system of planetary government.[15]

[15] For an in-depth discussion of world federalism see Glossop (1993) and Höffe (2007).

The history of federalist thinking and existing federal states provide ample material and models to draw upon for a conceptualization at the global scale. As Inman and Rubinfeld (2020, p. 1ff) point out, the federal state "now seems to be the polity of choice, both for emerging democracies and for established states undergoing economic and democratic reforms." Countries such as Argentina, Brazil, Iraq, South Africa or Nepal have joined the club of modern federal democracies that includes Australia, Canada, Germany, India, Mexico, Nigeria, Switzerland or the United States, among others. Part of the attraction of federalism is an ability of smaller component parts—the subnational units—to facilitate political participation and democratic deliberation and to provide local government services more efficiently. Further, a federal design enables component parts to provide protection against tyranny by a majority-controlled central government. It is a double security, though, because on the other hand, the central government can also check any tyranny developing at the level of any of the component parts based on common standards adopted for the whole, for instance in the federal constitution (ibid., p. 4). Federalism preserves the rights of the component natural units, and "allows for a considerable degree of independence and freedom in ethnic, linguistic, religious and cultural realms" which helps defuse corresponding conflicts (Höffe 2007, p. 100). Different levels of government within a federal centralized unit may reflect different layers of corresponding identities in the respective population and help create a balance between minority and majority interests.

Following the principle of subsidiarity, functions and powers thus would be dispersed vertically between the different levels of government from the local to the global, and always implemented at the lowest level possible. In some cases, subcontinental or continental levels of government that lie between the national and global levels may take over responsibilities, too. In addition, states and other component parts can carry out administrative responsibilities on behalf of the world federation, thus avoiding the creation of a large central bureaucracy. While the rules governing the legitimate use of force would be determined at the level of the planetary polity, there would be no centralized factual monopoly on military and police capabilities as these, too, would be dispersed following federalist principles. In a system of global fiscal federalism, the power of taxation would also be divided across different levels. Finally, democratic participation and representation of citizens as well as the rule of law, separation of powers, checks and balances and the protection of minority rights would have to be implemented at all levels.[16]

Conceptually, the power and democratic legitimation of a federal world state emanates from a combination of civic legitimation based on individual citizens and state legitimation based on the will of all states as component parts (Höffe 2007, p. 219). Not only the interests of the component parts but also those of the central unit as a whole need to be reflected in the institutional design. This leads to a bicameral division of the federal legislature into two chambers: an assembly democratically elected by all citizens that represents the common interest of humanity

[16]This paragraph is based on Leinen and Bummel (2019).

and another composed of representatives of state units. The exact functioning of such a global parliament and of a planetary polity in general eventually will have to be determined in a global constitutional process. There is no lack of proposals.[17] The world legislature for instance could be empowered to adopt framework legislation that needs to be transposed into national law and global regulations with direct and universal applicability inspired by the example of law-making in the European Union. Today's Security Council could be replaced by a Joint Security Committee set up by the two legislative bodies. The UN's secretariat and the administrative structure of the UN system as well as intergovernmental organizations outside the UN could be transformed into a World Commission, acting as a coherent executive branch with cabinet functions. A reformed International Court of Justice can be made responsible to oversee the World Commission, and to ensure that global legislation is in accordance with constitutional rules and equally applied across states (Bummel 2018).

8 Concluding Reflections

There is no determinism in human cultural evolution. History provides many examples not only for an integration of social units but also for their disintegration back to lower levels of complexity. It is not yet clear whether human civilization is on a path of global collapse or global unification. From a cosmic perspective, Earth in principle will remain habitable for a very long time. It will be about a billion years before the radiance and size of the sun have grown so much, and the surface temperature of the Earth has increased so much as a consequence, that life will no longer be possible on our planet. Nonetheless, at this moment in time human ability—or inability—to form a common planetary polity that is able to regulate and mitigate human impact on the Earth system and other species, as well as mitigate other global catastrophic risks, is one of the most important factors that will determine our future for centuries to come. Due to carbon emissions and other human impacts, the safe operating space for humanity that existed in the last 12,000 years of the Holocene is shrinking rapidly.[18] As Sagan (2011, p. 361) stressed, "if we are to survive, our loyalties must be broadened further, to include the whole human community, the entire planet Earth."

Acknowledgments Parts of this article are based on Leinen and Bummel (2018).

[17] See for instance Schwartzberg (2013) and Lopez-Claros et al. (2020). On a UN Parliamentary Assembly as a step towards a global parliament, see Brauer and Bummel (2020).

[18] On the safe operating space and planetary boundaries, see Rockström et al. (2009).

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Chapter 18
Widening Perspectives: The Intellectual and Social Benefits of Astrobiology, Big History, and the Exploration of Space

Ian A. Crawford

> *It is only when the different scientific disciplines and the different specialities choose to interact, and only when all cultures and states recognize that they have common interests, that humanity can evolve towards one single co-operative society (Aerts et al. 1994, p. 20)*

Abstract Astrobiology is the field of science devoted to searching for life elsewhere in the Universe. It is inherently interdisciplinary, integrating results from multiple fields of science, and in this respect has strong synergies with 'big history'. I argue that big history and astrobiology are both acting to widen human perspectives in intellectually and socially beneficial directions, especially by enhancing public awareness of cosmic and evolutionary worldviews. I will further argue that these perspectives have important implications for the social and political organisation of humanity, including the eventual political unification of our planet. Astrobiology and big history are also concerned with the future of humanity, and I will argue that this future will be culturally and intellectually enriched if it includes the exploration of the universe around us. An earlier version of this chapter was originally published in the *Journal of Big History*, Vol. III(3), pp. 205–224 (2019).

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1 Introduction

Astrobiology and 'big history' are two relatively new intellectual disciplines, the former focussed on searching for life elsewhere in the universe and the latter on integrating human history with the wider history of the cosmos. Despite some differences in emphasis these two disciplines share much in common, not least their interdisciplinarity and the cosmic and evolutionary perspectives that they both engender. In this chapter I will explore the relationships between astrobiology and big history and argue that both are acting to widen human perspectives in intellectually and socially beneficial directions. These include stimulating the (partial) re-integration of scientific disciplines after a period of extreme specialisation, and the (again partial) breaking down of barriers that exist between the sciences and the humanities. In addition, both disciplines act to enhance public awareness of cosmic and evolutionary perspectives which, I will argue, constitute a strong, if implicit, argument for the eventual political unification of humanity. Astrobiology and big history are also concerned with the *future* of humanity, and I will make the case that the future will be culturally and intellectually richer if it includes an ambitious programme of space exploration. Not only will the exploration of space further reinforce socially beneficial cosmic perspectives, but ultimately it may be the only way for human (and post-human) societies to avoid the intellectual stagnation once predicted for the 'End of History'.

