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Societal aspects of astrobiology and the impact of discovering life beyond Earth

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Abstract. This paper introduces a new branch of astrobiology, sometimes called "astrobiology and society" or the "astrobiological humanities." It summarizes ideas generated during the author's tenure as the second Baruch S. Blumberg NASA/Library of Congress Chair in Astrobiology, established in honor of the Nobelist who also served as the first Director of the NASA Astrobiology Institute. NASA and the Library of Congress inaugurated the Blumberg Chair in 2012 specifically to study the humanistic aspects of astrobiology, and the sixth Chair is now in place at the Library, located a few blocks from NASA Headquarters. Results reported here on the societal impact of astrobiology, in particular the societal impact of discovering life beyond Earth, are elaborated in two books (Dick 2015, 2018). The author argues that the humanities, philosophy, and social sciences should be an integral part of astrobiology.

Key words. astrobiology – social sciences – discovery – analogy

1. Introduction

The study of astrobiology and society is a subject whose time has come. As we discover habitable exoplanets through biosignatures and other methods, it is incumbent on practitioners in the sciences, social sciences, humanities, and philosophy to study the impact of such a discovery on society. The "astrobiological humanities" have sporadically been part of NASA Astrobiology Roadmaps and Strategic plans for the last twenty years. As the most recent Astrobiology Strategic Plan states "Astrobiology recognizes a broad societal interest in its endeavors [...] Especially in areas such as assessing the societal implications of discovering other examples of life [...] there is growing interest in developing these interdisciplinary studies within the astrobiological humanities" (Hays 2015).

Interest in these subjects extends beyond the United States; in the last several years societal aspects have become a foundational theme for the proposed European Astrobiology Institute (Capova et al. 2018). There is also a scattered research community on this subject; one good entrée is a special issue of the journal Astrobiology (Dunér 2012; Race et al. 2012), based on a conference held in Sweden. Kelly Smith at Clemson University has recently founded a new Society for Social and Conceptual Issues in Astrobiology (SSoCIA), and in the last two years a series of interdisciplinary meetings have been held at the SETI Institute in Mountain View, California and the Breakthrough Listen project at Berkeley.

Taken together, all these activities represent significant recognition from the scientific community that the humanities and social sciences are relevant to astrobiology and SETI.

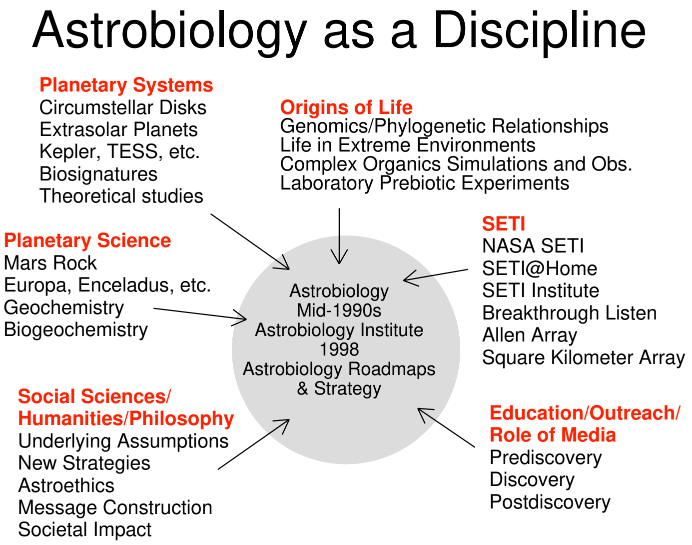

Fig. 1. Astrobiology as a Discipline. In addition to its scientific aspects, the social sciences, humanities, and philosophy must be added as an integral part of the discipline, as well as education and outreach to the public and media.

Figure 1 shows the components of astrobiology, which for many years have been seen to include planetary science, planetary systems science, origins of life research, and sometimes SETI, but which now must also be extended to include the social sciences, humanities, and societal aspects. These latter components need to become not just a peripheral effort, but an integral part of astrobiology. In addition the educational and outreach aspects also have growing importance to the field, both in educating the media and the public.

