Rethinking Life: Astrobiology and the Future of the Social, Behavioral, and Economic Sciences[1]

Kathryn Denning[a] and Margaret Race[b]

a. Dept. of Anthropology, and Graduate Program in Science & Technology Studies, York University, Canada
b. Carl Sagan Center for the Study of Life in the Universe, SETI Institute, Mountain View, CA

Abstract

Human beings have long been interested in the potential discovery of extraterrestrial life – but astrobiology is much more than this. Astrobiology addresses the definition, emergence, evolution, and future of life on Earth and in the universe, and intersects with the human exploration and exploitation of our solar system, our own deliberate evolution, and our relationship with our planet.

Astrobiology is challenging our views of, and engagements with, life itself, as well as humanity's position in the universe. The science presents issues that crosscut SBES disciplines at a fundamental level. All legal, ethical, theological, and cultural systems are based on `life as we know it', and astrobiology has begun to challenge those fundamental assumptions, as well as our anthropocentrism, and our terracentrism. A truly interdisciplinary approach is needed to understand the broad implications within human and social contexts –now, and in the future.

We therefore ask, How will advances in astrobiology research and exploration affect humanity? , and argue that it is necessary to foster an interdisciplinary community of SBES researchers who can address the human questions that astrobiology is presenting to us.

[1] Note: This work is licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License. To view a copy of this license, visit http://creativecommons.org/licenses/by-nc-sa/3.0/ or send a letter to Creative Commons, 171 Second Street, Suite 300, San Francisco, California, 94105, USA.

The Challenge Question: How will advances in astrobiology research and exploration affect humanity?

The Capability to be Created: An interdisciplinary community of SBES researchers who can address the human questions that astrobiology is presenting to us.

Astrobiology: a brief introduction

The scientific search for life on other worlds started 50 years ago, with the establishment of NASA's exobiology program, and the first radioastronomy search for extraterrestrial intelligence at NRAO Green Bank, West Virginia. In time, exobiology became astrobiology, a field that now goes far beyond the original exobiology efforts to design experiments to detect life on Mars. It is established that we live in a 'chemical universe', with well-understood chemistry that is the same on Earth and in space. The question now is whether or not we live in a similarly consistent 'biological universe' – that is, whether life has arisen only once, here on Earth, or many times throughout the universe. In exploring this question, astrobiology has become a broadly multidisciplinary field, encompassing research and exploration across a variety of fronts of importance to humanity and our collective future.

Astrobiology now includes such diverse fields as interstellar chemistry, the search for exoplanets, the geobiology of Earth, evolutionary biology, and the study of extremophile organisms on Earth. NASA's Astrobiology Program now addresses three fundamental questions: How does life begin and evolve? Is there life beyond Earth and, if so, how can we detect it? What is the future of life on Earth and in the universe? Research areas include the signatures of life, habitability in the universe, life in our solar system, the origins of life the future of life, evolution and environment, and life and environment (see http://astrobiology.nasa.gov/) , as well as environmental management and protection, and even planetary defense (against asteroid impacts). Astrobiology thus encompasses questions of evolution, sustainability, habitability, and life itself. The science of astrobiology builds on many existing disciplines, while also encouraging a multidisciplinary approach across sciences and technology. Research activities are diverse, ranging from the use of space telescopes to study interstellar chemistry or search for extrasolar planets, to rover experiments on Mars, to the exploration of analogue sites like deserts on Earth, to microbiology in the lab. Research in astrobiology is moving extremely quickly on the international scene.

The nexus of astrobiology and society

The field of astrobiology is extraordinarily generative in terms of human questions. There is, judging from public interest in extraterrestrial life, Mars exploration, and extrasolar planets, a significant human investment in the possibility of life beyond Earth, and in the search for it. But more than this, astrobiological research instigates a cascade of issues, practical and philosophical, ethical and theological, economic and technological, legal, cultural, and political. Three brief illustrations follow.

A single discovery of extraterrestrial life that is different from Earth life would imply that we live in a 'biological universe' where life has emerged and evolved in multiple places, whenever and wherever conditions are right. Such a finding would be as significant as the Copernican shift to a heliocentric solar system, and dramatically shift our views about life and our own place in the universe.

Astrobiological research focuses in part on the habitability of entire worlds: what makes a planet habitable? What conditions are necessary for life to emerge, and then to be sustained? What conditions will result in the demise of a biosphere? Theories and data generated by astrobiological science thus touch upon questions of intrinsic interest to all humanity, as we continue to experience climate change and to alter our own world.

As scientists study life from the broadest possible perspective, we are forced to rethink our own relationship to it – both to life as we know it, and to different life that we might find. In particular, we must consider our role in its protection. Life forms can be seen to have both intrinsic and instrumental value. Extraterrestrial life, should it exist, might have instrumental value in ways we cannot now predict. And if humanity chooses to accept that extraterrestrial life also has intrinsic value, then we must weigh that value against our own concerns – e.g., decide whether or not to protect bodies in the solar system from resource extraction. What values or considerations should we apply to environmental management or planetary protection? How should we determine acceptable actions towards different types of life? How should this be codified in laws or regulatory policies?

Importantly, even if no life of any other kind is ever found, the processes of looking and of focusing on astrobiological questions, are changing the way human beings see life, our home planet, and our place in the universe.

The fundamental issues for SBES in relation to astrobiology

The first image of the Earth from space led humanity to rethink the nature of the world and our relationship to it. This re-visioning of our planet and ourselves has reached into every realm of scholarly inquiry. Now, astrobiology is causing us to rethink *life itself*, in myriad ways. And whether or not a detection of extraterrestrial life is imminent – as many scientists expect it to be – this re-visioning will involve SBES in every way imaginable. Following are several brief examples of this entanglement.