2 Astrobiology and Big History

The intellectual case for 'big history' was first made by David Christian (1991) and, although still controversial in some quarters, it has now established itself as a distinct academic discipline. The International Big History Association (IBHA 2020; see also Rodrigue 2017) adopts the following working definition:

> Big History seeks to understand the integrated history of the cosmos, Earth, life and humanity, using the best available evidence and scholarly methods.

This is strikingly similar to a common working definition of the comparably recent discipline of astrobiology (NASA 2020):

> Astrobiology is the study of the origins, evolution, distribution, and future of life in the universe. This interdisciplinary field requires a comprehensive, integrated understanding of biological, geological, planetary, and cosmic phenomena.

Although the term "astrobiology" dates from the first half of the twentieth century (Lingam and Loeb 2020),[1] it is only in the last 25 years or so that it has become firmly established as a scientific discipline, with the appearance of dedicated

[1] And perhaps earlier—see the discussion by Mukesh Bhatt elsewhere in this volume.

Table 18.1 Syllabus of the Birkbeck College Introduction to Astrobiology module (each week comprises 3 h of face-to-face teaching; Birkbeck College 2020)

Week	Topic	Most relevant scientific field(s)
1	Origin and distribution of the chemical elements	Astronomy/Astrophysics
2	Conditions in the early Solar System	Astronomy, Planetary science
3	Earliest evidence for life on Earth	Geology, Palaeontology
4	Biological basics	Biology, Biochemistry
5	Pre-biological chemical evolution/Origin of life	Geochemistry, Biology, Biochemistry
6	History of life on Earth	Palaeontology/Evolutionary biology
7	Requirements for life	Biology/Biochemistry/Geochemistry
8	Prospects for life on Mars	Planetary science/Geochemistry/Biology
9	Life elsewhere in the Solar System	Planetary science/Geochemistry/Biology
10	Detection and habitability of exoplanets	Astronomy/Planetary science
11	Search for extraterrestrial intelligence	Astronomy

textbooks, journals, and university courses. The field is inherently interdisciplinary because any serious attempt to understand the prevalence and distribution of life in the universe requires familiarity with, at least, the established scientific disciplines of astronomy, biology, chemistry and geology (as well as established interdisciplinary combinations among these sciences, e.g., astrophysics, biochemistry, evolutionary biology, geochemistry, palaeontology, and planetary science). In order to illustrate the interdisciplinary nature of astrobiology more clearly, Table 18.1 summarises the syllabus of the undergraduate module "Introduction to Astrobiology" that the author has taught at Birkbeck College, University of London, since 2004.

A glance at Table 18.1 indicates that approximately half of this undergraduate astrobiology module could equally be described as big history. With the exception of the material covered in Week 4, which is included to ensure that non-biology students are familiar with at least the basics of biological knowledge, the material covered in Weeks 1–6 is all essentially 'historical' in nature (albeit invoking a range of scientific disciplines) and is invariably covered in the first few chapters of standard big history texts (e.g., Christian 2004, 2018; Brown 2007; Christian et al. 2014; Spier 2015). The overlap with big history has also been noted from an astrobiology perspective by Dick (2018, pp. 169, 235, 311). Of course, at some point in their respective curricula astrobiology diverges from big history, branching out to search for life elsewhere in the universe, while big history continues the historical narrative to include the evolution of *Homo sapiens*, human societies and human culture.

The links between astrobiology and big history may be further illustrated by means of a personal anecdote: the first half of the astrobiology syllabus outlined in Table 18.1 is based on an earlier course entitled "Cosmic Perspectives for World History" that I devised for the City University's adult education programme in 1994

Courses For Adults

CITY University

COSMIC PERSPECTIVES FOR WORLD HISTORY

TUTOR: Dr Ian Crawford
4A.05.04 10 meetings, weekly from Monday 10 October 1994, 6.30-8.30 £36.00

This course will present a short scientific history of the world from the Big Bang to the dawn of civilisation on Planet Earth some 5000 years ago. It is therefore intended to lay a foundation for subsequent studies of world history, and to provide a perspective which is often lacking in such studies. Topics to be covered will include:

- The Big Bang and the Origin of the Universe.
- Stars and the origin of the chemical elements.
- The formation of the solar system and Planet Earth.
- A discussion of what is currently known about the origin of life.
- A summary of biological evolution, with particular reference to the evolution of the vertebrates through the successive stages of fish, amphibians, reptiles and mammals.
- The evolution of Homo Sapiens, and of culture, agriculture and civilisation.

The course will consist of ten lectures, illustrated with the aid of slides and overhead projector notes.

Recommended Reading
The Universe and Life, by G.S. Kutter, Jones & Bartlett (1987).
Wonderful Life, by Stephen J. Gould, Penguin (1989).
Major Events in the History of Life, by J.W. Schopf, Jones & Bartlett (1992).

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Course for Adults, City University, Northampton Square, London EC1V 0HB
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Fig. 18.1 The syllabus of a course on "Cosmic Perspectives for World History" taught by the author at the City University, London, in the academic years 1994–1995 and 1995–1996. Image by the author (see Fig. 18.1). At the time I was unaware of big history as such, although Christian (1991) had already coined the term. However, as Fig. 18.1 reveals, I was partly inspired by Siegfried Kutter's (1987) book *The Universe and Life*, which is often identified as a big history precursor (Rodrigue 2017). In retrospect, it is clear that this early 'Cosmic Perspectives' course, which in time led to the Birkbeck College undergraduate module in astrobiology, was big history in all but name. This anecdote reinforces observations already made by others that the early years of big history were characterised by individuals and small groups working independently. It seems that by the late twentieth century big history was an idea whose 'time had come', although of course the subject has much deeper roots (see, e.g., Spier 2015; Rodrigue 2017; Katerberg 2018).

Katerberg (2018) has recently argued that the academic fields closest to big history are deep history (where 'deep' here refers to human pre-history), evolutionary history, and ecological economics. Based on the discussion above, however, I suggest that astrobiology is an even closer match, both in terms of content and perspective (where there is considerable overlap), but also in the way both disciplines have struggled, eventually successfully, for academic recognition over the last quarter of a century.

More important than the intellectual origins of interdisciplinary subjects like astrobiology and big history, however, is the extent to which they can produce lasting intellectual and societal benefits, to which we now turn.

