Astrosociological Implications of Astrobiology (Revisited)

Jim Pass

Astrosociology Research Institute
P.O. Box 1129
Huntington Beach, CA 92647
714-317-6169; jpass@astrosociology.org

Abstract. Supporters of astrobiology continue to organize the field around formalized associations and organizations under the guise of the so-called "hard" sciences (e.g., biology and the related physical/natural sciences). The so-called "soft" sciences – including sociology and the other social sciences, the behavioral sciences, and the humanities – remain largely separated from this dynamically growing field. However, as argued in this paper, space exploration involving the search for extraterrestrial life should be viewed as consisting of two interrelated parts (i.e., two sides of the same coin): astrobiology *and* astrosociology. Together, these two fields broadly combine the two major branches of science as they relate to the relationship between human life and alien life, as appropriate. Moreover, with a formalized system of collaboration, these two complimentary fields would also focus on the implications of their research to human beings as well as their cultures and social structures. By placing the astrosociological implications of astrobiology at a high enough priority, scientists interested in the search for alien life can augment their focus to include the social, cultural, and behavioral implications that were always associated with their work (yet previously overlooked or understated, and too often misunderstood). Recognition of the astrosociological implications expands our perception about alien life by creating a new emphasis on their ramifications to human life on Earth.

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INTRODUCTION: ASTROBIOLOGY AND ASTROSOCIOLOGY

Why should the scientific community grant astrosociology with a standing equal to astrobiology? After all, astrosociology is a developing field and by no means widely as astrobiology. As the founder of astrosociology, I possess obvious incentives to promote this developing field. Nevertheless, the more significant reason relates to the very nature of the sciences themselves, which are roughly divided into the natural/physical and social/behavioral categories. One curious fact still remains amid the furor that occurred over the rapid development astrobiology. Largely ignored was the fact that social and cultural implications associated with the study and discovery of extraterrestrial life affect the imaginations of laypeople and scientists alike, as well as their actions and larger patterns of behavior. This occurs at the micro, middle, and macro levels of social reality (from individual persons, to the community, to societal, and finally to global levels).

Thus, the effects of astrobiological activities in turn have astrosociological ramifications for societies, social groups and institutions, and people. The two branches of science, as defined here, consist of (1) the physical and natural sciences and (2) the social and behavioral sciences, the humanities, and the arts. These two subcultures are complementary to one another, and not diametrically opposed, as many space community traditionalists seem to believe. The problem of separation between these two branches has traditionally resulted in extremely limited input from the second branch

When astrobiologists and other space scientists speak about non-human life in the universe, they inevitably begin to touch on concepts associated with sociology and the other social sciences (as observed by Pass, 2005a). This fact

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unmistakably suggests an untapped relationship between the work of astrobiologists and the work of social scientists, with significant implications for societies around the world. Hence, while currently not formally accepted as a source for collaboration, the social sciences receive acknowledgement on an informal basis, perhaps making the divide between the two scientific camps seem less serious at first glance. Even so, the degree of separation between the physical and social sciences on a formal basis remains high enough to merit formal attention (Dudley-Rowley, 2004; Harrison, 1997). The time to formalize the informal recognition of the significance of the social and cultural ramifications of space activities, including the search for extraterrestrial life is long overdue.

Astrosociology specifically focuses on the relationship between any aspect of space-related activities and societies (or their structural elements). The very focus of astrosociology strongly implies that astrobiology possesses astrosociological (that is, societal) implications. Our species thought about questions such as "who are we?", "how did we come to be?", "where do we fit in the big scheme of things?", and "are we alone?" from the time rational thought was possible following the first human gaze into the heavens. We explored the Earth to provide some answers to these questions, so we will very likely continue our exploration of space for the same rationale. As Carl Sagan (2000) has stated, "The nature of life on Earth and the search for life elsewhere are two sides of the same question – the search for who we are." Expanding on this notion, the comprehensive answers to such questions truly involve *all* of the sciences because we are a social species and not just a biological one. Knowledge for knowledge's sake may be important in its own right, but the application of knowledge for the benefit of society raises its value to an even higher echelon. While astrobiology serves here as an obvious example of a field with strong ties to astrosociology, the other space sciences possess similar ties as well. At the same time, the search for extraterrestrial life holds a special place in human cultures, both past and present.

Incredibly, then, astrobiology and all the space sciences have historically pursued their scientific objectives largely without the benefit of *significant* input from the social sciences, even in the avenues of inquiry that are most suited to the social sciences rather than the physical sciences. This reality continues even as we move beyond the fiftieth anniversary of the space age. However, as we venture out beyond low Earth orbit, the approach that overwhelmingly relies on the physical sciences inevitably becomes less effective in its coverage of all the important scientific questions involved in the various areas of space travel, settlement, and exploration. Human groups will someday move into space in search of nonhuman life. While robots increasingly become more sophisticated and thus more capable, their ability to detect and properly analyze possible life on Mars or in other space environments will not soon match the prowess of human beings as exemplified in our versatile and wide-ranging skill set. Like planetary geologists, most astrobiologists would look forward to working in extraterrestrial environments, and all of humanity will receive news about their discoveries concerning our relationship to extraterrestrial life in our solar system and beyond.

DEFINITIONS OF ASTROBIOLOGY AND ASTROSOCIOLOGY, AND THEIR RELATIONSHIP TO ONE ANOTHER

When discussing astrobiology and astrosociology, it is of course important to define them. Of even greater importance, however, involves consideration of the relationship between the two, especially because this latter focus remains underemphasized. The greater significance relates to the connection between the two fields specifically and that between the physical and social sciences in general. Related to the former consideration is the necessity to encourage a much greater collaboration between the two fields of astrobiology and astrosociology so that the human dimension of space exploration becomes an important part of our understanding of extraterrestrial life. After all, humans conduct research to detect extraterrestrial life and humans will react to its detection. The human dimension is involved before confirmation of extraterrestrial life as well as after such a confirmation.

Therefore, the issue of creating a permanent and formal association between the two, an important objective of astrosociology, represents an overarching theme of this article. Astrosociology can provide the framework for correcting this ongoing absence of formal communication by focusing on all issues that somehow involve the relationship between space and society, and this includes astrobiology. The relationship between astrobiology and astrosociology is rooted in the relationship between the physical and social sciences, tied together by their mutual focus on outer space as both a physical and social environment. Both must contribute to our overall understanding of space exploration due to the simple reason that human behavior makes space exploration possible, and human behavior happens to be the focus of the social sciences.

Astrobiology Defined in a Social Context

In its *Astrobiology Roadmap*, Final Version released in 2003, NASA Ames Research Center's *Astrobiology at NASA* site defines astrobiology utilizing a combination of extraterrestrial and terrestrial terms as related in the passage below (http://astrobiology.arc.nasa.gov/roadmap/).

