

Expanding worldviews: cosmic perspectives

Ian Crawford summarizes the second of two meetings exploring the relationships between astrobiology, big history and cosmic perspectives.

In 2018, I reported on an interdisciplinary meeting at the Australian National University that explored scientific and social themes related to astrobiology, big history and cosmic perspectives (Crawford 2018, 2019a). Based on the success of that meeting – in which few colleagues from Europe and the UK were able to participate – a two-day meeting was organized at Birkbeck College, University of London in September 2019, on “Expanding worldviews: astrobiology, big history and cosmic perspectives”.

Olivia Judson (Imperial College/Freie Universität Berlin) got the first day underway with her talk on “Energy, evolution and the transformation of the Earth”. She began by noting that throughout its long history life has been a force for transformation of the Earth, changing the composition of the atmosphere, increasing the diversity of rocks and minerals, and modifying landscapes. Without life, Earth today would be a very different, and completely alien, planet. She argued that life has achieved this dominance of the Earth by expanding its access to energy sources through five epochs, successively: geochemical energy, sunlight, oxygen, flesh and fire. Each epoch corresponds to the evolution of life forms able to access new sources of energy (Judson 2017). With each new epoch the diversity of life has increased, ecosystems have become richer and life has increased its impact on the planet. Indeed, the use of fire, and the technology that it has facilitated, may enable Earth life to spread beyond its home planet. There are also implications for the kinds of biospheres that might be detected elsewhere in the universe: biospheres that have only passed through a few of the five energy epochs are likely to be less diverse than those that have passed through more. Ultimately, a flourishing, complex biosphere will depend on feedback loops between evolving life and its planetary environment.

The second talk was given by **Fred Spier** (University of Amsterdam) with the

intriguing title “Cultivating pepper plants: fresh views on the history of the biosphere, life and humanity”. Building on arguments presented in his book (Spier 2010), the speaker agreed with Judson on the importance of energy sources for driving biological evolution, and even proposed a “fourth law of thermodynamics”: “Life as a whole tends to maximize the capturing of free energy flows.” He illustrated this with an example of home-grown pepper plants which, in common with many other plants, rapidly increase the number of their leaves to maximize their total light collecting area. Considering the biosphere as a whole, Spier suggested that it may be misleading to focus on the emergence and development of individual species, but that we should rather consider the emergence and development of different strategies for capturing free energy as part of an overall “trophic pyramid”. The history of life could then be seen as the history of the trophic pyramid as a whole, including its emergent effects, in interaction with geological and cosmic circumstances. One such emergent property has been the evolution of culture and technology, which has further increased the access of one species, *Homo sapiens*, to sources of energy. He argued that much of human history can be explained by this quest for greater access to energy sources, issues to be explored further in his next book (Spier 2020).

In the final talk of the morning, **Andreas Bummel** (Democracy Without Borders) considered “The political implications of a planetary worldview”, arguing that a planetary view, such as provided by images of Earth from space, puts notions of national sovereignty into perspective (figure 1). He illustrated the process of sociopolitical integration in human history, which exhibits an evolutionary trend towards fewer, but more complex, political units (e.g. from perhaps 600 000 autonomous political entities in 1500 BCE to the roughly 200 nation-states recognized today). Bummel argued that growing global interdependence implies that there are *no* strictly independent political units on the Earth today. Rather, the world is rapidly becoming a single planetary system, but political institutions have yet to catch up with this reality. Following arguments presented by Leinen and

Bummel (2018), he argued that the evolution of institutions of global governance, for example the creation of a UN Parliamentary Assembly as a step towards a global parliament, is essential if humanity is to manage global existential threats. He concluded with some statistics from opinion surveys (GlobeScan 2016, GCF 2017) which indicate that most people do consider themselves to be global citizens in addition to being citizens of their home country, although the extent to which global citizenship is perceived as more, or less, important than national citizenship is highly variable across the world. Perhaps a growing sense of a “cosmic perspective” could help tilt the balance towards more cosmopolitan views?