3 Intellectual Benefits of Big History and Astrobiology[2]

The main academic and intellectual benefits of both astrobiology and big history (and related disciplines) arise from their inherent interdisciplinarity. In the case of astrobiology these benefits have already been noted by several authors (e.g., Connell et al. 2000; Race et al. 2012), and mostly result from interactions between scientific disciplines. For example, astrobiology encourages astronomers to work with biologists and geologists in the pursuit of finding life elsewhere in the universe. By producing well-rounded scientists, familiar with multiple aspects of the natural world, astrobiology is therefore helping to re-unify the sciences after a long period of intense specialization. Moreover, by considering questions related to the philosophical and cultural implications of the discovery (or non-discovery) of extraterrestrial life, astrobiology is also stimulating intellectual activity outside the normal scope of the physical sciences, including theoretical work in anthropology, ethics, linguistics, philosophy, and theology (e.g., Bertka 2009; Dick and Lupisella 2009; Race et al. 2012; Dunér et al. 2013; Impey et al. 2013; Vakoch 2013, 2014; Dick 2018; Peters et al. 2018). To this extent, astrobiology is well-suited to help close the gap between science and the humanities identified over 60 years ago by C.P. Snow in

[2]The astrobiology side of this discussion draws on an earlier publication (Crawford 2018a).

his 1959 Rede Lecture at the University of Cambridge (Snow 1963) and more recently by Wilson (1998).[3]

Similar arguments have been advanced for big history, although there are some differences in emphasis (e.g., Christian, this volume). Big history clearly has the potential to stimulate research activity in the natural sciences, on which it relies for much of its historical narrative, but in origin, and perhaps especially in outlook, big history is closer to the humanities than interdisciplinary natural sciences such as astrobiology. To my mind, this strengthens the synergies between them, not least because it means that big history is even better placed to bridge Snow's "two cultures" divide.

The synergies between big history and astrobiology are perhaps most apparent when it comes to interdisciplinary education, and this may indeed prove to be one of the most important legacies of both disciplines. Snow himself explicitly recognized the importance of interdisciplinary education when he returned to the problem of the "two cultures" with *Two Cultures: A Second Look* (Snow 1963; p. 61):

> In the conditions of our age, or any age which we can foresee, Renaissance man is not possible. But we can do something. The chief means open to us is education.. . . There is no excuse for letting another generation be as vastly ignorant, or as devoid of understanding and sympathy, as we are ourselves.

Interestingly, in the same year as Snow's *Second Look* appeared, the astronomer Harlow Shapley also made a powerful plea for interdisciplinary education. Shapley went as far as to characterise the 'vertical' separation of academic disciplines as "education-defeating" (Shapley 1963; p. 134) and proposed that an ideal undergraduate historical curriculum would

> present the history of the universe and mankind as deduced from geology, cosmogony, paleontology, anthropology, comparative neurology, political history, and so on . . . wide integration is the essential key (Shapley 1963; pp. 135–136).

In 2009, the art historian Martin Kemp contributed an article in *Nature* to mark the 50th anniversary of Snow's original lecture. He concluded that the main problem was not so much a division between "two monolithic 'cultures' of science and humanities", but the "narrow specialisation of all disciplines." As he put it (Kemp 2009):

> It is the perceived need for intense specialization of any kind—in history or physics, in languages or biology—that needs to be tackled. . . . What is needed is an education that inculcates a broad mutual understanding of the nature of the various fields of research.

This line of thinking has been taken up by others. For example, in an article stressing the desirability of producing scientifically minded citizens, Erika Offerdahl (2013) observed:

[3]Interestingly, in 1992 the cultural anthropologist Ben Finney made exactly this point in the context of the Search for Extraterrestrial Intelligence (SETI), itself an important component of astrobiology, when he asked "could it be that SETI is a project that could help bridge intellectual gulfs within our own species, as well as extraterrestrial ones?" (Finney 1992).

> The structure of undergraduate curricula and courses tends to compartmentalize science into discrete disciplines that focus on particular questions rather than an integrated, interdisciplinary way of understanding the world, let alone any discussion of the societal implications of the science.

If nothing else, big history (and related interdisciplinary subjects such as astrobiology) can provide precisely this kind of interdisciplinary education, and do so in a manner that students of all ages find very engaging (e.g., Chaisson 2014; Katerberg 2018; Voros 2018; Bohan, this volume). As Snow (1963, p. 61) himself noted, this will necessitate revising school and university curricula around the world, but the benefits of doing so are likely to be considerable (e.g., Katerberg 2018; Bohan, this volume; Christian, this volume).

4 Expanding Worldviews

Transcending the academic, intellectual, and even practical benefits of a broadly-educated citizenry, the *perspectives* provided by astrobiology and big history may result in positive influences over a wide range of societal and political concerns. In an earlier article (Crawford 2018a), I argued that wider public engagement with, and knowledge of, the topics covered by astrobiology (Table 18.1) would lead to beneficial social and political consequences. Based on the discussion above, it seems clear that these arguments are even stronger in the case of big history, which covers much of the same ground while explicitly articulating an evolutionary perspective rooted in deep time.The key point relates to the broadening and deepening of worldviews resulting from increased public awareness of cosmic and evolutionary perspectives. Here, I adopt the definition of a worldview given by Diederik Aerts and colleagues in their excellent and important monograph on *World Views: From Fragmentation to Integration* (Aerts et al. 1994; p. 9):

> A world view is a system of co-ordinates or a frame of reference in which everything presented to us by our diverse experiences can be placed. It is a symbolic system of representation that allows us to integrate everything we know about the world and ourselves into a global picture, one that illuminates reality as it is presented to us within a certain culture.

Aerts et al. (p. 8) also note that:

> World views . . . have a strongly motivating and inspiring function. A socially shared view of the whole gives a culture a sense of direction, confidence and self-esteem.

Unfortunately, at present, and in some quarters increasingly, the worldviews of many people are dominated by narrow nationalistic and religious ideologies. Although historically some of these restrictive, and often mutually exclusive, worldviews may have had (local) societal benefits, and a propensity to hold them may have evolved naturally through group selection in humanity's distant past (e.g., Wallace

1871, p. 313; Darwin 1874, p. 64; Wilson and Wilson 2007; Wilson 2012),[4] they are potentially disastrous at a time of growing global interdependence. Our world faces many global problems (including, but not limited to, proliferation of weapons of mass destruction, climate change, pollution, loss of biodiversity, over exploitation of the 'global commons', and insufficient provision of food, water and sanitation for millions of people) that can only be satisfactorily addressed through concerted global action. However, meaningful global action will be, and is being, impeded by nationalistic and other essentially tribal worldviews, in which a sense of global identity and responsibility is lacking (or even denied). As Kwame Appiah (2006, p. xi) put it in his influential essay on cosmopolitanism:

> The challenge, then, is to take minds and hearts formed over long millennia of living in local groups and equip them with ideas and institutions that allow us to live together as the global tribe we have become.