Even though astrobiology has become a robust discipline, skeptics might ask why we need to prepare for these discoveries; perhaps we should wait until they actually happen. Countering this skepticism is a study from the World Economic Forum, which has named the discovery of extraterrestrial life as one of five "X Factors" affecting our future. "Looking forward and identifying emerging issues will help us to anticipate future challenges and adopt a more proactive approach, rather than being caught by surprise and forced into a fully reactive mode", the authors of the study wrote (WEF 2013). There is a general recognition that the scientific community needs to consider the societal implications of its work. NASA has inaugurated a series of studies on the societal impact of spaceflight, in accordance with its initial charter (Dick & Launius 2007; Dick & Lupisella 2009). The same is true of the Human Genome Project, nanotechnology, and others projects.

This paper cannot present a comprehensive review of the rich overall field of the astrobiological humanities (Dick 2015, 2018; Vakoch 2013), but will focus instead on three crucial aspects of one problem, the impact discovering life beyond Earth: approaches to the problem, the need to transcend anthropocentrism, and an estimation of the possible impacts to society.

2. Approaches

How can we approach a seemingly intractable problem like the societal impact of discovering life beyond Earth? First, we can use *history* to illuminate the impact. The Martian meteorite ALH84001 episode is an important case study of the public, scientific, and media reaction when even nanofossil life was thought to have been found in a rock from Mars. Anyone who thinks the discovery of microbes will not have at least a short-term impact should study this episode. The rushed press conference at NASA Headquarters on August 7, 1996 was a spectacle to behold, with a 1.3-ounce piece of the Mars rock displayed in a place of honor at the front of the room along with the participating scientists, and the rest of the room crammed with reporters, scientists, and onlookers hoping to see history in the making (Figure 2). The furious reaction to the announcement can be analyzed over both the long and short terms. In the short term, President Bill Clinton called on NASA to "put its full intellectual power and technological prowess behind the search for further evidence of life on Mars" (Dick & Strick 2004). On a scale of hours, days, and weeks the press speculated about the implications of life on Mars, broaching theological and philosophical questions. Within five weeks Congressional hearings were held. Within a few months the National Academy of Sciences held a workshop on the implications, and by December Vice President Gore convened a Space Science Symposium that included not only scientists, but historians, journalists, and theologians. On a scale of years and decades, the fallout to the research community in terms of budgets and new directions was considerable, including the founding of the NASA Astrobiology Institute in 1998. All this is true even though the consensus now is that the putative nanofossils were not real. But it is instructive how long it took to reach this conclusion, even with the Mars rock in hand and subject to all of the analytical techniques science could offer (Dick 2018).

Fig. 2. Press conference August 7, 1996 at NASA Headquarters announcing the possibility of fossilized life in the Mars rock ALH84001. The photo, taken by NASA photographer Bill Ingalls, stunningly captures the excitement and media frenzy likely to occur with any announcement of life beyond Earth. Credit: NASA/Bill Ingalls

Secondly we can study the nature of *discovery* to highlight the structure of scientific discovery. I have shown elsewhere (Dick 2013) that discovery in science is an extended process consisting of detection, interpretation and understanding (Figure 3). At each stage there are technical, conceptual, and social elements, which play out in different ways depending on the community and the environment in which the discoveries are made. The details of these discoveries are the daily work of historians of science, who have illuminated just how this plays out. Their work should have a large role in analyzing how a discovery of life beyond Earth might occur. This considerable body of work in history of science argues that discovery will also be an extended process in astrobiology and SETI. So there is an anatomy of discovery, laid out in Figure 3, that can also be applied to our problem (Dick 2015). As with other astronomical discoveries, the discovery of life beyond Earth will likely be preceded by a prediscovery phase in which the microbe, biosignature, or electromagnetic signal is not recognized as extraterrestrial life. The discovery will then go through phases of detection and interpretation before understanding is achieved. The postdiscovery phase includes societal impact as discussed in this paper. These phases could be long or short, depending on the evidence, and might result in success or failure.