> Astrobiology is the study of the origins, evolution, distribution, and future of life in the universe. It requires fundamental concepts of life and habitable environments that will help us to recognize biospheres that might be quite different from our own. Astrobiology embraces the search for potentially inhabited planets beyond our Solar System, the exploration of Mars and the outer planets, laboratory and field investigations of the origins and early evolution of life, and studies of the potential of life to adapt to future challenges, both on Earth and in space.

According to the NASA Institute of Astrobiology (http://nai.nasa.gov/about/about_nai.cfm), the types of questions listed below "exemplify the breadth and depth of astrobiology."

- How do habitable worlds form and how do they evolve?
- How did living systems emerge?
- How can we recognize other biospheres?
- How have the Earth and its biosphere influenced each other over time?
- How do rapid changes in the environment affect emergent ecosystem properties and their evolution?
- What is the potential for biological evolution beyond the planet of origin?

Surely, the social and cultural implications of these questions, and the very pursuit of human beings to answer them, should be evident to everyone. Unfortunately, from astrobiologists and other physical/natural scientists, this recognition currently fails to receive serious consideration on an extensive basis.

The introduction to the *Roadmap* goes on to call for interdisciplinary research. As is common within the physical sciences, however, this reference seems confined to the physical sciences. The social and behavioral sciences receive no overt acknowledgement:

> Interdisciplinary research is needed that combines molecular biology, ecology, planetary science, astronomy, information science, space exploration technologies, and related disciplines. The broad interdisciplinary character of astrobiology compels us to strive for the most comprehensive and inclusive understanding of biological, planetary and cosmic phenomena (http://astrobiology.arc.nasa.gov/roadmap/).

In its *Principles* section, the roadmap continues by recognizing a "broad societal interest in its endeavor" and a "public interest in astrobiology." Unfortunately, it stops short of extending the interdisciplinary research effort beyond the physical and natural sciences. This approach in NASA's official position imposes a significant barrier due to its failure to invite participation by the social and behavioral sciences.

The pursuit of astrobiology in the traditional manner represents an extremely positive endeavor and it should continue, though the thrust of the argument presented here focuses on the need to *add* additional scientists to study the relationship between the search for extraterrestrial life and its effects upon societies and other social structures. That is, it strongly calls for the inclusion of the social sciences through the recognition of astrosociology as an important complementary field. From the perspective of social scientists currently working on issues related to space and its implications for human societies, they need to recognize the fact that they do so in isolation within their disciplines and from one another. Astrosociology was developed, in part, to allow these social scientists to come together as astrosociologists or overt supporters so they may collaborate under the banner of a single field. Once this occurs to an appreciable extent, they can then approach the field of astrobiology with an organized, coherent voice requesting formal working arrangements that will benefit both fields.

Astrosociology Defined in a Natural/Physical Sciences Context

Astrosociology is defined as the study of *astrosocial phenomena* (i.e., the social, cultural, and behavioral patterns related to outer space) Pass, 2004a). This definition places no values on the level of space-related development within a particular society. Astrosocial phenomena existed in ancient societies, they exist in contemporary societies incapable of spaceflight, and of course within space-capable societies. In other words, these particular forms of social phenomena simply relate to any human behavior that somehow relates to space. The preparations for sending a rocket into space qualify, but so do the activities of ancient astronomers at Stonehenge. An important implication of this, then, is that astrosociological perspective includes an historical component. The connection to astrobiology relates to the following type of question: how long have human beings gazed at the nighttime sky and wondered if they were alone? Indeed, ancient cultures have incorporated ideas related to their explanations of extraterrestrial life. Ancient murals and other writings hint at such beliefs. Additionally, ancient human societies have conducted astronomical research and even organized themselves around their findings.

The historical period that inspired the development of astrosociology is a much more recent one. Since the successful launch of Sputnik by the Soviet Union in 1957, humans from various societies around the world contributed directly and indirectly to the increasingly sophisticated achievements that characterize the space age, fueled on by the Cold War and other influences. Despite the long list of accomplishments and their relationship to human societies, the development of a social science field within sociology or the other social/behavioral sciences never developed. Individual social scientists of various disciplines have worked in the general area of astrosocial phenomena, though they never developed a scientific field to do so in an organized way. Such an approach would have allowed for collaboration among scientists. Scientific discoveries and technological advances associated with space research abound, yet we largely fail to inquire about how they affect human societies.

The Relationship between Astrobiology and Astrosociology

To be fair, the societal implications of astrobiology were never ignored totally. In the NASA publication entitled *Workshop on the Societal Implications of Astrobiology*, astrobiology is defined as:

> …the study of the origin, distribution, and future of life in the universe. It applies multiple scientific disciplines and space technologies to address how life begins and develops, whether life exists elsewhere in the universe, and life's future on the home planet and beyond. It thus integrates the interests of people who search for evidence of life beyond the Earth, and people who seek to establish a permanent human presence in space (Harrison and Connell, 1999).

In fact, it is clear that astrobiologists do recognize the social implications of their scientific perspective. Indeed, social scientists were involved in the NASA study that produced the definition above. In this report, they clearly call for social scientists to join the astrobiological community. While this general notion is noteworthy, it seems like a better strategy for social scientists to join them as astrosociologists specializing in astrobiology and SETI (i.e., the Search for Extraterrestrial Intelligence), rather than as dislocated individuals. In this way, the focus on the social implications of astrobiology will become part of the astrosociological literature and easily accessible to social scientists, astrobiologists, and all other parties interested in the relationship between space and society.

At that time, the advocacy for interdisciplinary collaboration in this NASA-sponsored report represented more of a recommendation than an actual development. Much difficult work awaits us in formalizing the interdisciplinary cooperation between the physical ("hard") sciences and social ("soft") sciences. The "soft" label itself implies that the social sciences are not really sciences, but something else less precise (Harrison, 2002). However, think about what could happen if we failed to understand human interaction in an isolated space society (i.e., settlement). Unlike a Martian rock, for example, human actors can change their minds and interact with investigators. This simply makes scientific inquiry more difficult, not less scientific. Additionally, their behavior falls into predictable patterns that we must understand if we expect successful human migration into space to occur.