Aerts et al. (1994, p. 5) had already identified global worldview formation to be central to meeting this challenge:

> It is our conviction that the time has come to make a conscious effort towards the construction of global world views, in order to overcome this situation of fragmentation.. . . It is precisely because we lack such global views of the world that our ability even to start looking for lasting solutions to these problems is limited.

There is therefore a pressing need to find unifying cosmopolitan perspectives that can counter the divisive and exclusionary worldviews of the past. In identifying such unifying worldviews, it will be essential that they are based on factual foundations that everyone can accept, and this is where big history and related disciplines are well-placed to help.

Spier (2016) has argued that big history should not be taken as an all-embracing worldview from which ethical implications can legitimately be drawn. He is undoubtedly correct that normative considerations cannot logically be derived from a factual history of the universe such as big history seeks to provide. However, this does not mean that big history cannot provide a worldview (or, at least, part of a worldview) in the sense developed by Aerts et al. (1994), and that this worldview, once grasped, will not influence human behaviour. Indeed, the recognition that fact-based universal histories have ethical, and even political, implications has long been a significant motivation for constructing them. For example, in 1844 Robert Chambers published (anonymously) his *Vestiges of the Natural History of Creation*, which is perhaps the first serious attempt to create a science-based (pre-Darwinian) evolutionary history of the universe and humanity's place within it. Chambers himself certainly saw it as such, writing (p. 388):

> as far as I am aware [my book] is the first attempt to connect the natural sciences to a history of creation. . . . My sincere desire in the composition of the book was to give the true view of the history of nature.

[4]For a scholarly discussion of the various controversies associated with the concept of group selection, and other evolutionary influences on human behaviour, see Segerstråle (2000).

Vestiges caused a huge sensation at the time (Secord 2000), and the following year Chambers felt the need to offer some 'Explanations' (1845). In the course of this (p. 184) he explicitly drew the ethical implication that the "new view of nature" articulated in *Vestiges* could contribute to:

> establishing the universal brotherhood and social communion of man. And not only this, but it extends the principle of humanity to the other meaner creatures also. Life is everywhere ONE.

This quotation is especially significant because it shows that Chambers was concerned not just with laying a foundation for "the universal brotherhood and social communion of man", but also his expectation that a proper understanding of cosmic and evolutionary perspectives would have ethical implications for relations with other living things (and to this extent anticipates Peter Singer's (1981) concept of an 'expanding circle' of ethical progress).[5]

The year following the publication of *Vestiges*, Alexander von Humboldt (1845) published his first volume of *Cosmos*, which also combined many different aspects of knowledge into an integrated view of humanity's place in the universe (albeit without the evolutionary emphasis of *Vestiges*). There is little doubt that Humboldt was fully aware of the unifying societal implications of this perspective because, in the Conclusion to Volume I of *Cosmos* (p. 358), he quotes from one of his brother Wilhelm's works on language to the effect that:

> If we would indicate an idea which, throughout the whole course of history, has ever more and more widely extended its empire . . . it is that of establishing our common humanity—of striving to remove the barriers which prejudice and limited views of every kind have erected among men, and to treat all mankind, without reference to religion, nation, or color, as one fraternity, one great community.

This perspective was not lost on at least some of Humboldt's contemporaries. The American physician and author James Whelpley (1846) noted in his review of *Cosmos* that "the individual is made to feel that he is connected, by the very nature and substance of his body, with every part of the universe", and drawing the implication (p. 603) that:

> If the world is ever to be harmonized it must be through a community of knowledge, for there is no other universal or non-exclusive principle in the nature of man.

It appears that what Whelpley took from *Cosmos* was a sense that humanity might be able to "harmonize" itself socially and politically if it could only agree on a common integrated worldview of the kind Humboldt had developed.

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[5] *Vestiges* had a major influence on Winwood Reade, another Victorian writer of an evolutionary universal history, *The Martyrdom of Man* (1872), who in turn influenced Wells (see Hesketh 2015). Reade also sensed the ethical and political implications of the evolutionary perspective, arguing that it pointed to a future in which "our enlightened posterity will look back on us who eat oxen and sheep just as we look back upon cannibals" (p. 513) and that "[t]he whole world will be united by the same sentiment which united the primeval clan, and which made its members think, feel and act as one. Men will look upon this star [i.e., planet] as their fatherland" (p. 514).

Several twentieth century advocates for what we might today call a 'big historical' worldview have likewise drawn attention to the societal benefits of the resulting cosmopolitan perspectives. H.G. Wells' *The Outline of History*, written in the appalling aftermath of the First World War, is arguably the foremost example, and Wells (1920, p. v) left no doubt about his reasons for writing it (emphasis in the original):

> The need for a common knowledge of the general facts of human history throughout the world has become very evident during the tragic happenings of the last few years. . . . *There can be no common peace and prosperity without common historical ideas*. Without such ideas to hold them together in harmonious co-operation, with nothing but narrow, selfish, and conflicting nationalist traditions, races and peoples are bound to drift towards conflict and destruction.

These considerations famously led Wells to conclude (p. 608) that "human history becomes more and more a race between education and catastrophe." He was convinced that every thinking person should do what they can to help win this race, and that finding a common historical perspective was the key (p. 603, emphasis in the original):

> The essential task of men of goodwill in all states and countries remains the same, it is an educational task, and its very essence is to bring to the minds of all men everywhere, as a necessary basis for world cooperation, *a new telling and interpretation, a common interpretation of history*.

Other examples of arguments for the societal benefits of big historical/astrobiological perspectives include works by the astronomers Harlow Shapley and Hubert Reeves. Shapley, in particular, dedicated much of his career to popularising the cultural benefits of a cosmic perspective (see Palmeri 2009) and began the preface of his book *The View from a Distant Star* (Shapley 1963; p. 5) by noting:

> Mankind is made of star stuff, ruled by universal laws. The thread of cosmic evolution runs through his history.

The phrase "Mankind is made of star stuff" is often attributed to Carl Sagan but, as far as I am aware, Shapley was the first to use it. He argued that this vast perspective could, indeed *should*, "incite orientating thoughts" (see pp. 38, 93, 161) that would, among other benefits, help "take us through the present and future predicaments" (p. 97) facing humanity.