Alien big histories

After lunch, **Mike Garrett** (University of Manchester) asked “Can SETI expand the horizons of astrobiology and big history?” He began by noting that “big history” attempts to describe the history of humankind in the broadest sense, presenting a big picture perspective of successive thresholds in complexity, culminating in the emergence of a technical civilization. He argued that, while there is value in this approach to teaching history, it risks oversimplifying scientific concepts and underestimates the limitations of current knowledge. Moreover, it presents a very anthropocentric perspective on the history of the universe. If intelligent creatures have evolved elsewhere they will have their own big histories, some parts of which will overlap with our own, but others will be unique to their particular circumstances and evolutionary history. Thus, thinking about SETI expands our view of the universe and all of its possibilities and, should SETI ever make contact with other civilizations, our understanding of big history will be greatly enlarged. In this sense, SETI has the potential to put the “big” back into “big history”! In addition, SETI contributes to the development of “big historical” worldviews by making us think about our own future in order to better understand the possible futures of other civilizations in the universe. Garrett concluded that the perspectives provided by both big history and SETI carry with them the ethical implication that we need to take better care of our



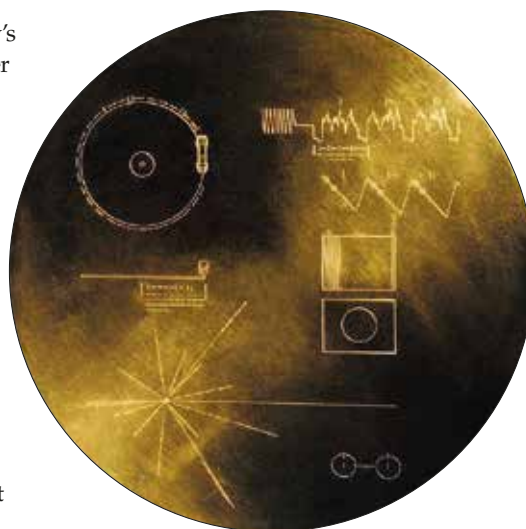
1 The Earth photographed by astronaut Nick Hague on the ISS on 1 October 2019. Images such as this provide a cosmic perspective on our world, and powerfully illustrate the artificiality of national borders. (NASA/N Hague)

home planet and our fellow humans.

Science-fiction author **Stephen Baxter** then discussed “The visibility of big history”, asking when human history first became visible to external observers. For example, if equipped with sufficiently powerful observational tools, alien observers might have noticed changes in atmospheric composition some 10000 years ago from the spread of agriculture, followed by acceleration in CO₂ concentrations since the industrial revolution. Our civilization is potentially much more visible now, with our increasing production of radio waves and other sources of electromagnetic radiation. Although harder to detect and discriminate from natural processes, the older signatures of humanity’s existence will have penetrated much further into our galaxy. Conceivably, technological civilizations within about 10000 light-years may be able to infer the presence of intelligence, if not technology, on our planet. In the future, we might expect our detectability to increase, especially if we become a space-faring civilization and begin to advance up the Kardashev scale of civilizations (Kardashev 1964). On the other hand, should our civilization collapse or, alternatively, transition to a form that is indefinitely sustainable, then it will become less detectable at interstellar distances. Either of these possibilities might explain the non-detection of other technological civilizations in our galaxy, but if this is a choice that all civilizations have to face then clearly sustainability is preferable to collapse. With this in mind, Baxter reiterated HG Wells’s view that “human history

becomes more and more a race between education and catastrophe” (Wells 1920).

Baxter was followed by **Paul Quast** (Beyond the Earth Foundation), who continued the theme of humanity’s detectability in the universe with his talk on “A profile of humanity: the cultural signature of Earth’s inhabitants beyond the atmosphere”, describing his catalogue (Quast 2018) collating the eclectic range of artefacts and messages that humanity has already dispatched into space. These include deliberate radio transmissions to the stars (e.g. the Arecibo message of 1974), inscribed messages on spacecraft (e.g. the Voyager Record, figure 2),



2 The Voyager record, currently *en route* to the stars attached on the Voyager 1 and 2 spacecraft, is an example of the dispersal of human cultural artefacts into the universe; for details of its contents, see Drake *et al.* (1978). (NASA)

and time capsules of various kinds. But so far there have been few comparative studies of how these various objects and events collectively convey an impression of our species and the planet that it inhabits. A better understanding of this could contribute to the development of practical and ethical guidelines for future efforts to depict our contemporary civilization, both for our own posterity and, potentially, for visitors from elsewhere in the galaxy in the distant future.