One cannot overestimate that, in the present context, the most important element of the astrosociological approach relates to the collaboration among astrosociologists within the social/behavioral sciences with one another as well as their collaboration with space scientists and engineers interested in the social implications of space exploration

(including astrobiology). Although astrosociology originally started out to fill a void created by the historical absence of a sociological focus on space as a subfield, it became clear almost immediately that a multidisciplinary field was required. Whenever humans organize themselves to accomplish something, including the exploration of space, then the connection of the physical sciences to society and culture becomes a vital focus. In reality, however, it is not obvious or people view its importance as insignificant. Astrosociology seeks to bridge this historical isolation in a formal and purposeful way so that scientists from both branches of science and all members of a particular society benefit in ways not currently possible. Astrosociology encourages multidisciplinary collaboration among all scientists as a principal approach and this produces a more balanced understanding than is impossible with an approach reliant exclusively on the physical and/or natural sciences (Pass, 2005b).

ASTROSOCIOLOGICAL IMPLICATIONS OF ASTROBIOLOGY

The astrosociological implications of astrobiology can be revealed through astrobiological research on societies and their cultures, including the investigation of terrestrial analogs and the search for alien life, as well as the indirect work done to support such activity, and any additional tangential efforts that support astrobiology. These implications refer to the following types of substantive areas. This is an incomplete, though representative, list:

- the cultural justifications for the search for extraterrestrial life from scientists, public, and others;
- counteracting social forces opposed to astrobiological research;
- the social organization required to conduct the search for extraterrestrial life;
- social-structural forms of astrobiological research organizations, including how they conduct their research and interactions with other types of physical/natural scientists (i.e., organizational analysis);
- how resources are allocated and spent, and who is involved in such decisions;
- interpretations of new research findings, including those within various societies and subcultures;
- the social/cultural ramifications of relevant astrobiological discoveries that fall short of discovering extraterrestrial life;
- and the impact of an outcome: (1) the detection of a message from an extraterrestrial intelligence, (2) discovery of a microbial form of alien life, or (3) the perceived failure of the search (we give up and turn our of attention elsewhere).

To reiterate, any social, cultural, or behavioral patterns that somehow relate to extraterrestrial life directly or indirectly possess astrosociological implications. The astrosociological implications of astrobiology exist simply because the search for alien life occurs within a stable and enduring social environment. Everything humans do involving space science and exploration occurs within the context of a social system and therefore possesses social and cultural implications for the rest of that society. Astrobiology and SETI are no different.

In turn, human actions result in reactions from the other elements of society. In sociology, such ideas are part of the *functional perspective*, which states that all parts of society are interconnected and contribute to an existing normal state or equilibrium. When social forces affect one of these parts resulting in social change, this new reality has effects on the other parts of that society because they seek to compensate to preserve order. Social change is viewed as an evolutionary process. Of course, the discovery of extraterrestrial life would involve revolutionary social and cultural change (a prediction from the *conflict perspective* in sociology that views the various types of conflict in society as the direct causes for change).

The overriding assumptions here relate to the ideas that (1) all astrosocial phenomena possess social implications for their societies and (2) astrobiological forms possess special implications due to the very nature of their field. Astrobiologists seek answers to fundamental questions about life in the universe. Until recently, their ability to address such questions seriously was frustratingly out of reach. Astrobiology developed into a serious field in large measure due to the advancements of science and technology that finally allowed for its credible development and support by scientists and non-scientists alike. Not too long ago, people of all backgrounds were scoffing at the possibility of alien life, calling it the “search for little green men” (Harrison, 2005). Today, a lot of these same individuals no longer see the absurdity they once did in the search and understanding of extraterrestrial life. Let us look at this in more detail.

In the early 1960s, the idea to search for alien life in the Milky Way galaxy seemed like a fool’s errand to many within the scientific community, not to mention the majority of the public. Today, a great number of scientists from

various fields, and a growing number of individuals from various other walks of life, believe that the existence of extraterrestrial life seems more likely than not. By 1996, nearly 72% of the public believed that alien life in some form exists elsewhere in the universe (according to a Gallup Poll from that year), though it dropped to 61% in 1999 (http://www.poll.gallup.com). The development of astrobiology as a legitimate new field attests to a core support of scientists who joined with others to forge a general change in attitude. Recently, the level of indirect evidence consistent with the possibility of extraterrestrial life has accumulated to reinforce this evolving line of reasoning and acceptance. The more we study the problem of detecting extraterrestrial life, including analogs here on Earth, the more we find clues that support the strong possibility of the existence of such life rather than those that tend to refute it.

Social/Cultural Connections to Astrobiological Findings

The work and passionate explanations of astrobiologists (and space scientists generally) establish strong connections to other elements of society (i.e., individuals, social groups including organizations, institutions, larger society, and a society's culture). Again, the work of astrobiologists especially speaks to the age-old question: are we alone in the universe? The possibility of alien life represents an idea that most human beings seem willing to accept in contemporary societies, yet it was unthinkable before Nicolaus Copernicus' heliocentric planetary theory became widely known during the mid-sixteenth century and started humanity on the road to a new mindset. Is it truly possible that human beings comprise the only intelligent species among all the planets orbiting around the billions of stars within the billions of galaxies in the universe? We live on a seemingly ordinary planet at the outskirts of a typical spiral galaxy in an average part of the cosmos. It seems common today to think that we just cannot be alone. The more we learned about our physical location in the cosmos, the more ordinary we became. Nevertheless, when SETI researchers first set out on their basic undertaking to detect an alien signal, their optimism of success was much higher than that of the average citizen in the United States.

Recently, tangible discoveries have changed things on more of a revolutionary basis. Scientific discoveries made possible by technology supplement our hopes in the existence of extraterrestrial life, suggesting that life in the universe is not confined only to Earth. The possibility of extraterrestrial, *non-human* life, especially microbial life, seems more likely today than even ten years ago due to several astounding developments as related below.

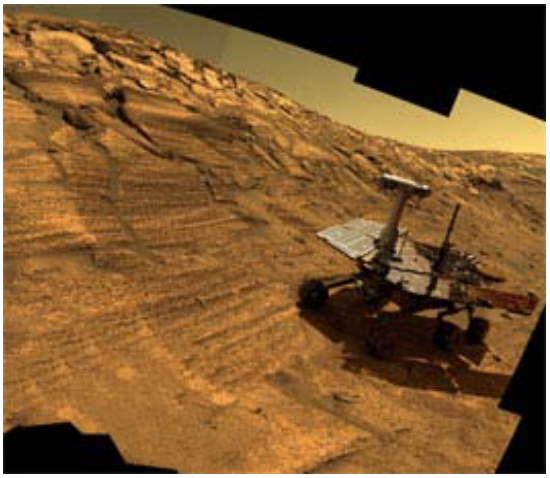

Figure 1. The important findings of the Mars Rovers *Spirit* and *Opportunity*, and supportive orbiting spacecraft, point to past and perhaps present water on the planet, and consequently the possibility of past and/or present life. In 2009, NASA researchers discovered gullies that appeared to collapse due to water seepage from beneath the surface. The rovers represent far-flung elements of material culture; tangible proof of humanity's yearning to explore relatively unknown frontiers for life and for the benefit of humankind. (Photo: NASA).