In his book *The Hour of Our Delight: Cosmic Evolution, Order and Complexity*, Reeves (1991) was similarly motivated by potential societal benefits arising from a knowledge of cosmic evolution and by the hope that the resulting "sense of wonder" would help turn humanity away from violence, conflict, and, especially, nuclear war. Reflecting on the contrast between the wonder of cosmic evolution revealed by modern science, and the often absurd pointlessness of human conflict, he wrote "The awakening of a sense of wonder and delight is the best antidote to absurdity at all levels" (Reeves 1991; p. 8), and went on to propose that an understanding of cosmic evolution evokes an argument for human solidarity and dignity (p. 185, emphasis in the original):

> A new vision of humanity emerges from contemporary scientific knowledge. Though mankind can no longer pretend to be the center of the world, our new position gives us our real dignity.. . . we occupy the top level of the pyramid of nature's organised entities. We reached this level after a gestation period of fifteen billion years, in which all of the cosmic phenomena participated. *All human beings, regardless of their origin, have an equal claim to this dignity*. The respect for human rights implies also an awareness of the importance of every individual in the history of the universe.

Perhaps the clearest recent enunciation of why the perspectives provided by big history and related disciplines have the potential to help unite humanity was made by the biologist Ursula Goodenough in her 1998 book *The Sacred Depths of Nature* (p. xvi):

> Any global tradition needs to begin with a shared worldview: a culture-independent, globally accepted consensus as to how things are.. . . our scientific account of nature, an account that can be called The Epic of Evolution.. . . this is the story, the one story, that has the potential to unite us, because it happens to be true.

Although the title of Goodenough's book suggests a theistic outlook, her actual perspective is one of 'religious naturalism' which combines a naturalistic worldview with emotional and ethical perspectives normally associated with religion (e.g., Hogue 2010). It seems important to recognize that if the 'Epic of Evolution' (aka big history) is perceived to be consistent with at least some religious worldviews that may aid its wider acceptance, although big history itself is probably better seen as a secular 'origin story' anchored in scientific knowledge (e.g., Christian 2018).

5 Geopolitical Implications

The importance of developing a planetary perspective as a prerequisite for effectively tackling planetary-scale problems has long been recognized in the professional international relations community (e.g., Morgenthau 1948; Herz 1962; Ward 1966). The potential role of big history in developing this perspective, with geopolitical implications, has recently been noted by Jo Leinen and Andreas Bummel (2018) in their book *A World Parliament: Governance and Democracy in the 21st Century* (p. 361):

> Big history provides an account of the origin of all existence and of life on Earth on a strictly scientific basis. The cosmological worldview thus helps us on the path to an integral consciousness and creates an important frame of reference for planetary identity.

The need for such a perspective is also developed in the *Planet Politics Manifesto* advanced by Anthony Burke et al. (2016). They argue that the existing, state-centric, political organisation of the world is "failing the reality of the planet", and seek to reorientate the study of international relations to answer the question "Can we match the planet with our politics?" They conclude that:

> Our fundamental image of the world must be revolutionised. Our existence is neither international nor global, but planetary. Our anthropocentric, state-centric, and capital-centric

> image of international relations and world politics is fundamentally wrong; it perpetuates the wrong reality, the wrong commitments and purposes, the wrong ‘world-picture’.

Importantly, they stress that in order to make progress “we don’t need more reports or policy debates. We need new practices, new ideas, stories and myths.” By providing a common, scientifically robust, “origin story” (or, viewed another way, a “myth” describing humanity’s place in the universe that is as true as modern science can make it), big history and related disciplines can help satisfy the last two of Burke et al.’s prerequisites for progress, while in parallel stimulating interdisciplinary advances in the first two.

It is interesting to consider the potential longer-term political implications of a “planetary identity” engendered (in part) by big history. Spier (2015) has drawn attention to the fact that academic history in its modern form emerged in the nineteenth century, largely to support the formation and consolidation of nation-states, and that this nationalistic imperative has led to the downplaying of integrated human, or universal, histories. This then leads him (Spier 2015, p. 12) to make the following observation:

> [T]he study of human history as a whole has only rarely been practiced up to the present. This remarkable situation may be linked to the fact that to do so would produce global identities, which are not directly associated with any presently viable state society.

This raises the question, already alluded to in the title of Leinen and Bummel’s book quoted above, of whether the creation of “global identities” through the promulgation of big history and related perspectives could help in the development of global political institutions above the level of the nation-state. Both Wells and Shapley were convinced of this, and both devoted chapters of their books to making the case for world government. Moreover, although authors like Wells and Shapley might easily be dismissed as overly idealistic and lacking in professional expertise in the field of international relations, essentially the same conclusion was reached by such leading ‘realist’ international relations scholars as Hans Morgenthau (1948) and John Herz (1962). Daniel Deudney (2018a) has recently summarised Morgenthau’s position as follows: “humanity thus faces a tragic impasse: it needs a world state for security, but lacks a sufficiently thick sense of common identity both to make it possible and to prevent it from being threatening.” Morgenthau himself (1948, p. 419) appears to have viewed this as a challenge to be overcome:

> If the world state is unattainable in our world, yet indispensable for the survival of that world, it is necessary to create the conditions under which it will not be impossible from the outset to establish a world state.

Morgenthau saw the way forward through international diplomacy, but was clearly aware that developing a sense of common identity would be a prerequisite for success, just as “the community of the American people antedated the American state . . . a world community must antedate a world state” (Morgenthau 1948, p. 406).

This is not the place to reiterate all the arguments for or against the creation of a world government, or the various forms such a government might take. There is a large literature on this topic to which the interested reader can refer (e.g., Kant 1795; Russell 1916; Laski 1925; Reves 1946; Toynbee 1972; Kerr 1990; Hamer 1998; Wendt 2003, 2015; Yunker 2007, 2018; Cabrera 2011; Leinen and Bummel 2018; Lu 2018), and comprehensive historical overviews of world government proposals have been provided by Wynner and Lloyd (1944), Heater (1996), and Baratta (2004). My own view (e.g., Crawford 2015, pp. 206–209) is that a federal world government, implementing the principle of subsidiarity on a global scale, would be the most appropriate institutional response to tackling the many planetary-scale problems that human civilisation will face in the twenty-first century. That said, I find myself in agreement with Morgenthau and others that such geopolitical developments, while desirable, may be impractical until humanity develops a greater sense of its common identity, what Herz (1962, p. 317) termed a "planetary mind", Anderson (1991, p. 6) a sense of "imagined community", and Ward (1966, p. 148) "a patriotism for the world itself."[6]

It seems to me that the temporal and evolutionary perspectives provided by big history and astrobiology, combined with the spatial ('cosmic') perspectives provided by the exploration of space (discussed below), will play a valuable, and perhaps essential, role in forging the common human identity likely to be a prerequisite for the evolution of a future world government (see also Crawford 2018b; Leinen and Bummel 2018, pp. 351–365; Deudney 2018b; Som 2019[7]).