In addition to being an extended process, it is important to emphasize that the impact will depend on the discovery scenario. Numerous scenarios for the discovery of life beyond Earth have been imagined in science fiction literature and film. Although there are many variables, discoveries will be especially dominated by two of them, complexity and proximity. In terms of complexity we need first to separate microbial life discoveries from complex/intelligent life discoveries. Each of these

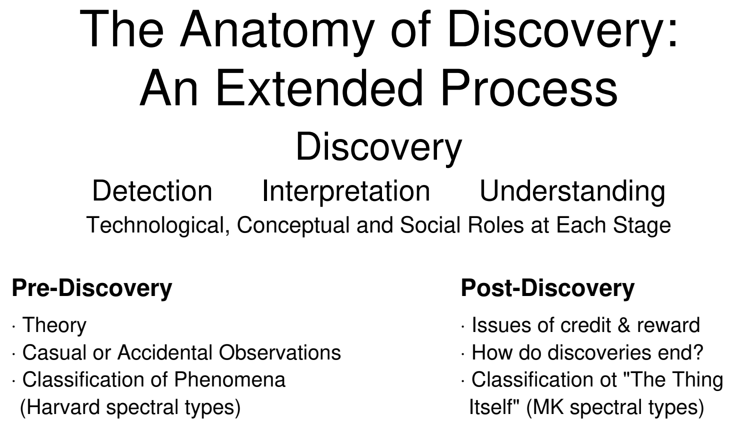

Fig. 3. The extended structure of discovery, showing its three stages of detection, interpretation and basic understanding, as well as prediscovery and postdiscovery phases. Discovery also has a microstructure consisting of conceptual, technical and social roles. From Dick (2013), where this image was used to illustrate the structure of discovery of new classes of astronomical objects, including their classification. In the long run the discovery of life beyond Earth may also require classification.

may then be parsed. Thus microbial life discovery scenarios may be direct or indirect, terrestrial or extraterrestrial. Complex/intelligent life discoveries (Figure 4) may be parsed in the same way. We can see from Figure 4 how very different the impacts would be if, say, an alien spaceship landed on Earth, versus the detection of a signal, artifact, or biosignature. It is almost meaningless to ask "what is the impact of discovering life beyond Earth?" unless the discovery scenario is stated.

Thirdly, *analogy* is an important tool to provide guidelines for impact. Astrobiology science frequently employs analogy, as in the Atacama desert for conditions on Mars, terrestrial extremophiles for alien microbes, lake Vostok for the Jovian moon Europa, and microbial mats in sinkholes in Lake Huron for the low oxygen environment on early Earth. The utility of analogy for analyzing the impact of astrobiology is arguably no different. In the context of SETI, a frequent analogy is culture contacts on Earth, especially the European conquest of the Americas in the Age of Discovery. But the Spanish conquest of the Aztecs, for example, is not a good analogy for at least two reasons: physical contact with aliens is unlikely, and even if this scenario occurred there are plenty of more benign analogies like the Ming Dynastic contacts in the 15th century.

The are many other analogies that can be deployed depending on the discovery scenario, but particularly useful is the idea of life on other worlds as a kind of worldview, sometimes termed the biological universe, or even the biophysical cosmology (Dick 1996). From this point of view the impact of successful astrobiology and SETI programs can be framed in terms of changes in worldview, especially scientific worldview. And historians of science have studied these changes in great detail, opening another avenue of research.

In summary, while the lessons of history are difficult to learn, history, discovery, and analogy offer a grounding in experience. We cannot make predictions about impact, but we can lay out impact scenarios and guidelines, realizing that discovery is an extended process and that impact will depend on those scenarios. Analogy can be as powerful in history as it is in science, but must be used with caution. And while it is true the discovery of alien life may be unique, the alternative to anticipating societal impact through these approaches or others

	TERRESTRIAL (Earth or Vicinity of Earth-Moon System)	**EXTRATERRESTRIAL** (Beyond the Earth-Moon System)
DIRECT (In the Form of Extant Life, Fossil Life, or Active Artifact)	**Encounter Type 1** Alien Space Exploration Resulting in: UFO Phenomenon Alien Landing Robotic Spacecraft Active Alien Artifacts	**Encounter Type 2** Human Space Exploration Resulting in Discovery of: Extant Aliens Active Alien Artifacts
INDIRECT (In the Form of Extant Life, Fossil Life, or Passive Artifact)	**Encounter Type 4** Extant Life Fossil Life Passive Artifacts	**Encounter Type 3** Radio/other Remote Contact Via SETI or METI Passive Artifacts Dyson Spheres and other Macro-Engineering Artifacts

Fig. 4. Intelligent Life Discovery Scenarios

is to give up. Finally, even if no life is found, these are good thought experiments.