Figure 2. Terrestrial *extremophiles*, or organisms adapted to live in extreme conditions, demonstrate that life is far more tenacious and thus much more common than previously believed. They include tubeworms that represent life not dependent on the Sun's energy, discovered deep on the ocean floor, as shown to the right. Additional examples of extremophiles include life found: (1) in Mono Lake (a highly

alkaline environment), (2) in Yellowstone's Sylvan Springs (sulfuric acid), (3) within caves deep under-ground in harsh conditions), (4) within Antarctic ice sheets (including Lake Vostok), and (5) thriving on highly radioactive control rods in nuclear power plants. (Photo: National Science Foundation (NSF)).

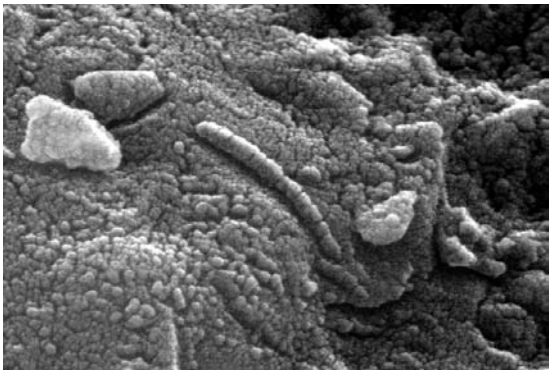

Figure 3. Meteorite ALH 84001, found in the Allan Hills region of Antarctica in 1984, may contain Mars fossils as reported by a NASA team. Whether the claim is true or not, the very possibility provided an additional stirring of the imagination as it relates to alien life. It contributed to the cultural imperative to explore Mars and seek life elsewhere in the solar system (see McKay et al., 1996 for a full discussion. (Photo: NASA).

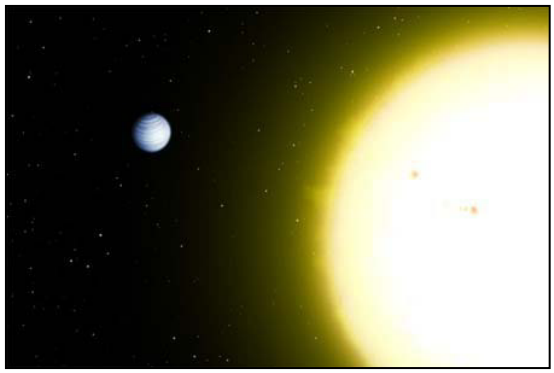

Figure 4. The discovery of more than 370 extrasolar planets as of August 2009 indicates that our solar system is not unique after all. The hunt began with the discovery of *51 Pegasi b* in 1995, a gas giant that is only about 40 light years away. *51 Pegasi b* is a "hot Jupiter" about 150 times the size of Earth and it circles its star called Bellerophon once every four days. Even the discovery of huge gas giants proves our solar system is not unique in the cosmos. Following the detection of what seemed like nothing but large planets such as *51 Pegasi b*, the quest began even more earnestly for Earth-sized planets. The Earth-type planet represents the current challenge and astronomers have had some success. It greatly increases the perceived likelihood of finding extraterrestrial life. NASA's Kepler promises to help place Earth in the proper context. Is Earth unique, uncommon, or "run of the mill" in our universe. Even before Kepler launched, astronomers around the globe had already started their search for Earth-sized planets. (Photo: artist's depiction, en.wikipedia.org).

Figure 5. An "Earth-sized" planet only 5.5 times more massive than Earth, dubbed OGLE-2005-BLG-390Lb, was announced on January 25, 2006. This discovery, depicted to the right, was possible by using the method of "gravitational microlensing." It orbits a red dwarf star approximately 28,000 light years away at 2.5 astronomical units. While probably too cold to support life at more than 360 degrees below Fahrenheit, it provides hope for life elsewhere in the cosmos. It proves smaller planets *do* exist beyond our solar system. In 2009, European scientists from the University of Hertfordshire announced that Gliese 581 e is only 1.9 times the size of Earth but is too close to its star to support life. However, they announced that Gliese 581 d, already known since 2007, lies in the habitable or "Goldilocks" zone. Gliese 581 d could well have a large deep ocean. MOA-2007-BLG-192-L b was discovered in 2008, but recent observations suggest that it is only 1.4 Earth masses representing the closest known planet to Earth's size besides Venus. Similar findings are beginning to accumulate. (Photo: Space Telescope Science Institute (STScI)).

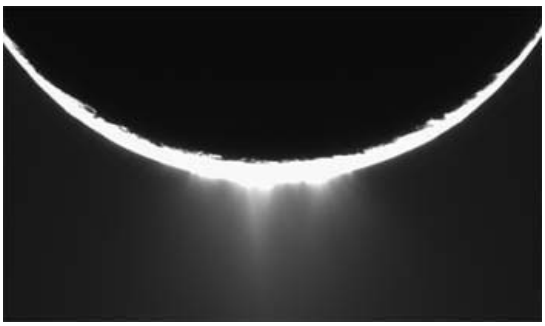

Figure 6. The Cassini spacecraft captured pictures of jets, confirmed as water geysers, coming from the southern polar region of Saturn's moon Enceladus in February, March, and July 2005. Scientists found a relationship between four prominent tiger stripe fractures in hot surface areas and the geysers. This moon orbits close to Saturn and appears as one of the brightest objects in the solar system. The third flyby, only about 170 km above the southern pole, actually flew through the ejected gas. In 2009, scientists found support for water as the source for Enceladus' icy plumes This tiny moon joins Europa, Callisto, Ganymede, and Mars as possible current locations for water in our solar system, and thus for possible extraterrestrial life as well. Water is an essential requirement for life, as we currently understand it (Photo: NASA/JPL).