6 Space Exploration: Augmenting the Cosmic Perspective

Big history and astrobiology are both concerned with the *future* of humanity as well as the past, and, barring some unforeseen calamity, it seems likely that the exploration of space will be a part of this future. Certainly, if some of the more ambitious aspirations to make humanity a multi-planet species are realised, space exploration and development could become a very large part of the human (and post-human) future. Even if these aspirations are never fully realised, it seems likely that we will continue to explore our Solar System with robotic space probes, and probably also with astronauts. In this section I will therefore briefly examine the synergies, as I see them, between astrobiology, big history, and the exploration of space. Of course,

[6]Barbara Ward's slim book "Spaceship Earth" (1966), based on her George P. Pegram lectures at Columbia University, contains much of interest to the present discussion; of particular importance is her insistence on the need to build global institutions for planetary management.

[7]I should stress that Som (2019) does not discuss the concept of world government, and indeed the tenor of his article seems opposed to such institutional innovations. Rather, he argues that cosmic perspectives can help cement a common human identity, and that this will enhance the survival chances of human civilisation without the need to develop new institutions. My own view is closer to that of Ward (1966) in that I think a common human identity, in part induced by the cosmic perspective, will prove to be of practical value by providing the psychological foundations on which global institutions may be built.

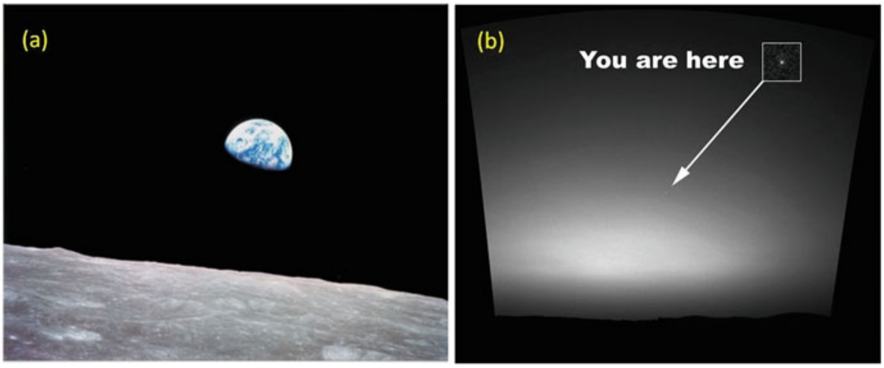

Fig. 18.2 The cosmic perspective: (**a**) Earthrise over the lunar surface, photographed by the crew of Apollo 8 in December 1968. (**b**) The Earth photographed from the surface of Mars by the Mars Exploration Rover Spirit in March 2004. Such images powerfully reinforce a 'cosmic perspective' that can have a unifying influence on human affairs. Images courtesy of NASA

space exploration is already an important component of astrobiology, because space probes are required to search for life on other planets, and discoveries made by space probes and space telescopes also inform big history. However, beyond these essentially practical synergies, I contend that important socio-political benefits will also result from an ambitious programme of space exploration, and that these will reinforce the societal benefits of big history and astrobiology discussed above.

Most importantly, space exploration provides a *spatial* perspective on human affairs which complements the temporal and evolutionary perspectives of big history. Any society that is rigorously exploring the Solar System, can hardly fail to be aware that Earth is a very small planet when viewed in its cosmic setting (Fig. 18.2). The social, cultural and psychological importance of this perspective has been noted by multiple authors (e.g., Clarke 1946, 1951a; Hoyle 1950; Ward 1966; Sagan 1994; Poole 2008; White 2014; Deudney 2018b; Som 2019). For example, even before any images of Earth from space had been obtained, the astronomer Fred Hoyle (1950, p. 9) wrote that:

> Once a photograph of the Earth, taken from the outside, is available, we shall, in an emotional sense, acquire an additional dimension ... once let the sheer isolation of the Earth becomes plain to every man, whatever his nationality or creed, and a new idea as powerful as any in history will be let loose.

There is certainly persuasive evidence that images of the Earth from space have raised environmental awareness, and thus contributed to popular movements for the reduction of pollution and the preservation of biodiversity (e.g., Zimmerman 1998; Poole 2008; Henry and Taylor 2009; Spier 2019). For example, Zimmerman (1998, p. 275) reproduces a diagram from Balzhiser (1990) which shows a dramatic growth in US environmental legislation in the late 1960s, and while not proving a causal link to images of the Earth from space the timing is suggestive. Spier (2019) has drawn attention to the differences in cultural impact of the original Apollo 8 'Earthrise' image (Fig. 18.1a above) in the United States and Europe, and argues that although the immediate impact, especially outside of the US, may not have been as great as is often assumed, its legacy has proved lasting and influential. It is true that the cosmic perspective of ‘Spaceship Earth’ (Ward 1966; Fuller 1969) has yet to trigger a sufficiently strong global response to solve our environmental problems, but raising awareness of their planetary scale is nevertheless an important contribution of space exploration and a prerequisite for political action.

Similar observations can be made regarding the geopolitical implications of the cosmic perspective. Even before the space age, the science fiction author and space visionary Arthur C. Clarke (1946, p. 72) had noted that:

> It is not easy to see how the more extreme forms of nationalism can long survive when men begin to see the Earth in its true perspective as a single small globe among the stars.

Hoyle (1950, p. 9) echoed this sentiment a few years later, when he noted that this new perspective “must increasingly have the effect of exposing the futility of nationalistic strife.” By the 1960s, when images of the Earth from space had been obtained, the implications were not lost on at least some professional diplomats. For example, Adlai Stevenson, then US Ambassador to the United Nations, expressed his view that “we can never again be a squabbling band of nations before the awful majesty of outer space” (Stevenson 1965).

More recently, Deudney (2018b, pp. 273–274) has argued that images of the Earth from space have led to widening recognition of a “practical geography of Planetary Earth” where “the Earth as a whole is now a place” and that this “type of Earth-place sensibility amounts to a kind of Earth nationalism”.[8] Deudney (p. 257) sees this shift in perspective as being helpful for what he terms “the ‘terrapolitan project,’ the project of building a polity suited to the . . . circumstances of the Earth as a place”, a place with multiple common interests and facing a wide range of existential threats.