After a coffee break, **Robert Poole** (University of Central Lancashire) spoke on “Where were they? ETI in historical perspective.” He noted that the late 1950s and early 1960s saw a rapid establishment of the scientific belief in the existence of extraterrestrial intelligence (ETI), becoming something like orthodoxy within a decade of the beginning of radio astronomy. Poole even suggested that never have so many non-religious scientists been so certain about something in the absence of evidence. He felt that the pioneers of the search for ETI (SETI) who formed the Order of the Dolphin (Drake & Sobel 1997) would have been very surprised that, after nearly 60 years, searches for ETI on a scale unimaginable in 1960 had not discovered any evidence for its existence. Poole argued that the future of life in our galaxy most probably lies on Earth and nowhere else. He further argued that, from a historian’s perspective, the beliefs of the pioneer SETI searchers were largely determined by the conditions of the cold war: far from decentring humanity, the first phase of SETI was deeply anthropocentric, and might even be seen as a kind of cold

war cargo cult. He concluded by suggesting that claims that big history embodies cosmic perspectives should be advanced with caution, because what appear to us to be cosmic perspectives may turn out to be merely Earthly perspectives.

Poole was followed by **Mukesh Bhatt** (Birkbeck College) with his talk on “The uncentred universe: transcultural perspectives from India and China”. Bhatt began with a “small history” of astrobiology as a concept, noting its appearance in European publications in the late 19th and early 20th centuries. He then turned to consider astrobiology and big history from non-western perspectives. Of the major nations with space capabilities, India and China represent almost a third of the world’s population and have cultures that differ from the Eurocentric and Christian-centric West. Indeed, many of the cosmic perspectives implicit in astrobiology, such as cosmic and biological evolution, appear much more natural within Eastern (Hindu–Buddhist) worldviews than in Western ones (figure 3).

The final talk on the first day of the meeting was given by **Ian Crawford** (Birkbeck College) who spoke on “Expanding worldviews: astrobiology, big history, and the social and cultural benefits of the cosmic perspective”. He began by making the link between big history and astrobiology, illustrated by a personal anecdote: a large part of the astrobiology module that he currently teaches at Birkbeck began life as a big history course that he developed for the City University in 1994. Crawford argued that big history and astrobiology both act to widen human perspectives in beneficial directions (see Crawford 2019b). These include stimulating interdisciplinary education and research, helping to break down barriers between CP Snow’s (1959) two cultures of the sciences and humanities, and enhancing public awareness of cosmic and evolutionary perspectives. He argued that these perspectives constitute a strong, albeit implicit, argument for the eventual political unification of humanity, and he agreed with Bummel (and Wells 1920) that a world federation would be an appropriate means of achieving this. Like Baxter earlier, Crawford also concluded his talk with HG Wells’s (1920) observation on the competition between education and catastrophe in human history, contending that astrobiology and big history could become powerful contributors on the side of education.

Day two began with three talks with philosophical themes: **David Dunér** (Lund University) began by focusing on “Extraterrestrial life and the human mind”. Dunér began by describing the emerging field of astrocognition, which aims to study the

origin, evolution and distribution of intelligence in the universe (Dunér 2013, 2019). Intelligence could be explained as cognitive flexibility, an ability to adjust to changes in the physical and sociocultural environment. As currently conceived, astrocognition has two main research programmes. The first concerns terrestrial intelligence and the cognitive phenomena involved in the human search for ETI. This is important because we want to understand how humans, who have evolved within a particular environment, will be able to understand beings whose entire evolutionary history will be different. Second, astrocognition deals with ideas regarding the evolution of ETI itself. Dunér argued that an indispensable requisite for the evolution of intelligence, sociability,

.....
“Human history becomes a race between education and catastrophe”
 communication and advanced technology is intersubjectivity. Thus, an intelligent being that has developed advanced technology would be likely to have a complex social

system, complex communication and a high degree of distributed cognition. He went on to consider the possibilities for terrestrial–extraterrestrial interaction, and whether two distinctly evolved creatures could be able to understand each other. Here he argued that insights provided by cognitive semiotics will be crucial, because we will have to understand the *meaning* attached to whatever signs or symbols are exchanged.

