NASA Technical Memorandum

WORKSHOP ON THE SOCIETAL IMPLICATIONS OF ASTROBIOLOGY

FINAL REPORT

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DATE: December 15, 2000

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Attached is the final report of the Societal Implications of Astrobiology Workshop. Those of us who labored to bring this workshop into being are indebted to the authors of the Astrobiology Roadmap, which confirms the importance of societal issues to the Astrobiology Program at NASA.

As an unfunded activity we have depended upon the generosity of friends of astrobiology, particularly Dr. Steven Dick, Dr. Ken Rose, and Dr. Al Harrison. I want to take this opportunity to thank you for your continued support and encouragement with respect to investigation into the societal implications of astrobiology. I am confident the findings of this workshop will build a firm foundation for the next level of research in this critical area of importance to both NASA and the general public.

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SOCIETAL IMPLICATIONS OF ASTROBIOLOGY
EXECUTIVE SUMMARY

Revised January 20, 2001

Astrobiology is 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 seek to understand the origins and evolution of life, people who search for evidence of life beyond Earth, and people who seek to establish a permanent human presence in space. Astrobiology addresses some of the most crucial and provocative issues ever explored by humankind. Only now, with new capabilities to access of space coupled with convergent revolutions in many technologies, can we expect to become a spacefaring people and find answers to these age-old questions.

Astrobiology rests upon a remarkable confluence of science, technology, and popular culture. This historical juncture invites collaborative and indeed synergistic action on the part of scientists from virtually all disciplines and the public. Through astrobiology we learn about the boundary conditions surrounding our own existence. Discovering how life begins and develops, finding out whether life exists elsewhere, and determining our future on Earth and beyond will have a profound and fundamental effect on the human species. Astrobiology affects our views of the universe, our science, our culture, and ourselves—in short, every aspect of our existence.

The Societal Implications of Astrobiology Workshop convened at NASA Ames Research Center on November 16-17, 1999, to discuss topics such as, the implications of astrobiology for human psychology, society, and culture, and the contributions that the social sciences can make to the field of astrobiology. The workshop was organized around four questions; (1) Why do we search for life or its beginnings? (2) What are the implications of observation of life and human exploration off the home planet? (3) How should we respond to the discovery of life elsewhere? (4) What is the evolutionary fate of human societies and cultures beyond the home planet? The workshop concluded with a general discussion leading to a set of research topics and action items.

Summary of Findings

- Research on the societal implications of Astrobiology is an important corollary of core research in the physical and biological sciences. This type of research is crucial for understanding public support for Astrobiology and for gauging public reaction to astrobiological discoveries. Preparing for future developments in

space exploration of all types requires establishing clear ways to address issues in philosophy and religion while inspiring society's appreciation of the cosmos as a possibly infinite sea of living worlds. Research on the societal implications of astrobiology can inform policy decisions.

- Interdisciplinary and multidisciplinary work is imperative. There must be close coordination between the scientists who conduct the research and those who can shed light on the social implications. A satisfactory overall research program would be broad, multidisciplinary, and structured in such a way as to permit meaningful quantitative comparisons, and enable cogent explanations of the findings. Thoughtful and effective collaboration may break down the barriers that separate different intellectual fields and move us in the direction of consilience, or the unification of knowledge.

- Large segments of the public are already interested in astrobiology. There are long-standing and strong interests in the possibility of life elsewhere and in human activity beyond our planet's surface. Each of these twin pillars of astrobiology has religious, moral, and ethical dimensions. Astrobiology is a great opportunity to raise the level of public discourse by involving people in discussions of the major issues of the cosmos. Ultimately, Astrobiology's success or failure will depend on public support. Not everyone is interested in astrobiology, and there may be strong resistance from people whose religious beliefs or worldviews are challenged by the assumptions or findings of astrobiology.

- To engage the public will require a true interactive dialogue. To achieve this, we must foster mutual respect and learn as well as teach. We must ac-knowledge that for many people science does not have all of the answers.

- During the last 50 years science has given us an increasingly convincing story of cosmic evolution, and placed theories of simple, complex, and even intelligent extraterrestrial life on a firm footing. Changing ideas about the abundance of life in the universe have affected people's worldviews, and the actual discovery of extraterrestrial life could have a phenomenal impact.