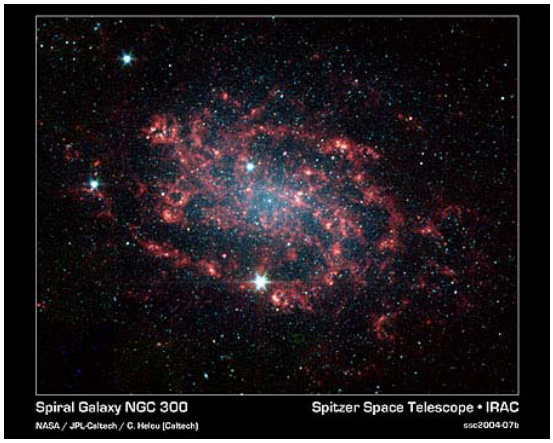

Figure 7. Astronomers have discovered various organic molecules and compounds, including gaseous precursors to DNA and proteins. One example includes a class of molecules called polycyclic aromatic hydro-carbons, or PAHs, found in copious quantities in space. PAHs are used as biomarkers by some researchers. Other examples include organics within comets and asteroids, around young stars, and within cosmic nebulae. The example to right from the Spitzer Space Telescope reveals such organic compounds intermingled among the dust and other materials within Spiral Galaxy NGC 300, a typical galaxy much like our own Milky Way. Based on assumptions consistent with our current understanding of life on Earth (as an analog), this abundance of organic substances in space infers that life itself may well be abundant throughout the universe on planets and other bodies. Recent evidence of this surfaced in 2009 when astronomers at the Max Planck Institute for Radio Astronomy in Bonn, Germany detected two of the most complex molecules ever found outside of our solar system; namely, ethyl formate and n-propyl cyanide (Photo: NASA/Caltech).

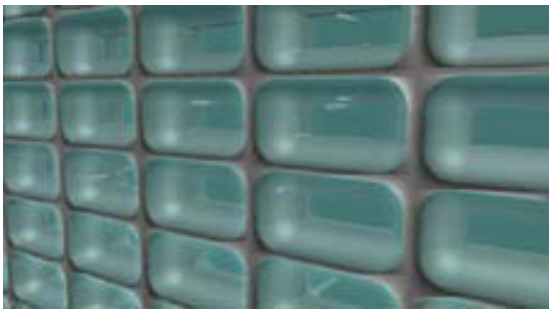

Figure 8. On January 2, 2004, NASA's Stardust spacecraft flew through the dense dust and gas surrounding the icy nucleus of comet Wild 2. In August 2009, scientists discovered for the first time ever one of life's building blocks in the tray of the spacecraft that had returned to Earth in January 2006. Scientists found glycine, an amino acid used by living organisms to make proteins. This discovery is important because, once again, it indicates that the common components of life are common in the universe. This increases the possibility that (1) life exists beyond Earth and (2) the components of life were transferred to Earth long ago by comets and meteorite impacts. The photograph above is an artist's rendition of particle hits on Stardust's aerogel collection grid. Particles appear as dots at the tips of the teardrop-shaped streaks. (Photo: NASA/JPL).

These types of discoveries possess scientific significance in their own right, of course. However, the effects that such discoveries have on the public typically remain overlooked, including influences on non-space scientists.

Hence, astrosociological implications add a missing dimension. Greater awareness among non-astrobiologists potentially provides added support for astrobiology and SETI in the form of encouragement to continue as well as voluntary assistance and monetary donations from public and private circles. This will prove invaluable as NASA faces decreased funding allocated to its science programs generally, and astrobiology specifically, in order to specifically to pay for the President Bush's *Vision for U.S. Space Exploration*, including the *Constellation* program. Potentially, an increasing number of "ordinary" people may indeed feel an increasing level of excitement as the types of indirect evidence discussed above accumulates. In what specific ways does this trend affect the cultures of societies and their socially organized efforts to respond to it? This area of research requires scientific investigation.

In no small manner, the growing supportive evidence for the possibility of alien life in our galaxy creates a growing need to answer questions about where we fit in the cosmic scheme of things. Time and time again, humans theorized that the Earth and humankind were at the center of the organization of the universe only to be proven wrong on a consistent basis. Ideas in our culture today that relate to the possibility of extraterrestrial life contribute to the recently established movement toward favoring the possibility of alien life in contrast to the historically longstanding belief that our human species exists alone at the center of our vast universe. Religious values that once supported the idea that humankind represents the only form of intelligent life in the cosmos had to adapt to changing scientific findings and change their longstanding cultural ideas. Some religious groups, such as the Catholic Church, initially had difficulties with such ideas, but later had an easier time with this process of adaptation than others, which include many fundamentalist groups and anthropocentric cults (Pass, 2005a). Historically, religious groups had to cope with new verified scientific realities that pushed humanity further from its original place of central importance. The increasing insignificance of humankind in the cosmos has undoubtedly affected human thinking and values. Just how this has occurred requires further investigation.

EXPANDING ASTROBIOLOGY

In general, despite its recognition of possible contributions outside of its field, the current focus of astrobiology remains largely preoccupied with biology, planetary geology, and the other physical and natural sciences. Despite this ongoing reality, it seems logical that expansion of this focus to include social and cultural considerations represents the next step. Formal collaboration with astrosociologists would ensure an enduring relationship and a constant focus on the social implications of astrobiological research. It would benefit astrobiologists by providing an expanded perspective, of course. The inclusion of astrosociological issues would demonstrate a connection between astrobiological research findings and their relationship with society. This type of collaboration would provide (1) all scientists with an understanding of astrobiological issues in a broader context and (2) all citizens with a greater understanding about the relationship between alien life and terrestrial life (i.e., to their social lives).

While this proposal does not involve changing the central focus of astrobiology itself, it does in fact involve, as a minimum, the expansion of its ties to the social sciences in the form of formal collaboration with astrosociologists. In the future, one can envision astrosociologists specializing in astrobiological issues, spending their entire careers on the significant implications of astrobiological research on society (and vice versa). Arguably, the social implications of astrobiology and SETI are much more important than the astrobiological findings themselves.

THE ASTROBIOLOGICAL AND ASTROSOCIOLOGICAL IMPLICATIONS OF SETI

Although it developed as purely an independent field, SETI became part of the growing field of astrobiology. In many important ways, this development resulted in a greater scientific standing for SETI. As discussed earlier, the general idea of "trying to communicate with little green men" served as a longtime problem for SETI (Harrison, 2005). In fact, astrosociology and SETI share an interesting common problem: both faced criticism for being linked to topics such as UFOs, alien abductions, crop circles, astrology, and other topics related to the so-called "pseudosciences" (Pass, 2004c). For the most part, SETI has removed the shackles applied to it by critics alleging its connection to non-scientific topics. Astrosociology, in contrast, finds itself at a very early point in its development and therefore more susceptible to such criticisms. It is certainly conceivable that a subdiscipline similar to astrosociology never formed previously due to perceived connections to unscientific subject areas (Pass, 2004c). Collaboration depends on perceptions that both fields are legitimate, so astrosociology must overcome

inaccurate perceptions regarding its true focus although this misconception among some is not serious enough to forestall formal collaborative efforts.