This perspective is, understandably, much more visceral for people who have actually seen our planet from outside (White 2014), and it is worth quoting one such observation here:

> You look down there and you can’t imagine how many borders and boundaries you cross, again and again and again, and you don’t even see them. There you are—hundreds of people in the Mid-East killing each other over some imaginary line that you’re not even aware of. . . . And from where you see it the thing is a whole, and it’s so beautiful. You wish you could take one in each hand, one from each side in the various conflicts, and say, ‘Look. Look at it from this perspective. . . .’ (Schweickart 1977).

It has to be admitted, as Deudney (2020) has pointed out (see also Dark 2007; Bjørnvig 2013, and Schwartz 2020), that to-date the cosmic perspective provided by space exploration has had little practical effect on the worst manifestations of human tribalism. Still, as space exploration proceeds more people will be exposed to this

[8]Compare with Barbara Ward’s (1966) concept of “a patriotism for the world itself.” Deudney (2018b, p. 257) draws the political conclusion that managing the common interests of “Earth as a place” will “almost certainly require the erection of some version of substantial world government.”

perspective, both in person and vicariously, and the more it is likely to diffuse through society.[9] Such an enlargement of perspective may be expected to strengthen the sense of planetary identity inherent in big historical and astrobiological world-views (see also the discussion by Som 2019). Indeed, images of Earth from space, and especially personal experiences of this perspective, are likely to be even more effective in this regard because they prompt an instinctive, emotional, appreciation of 'one worldness' that the more intellectual perspectives provided by big history, astrobiology, and related academic disciplines cannot. We may hope that this perspective will gradually gnaw at the minds of political leaders (as it clearly did for Adlai Stevenson), and the minds of the wider public, until it leads to the emotional realisation that human activities affecting the planet as a whole need, and *ought*, to be organised collectively (e.g., Crawford 2017). Only space exploration can provide this perspective, which has led White (2014, p. 102) to argue that:

> It is time for the influence of space exploration on human consciousness to be seen as a legitimate justification for investing in it.

7 Cultural Benefits of Space Exploration

In addition to providing a valuable, and uniquely compelling, spatial perspective on human existence, an ambitious future programme of space exploration will also result in a range of additional social and cultural benefits. Leaving aside the strictly scientific benefits, to which the whole history of space exploration can attest, I think we can also identify potential cultural benefits of space exploration under the broad headings of 'art', 'philosophy', and, albeit in the more distant future, 'diversity'. As argued in earlier publications (e.g., Crawford 1993, 2014), which I summarise here, these wider aspects of space activities may even help prevent the future stagnation of human civilisation.

7.1 Art

William McLaughlin (1993) considered the potential impact of space exploration on the fine arts and concluded that the influence is likely to be considerable. At one level

[9]Schwartz (2020, p. 141) is concerned that what White (2014) terms the "overview effect" is based on anecdotal reports of astronauts and has not been tested in a controlled manner. Such experimental tests would be desirable and may be possible using virtual reality (see the chapters by Annahita Nezami et al. and Daniela de Paulis and Frank White elsewhere in this volume). Despite his scepticism on this point, Schwartz nevertheless notes "that does not mean we are wrong to suspect that the experience of the space environment will alter our beliefs and values in important ways." Bjørnvig's (2013) criticism is based largely on what he sees as an overly 'religious' element to some aspects of White's conception of the "overview effect"; he doesn't present any evidence against its validity as a psychological phenomenon.

it seems obvious that new space scenes, and novel space events and experiences, must inspire new works of space art. It is difficult to see how this could be otherwise. However, the potential long-term artistic impact of space exploration is likely to be more profound owing to the increasing dominance of the cosmic perspective on human thought. Not only will it be necessary to find ways of portraying and communicating human (and human-derived) values in the face of a universe whose strangeness will likely become ever more apparent as exploration proceeds, but the human (and post-human) mind is itself likely to become increasingly 'cosmicized' (Finney 1988) in a way that can hardly fail to be reflected in artistic and cultural evolution. Indeed, Clarke (1951b) anticipated this in a fictional work published before the dawn of the space age, suggesting, from the perspective of the far future, that:

> space travel was one of the best things that ever happened to art. Travel, exploration, contact with other cultures—that's the great stimulus for all intellectual activity.

Twenty years later, once space exploration was a reality, the American literary scholar Joseph Campbell (1972, p. 233) made a similar point:

> For although our voyage is to be outward, it is also to be inward, to the sources of all great acts, which are not out there, but in here, in us all, where the muses dwell.

And, further (p. 236):

> All the old bindings are broken. Cosmological centers now are any- and everywhere . . . all poetry now is archaic that fails to match the wonder of this view.

7.2 Philosophy

If anything, the stimulus that space exploration will provide for the philosophical disciplines may be even more profound. In Table 18.2, I summarise some philosophical issues that are likely to be stimulated as humanity (and post-humanity) moves out into the Solar System, and perhaps beyond. I have made a distinction between natural, moral and political philosophy, but we must also expect that the vast and mysterious universe in which we live very likely contains the seeds of entirely new fields of philosophical investigation waiting to be discovered.

7.3 Diversity

In the longer term, one of the most important socio-cultural contributions of space exploration may be the opportunities it will provide for increasing human (and post-human) cultural diversity. This will be especially true if colonisation of other

Table 18.2 Some philosophical issues that are likely to arise as space exploration proceeds

Natural philosophy	Moral and ethical philosophy[a]	Political philosophy
How secure is our basic physical understanding of the universe?	Extension of environmental ethics to other planets	Consideration of the ownership of extraterrestrial resources
Can we define 'life' in a cosmic context? Is this even important?	What are the moral and ethical relationships between humanity and extraterrestrial life (should any be encountered)?	Consideration of appropriate forms of planetary and interplanetary governance
If life can be defined, how common is it in the universe? What are the ultimate constraints on the origin of life and its distribution?	What are the ethical implications of spreading Earth-life through the Solar System and the Galaxy?	Consideration of political relationships with advanced extraterrestrial societies (if any); what limits would *biological* differences place on developing political institutions?