- The discovery of cosmically local, independent life or "second genesis" will suggest that the universe is teeming with life. Eventually, we might conclude that the universe tends towards creating life forms that are complex, intelligent, and conscious and that we ourselves are but one example among a multitude. This could lead to shifting our frame of reference from Earth to the cosmos, and a conviction that life everywhere is highly valuable. Policy measures should be taken to ensure the integrity of extraterrestrial life.

- Despite preconceptions, we have no real knowledge about extraterrestrial life forms and civilizations, if such exist. Whether the first confirmed detection is

fossilized or alive, microbial or intelligent, it is extremely important for us to be highly knowledgeable about the likely reactions of different constituencies (the press, various religious groups, political leaders, and the general public). We would be foolish and negligent if we did not study such reactions well ahead of time and make state-of-the art preparations for major discoveries. Carefully prepared plans should be in place very soon, because evidence of extraterrestrial life could be found at any time.

- Advanced planning should encompass a range of detection scenarios, with more emphasis on the kinds of discoveries that might be made through astrobiological research. Some scenarios have received closer scrutiny than have others; for example, a fair amount of work has been done on the consequences of detecting, by means of radio telescope, an extraterrestrial civilization elsewhere in the galaxy. But very little work has been done on the consequences of detecting a single-celled life form elsewhere in the solar system. Confirmed discoveries of single-celled fossils on Mars or simple life forms on Europa could have profound effects on world-views and religious beliefs, and will raise many ethical and practical issues. We need formal post-detection protocols for single celled organisms as well as for advanced technological civilizations.

- For many people religion is a useful adaptive tool and discovery of extraterrestrial life may stimulate a worldwide resurgence in religious activity. In the actual event of encountering extraterrestrial life, some of the needs of humanity as a whole may require the kind of non-scientific solutions provided by religion.

- Human migration into space is likely to yield five major benefits. Tomorrow's spacefarers are likely to enjoy. (1) Mining, low-gravity manufacturing, tourism, and other material benefits. (2) A new frontier, a destination for pioneers and adventurers. (3) Greatly reduced chances of human extinction from a worldwide war, meteor impact, or other catastrophe. (4) The evolution and flourishing of a diversity of cultures. (5) A suitable off-Earth meeting ground if needed for interaction with intelligent extraterrestrial beings or robots.

- The immediate benefits of space exploration are very important. In our efforts to understand our neighbors, the Moon and Mars provide opportunities for students to become involved in learning about science. Recent exploration has stimulated an interest in math, science, and engineering, but history shows that there must be significant, ongoing events to maintain that interest.

- For decades, international treaties have guided space-exploring nations and policies aimed at avoiding harmful cross contamination, but there has been little attention paid to the ethical dimensions of exploration itself. In light of our advancing capabilities, it is prudent to consider not only how we undertake

space exploration but also the implications of invasive activities on planets where life is encountered.

- Ethical issues surround not only interference with a flourishing ecology but also initiating ecopoiesis, terraforming, and other activities that could bring a "dead" planet to life. Normative principles of environmental ethics are based on some combination of three fundamental positions: (1) Anti-humanism, the notion that human action is inevitably harmful. (2) Stewardship, a requirement that humans must use nature wisely for their own benefit. (3) Intrinsic worth, the supposition that planetary resources, including indigenous life, have value regardless of their utility to humans.

- If we continue to refer back to past human experience to think ahead about the coming human expansion into space, we should do so by critically examining the human record over the entire globe. Such an exercise should be coordinated also with a serious consideration of what key technologies lie over the horizon. Then mix these together to simulate not one rigid path to the future, but a number of possible scenarios for expansion beyond Earth. There is no single future to predict only alternative futures to model.

- Policy implications of establishing a permanent presence in space include. (1) Allocating sufficient resources to enable increasingly larger groups of people to live far from Earth. (2) Moving beyond the traditional view of astronauts and cosmonauts and encouraging diversity among spacefarers (3) Exploring genetic engineering and bioengineering as tools for helping spacefarers adapt to their extraterrestrial niches. (4) Giving spacefarers as much freedom as possible to evolve their own adaptive sociopolitical forms and cultures.