Anthropocentric ethics

Clément Vidal (Vrije Universiteit Brussel) continued the theme with a talk on “Universal ethics: thermodynamic, computational and cybernetic perspectives to expand our notions of good and bad”. Vidal argued that ethics has been anthropocentric; it is in need of a Copernican revolution towards a more universal ethics. By universal, he had in mind an ethical framework applicable to any moral agent, such as artificially intelligent agents, robots, organizations of all sizes and extraterrestrial life forms. In addition, he argued that it seems desirable to be able to assign value to any physical object in the universe (Vidal & Heylighen 2019). Vidal presented three candidate universal ethical frameworks. First, thermoethics focuses on how to best extract, use, store and distribute energy to maximize the growth in complexity in the universe while minimizing entropy production (Vidal 2014). Second, the ethics of organized complexity (Vidal & Delahaye 2019) proposes that we should preserve, augment and promote organized complexity; in essence, the harder it is to rebuild an object from scratch, the more value it has. Third, a systems ethics is needed to facilitate decision-making in the real world, and Vidal proposed a range of principles derived from cybernetics, system theory and complexity



3 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. (Ryan Bodenstien 2017/ Creative Commons)

science. These three ethical frameworks are not mutually exclusive, and the speaker argued that they will prove helpful guides for action in our increasingly complex, changing and accelerating world.

Tony Milligan (King’s College London) gave the next talk on “Astrobiology and the outer limits of human ethics”. He noted that our ethical theories, insights and values are the legacy of a distinctively terrestrial and human history. Part of this history has involved the valuing of non-human objects (e.g. artefacts, animals, places, things) as important in their own right. And, although this list has always covered more than rational agents or sentient beings, it has rarely included microbes. To include the latter would be at odds with routine terrestrial practices. After all, here on Earth, we routinely kill microbial life in vast numbers, and in practice cannot avoid doing so, irrespective of the ethical theories that we happen to hold. However, it is far from obvious that this local terrestrial history, and the ethical stories that it has produced, have left us well-equipped for the discovery of microbial life elsewhere. For example, if we were to discover microbial life elsewhere we would presumably go to considerable lengths to protect it. Even if, in biological terms, such life was almost indistinguishable from microbial life on Earth, our attitude towards it would be very different. Milligan argued that such considerations may help us understand how human ethical obligations are likely to be transformed by the expansion of space exploration (Milligan 2014).

These philosophical talks were followed by two presentations on the social and psychological impact of space exploration. The first was by chartered psychologist **Annahita Nezami**, who spoke on “The psychology of the ‘overview effect’: what lies beneath?” The overview effect (White 2014) describes the psychological effect of viewing natural landscapes from an expansive vantage point; seeing Earth from space is the epitome of this type of experience (figure 1). To-date, fewer than 600 people have had this experience, and with it the opportunity to encounter a radically different perspective of life, Nature, the planet and the cosmos. Astronauts’ diaries, interviews and autobiographies reveal that a significant number of space travellers report that they felt a deep sense of interconnection with all life, came to see themselves and their world differently and returned to Earth with a renewed sense of purpose (White 2014, Gallagher *et al.* 2015, Nezami 2016, Yaden *et al.* 2016).

Nezami argued that notions of growth, self-actualization and meaning are often missing from mainstream culture, education and mental health.

She showed how this gap

can be addressed by using virtual reality to simulate the Earth-gazing experience to induce the overview effect, and how this therapeutic approach has the potential to promote healthy escapism and well-being.

The final talk before lunch was given by the space writer **Nick Spall** on “Big history and the significance of the Apollo Moon landings”. Spall began by putting Apollo in the big historical perspective of human evolution over approximately 2.5 million years. Echoing points made earlier by Dunér, Spall argued that the sophisticated language development, social cooperation and the cognitive imagination of *Homo sapiens* allowed for an acceleration of technological development, enabling the first Moon landing by 1969. Although born out of planet-wide social and economic conflict during the cold war, he argued that the Apollo programme brought a heightened level of environmental awareness and a sense of global cultural identity. In terms of short-term geopolitical history, Apollo may also have accelerated the eventual collapse of the Soviet Union. Agreeing with Nezami (and White 2014), Spall drew attention to the importance of the distant Earth overview effect triggered by Apollo. Approximately 650 million people watched the Apollo 11 Moon landing and, despite the short-term national competition that led to its birth, it showed in an inspiring and heroic way that humanity can achieve extraordinary goals. Spall contended that the Apollo programme, including its many technological, scientific and inspirational

legacies, has left humanity in a more positive state than would have been the case otherwise. Thanks to Apollo, he concluded that humankind is now better equipped to expand across the solar system and, eventually, our galaxy, entering a new stage of evolution as a space-faring species.