3. Thinking out of the box

Figure 5 helps us to think out of the box. If we wish to return to first principles for possible types of life beyond Earth, at least four categories come to mind: 1) biochemistry, genetics, and solvents; 2) morphology; 3) cognitive capacity; and 4) space-time filters. Each of the boxes in Figure 5 generates many non-anthropocentric scenarios. A great deal has been written in astrobiology journals and elsewhere about the first two boxes at the top having to do with biochemistry and morphology. So let me focus briefly on the bottom two boxes (cognitive capacity and space-time filters) both of which are especially important to SETI.

3.1. Cognitive Capacity and the Nature of Intelligence

When it comes to cognitive capacity, there is a large literature on consciousness, cognition and intelligence, but not deployed in the context of SETI. The assumption has been that, as long as the aliens send some kind of detectable signal, we need not talk much about the nature of intelligence. The mantra has been to look for things "like us." But perhaps it is time to look for things that are not like us. Social sciences scholars like Lori Marino and Kathryn Denning have broadened our ideas of intelligence in the context of SETI (Marino 2015). In general the field of cognitive science raises an array of questions such as what is intelligence? How does astrobiology change our core conceptions of intelligence? Under what conditions does intelligence develop? What metaphysical assumptions underlie our ideas about intelligence? In the context of the search for alien microbes, the same kinds of questions can be asked about life itself.

Philosophers of science such as Peter Godfrey Smith can also offer novel insights. His book *Other Minds: The Octopus, the Sea, and the Deep Origins of Consciousness* argues that octopoid intelligence is the closest we will come to meeting an alien – until it actually happens. It would therefore repay astrobiologists to understand and further research the field of

BIOCHEMISTRY/GENETICS/SOLVENTS	MORPHOLOGY
Carbon//DNA/Water	Body Patterns:
Carbon/RNA/Water	Size
Carbon/Protein/Water	Shape
Silicon/?/Nitrogen	Mass
Ammonia/?/Methane	
SPACE-TIME FILTERS	**COGNITIVE CAPACITY**
Geometry	Sensory Apparatus
Mathematics	Consciousness
Sense of Time	Cognition
	Biological Intelligence
	Postbiological Intelligence
	Collective “Hive” or “Swarm” Intelligence

Fig. 5. Principles for Possible Types of Life Beyond Earth

cephalapod intelligence – an entirely different evolutionary line than *homo sapiens*. The same holds true for animals such as dolphins. In general the field of “embodied cognition” argues that cognition depends very much on the body it inhabits. Indeed, the historian David Dunér has coined the term “astrocognition” to study the origin and evolution of cognitive abilities in extraterrestrial environments, as well as a variety of other issues related to space. This set of issues is also related to one of the major fields of philosophy, epistemology, which studies how we know what we know, and how universal our knowledge might be. The opportunities for real empirical research shedding light on these issues are numerous.

Another possibility in terms of thinking out of the box is postbiological intelligence. As reviewed in Dick (2003), many have argued that we may live in a postbiological universe, a product of cultural in addition to biological evolution, the final two crucial parameters of the Drake Equation. The key realization here is that cultural evolution is not often taken seriously enough in imagining what extraterrestrial intelligence might be like. It may well give rise not only to technology, literature and all the things we normally associate with culture, but also to changes in human nature, including postbiological intelligence. This is especially true if we recognize the necessity of thinking in what we may call Stapledonian timescales, on the order of millions or billions of years, when we are contemplating the nature of intelligence in the universe today. After all, we now know that we live in a universe 13.8 billion years old, the product of astronomical, biological, and cultural evolution.