The astrosociological implications of SETI involve issues related to both human societies and extraterrestrial societies. Without the discovery of extraterrestrial message, even scientists can only speculate about (1) how the discovery of such life would affect humans and their societies and (2) what the discovery would yield in terms of the possibilities associated with studying the extraterrestrial civilization in contact with us. Nevertheless, these unknown circumstances compel many individuals and social groups to follow the path of exploration. This process may well better prepare us as a species to cope with the advent of discovering life when it actually occurs. An astrosociological approach can make social problems associated with detection (without evidence of eventual success), such as an reluctance to invest in continuing the search, easier to identify and perhaps easier to mitigate.

As related by Steven Dick below, the more we apply sociology along with the other social sciences and humanities to astrobiological theory and research, the more comprehensive our knowledge becomes for all scientists.

> The goals of involving social scientists and scholars in the humanities in astrobiology include increasing understanding, developing information useful for policy and moving towards "consilience" or the unification of knowledge (Steven Dick in Harrison and Connell, 1999:27).

Each of these benefits is significant. First, astrobiologists do their work in the context of society, and thus the implications of their work involve understanding astrobiological issues in a social/cultural context, both with applications to human societies and potentially even to extraterrestrial societies. The very exercise of investigating the Milky Way Galaxy for non-human life pays dividends in many forms, including gaining a better understanding of ourselves in the process. Second, space policy regarding extraterrestrial life must take into account social and cultural considerations that move the process well beyond just focusing on astrobiological criteria (in the present case). Without a more expansive view, well-informed decisions are less likely. Policy decisions in other areas benefit from input from multiple perspectives, so space policy must take a similar approach and take advantage of astrosociological research. Third, the unification of knowledge always represents a grand goal of science. Any field, including astrobiology, possesses less explanatory power and less relevance in isolation. The addition of astrosociological knowledge results in a new and powerful perspective currently relatively unknown to most astrobiologists. Each of these areas further points to the increasingly important relationship between astrobiology and the developing field of astrosociology.

The social and cultural implications of space phenomena reflect preexisting concerns (though the study of them remains largely untapped). In fact, in 1961, at the first SETI meeting in Green Bank, West Virginia, radio astronomer Frank Drake first proposed his analytical tool for estimating the number of communicative civilizations in our galaxy. Since that time, scientists have proposed several attempted refinements to Drake's proposal (Seeds and Backman, 2009; http://www.cplire.ru/html/ra&sr/irm/Drake_equation.html). The original Drake equation appears below (http://www.seti.org/drakeequation):

$$N = R_* \bullet f_p \bullet n_e \bullet f_l \bullet f_i \bullet f_c \bullet L,$$

where **N** = the number of civilizations in the Milky Way Galaxy whose electromagnetic emissions are detectable;
$\mathbf{R_*}$ = the rate of formation of stars suitable for the development of intelligent life;
$\mathbf{f_p}$ = the fraction of those stars with planetary systems;
$\mathbf{n_e}$ = the number of planets, per solar system, with an environment suitable for life;
$\mathbf{f_l}$ = the fraction of suitable planets on which life actually appears;
$\mathbf{f_i}$ = the fraction of life bearing planets on which intelligent life emerges;
$\mathbf{f_c}$ = the fraction of civilizations that develop a technology that releases detectable signs of their existence into space; and:
L = the length of time such civilizations release detectable signals into space.

Most of the variables in the equation obviously relate to space phenomena, yet the final two also relate to a different set of astrosocial phenomena related to a non-human, currently hypothetical civilization. These two variables place a great deal of unpredictability into the solution of the dependent variable, N, once intelligent life emerges. They point out that extraterrestrial societies must develop and progress for an appreciably long time in order to make radio astronomy and other technologies possible. How common is this? Currently, we can only guess. The last variable, L, is probably the most controversial estimate, though the successful survival of the human species beyond the Cold War perhaps provides many scientists with greater optimism. Others, however, can point to the fact that humanity's survival during that era faced several precarious moments. Objectively, the possibility of a civilization destroying itself appears to be a very real danger if humanity's modern history is any indication.

What do our estimates of these values tell us about ourselves, including how much we dislike the idea of being alone in the universe? What do they tell us about how we will react to the detection of extraterrestrial life, should it occur? We do not want to be alone in the universe. On the other hand, can we handle definite proof of intelligent extraterrestrial beings? Perhaps at least some of those who offer low values are trying to protect the status quo of a solitary human intelligence. Examples may include fundamentalist sects and various types of cults. Nonscientific agendas always exist among scientists, as they do with all professions.

The contributions of social scientists and scholars in the humanities represent a vital source of missing data. The example of the Drake equation serves to illustrate the point that the silence of these scientists and scholars virtually guarantees a greater level of uncertainly about their most logical values. The last two variables directly relate to extraterrestrial societies and require input from the very scientists who specialize in the study of societies and behavioral issues. The Drake equation should have made it clear long ago that the social sciences and humanities were essential. Why have the space scientists shown reluctance to invite a greater level of formal participation from the social scientists? Conversely, why have the scientists within social science disciplines failed to demand their inclusion? While a few social scientists and scholars from the humanities participated all along, the formal development of a new social science-based field never occurred until now; and hence a coordinated, large-scale form of collaboration was never likely. Arguably, the need for formal collaboration between astrobiology and astrosociology exists now more than ever before. For example, leading SETI scientist Seth Shostak of the SETI Institute has predicted the successful alien contact within the next twenty years (Shostak and Barnett, 2009). This prediction assumes that alien life exists and other factors.

The Social, Cultural, and Ethical Implications of Detection

The potential of the social sciences to contribute appreciably to our overall understanding of astrobiological issues cannot be judged as a truly new approach as exemplified by social scientists' ongoing, though uncommon, participation. One cannot overestimate the need for their *formal* collaboration with the physical and natural sciences too strongly or too often due to the significant knowledge that can result for the field of astrobiology. The confirmed detection of extraterrestrial life by astrobiologists involves complex and varied issues that require serious and advanced investigation. That is, such a confirmation, especially regarding intelligent life, would transform human societies in countless and unexpected ways (see, for example, Vakoch and Lee, 2000; Tough, 1998; Harrison, 1997). The policy makers of different societies will need facts within the proper cultural context in order to manage crises and other forms of social change that may occur.

> There are important questions about the days, weeks and months after detection, then the intervening years as we get used to the idea that we are not alone, and then the long term consequences, which will mirror in their significance the discoveries of Galileo, Newton and Darwin. These questions embrace most fields of human endeavor. They are of obvious import for science. However, the point of this meeting is to examine the broader societal issues, and so focus on human behavior. Key areas are anthropology, sociology, and individual, group and social psychology. Reactions will vary according to the social attributes of individuals, and the social, economic and political contexts within which the discovery has occurred. Other important questions are the history of analogous events in our past; political, institutional, international, governmental and legal affairs; the effects on different organized and diffuse religions; the media; and education. There are broad cultural and ethical issues [as well] (Harrison and Connell, 1999).