- Given the immeasurable value of life, intelligence, and consciousness. Also given that we are aware of the possibility of extinction and can consciously and proactively seek to ensure our long term survival, we should explore long-term survival issues such as genetic engineering, extraterrestrial migration, directed panspermia, and willingness to collaborate with extraterrestrial civilizations if such are found.

- The crucial turning point for humanity will come when we view our home as the cosmos, not just as the Earth. At that time we will not be one species, we will be many, and given the varied ecological niches in space, our diversity will be a virtue.

Areas for Future Research

Workshop participants developed a strong case for a high level of research and outreach efforts before the fact. Research on the societal implications of

astrobiology should be incorporated into core science initiatives as well as education and outreach activities.

- What are the biological, psychological, and cultural factors that compel humankind to envision life beyond our planet's surface? Why do we seek evidence of extraterrestrial life and intelligence, and why do we strive to establish a continuing human presence off of our home planet? Is there an "extraterrestrial imperative" that pushes us towards the stars? How do these forces vary across individuals and cultures? The public's attitudes towards astrobiology rest on multiple motives that are important to understand in their own right, also because they can speed or retard astrobiological research

- There are many cultural and individual differences in expectations about life in the universe. 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. We may not be able to make specific predictions of reactions to extraterrestrial life, but we can explore the possibilities in a systematic way. By developing sound research strategies and measurement devices early on, we will be able to mount prompt research efforts following any announcement of the confirmation of extraterrestrial life. At that point we will not have to undertake lengthy preparations before we can collect the information that we need to "manage" contact and plan for the post-contact world.

- Our discussion has focused on attitudes found within contemporary western society. Yet, astrobiology has implications for all of humankind. One urgent requirement is to extend our explorations to people from radically different societies, religions, and cultures. As we conduct such investigations we must be mindful to avoid arrogance and show sensitivity to cultural differences.

- How can we formulate a cohesive plan of action for short-term and long-term response to Extraterrestrial Intelligence (ETI)? Possible strategies include the following. (1)Developing scenario-contingent strategies for managing discovery and its aftermath; undertaking studies based on analogues in the humanities and history. (2) The social and behavioral sciences, and science fiction to determine likely reactions. (3) Undertaking carefully planned cross-cultural polls and other empirical studies. (4) Exploring the capacity of religion as a resource to absorb impact of discovery and to maintain beneficial relations with ETI.

- The consequences for society of the discovery of extraterrestrial life will greatly depend very much on the nature of that life, where it is found, and how the discovery unfolds. Whereas we cannot with any certainty predict this response, we can systematically review some of the possibilities. This will require further discussions involving representatives of disciplines and viewpoints that were not

present at this workshop, empirical research, and efforts to tie research to policy recommendations.

- What are the implications for humans of different strategies for robotic and piloted missions within our solar system and beyond? What are possible biological, psychological, and cultural consequences of human migration beyond our home planet? How might we envision interplanetary and interstellar humanity?

- What are the ethical issues involved in exploring other planets? How might these lead to policies that define appropriate and inappropriate life-altering interventions? What practical steps could we take to implement these policies?

- How can we use astrobiology to develop new and powerful educational tools to engage the interests of contemporary students and broaden their understanding of physical, natural and social sciences? Can we develop a multimedia approach based on a combination of interactive web sites, television programming, and publications? Would it be possible to engage partners from the private sector in this massive venture?

Action Items

- *Establish a Steering Committee* composed of a small but diverse group of astrobiologists, social scientists, and scholars in the humanities to develop a long-range plan and guide its implementation.

- *Establish a Circle of Consultants* to assist the Steering Committee. Comprised of known leaders within various fields, members of the circle would draw the attention of the Steering Committee to pertinent high quality research within the group members' scholarly discipline.

- *Ensure Close Coordination among Scientists, Social Scientists, and Scholars in the humanities.* Science and society are deeply and irrevocably intertwined. and A mutual appreciation of the close relationship is vital to the integrity of both fields.

- *Establish an Electronic Forum for Continuing the Dialogue.* As a relatively low cost and quick measure, we recommend establishing an electronic forum on the World Wide Web.