After lunch, **Lewis Dartnell** (University of Westminster) spoke on “Origins: how the Earth shaped human history”. Summarizing his recent book (Dartnell 2019), he argued that the evolution of the Earth as a planet has profoundly influenced human history. He showed how an unusual combination of tectonic shifts and cosmic cycles in East Africa over the last 5 million years drove our evolution to become an intelligent and adaptable species. Plate tectonics also created suitable locales for the emergence of the earliest civilizations. Moreover, the circulation currents of the atmosphere determined the trade routes of the Age of Exploration, and thus the pattern

.....
“We have been swept up by concern for the future for quite some time now”

of empire building and the first stage of globalization that built the modern world. Indeed, Dartnell showed how the underlying signature of planetary processes can still

be seen in politics and current affairs today. This is not to deny that political, social, economic and cultural effects have been critical throughout history, but he stressed that beneath these top-level explanations for historical developments lie the deeper strata of planetary forces. Such a “big historical” approach, combining planetary sciences and geology with evolutionary biology and anthropology, enables us to understand how different features of planet Earth have deeply influenced world history.

Existential risk

Thomas Moynihan (University of Oxford) then spoke on “The summons of a silent universe: existential risk and the cosmic vocation of *Homo sapiens*”. He began by noting that so-called “existential risks” have increasingly become the topic of serious research. The longest-term fate of intelligence within the cosmos is, more and more, the target of serious attention. Moynihan showed that this tendency itself has a history: we have been swept up by concern for the future for quite some time now (e.g. Moynihan 2019a). He introduced, and updated, the Enlightenment notion of a human vocation in light of contemporary astrobiology to draw attention to the complex and still-unfolding connection between the “starry heavens above” and “the moral law within” (Kant 1788). Moynihan argued that it was realizing the silence of outer space that made us first truly appreciate our precarious position on our own planet, and thereby summoned us to the daring and

Promethean project of asserting ourselves, and our values, in the face of an otherwise inhospitable cosmos. Only by discovering that intelligence is astronomically precarious have we started to acknowledge that it is also astronomically precious and started to consider the accountability that this entails (Moynihan 2019b). Moynihan argued that what we now call astrobiological concerns have in fact always been drivers of modernity. And, insofar as the project of answering our cosmic vocation represents an unfinished and ongoing trajectory, reflecting its beginnings may help us understand where we might be heading.

The next talk moved discussion towards the contribution of the arts to a developing astrobiological worldview and was given by **John Timberlake** (Middlesex University) on “Breath and darkness: realism and representation in astronomical illustration and cinematographic special effects”. Asking what is effected by special effects, he argued that, despite their inevitable lacunae and elisions, visual forms within science fiction (SF) constitute a mode of representation that allows us to understand humanity’s engagement with the cosmos. Drawing on both filmic tropes of space flight and interplanetary travel since Klushantsev’s *Road to the Stars* (1957) as well as Apollo documentation, Timberlake examined the concept of work both as historic act (Marx 1845), and as something necessitated by conditions of solitude or isolation (Levinas 1947, 1961). Looking at representations found in films from Kubrick’s *2001* (1968) to Christopher Nolan’s *Interstellar* (2014) and Sebastián Cordero’s *Europa Report* (2014), he proposed representations of astronomical work as a foundational element of a possible “écriture cosmique” through which humanity’s relation with the cosmos can be articulated.