Unfortunately, insights such as those above continue to exist on the outer periphery of acceptance within the physical and natural sciences, at least in practice. The successful meeting of the goals of SETI, and more generally of astrobiology, clearly requires the support of social scientists. If SETI researchers and astrobiologists truly expect to discover extraterrestrial life, they should strive to prepare themselves for this eventual outcome. From the other side of the divide, astrosociologists must organize themselves *now* and formally collaborate with space scientists. Otherwise, their assistance will occur after the fact in the midst of the confusion caused by news of the discovery of extraterrestrial life, especially intelligent life. Under such circumstances, social scientists are much more likely to participate in an unorganized fashion, yielding less helpful results. An unprepared society may well prove more likely to make unethical decisions regarding their citizen's various reactions should they prove excessively threatening to social order. An analogous example involves how authorities react to civil disorders that occur on a massive scale following power outages. Wide-scale panic following news of the conformation of alien life could occur, and excessive force may result as a way to quell the deviant behavior that follows.

According to Douglas Vakoch of the SETI Institute, we should conduct research prior to detection in order to anticipate the various reactions from various cultures and subcultures around the world so that we can develop relevant and effective policies when detection occurs:

> There are many cultural and individual differences in expectations about life in the universe and how different expectations are likely to prompt different responses to the discovery of extraterrestrial life. Therefore we should conduct empirical studies relating cultural and individual differences to beliefs in extraterrestrial life and how the discovery of such life could influence humanity (Harrison and Connell, 1999).

Because various societies possess dissimilar cultures and social structures beyond very general universals, dissimilar reactions to proof of an extraterrestrial civilization will inevitably occur. The major institutions of these different societies (e.g., politics, economy, religion, family, criminal justice system, education) would logically need to adapt differently. Even subcultures within various segments of the same society would vary. The greater we can understand all of these differences among all of our social systems, and differences within each of them, the better we can hope to deal with the news that we are no longer alone in the universe.

Although the citizens of human societies are exposed continually to new discoveries associated with the seemingly greater likelihood of extraterrestrial intelligence – tempered greatly by evidence of possible microbial life as discussed earlier – the actual detection of an extraterrestrial signal would reflect a much different set of reactions. We cannot assume that humankind ever experienced this type of shift in its sense of social reality; and so, we cannot expect to know how various social groups and individuals will react to it. The analogous examples of clashes between human cultures for the first time, as occurred during human history, may serve as a helpful model, though the extraterrestrial component may well present humanity with an unprecedented new perspective regarding its place in the universe. Accordingly, the need for the involvement of astrosociologists in preparing for, and reacting to, a confirmed indication of extraterrestrial intelligent life seems obvious and therefore represents a high priority.

Social/Cultural Considerations Related to Sending Interstellar Messages

The social sciences can prove themselves valuable in devising added ways to construct interstellar messages. In order to communicate successfully with an alien species, it becomes necessary to understand their culture and social organization. While possessing such knowledge is obviously impossible, we can make educated guesses about alien civilizations. The best way to do this with any modicum of success relates to the idea that we must first understand human cultures and extrapolate from there. Astrobiologists currently focus overwhelmingly on the potential biological characteristics of extraterrestrial beings, though many consider issues related to the potential characteristics of their psychology and social systems (Shostak, 1998). The collaboration between astrobiology and astrosociology would result in a complementary approach and, in so doing, a comprehensive perspective.

Shifting to the area of message construction, mathematical formats may prove to be universal forms of communication as many SETI scientists argue. However, it seems best to formulate and send messages based on several different root concepts, including those from the social sciences, humanities, and the arts. Mathematics

seems like the more obvious approach while the assumptions made for messages based on social and cultural concepts may prove a bit more difficult. Nevertheless, determination of universal social and cultural concepts can prove an extremely useful exercise in trying to understand alien civilizations and ourselves as well. We cannot know how best to communicate with an alien intelligence beforehand, so we should develop alternative methods – any of which may prove helpful as a single tool or combined with others. We should not focus solely on principles related to mathematics or the concepts of the "hard" sciences lest we miss the chance to develop a breakthrough by establishing shared meaning.

Music represents another form of mathematical communication created within social groups by individuals for the enjoyment of themselves and others in various segments of a particular society and worldwide. We find certain patterns of sounds enjoyable, so we must consider the possibility that sending messages based on musical notation may indeed tie into a universal body of knowledge on a cosmic scale. Music is a good example of the combination of the physical and social sciences. Culture plays an important role as do the atmospheric conditions of a civilization's planet. However, knowledge about the musical notations of an extraterrestrial society may reveal important clues about its culture. For our part, humanity sent a disc aboard the two Voyager spacecraft that included musical examples from cultures around the Earth in addition to other selections. While largely symbolic, it demonstrates that music is a central feature of human social interaction. In addition, we must also look for musical coding within any messages we may detect. Musical notes are universal, based on a shared physics throughout the cosmos, so we can assume that certain commonalities may exist.

Exercises involving construction of interstellar messages possess important lessons for humanity. They can assist us in determining our levels of ethnocentrism and thereby allow us to overcome them. Even if we never detect intelligent extraterrestrial life, we can learn more about ourselves as well as our differences among human cultures. On the other hand, such exercises will prepare humanity for interacting with another intelligent species, if that is indeed possible. Through understanding our own cultural idiosyncrasies and deficiencies, we may be better prepared to communicate with aliens without projecting arrogance, hostility, or other potentially negative traits. We should keep in mind that we could better anticipate future possibilities by examining past cultural ideas and actual events (Vakoch, 2000). This will assist us to advance as a species and our societies will advance as well.

We must view both the construction of interstellar messages and the pursuit of their detection as exercises that contribute to our own development as both a species and a collection of social beings capable of bettering ourselves along with the societies in which we live. Astrosociologists can help us to identify the lessons we learn along the way and incorporate them into our own development as an intelligent terrestrial species. This element of our pursuit of verifying extraterrestrial life is vitally important to the human species, and therefore it deserves attention in its own right. Under this line of reasoning, we may then consider the confirmation of a signal signifying extraterrestrial intelligence as a secondary outcome.

SUMMARY: COLLABORATION AND INCREASED UNDERSTANDING

This article has touched on important issues related to astrosociology's development and its relationship to astrobiology, a relationship highly relevant to the other space sciences in many ways. Its primarily purpose relates to the promotion of new ways of thinking about the connections between the two fields of astrobiology and astrosociology, and thereby about one more important reason for establishing formal collaboration between the two. The astrosociological implications of astrobiology abound yet, historically, they attract very little formal interest from the professional organizations within the space sciences and, sadly, from the main professional organizations representing the social sciences. Among the important objectives of the development of astrosociology are changes consistent with fostering formal collaboration with the fields of astrobiology and SETI.