Conclusion

The twin pillars of astrobiology—searching for evidence of extraterrestrial life and preparing for a future where men and women will live far away from their native planet—have profound implications for current and future generations. Astrobiology provides an excellent opportunity to captivate the interest of the public and initiate a broad dialogue on humanity's future. This rich and multifaceted field offers a magnificent opportunity to raise the level of public discourse, to involve people in discussions of the major issues of the cosmos.

In our attempts to engage the public in astrobiology, we must foster mutual respect and build a true dialogue. A dialogue is not to be confused with telling people how it is, or what they should do. We should present our ideas, but also listen. Because of the complex multidisciplinary nature of astrobiology and because of its profound implications we must be attuned to society. Rather than avoiding controversy we should engage controversy rapidly and fully. We must also recognize that for many people science does not have all of the answers. As experts, our views will not necessarily be given more weight than anyone else's will. Religion shapes many people's worldviews and helps them adapt to changing conditions.

Scientists who do cutting edge research are not necessarily the best communicators. People who can serve as interpreters—representing scientific views to the public and the public's views to the scientific community—will be very valuable. Unfortunately, K-12 teachers, lecturers, and other people who serve interpretive roles tend to be undervalued.

As we work with the public we can capitalize on their sense of awe and wonder, on their pre-existing interest in the "deepening mystery" of the universe. We can discuss strange and wonderful possibilities. Yet it is crucial to maintain scientific values and research credibility despite engaging in very far-ranging discussions with a wide variety of people. Astrobiology is posed to be a new and powerful interface between the space science and the public. NASA is advised to actively embrace the inherent dialogic opportunities that this meta-science offers.

TUESDAY, NOVEMBER 16, 1999
PLENARY SESSIONS

Introductions
Greg Schmidt, NASA ARC

Welcome to the Meeting
Henry McDonald, Director, NASA ARC

Astrobiology is an important interest within National Aeronautics and Space Administration (NASA) and a specialty at Ames Research Center. Astrobiology is concerned with life in space—both the search for extraterrestrial life and human life within the solar system and beyond. In science, astrobiology provides an umbrella for a broad array of research activities with profound theoretical and practical implications. For the public, astrobiology combines two exciting topics that have already captured many people's interests. For many people, some mixture of science and imagination have already led to the presumption that there is life out there, or to the presumption that some future generation of humans might migrate to the stars. These presumptions may or may not be correct, especially in their particulars. Consequently, we must at once improve our understanding of likely societal reactions to astrobiology discoveries and achievements, and mount educational efforts to create realistic expectations and smooth the path for our scientific efforts.

Overview of Astrobiology
David Morrison, Director, Space, NASA ARC

Astrobiology provides a biological perspective to NASA science. Astrobiology's three profound thematic questions—How does life begin and evolve? Does life exist elsewhere in the universe? What is life's future on Earth and beyond?—Link such far-ranging topics as the search for habitable planets, exploration missions to Mars and Europa, ecological implications of Global Change, and human expansion into space.

How does life begin and evolve? This question subsumes understanding how life arose on the Earth; determining the general principles governing the organization of matter into living systems; exploring how life evolves on the molecular, organism, and ecosystem levels; and determining how our planet's biosphere has co-evolved with the Earth.

Does life exist elsewhere in the universe? Critical here are establishing limits for life in environments that provide analogues for conditions on other worlds; 1) determining what makes a planet habitable and how common these worlds are in

the universe; 2) determining how to recognize the signature of life on other worlds; 3) and determining whether there is (or once was) life elsewhere in our solar system, particularly on Mars and Europa.

What is life's future on Earth and beyond? To address this question we must determine how ecosystems respond to environmental change on time-scales relevant to human life on Earth. We must also understand the response of terrestrial life to conditions in space or on other planets.

Astrobiology has four operating principles. First, astrobiology is a multidisciplinary science. The field requires meta-strategies which are over and above disciplinary based strategies, and many different disciplines working together to achieve astrobiological goals. Second, astrobiology requires planetary stewardship. This includes the protection of Earth, and careful attention to the ethics of exporting terrestrial life and terraforming other planets. Third, there is a strong ethic of social responsibility. Astrobiology has important implications for philosophy, theology, health, politics, and many other crucial disciplines. Finally, astrobiology has great public appeal, and it is crucial for astrobiologists to share their work with students and the public.