The basic outline of the postbiological argument states that intelligence leads to culture, culture leads to cultural evolution, which might lead in one of its manifestations to artificial intelligence and a postbiological universe (Dick 2003). So we need to think about artificial intelligence (AI) in the context of SETI. General AI does not yet exist on Earth in any sophisticated form that would be judged better than human intelligence, but scientists have argued it may happen on Earth in a few generations (Kurzweil 2005; Moravec 1988). The last few years have indeed seen tremendous progress in AI technology in specific domains.

The question remains whether artificial general intelligence is possible. If it is, because the laws of physics inherently limit a biological brain from increasing its intelligence even over long time scales, long-lived technical civilizations, for whom the improvement of intelligence may be a driving force of cultural evolution, will likely seek to increase intelligence through other means. We are thus lead to what I call the Intelligence Principle: *The maintenance, improvement and perpetuation of knowledge and intelligence is the central driving force of cultural evolution, and that to the extent intelligence can be improved, it will be improved*. Failure to do so may cause cultural evolution to cease to exist in the presence of competing forces.

The idea of postbiologicals has become increasingly accepted over the last two decades, including by the physicist Paul Davies, the astronomers Martin Rees and Seth Shostak, and the philosopher Susan Schneider (Schneider 2015). I argue further that if we live in a postbiological universe this can and should affect SETI programs. A starting point on possible options is Nick Bostrom's volume on *Superintelligence* (Bostrom 2014). There are other possibilities for intelligence, listed in Figure 4, but perhaps enough has been said to see how we can and should think out of the box when it comes to intelligence.

3.2. Space-Time Filters

Our fourth principle in the Figure 5 is space-time filters, a recognition of the possibility of the unknowability of the alien. The idea here is that perceptions of space and time by conscious/cognitive/intelligent beings may be very different from ours. Surely the fundamental basis of life's interaction with the external world will depend on how any given life form sees that world in terms of geometry and mathematics, if it sees it at all in those terms, and how it employ its perhaps very different sense of time. A valiant and delightful attempt at non-anthropocentric thinking about the spatial dimension was made 130 years ago when British schoolmaster Edwin A. Abbott penned *Flatland: A Romance in Many Dimensions* (1884). Even this attempt, however, may not have been bold enough.

Similarly, fundamental questions about time arise in the contemplation of aliens. We are not talking here about "mechanical time," but about the perception of time, sometimes called "subjective time" or psychological time, related to how any given nervous system processes sensory information. We know that on Earth animals have very different perceptions of time, and that this perception is related to body mass: the smaller the animal, the faster its metabolic rate and the slower time passes. A mouse has a very different perception of time than an elephant (Reas 2014). The same may be true with aliens, or their body clocks may operate according to some other variable. This difference in time perception in the terrestrial context is the subject of much research, and has occasionally been the subject of science fiction such as the physicist Robert Forward's imaginative novel *Dragon's Egg* (1980), where the sesame-seed-sized intelligent cheela live out their lives on a neutron star with 67 billion times the surface gravity of Earth. In another example of a different variety the aliens in Kurt Vonnegut's *Sirens of Titan* do not distinguish among past, present and future, just as the heptapods in the movie *Arrival* do not.

The "space-time filter" concept is also related to the idea of universal knowledge, for it is a problem not only of transcending anthropocentrism, but also of philosophy, psychology, and cognitive science. Space-time filters may affect our search for extraterrestrial intelligence and may even account for the Fermi Paradox, explaining why we do not see extraterrestrials everywhere.

3.3. Technology and Communication

In the same way that we have looked at intelligence, we could examine fundamental terrestrial concepts like culture and civilization, technology and communication. In communication, for example, the problems of communication, including language, depend on the possible domains of mental structure, the space-time filters we were just discussing. I have suggested (Dick 2018) that at the topmost level of generality we may envision three cases when comparing terrestrial and extraterrestrial minds (Figure 6). In case 1 our mental structures and modes of perceiving and thinking may overlap entirely, in which case dialogue may be relatively “easy.” In case 2 they may overlap only partially, yielding some common basis for dialogue. In case 3 there is no overlap at all, in which case there is no dialogue at all. But all hope is not lost; for in case 4 a ”dialogue chain” of partially overlapping mental structures may eventually enable dialogue. These Venn diagrams of “mental structures” at the physiological level, or “modes of thinking” at the output level, embody many problems and require more research in diverse areas before any conclusions can be reached about their effect on communication.