[a]For a more detailed discussion on specifically ethical philosophical issues related to astrobiology and space exploration, see, e.g., Green (2014), Randolph and McKay (2014), and Vidal (2014, Chap. 10)

locations in the Solar System, or even beyond, proves possible.[10] In the nineteenth century, John Stuart Mill drew attention to the benefits of what he termed different "experiments of living" (Mill 1859, p. 120), but such experiments are becoming increasingly difficult in today's globalizing world. The idea that the expansion of humanity beyond Earth might help in maintaining, and expanding, cultural diversity was actually proposed a decade before the dawn of the space age by the philosopher Olaf Stapledon (1948) when he expressed the view that:

> The goal for the solar system would seem to be that it should become an interplanetary community of very diverse worlds each inhabited by its appropriate race of intelligent beings, its characteristic "humanity" . . . Through the pooling of this wealth of experience, through this 'commonwealth of worlds' new levels of mental and spiritual development should become possible, levels at present quite inconceivable to man.[11]

[10]The term 'colonisation' is sometimes felt to be problematic due to its historical ties to European imperialism and exploitation (I am grateful to Lewis Dartnell for this observation). These concerns have much less force when applied to prospective human colonisation of lifeless extraterrestrial environments, but may still stimulate philosophical discussion (see Sect. 7.2). Of course, any attempt by humanity (or post-humanity) to colonise locations where indigenous life already exists would raise enormous ethical concerns, not least because it would violate the 'Cosmic Golden Rule' proposed by Randolph and McKay (2014).

[11]Much of Stapledon's thought is relevant to big historical and astrobiological perspectives, and I recommend especially his science fiction novel *Star Maker* (Stapledon 1937); for a more detailed discussion of Stapledon's ideas in the context of space exploration, see Crawford (2012).

7.4 Avoiding the 'End of History'

Thirty years ago, the American political philosopher Francis Fukuyama (1989, 1992) argued that increasing global political and cultural homogenization may lead to political and cultural stagnation. Following Hegel (1832), Fukuyama infamously termed this perceived endpoint in human cultural evolution the 'End of History'. Subsequent events suggest that this process is proceeding more slowly than Fukuyama perhaps envisaged, but some of the trends he identified seem likely to continue. Although, as I have argued above (Sect. 5), increasing *political* unification of humanity is positively desirable, Fukuyama's concerns regarding cultural stagnation in a politically unifying world do need to be taken seriously. He was especially concerned that:

> The end of history will be a very sad time. The struggle for recognition, the willingness to risk one's life for a purely abstract goal, the worldwide ideological struggle that called forth daring, courage, imagination, and idealism, will be replaced by economic calculation, the endless solving of technical problems, environmental concerns, and the satisfaction of sophisticated consumer demands. In the post-historical period, there will be neither art nor philosophy, just the perpetual caretaking of the museum of human history (Fukuyama 1989, p. 18).

It seems clear that, if we are to avoid this rather dismal view of humanity's future, we will need to find new sources of cultural and intellectual stimuli, and space exploration may be one of the few options left open to us. Indeed, the possibility that an ambitious programme of space exploration could help prevent just this kind of cultural and intellectual stagnation was recognized by Clarke (1946, p. 72) when he wrote:

> Interplanetary travel is the only form of 'conquest and empire' now compatible with civilisation. Without it, the human mind, compelled to circle forever in its planetary goldfish bowl, must eventually stagnate.

Human expansion into the Solar System, and eventually beyond, will certainly present a vast new field of human activity, with literally infinite potential for discovery and intellectual stimulation on multiple levels. As Dunér (2013, p. 13) has argued more recently:

> Encounters with the unknown outer space will ... change our thinking, conceptions, categories, belief systems, culture and meanings of things. What we have come to believe so far through science and human cognition will face anomalies. The old categories, systems, and beliefs will fall short when we try to understand these new unfamiliar things. Our thinking, science, and belief systems will then have to be revised.

From a perspective based on the philosophy of science, Gonzalo Munévar (1998, pp. 176–177; quoted by Schwartz 2020, p. 94) came to a similar conclusion:

> Scientific exploration places science in new circumstances and presents it with new ideas. Thus scientific exploration leads not merely to the addition of a few, or even many, interesting facts but to the transformation, perhaps the radical transformation, of our views of the world.

For these reasons, as White (2014, p. 84) succinctly puts it, "a society firmly committed to space exploration would find it difficult to stagnate." Whichever way one views it, there seems little doubt that a future in which space exploration plays a significant role will provide a far richer range of cultural and intellectual stimulation than we could ever hope to experience if we never leave our home planet. Sagan (1994, p. 285) perhaps expressed it as well as anyone:

> We're the kind of species that needs a frontier—for fundamental biological reasons. Every time humanity stretches itself and turns a new corner, it receives a jolt of productive vitality that can carry it for centuries.

In the long run, the exploration of space may help us avoid Fukuyama's 'End of History' by keeping history *open* while simultaneously helping to unite human cultures on Earth. That said, the exploration and colonisation of space will also create additional risks: we don't want to unite the Earth only to live in a politically anarchic Solar System where colossal energies would be available to anyone (or anything) minded to use them destructively (e.g., Baxter and Crawford 2015; Deudney 2016, 2020). For this reason, care will have to be given to developing appropriate interplanetary institutions able to mitigate these risks (Crawford 2015). Fortunately, as argued in Sects. 5 and 6, the cosmic and evolutionary perspectives provided by astrobiology, big history, and space exploration itself, may help lay the psychological foundations on which such institutions could be built.

8 Conclusions

The twin, and closely related, academic disciplines of big history and astrobiology have the potential to yield a wide range of social and intellectual benefits. Indeed, intellectual enrichment is already resulting from the interdisciplinary research agendas of both astrobiology and big history, which involve scholars from a wide range of sciences and the humanities working closely together. More importantly, both disciplines rely on, and naturally engender, cosmic and evolutionary perspectives which, I argue, ought to form part of the worldview of every educated person (see also Elise Bohan's chapter in this volume).

By powerfully reinforcing the fact that all human beings, and all human societies, exist on the same small planet, and are related by a common evolutionary history, I have argued that cosmic and evolutionary perspectives strengthen intellectual and emotional arguments for the eventual political unification of humanity. My own view is that a federal world government would be an appropriate institutional framework for a united humanity, and that a world government of some kind may be necessary if serious global problems are to be properly managed. However, such a political outcome is only likely to become realistic if humanity develops a greater sense of its common identity, what Barbara Ward (1966, p. 148) called "a patriotism for the world itself." The perspectives provided by big history, astrobiology and space exploration can all help achieve this objective. That said, I also agree with

Fukuyama (1989) that a politically homogenised world may lack sufficient sources of intellectual stimulation to maintain a vibrant culture, and I have argued that an ambitious programme of space exploration would help in this respect. Needless-to-say, the exploration of space will also yield new knowledge about the universe, informing both the science of astrobiology and the ever-evolving big historical worldview.

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