Each of astrobiology's four operating principles underscores the need for including social scientists and scholars in the humanities in the overall effort. Particularly pertinent for the present worskshop is Principle Three, that acknowledges a broad societal interest in such areas as the search for extraterrestrial life and engineered life forms adapted to live on other worlds. In keeping with the spirit of Principle Three, the July 1998 Roadmap Workshop formulated the following question: How will astrobiology affect and interact with human societies and cultures?

The Mission of the Workshop
Baruch Blumberg, NASA Astrobiology Institute Director

A long chain of events gave rise to astrobiology. This chain goes back to Copernicus's discovery that the Earth revolves around the Sun and includes modern findings such as the Big Bang theory, the expansion of galaxies, and Carl Sagan's view of Earth as a lonely "pale blue dot." For some people, astrobiology's issues have an almost mystical quality. Who are we? How did we get here? What is our role in the Universe? Are we alone? As Lewis and Clark were once prepared to depart into uncharted areas of North America, astrobiologists are prepared to explore the furthest reaches of space. Even though some of the questions of astrobiology have strong emotional significance, we must remember that we are scientists with powerful means for addressing these questions. We are able to maintain objectivity while studying topics that some people associate with science fiction. We are able to find evidence and evaluate it impartially.

Discovering how life begins and develops, finding out whether life resides elsewhere, and determining life's future on Earth and beyond will have a profound and fundamental effect on the human species. It will affect our view of the universe, our science, our culture and beliefs—in short, our very existence. The mission of the workshop, then, is to explore how astrobiology will affect and interact with human societies and cultures. Astrobiology is a major, long-term effort, and those of us who are interested in societal implications must be in for the long run. We need to engage and educate the public even though considerable time may pass before society must face immediate, direct, and practical implications. We must undertake long term-advanced preparation for long term missions.

TUESDAY, NOVEMBER 16, 1999
MORNING PANEL

Question 1. Why do we search for life or its beginnings?

How did we become both the subject who wants to explain and the object that should be explained? How has life's evolving definition altered society? What will our search for life's origins on the home planet and beyond tell us about ourselves? What will be the social consequences if and when we unlock a "unified field theory" of life's beginnings and evolution? What myths, legends, and tales about origins intersect with astrobiology? How will different cultures respond to a discovery of life's origins? What are the ethical or moral considerations, if any? What recommendations to the Astrobiology Program may result?

Session Chair:	Baruch Blumberg, NASA ARC
Session Reporter:	Kathleen Connell, NASA ARC
Session Panelists:	Mark B. Adams, University of Pennsylvania
	Bruce M. Jakosky, University of Colorado
	Mark Lupisella, NASA Goddard

The Visionaries: Toward a Cultural History of Astrobiology[1]
Mark Adams, University of Pennsylvania

The search for life and its beginnings is a long-standing dream in Western culture. Very early on, astronomers raised questions about what life would be like on other worlds. A century ago these interests crystallized over the possibility of life on Mars. By 1898, science fiction author, H. G. Wells had raised many of the ideas that remain with us today. These include the ideas of alien life, cosmic infection, interstellar travel, and the danger of emergent life forms. Experimental biology at the turn of the 20th Century shifted attention towards a vision of human evolution that included the engineering of humans and other species to live on this world, combining the futurism of H.G. Wells, specifically humanity's future, with the excitement of research in biology.

Writers in the 1920's and 1930's explored the moral and cultural dimensions of this vision and traced its significance for the long-term survival and evolutionary testing

[1] Most of the brief overviews presented in the text are capsule summaries based on the authors' abstract and remarks during the presentations. Each presenter has had the opportunity to review the encapsulation of his or her talks. The actual abstracts are presented in their entirety in the appendix.

of humankind. Many of the early astronomers had vision and imagination, a fact that is lost on many people in this age where we have split scientific and humanist cultures. This separation is a post-World War II anomaly. A visionary legacy is part of the history of astrobiology, and the present workshop may be a step towards reducing the divisions between scientific and humanist cultures. As we look back over time we learn that history has many lessons for understanding the societal implications of astrobiology.