4. Impact of discovery: a role for the humanities and social sciences

For practical reasons such as discussed in Section 3, we argue that the social sciences, humanities, and philosophy should be an integral part of the astrobiology endeavor. NASA scientist John Billingham realized this 25 years ago with a series of workshops preceding the inauguration of the NASA SETI program (Billingham et al. 1999). There have been a number of Symposia since then, as well as books and articles, to the extent that there is now a rather substantial literature (reviewed in Dick 2018).

There are many lessons learned for astrobiology in this literature. Dick (2018) poses a hierarchy of worldviews ranging from the cosmological to the theological, ethical, and cultural. The cosmological realm encompasses the transition from a physical cosmology to a biophysical cosmology. Along with the mysteries of dark energy and dark matter, the abundance of or lack of life is one of the most fundamental *cosmological* discoveries yet to be made. As physicist Freeman Dyson put it in slightly different fashion, “The prospects are bright for a future-oriented science, joining together in a disciplined fashion the resources of biology and cosmology. When this new science has grown mature enough to differentiate itself clearly from the surrounding farrago of myth and fiction, it might call itself ’cosmic ecology,’ the science of life in interaction with the cosmos as a whole. Cosmic ecology would look to the future rather than to the past for its subject matter, and would admit life and intelligence on an equal footing with general relativity as factors influencing the evolution of the universe” (Dyson 1988). Fine-tuning and the multiverse are two concepts that may prove central to this task. In such a ”cosmic ecology”, life and intelligence do indeed play a central role in the evolution of the universe, no less than its physical laws. The biological universe may be not the result but the cause of the physical universe, part of its very fabric, and more surprisingly fundamental than we have ever realized.

In the realm of theology and philosophy, the issues center around how current theologies might change in light of a SETI success, how new theologies might come into being, and how philosophical problems, like objective knowledge and the universality of human knowledge, will be advanced if we can communicate with extraterrestrials. The impact of the discovery of life beyond Earth on these theologies is likely to be pervasive, foundational, and personal. Such impacts will vary depending on the nature of the discovery and the particular religion and theology involved. Because theological worldviews are so deeply held by such a large part of the population, changes in worldviews at this level – whether those worldviews are objectively true or not – are sure to have profound effects. Conversely, however, they also have the potential to help Earthlings cope with the discovery in whatever form it takes. The actual impacts of changes in theological worldview must remain speculative, but in examining the possibilities we can draw on at least three sources: historical discussions of the religious impact of possible inhabited worlds; theological reactions to putative discoveries of life beyond Earth; and empirical surveys of theological and public opinion on the subject. All of these streams of thought have resulted in what is now a considerable scholarly discussion of the subject, known variously as exotheology, astrotheology, and cos-

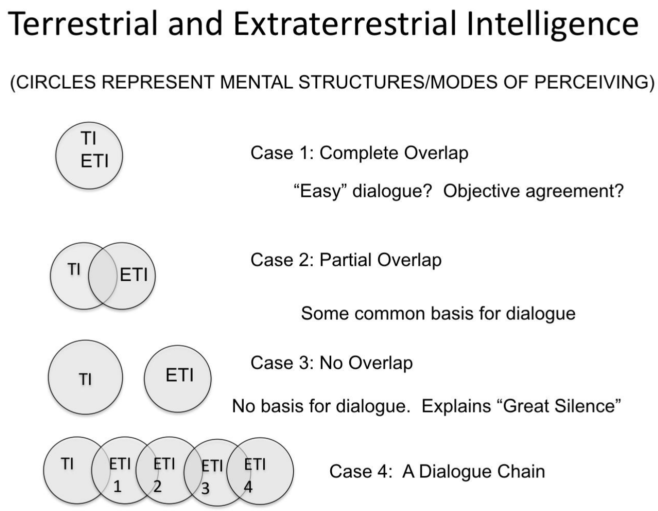

Fig. 6. Possible scenarios in the relationship between extraterrestrial intelligence and terrestrial intelligence. The Venn diagrams may be taken as representing mental structure or modes of perceiving and thinking, and will affect our abilities to communicate.

motheology (Dick 2000, 2018; Peters et al. 2018).