After a coffee break, **Caroline Edwards** (Birkbeck College) continued the artistic theme with her talk “From clean energy to climate change: early martian literary utopias, 1877–1964”. She considered how the early utopian fiction about Mars was influenced by climatological crises. The earliest martian utopias appear in the late 19th century, when problems of industrial pollution on Earth were becoming apparent. Edwards showed how literary depictions of Mars could be used to suggest solutions. For example, in the perfect martian society depicted in Alice Jones and Ella Merchant’s *Unveiling a Parallel: a Romance* (1893), readers were treated to a utopian world of clean electric power, full automation and a life of aesthetic pursuits enjoyed in impeccable health. In contrast, she argued that it is climate change that most characterizes martian SF in the 20th century. Emerging theories of comparative planetology suggested that, as a smaller planet, Mars would have cooled

more quickly than Earth and lost most of its atmosphere, leading to speculation that sentient life would have adapted to living on a dying planet of declining resources (e.g. Lowell 1908). Edwards argued that it is worth returning to early martian utopias, many of which have been overlooked in SF scholarship, because of the perspective they give on ecological change on a planetary scale.

Rachel Hill (Goldsmith's College) then spoke on "Unfathomable. Bottomless. Very deep: astrobiology, water-worlds and Earth's oceans", noting that our solar system is predicated to harbour multiple water-worlds, with subsurface oceans thought to exist on, at least, Enceladus, Europa, Ganymede and Callisto. Exoplanet discoveries also suggest that water-worlds are common. This is an important focus for astrobiology, with terrestrial oceans becoming a blueprint for how extraterrestrial ecospheres and alien life are conceptualized. Conversely, Earth's oceans, with sea level rise, pollution and deep-sea desertification, are becoming increasingly alien. Hill argued that SF can be used to model ethical encounters with both alien and terrestrial life in such environments. As our planetary imaginaries are increasingly freighted with concepts of watery space, she argued that more unbounded, oceanic worldviews are necessary. The term "tidalectics" has been coined for such a worldview (e.g. Hessler 2018) and Hill adopted this approach to put astrobiological hypotheses, terrestrial oceans and SF into conversation. She showed not only how oceanic resonances are increasingly established across space, but also that such resonances can only be properly apprehended through the integration of a more cosmic perspective within our thought processes.

The final talk was given by space artist Daniela De Paulis on her project "COGITO in Space". This is an interdisciplinary project, based on six years research at the Dwingeloo



4 The Dwingeloo radio telescope is part of a project beaming brainwaves into space. (Sandro Bocci/COGITO in Space)

radio telescope in the Netherlands (figure 4); human brain activity, recorded by an electroencephalogram, is transmitted into the cosmos while the subject watches an immersive video showing the Earth from space. The project thus focuses mainly on two concepts: the unresolved question of mind/body dualism and the overview effect (White 2014). An important intellectual influence was the novel *Solaris* by Stanislaw Lem and the eponymous film by Andrei Tarkovsky. The reasoning around the project began as a reflection upon the use of the electromagnetic spectrum by radio astronomers for gathering data of cosmic phenomena and upon the type of knowledge we can gain from remote events that cannot be known through direct sensory experience. Working alongside radio astronomers, De Paulis had the opportunity to better understand the relevance of radio transmissions in contemporary thought and their cultural

impact. She argued that radio waves have become a means for virtual human space travel and the carriers of a new-found cosmic awareness, transcending their scientific and technological function. One of the questions motivating her research is: "How

.....
**"The anticipated
 ubiquity of planetary
 oceans is an important
 focus for astrobiology"**

does knowledge acquired through remote observation of the universe influence our cognition and how does the mind interact with the matter of the distant universe, and

vice versa?" Further details can be found at cogitoinspace.org.

Overall, this meeting, like its predecessor in Australia last year (Crawford 2018), successfully demonstrated the interconnections between the wide range of topics discussed and proved helpful in forging links between scholars working in disparate disciplines. More such meetings would be desirable so that bridges can continue to be built between Snow's "two cultures" in big historical and astrobiological contexts. ●

AUTHOR

Ian Crawford is professor of planetary science and astrobiology at Birkbeck College, University of London.

ACKNOWLEDGMENTS

I thank all the speakers for contributing to this interesting meeting. The summaries given here are based on the authors' submitted abstracts and my own notes. I accept responsibility for any errors in interpretation. I thank the Birkbeck Centre for the Humanities, the Birkbeck Centre for Legal Futures, and the UCL/Birkbeck Centre for Planetary Sciences for financial support of the meeting, and Lou Miller for all her help with the organization.