Exploration and the Role of Science in Society
Bruce Jakosky, University of Colorado

Curiosity and exploration are the drivers for astrobiology. Through astrobiology, we are trying to learn about the boundary conditions surrounding our own existence. As we learn about the universe, we learn about ourselves. There is high public interest in the search for extraterrestrial life and human migration into space, but some of this may not be based on a correct perception of astrobiology as basic research. We can engage the public's interests in these fields to help the public understand science and its role in society today, and to build public support for our endeavors. As we do this, we must freely admit that especially at first, astrobiology will have few practical implications and lack the excitement of fictional accounts as in the movies "Contact," "Armageddon," and "Deep Impact." The goal is less, one of acquiring specific new knowledge than one of learning more about the universe,about us. There should be more emphasis on process less emphasis on product.

To some extent, the public has been disengaged from science since World War II, and astrobiology provides the opportunity to re-engage their interest. Important informational elements include explaining what science is, why it is done, and why it is valued. It is important to involve astrobiologists as well as social scientists in the efforts, and make sure that there is excellent coordination between the astrobiologists and social scientists. As we engage the public we must not drift from our own scientific standards; we must continue to do first-rate mainstream science.

The Criticality of Biology's Second Data Point
Mark Lupisella, NASA Goddard Space Flight Center

Results from the search for extraterrestrial life will certainly be critical for science, and may, perhaps more importantly, have profound impacts on worldviews. Ranging from a completely meaningless universe to a "bootstrapped universe" to a deeply meaningful and purposeful universe.

After sufficient searching (an interesting issue in its own right) the absence of extraterrestrial life could be interpreted to suggest that life is a rare and random phenomenon in a universe that is otherwise indifferent to the plight of life. From a biocentric point of view, life as a rare and random phenomenon

essentially equates to a kind of Random Universe worldview, one in which the universe is essentially seen as meaningless at least as far as the role of life is concerned and perhaps in any broader objective sense, as well. Coming to terms with such a reality might be one of the most important challenges to face sufficiently aware beings. In such a worldview, we might see the human condition and more generally, the biological condition as fundamentally in tension with the nature of the universe, particularly the second law of thermodynamics. In a Random Universe worldview, we might see life as a diamond in the rough, with perhaps no truly objective absolutes to guide our actions. In this worldview, we are masters of the universe—it is ours to take, to consume, to ultimately make of it what we desire. We are Nietzsche's Super Humans. This view, while inconsistent with traditional religion, can be liberating and empowering, and can also, consistent with traditional religion, motivate us to turn to each other with a deep reverence since we are not only diamonds in the rough, but we are all we have to protect and sustain us in an otherwise hostile universe.

However, the same result could lead to a kind of "Bootstrapped Universe" interpretation whereby the universe is seen as having bootstrapped itself into the realm of value and meaning via the creation of beings with interests, consciousness, and culture which literally bring forth value and meaning where there may have been none prior. With cosmic evolution as the premise, this is, strictly speaking, a meaningful universe worldview—perhaps a kind of "cosmobiocentric" worldview. The universe created value and meaning via us, and we are the ultimate arbiters of that value and meaning.

The discovery of a cosmically local, independent origin of life or "second genesis" will, for statistical reasons, suggest that the universe is teeming with life. Combined with a sufficiently compelling theory, we might conclude that the Universe tends toward the creation of complex systems such as life, intelligence, and consciousness, and that as result, we are an inevitable realization of the nature of the universe. In this worldview, life is perhaps intrinsically cosmically valuable, and so we might see ourselves as truly at home in the universe that gave birth to us and gave itself life.

In all three worldviews, life, intelligence, and consciousness can be seen as uniquely valuable, but for very different reasons, and with potentially quite different outcomes. Perhaps surprisingly, this potentially makes the question of the meaning of the universe and the meaning of life in the universe, an empirical question depending on results from the search for extraterrestrial life.

At least three recommendations follow: (1) Policy measures should be taken to ensure the integrity of extraterrestrial life—biology's second data point (e.g. via a NASA and/or international planetary protection policy for human missions). (2) Given the unique and immeasurable value of life and consciousness, and given that we appear to be the first species aware of extinction and with the capability to

consciously and proactively ensure our long-term survival. We should formally (so as to directly inform public policy) explore long-term survival and evolutionary strategies, including, for example, the role of extraterrestrial migration, directed speciation (or more generally, genetic engineering), SETI readiness, and the proactive exploration of what are presently unknown threats. (3) Establish a forum for rigorous dialogue between scientists, philosophers, theologians, policy makers and the wider community regarding the potentially profound implications of the search for and discovery of extraterrestrial life – so that we understand what could be at stake, and so we are as prepared as we can be, helping to minimize any adverse effects.