Therefore, astrobiologists and other scientists in the physical/natural sciences comprise the intended audience of this article. Social scientists comprise a vital secondary audience, especially for those already focusing on astrosocial phenomena as individuals or within small groups. For the field of astrosociology, it is important to begin development of a coherent body of knowledge and literature focusing on the astrosociological implications of astrobiology. Such an organizing effort creates something tangible for those interested in astrosocial phenomena with which to identify and connect. Astrosociology must develop simultaneously by better organizing itself and by seeking collaborative relationships with astrobiologists.

We must open ourselves up to possibilities that are more inclusive for the future. Rather than utilizing space exploration to stir the imaginations of only potential space scientists and engineers among our youth, we should also do the same to motivate all potential scientists. As an additional step, we must utilize space exploration to encourage potential astrosociologists to follow a different, though related, path. In order to ensure the greatest, most comprehensive understanding of humanity's destiny in space, we must encourage participation by students in the physical and natural sciences along with those in the engineering disciplines, who serve as the usual targets. Moreover, we need to encourage those in the social and behavioral sciences, and the humanities, to become involved in the study of astrosocial phenomena in an astrobiological context. This implies that government agencies and private organizations should bring the inspirational effects produced by outer space into social science classrooms. It is in our best interests to make funding available for astrosociological programs as well as for astrobiological ones.

Those in the "soft" sciences will become increasingly important in the future. Many social scientists refer to their particular disciplines as comprising the "harder sciences" due to the difficulty of studying a subject matter that is both complex, reactive to investigations, and ever changing. This makes the "laws of behavior" more elusive than the laws of inorganic nature. While many may see this shifting characteristic of social forces and behavioral laws as a weakness, we should view it as simply a greater difficulty facing social and behavioral scientists, and nothing more. For astrosociologists, social reality is a fact that lends itself to scientific scrutiny, and hence social forces and social conditions are identifiable and testable. They result in a greater understanding of the human condition. More precisely, because astrosocial phenomena exist, they must receive the attention of astrosociologists and others lest we venture into the cosmos blindly, both literally and figuratively.

The work of astrobiologists increasingly makes the possibility of extraterrestrial life seem more and more likely. Astrosociologists, in the process, increasingly recognize the implications of this trend for all elements of human organization and future possibilities. Social scientists have shown that ideas can have powerful effects on social and cultural patterns. We must recognize how accumulated knowledge regarding the growing possibility of detecting extraterrestrial life produces changes in nonscientific parts of societies, and how these changes influence the level and orientation of human efforts to continue the search in the future.

ET life may not exist at all (Ward and Brownlee, 2000). Even so, the very search for extraterrestrial life affects societies. However, imagine what would happen to them if astrobiologists actually verified ET life beyond question! Astrobiologists would be elated should such a reality occur. At this point, astrosociologists would need to determine how this discovery affects societies, their social groups and subcultures, and various individuals. This scenario clearly provides another example that justifies the need for astrosociology at some future point in history. Even before contact, astrosociologists should concentrate on the connection between the public and science (Jakosky, 2006) – astrobiology in the present case – in order to establish better predictive models concerning the reactions of various social groups to the confirmation of ET life.

Thus, in the present context, astrosociology focuses on how astrobiologists produce new knowledge and how this knowledge affects society. This focus includes the practical uses of astrobiological discoveries as well as how these discoveries affect a particular society's larger culture, its subcultures, and its social structures. Astrobiologists should find interest in astrosociological research because they conduct their research within a society; and more specifically, within a supportive organization within their society. Like all of us, they do not work in a vacuum. Astrobiologists have much to gain by embracing astrosociology because the social and cultural implications of their work impact greatly on their societies and their societies influence them as well.

On an abstract level, the impact of astrobiologists' work on society is relevant as contributory to the existing knowledge base. That alone should suffice. Scientific and technological applications of their work in other areas of social life are much more tangible. On a more practical level, the impact of their work on society also relates to their funding level in the overall scheme of priorities. No matter how one chooses to view it, the relationship between astrobiology and astrosociology is significant and therefore deserves attention. Astrosociology provides a context for astrobiology; that is, a social/cultural orientation for an important area of study within the natural and physical sciences.

CONCLUSION

Consider the following question. Based on the foregoing arguments, how can we continue practicing space science and engineering without input from the social and behavioral sciences, the humanities, and the arts (represented by the field of astrosociology)? Human behavior becomes much more critical to our efforts as humans move farther into the vastness of space. We must find ways to compel each of the relevant sciences to work together as a comprehensive whole. Astrosociology can serve as the catalyst and common denominator making a multidisciplinary field possible. While it will not focus on the same exact pursuits relevant to making discoveries concerning extremophiles and a second genesis of life within the natural and physical sciences, it will focus on how these discoveries and their related ideas affect human societies. In addition, astrosociology will ideally contribute by demonstrating the importance of space science and exploration to society. Currently, this social reality largely eludes us.

The examples provided regarding discoveries made by astrosociologists that are supportive of extraterrestrial life beyond Earth are occurring with increasing frequency. Despite the fact that we live in a violent and destructive universe, it seems only a matter of time before the first discovery of the evidence for alien life presents humanity with a serious reorientation of its place in the overall scheme of things. Such a shakeup to our long-term perspectives requires understanding about how this new knowledge affects social reality on the individual, group, subcultural, cultural, societal, and global scales. Humanity as a species will change in fundamental ways.

While important work regarding the social-scientific implications of astrobiology have occurred, the scope has been limited and needs to increase in the near future. We need to take an interdisciplinary approach to a multidisciplinary subject matter that incorporates both major branches of science. The astrosociological implications of astrobiology demand an expansion of traditional approaches due to their significant effects on humanity: past, present, and future. Consequently, the astrosociological implications of astrobiology strongly suggest that astrobiologists should take advantage of what social and behavioral scientists can offer them.

It thus remains important for both astrobiologists and astrosociologists to recognize that each of their fields corresponds to one side of a two-sided coin. Each side must be willing to turn over the coin in order to reveal the other side, and thereby gain a more comprehensive perspective common to both as represented by the entire coin. Otherwise, astrobiologists along with all space scientists and engineers will continue to conduct their work and affect societies in the process as usual, though no one will fully understand either the characteristics of their influences or how to take advantage of this missing knowledge for the benefit of all levels of social reality. In closing, another question comes to mind: Can we afford to operate within the limited constraints of the status quo or should we take advantage of both sides of that conceptual coin?

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