First, in searching for life as we don't yet know it, scientists now ask: what *is* life? What exactly does it mean to be alive, and what are the limits of the possibilities for life? As scientists examine ever-more-surprising forms of Earth life – extremophiles living in conditions previously believed impossible for life – their understanding of life's edges is expanding. Even more than this, astrobiologists are taking a much closer look at our own world: the search is on for 'weird life', a `shadow biosphere' or 'second genesis', *i.e*., microbial life forms that arose independently from our own lineage, and are biochemically different from all the DNA/RNA-based life we know, yet coexisting with us on Earth. This radical reconsideration of the defining characteristics of life and non-life, different types of life, and our home planet will have far-reaching implications. SBES fields may be impacted in ways that have not yet been predicted. When places previously considered dead are found to harbour life, and when human beings are literally finding a new understanding of the ground beneath our feet, then everything from environmental consciousness to the economics of land use to theories of evolution begins to change, and approaches in SBES will shift accordingly.

Second, work in astrobiology forces us to consider what to do about other forms of life in our solar system, or beyond. The rate of life-related discoveries is rapidly outpacing our human frameworks. Accordingly, this area – involving planetary protection, UN conventions and treaties concerning space, metalaw, and bioethics – is an incredible opportunity for SBES researchers: their perspectives and contributions are greatly needed.

Third, astrobiology is not solely about extraterrestrial life. It is tightly connected to synthetic biology, biogeochemistry, concepts like terraforming, the sustainability and future of life, and deliberate evolution writ large. We live in the Anthropocene era: we are changing our world, and with it, ourselves, at an unprecedented rate. The culture/nature divide, such as it was, is collapsing. Through research within and connected to astrobiology, we are also coming to understand planetary scale phenomena, the limits of habitability, and life's fragility on Earth. What are the likely impacts upon human consciousness, behaviour, culture, and social systems? How should they be studied?

Fourth, through astrobiology and related sciences, the entire context within which SBES research is carried out, is changing – and fast. It is not business as usual. As noted, we live in a time when: life itself is being re-conceptualized; we are understanding life on our home world in entirely new ways; the relationship of Earth to the cosmos is being reconsidered; we are gradually becoming capable of engineering the future of our biosphere, and of other potential biospheres; human beings are considering the possibility that we may not be special in the ways we have always assumed ourselves to be. All this is a profound challenge to our constitutive human relationships, and the tools we have developed in the social sciences to study those relationships are no longer enough – we must reach further and find new ways to think.

In short, we do not just need regular/established SBE approaches to the human questions at the nexus of astrobiology and society – we also need fundamentally new approaches that can accommodate the multicultural scope of the issues raised, can handle the intensely multidisciplinary science, and can work on horizons of 10, 20, 50, 100 years, and longer. Effectively tackling the human questions that arise from the scientific work of astrobiology would require all the following, and more:

- integration of perspectives from ethics, religion, law, science policy, anthropology, moral philosophy, international governance, and history and philosophy of science / science & technology studies
- examination of the ways in which representations of life and the biosphere (verbal, visual, multimedia) affect local and global decisions about how to interact with that life
- strategic use of historical analogues concerning discoveries within biology, astronomy, and cosmology, and discoveries of significant new territories and resources
- exploration of simulations and forecasting strategies to better understand the long-term consequences of decisions in realms of planetary protection and the uses of life and its habitats both on Earth and in space, etc.

Serious support of work at the nexus of astrobiology and society would advance the domain of SBES by pushing disciplinary integration to the maximum. Similarly, work in this area forces an outlook that is not merely global in scope, but much broader, and attention to timelines which extend much further into the future than social scientists usually look.

Building capacity

Relevant scholarly work already exists, but its authors are not well-consolidated into a research community. Capacity and infrastructure relating to astrobiology has grown very quickly within the sciences, but the complementary support in the SBES fields has lagged. Significant multidisciplinary workshops have taken place internationally (*e.g.* at the NASA Astrobiology Institute, Royal Society, and the Vatican), and edited volumes already exist, but few scholars work full-time at the intersection of astrobiology and SBES.

The authors of this paper have recently (mid-2010) started a NASA Astrobiology Institute Focus Group on Astrobiology & Society, but this effort to bring together like-minded scholars in SBES, humanities, and astrobiology to create a research agenda for coming years, is one of the very first efforts towards capacity-building in this area. There are, as yet, no dedicated research centers or graduate programs for SBES work emerging from astrobiology. The NSF can encourage a new cohort of scholars in SBES who will be skilled at examining and addressing complex science/technology questions with important societal implications, and foster long-term, systematic, interdisciplinary research initiatives of worldwide importance. There is a need to consolidate a research community, to tap into existing research expertise in many disciplines, to develop truly interdisciplinary approaches that contribute the examination of our shared future, and to train a new generation of thinkers ready for a new generation of human questions. We need researchers who can address the issues that will arise from humanity's altered views and relationships with life... in whatever diverse forms we find it.

Finally, of course, the SBES mission includes understanding the structure and development of science itself. Relevant work on the history and anthropology of astrobiology already exists, but greater support for scholarship in such fields is timely.

This is, in the end, a matter of utmost practicality. The decisions humanity makes now about how we choose to relate to life, and to the solar system and space beyond, will affect all our descendants.

References

NASA Astrobiology website: http://astrobiology.nasa.gov/

The Astrobiology Primer, in *Astrobiology*. 2006, 6(5): 735-813. doi:10.1089/ast.2006.6.735
http://www.liebertonline.com/doi/abs/10.1089/ast.2006.6.735?journalCode=ast

The NASA Astrobiology Roadmap, 2008: http://astrobiology.nasa.gov/roadmap