It has been suggested by some that either answer to whether or not extraterrestrial life exists is equally frightening. The above interpretations suggest that either answer could also be equally exhilarating.

Discussion of Tuesday Morning Presentations

Why do we seek evidence of other life in the universe? For scientists, the answer is partly a matter of feedback. The past few centuries have been marked by a succession of discoveries suggesting that the principles of physics, chemistry and biology hold true throughout the universe, so that life should have evolved again and again. A clear answer would be the final piece of the puzzle, proving that we have been following the right track or suggesting that they have been misled by centuries of illusory progress. For some scientists and for many members of the public, the answer to the question "Are we alone?" will have profound philosophical implications. The answer could validate or challenge religious beliefs and worldviews. We seek evidence of extraterrestrial life to understand our place in the universe. Not everyone fully shares this interest – for example, a person who is absorbed by practical issues and lives very much in the "here and now" might not care one way or the other if the fossil of a microbe was discovered on Mars or Europa. But interests in astrobiology are shared widely enough that the discussion of "Why do we seek evidence of other life in the universe" focused almost exclusively on establishing a dialogue with the public.

The possibility of life elsewhere, and the rich tradition of interest in the religious, moral, and ethical dimensions of its discovery, provide a wonderful opportunity to engage the public and build support not only for astrobiology but also for the whole enterprise of science. It is essential that those of us who are involved in astrobiology actively engage the public to ensure that they are informed and pave the way for appropriate policy and research measures. In our attempts to engage the public in astrobiology, we must foster mutual respect and build a true dialogue, which means that we
must learn as well as teach. We must show how astrobiology relates to moral, spiritual, and religious issues.

A dialogue is not to be confused with telling people how it is, or what they should do. A dialogue requires listening carefully to what the public has to say. We must also be aware that, as experts, our views will not necessarily be given more weight than anyone else's will. We live in an anti-elitist society where everyone is entitled to a view, so despite spending 20 years on the topic we may have to first establish our credentials! Scientists who do cutting-edge research are not necessarily the best communicators. People who can serve as interpreters—representing scientific views to the public and the public's views to the scientific community—will be very valuable. Unfortunately, K-12 teachers, lecturers, and other people who serve interpretive roles tend to be undervalued.

Although astrobiology is a NASA endeavor, ultimately our efforts should be international and cross-cultural. People in Western Europe and the United States may be more prepared to enter into dialogue than are people in China, India, South America, and Africa. Within the United States, different subpopulations—for example, Native Americans and Chicanos—may have very different views of life among the stars. As we work with people from many different backgrounds we will be rewarded with insights and perspectives arising from very different traditions.

As we work with the public we can capitalize on their sense of awe and wonder, and on their pre-existing interest in the "deepening mystery" of the universe. We can discuss strange and wonderful possibilities. There may be ways to make the efforts "fun" or entertaining, as well as educational. Yet it is crucial to maintain scientific values and research credibility despite engaging in very far-ranging discussions with a wide variety of people. Astrobiologists who conduct basic research and social scientists who work with the public must remain highly coordinated with each other. When it comes to life in space there is a strong temptation to confuse fact with fiction, and it is important to be part of the solution, rather than part of the problem. Maintaining the highest levels of scientific integrity is crucial for creating a proper educational forum and for deterring other scientists from marginalizing astrobiology.

TUESDAY, NOVEMBER 16, 1999
AFTERNOON PANEL

Introductory Comments
Greg Schmidt

Revolutions in science have always had a profound impact on society. With the rebirth of science during the Renaissance, Copernicus in particular advanced theories which took away humanity's cherished place at the center of the universe and placed us instead on a planet orbiting the Sun, a decidedly ordinary place in comparison to our exalted pedestal in the earlier Ptolemaic system. Galileo's observations provided the final nails in the coffin of the earlier theory, although his subsequent house imprisonment demonstrated the lengths that many can go in order to preserve our cherished place. Science since this time has continued to advance in the direction of a less central place for humankind, and in particular Darwin advanced the idea that all species—including humans—had evolved from earlier ancestors and were all connected through the earliest ancestral linkages. The advent of the understanding of the heritage of life itself through the structure of deoxyribonucleic acid—DNA, the code of life—has furthered the view that all life on Earth has been connected through the same thread through the nearly 4 billion years of its existence on this planet.