In the ethical realm, there has already been considerable work on issues such as the evolution of extraterrestrial altruism, the status of non-human organisms, how to treat alien life, whether or not we should answer a SETI message, and whether or not we should send messages to extraterrestrials (METI). The answers to these issues depend on which theory of moral status we adopt. There is already a considerable literature on astroethics (Impey et al. 2013). Persson (2012) distinguishes four ethical theories of moral status, in order of increasing inclusivity: *anthropocentrism*, in which only humans have moral status; *sentientism*, in which all and only sentient beings have moral status; *biocentrism*, in which all and only living beings have moral status; and *ecocentrism*, in which all living beings, species and ecosystems, and perhaps even nonliving matter, have moral status. Others, such as Lupisella (2016), would go even further and espouse cosmocentrism, in which the entire cosmos and its constituent parts have moral value. Many religious people would fall in the anthropocentrist camp if moral status is expressed in terms of a soul, and so would Kant if expressed in secular terms; Smith (2014) argues for ratiocentrism; Albert Schweitzer and his many followers would be biocentrists; many environmentalists, such as Aldo Leopold, would be ecocentrists. Persson himself proposes that sentientism may be the most plausible theory to apply to extraterrestrial life.

At the bottom of this pyramid of worldviews is the transition from culture to astroculture. Astroculture is a relatively new umbrella concept used to describe the array of images, events and media reactions that "ascribe meaning to outer space while stirring both the individual and the collective imagination." In a landmark international meeting on the cultural history of outer space held in Germany in 2008, German historian Alexander Geppert introduced the concept, which was then given concrete form by more than a dozen authors (Geppert 2012). Geppert's goal was to examine whether a unique Western European perspective on space existed in the three decades following World War II, in the same way that American historians had examined the cultural history of space in the United States. We can expand the concept to argue that, while different perspectives on space may exist in different cultures, humanity as a whole is increasingly creating and immersed in an overarching astroculture that transcends national boundaries, a kind of *global astroculture*. This transformation is much broader than the possibility of life beyond Earth, but the idea of alien life has for some time been a major component of culture (at least Western culture), and is sure to accelerate if a discovery is made of life beyond Earth. We are already well on our way in this transition, expressed in colorful terms already in the 1970s in Carl Sagan's *Cosmic Connection*, given impetus by the spectacular Earthrise image first seen from Apollo 8, the blue marble image from Apollo 17, Voyager 1's pale blue dot image of Earth, and the stunning images emanating continuously from the Hubble Space Telescope.

Finally, there is also the question of what do we do if a discovery of extraterrestrial life is made. This is the area of astropolicy, a nascent field that was evident in 2013 during Congressional testimony on astrobiology. No action has been taken, but certainly when the discovery is made there will be a great deal of government interest – and perhaps funding, in the same way that 3% of the 3 billion Human Genome Project was spent on ethical, legal and societal issues once genetic issues became a burning societal problem.

5. Conclusions

In summary, we need to think deeply about our underlying assumptions about life & intelligence, culture and civilization, technology and communication. We need to put philosophy, humanities, and the social sciences to work for SETI and more generally for astrobiology, both for issues of search strategy and for societal impact. And we need to lay the foundations now for new disciplines such as astrocognition, astrotheology, and astroethics. With these fields as part of a broadened discipline, astrobiology can become a focus for what E. O. Wilson has called consilience, the unity of knowledge. All of this will help us prepare for discovery.

While some of the ideas in this chapter might seem speculative even to astrobiologists, let me close with two relevant quotes. Carl Sagan opined that in scientific work "What is called for is an exquisite balance between two conflicting needs: the most skeptical scrutiny of all hypotheses that are served up to us and at the same time a great openness to new ideas." And the equally irrepressible Richard Feynman stated more succinctly, but with similar effect, "Keep an open mind, but not so open that your brains fall out."

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