MEETING DETAILS

"Expanding Worldviews: Astrobiology, Big History and Cosmic Perspectives" was held at Birkbeck College on 19–20 September 2019, bbk.ac.uk/events/remote_event_view?id=5699.

REFERENCES

Crawford IA 2018 *Astron. & Geophys.* **59** 5.33
 Crawford IA (ed.) 2019a *Journal of Big History* special issue: *Big History and Astrobiology III*(3)

Crawford IA 2019b *Journal of Big History III*(3) 205

Dartnell L 2019 *ORIGINS: How The Earth Made Us* (Bodley Head)

Drake FD & Sobel D 1997 *Is Anyone Out There? The Search for Extraterrestrial Intelligence* (Pocket Books)
 Drake FD et al. 1978 *Murmurs of Earth: the Voyager Interstellar Record* (Random House)

Dunér D et al. (ed) 2013 *The History and Philosophy of Astrobiology: Perspectives on Extraterrestrial Life and the Human Mind* (Cambridge Scholars)

Dunér D 2019 in *Handbook of Astrobiology* Kolb VM (ed.) (CRC Press)

Gallagher S et al. 2015 *A Neurophenomenology of Awe and Wonder: Towards a Non-Reductionist Cognitive Science* (Palgrave Macmillan)

Global Challenges Foundation (GCF) 2017 *Attitudes to Global Risks and Governance* api.global-challenges.org/static/files/ComRes.pdf

GlobeScan 2016 *Global Citizenship: a Growing Sentiment Among Citizens of Emerging Economies* globescan.com/global-citizenship-a-growing-sentiment-among-citizens-of-emerging-economies-global-poll

Hessler S 2018 *Tidalectics: Imagining an Oceanic Worldview through Art and Science* (MIT Press)

Judson OP 2017 *Nature Ecology & Evolution* **1** 0138

Kant I 1788 *Critique of Practical Reason* Gregor M (trans.) (CUP 2015) 171

Kardashev NS 1964 *Soviet Astronomy* **8** 217

Leinen J & Bummel A 2018 *A World Parliament: Governance and Democracy in the 21st Century* (Democracy Without Borders, Berlin)

Levinas E 1947 in Hand S (ed.) *The Levinas Reader* (Blackwell 1989) 38

Levinas E 1961 in Hand S (ed.) *Difficult Freedom: Essays in Judaism* (John Hopkins 1997) 231

Lowell P 1908 *Mars as an Abode of Life* (Macmillan)

Marx K 1845 *Theses on Feuerbach* in *The German Ideology* (Prometheus 1988) 29

Milligan T 2014 *Nobody Owns the Moon: the Ethics of Space Exploitation* (McFarland)

Moynihan T 2019a The end of the world: a history of how a silent cosmos led humans to fear the worst *The Conversation* theconversation.com/the-end-of-the-world-a-history-of-how-a-silent-cosmos-led-humans-to-fear-the-worst-120193

Moynihan T 2019b The end of us *Aeon* aeon.co/essays/to-imagine-our-own-extinction-is-to-be-able-to-answer-for-it

Nezami A 2016 *The Overview Effect and Counselling Psychology: Astronaut Experiences of Earth Gazing* PhD dissertation (City University)

Quast PE 2018 *Internat. J. Astrobiology* (in press) doi.org/10.1017/S1473550418000290

Snow CP 1959 *The Two Cultures* (Cambridge University Press)

Spier F 2010 *Big History and the Future of Humanity* (Wiley-Blackwell)

Spier F 2020 *Cultivating Pepper Plants: a Unified View of the History of the Biosphere, Life and Humanity* (forthcoming)

Vidal C 2014 *The Beginning and the End: the Meaning of Life in a Cosmological Perspective* (Springer) 272

Vidal C & Delahaye J-P 2019 in *Evolution, Development and Complexity* G G Yordanov et al. (eds) (Springer) 135

Vidal C & Heylighen F 2019 in *Investigating Transhumanisms and their Narratives* Jorion P (ed.) doi.org/10.5281/zenodo.3514912

Wells HG 1920 *The Outline of History* (George Newnes) 608

White F 2014 *The Overview Effect: Space Exploration and Human Evolution* (American Institute of Aeronautics and Astronautics)

Yaden DB et al. 2016 *Psychology of Consciousness: Theory, Research and Practice* **3**(1) 1