The advent of astrobiology, the study of the thread of life in the universe itself, furthers the ideas started by Copernicus and Galileo into a new realm. The fundamental questions raised by astrobiology deal with life's origins, extent, and future in the universe, questions central to human existence since our own origin as a species. Only now, with the capabilities of access of space, coupled with convergent revolutions in our technologies, may we truly begin to seek out real answers to these age-old questions. Much as Galileo turned his early telescope outwards towards our solar system companions, the planets (which comes from the Greek, meaning the "wanderers"), we now have the capabilities to extend our reach through our robots. To wander through our solar neighborhood and peer beyond to the stars, and perhaps within a generation to answer the question "Are we alone?" The answer to this question—either yes or no—will have profound and long-reaching consequences to the way we view our home planet and ourselves.

Question 2. What are the implications of observation of life and human exploration off the home planet?

How have ground-based studies of the cosmos and resulting technologies, including human and robotic space exploration, affected global, national, group, and individual perspectives, as well as values, expectations, policies, undertakings, and relationships throughout history and into the present era? What are the belief systems—myths, legends, archetypes, hopes and fears—generated by space observation/exploration through human history? What are the effect, role, and impact of space/sky observations, theories of the universe, and human explorations of space upon our perspective of the globe and component communities and cultures? Are there origins of exploration in human biology? What is the impact of exploration in human cultural evolution? What has been the social impact of lunar exploration? What are the social aspects to sending human beings to Mars? Who should go? Should we engineer new life forms to adapt to live on other worlds? If so, what will be the social effect of such engineering? What responsibilities do we have regarding exploration? What recommendations should be made to the Astrobiology Program?

Session Chair: Lynn Harper, NASA ARC
Session Reporter: Greg Schmidt, NASA ARC
Session Panelists: Ben Bova, Author
Christopher P. McKay, NASA ARC
Del Schuh, Aerospace States Association

Life and Human Exploration beyond the Home Planet
Ben Bova, Author/Futurist

The observation of life and human exploration off the home planet will have a plethora of far-reaching implications that may not be appreciated fully by today's humanity. Studies of the heavens were practical to ancient man because such studies helped them plant their crops and entered into their religious systems. Astronomical studies in the Renaissance led directly to the rise of science, the attenuation of church authority, and indirectly to an era of global European domination. Science fiction whetted people's interests in topics that are central to astrobiology. Unfortunately, while science fiction opens people's minds to new possibilities, science fiction does not always present an accurate picture.

People may see the search for extraterrestrial life, space exploration and similar activities as personally irrelevant since they are undertaken by an arcane group of specialists and seem to have little or no obvious bearing to the common person and to everyday life. Astrobiology may be particularly remote to people from subsistence societies. As astrobiological research accelerates, we will "raise the ante"; earning

more accolades but also giving rise to more fears. Many people still fight the concept of Darwinian evolution, and some people may be truly fearful of extraterrestrial life. Some of these people may use their political clout to deter astrobiology. For people who believe that they were created in God's image, discoveries of other life forms could prove devastating and perhaps lead to violent reactions. Astrobiology could replace the Cold War as a source of ideas and controversies. This could continue for decades.

Actual discovery of life elsewhere may force us to rethink what it means to be human. Perhaps religious thinkers will gain new insights, and conclude that we were not created in God's physical image, but in other ways reminiscent of our images of a Supreme Being.

The Environmental Ethics of Bringing Mars to Life
Christopher P. McKay, NASA Ames Research Center

Profound ethical issues accompany changing the ecosphere of another plane, for example, bringing Mars to life through some form of planetary engineering. There is a potential conflict between unrestrained human activity and preserving an off-world environment. Environmental ethics are based on some combination of three fundamental axioms; (1) Anti-humanism, a notion that human action is inevitably harmful and that we should leave everything alone; (2) Stewardship or enlightened self-interest, a requirement that humans must use nature wisely for their own benefit; and (3) Intrinsic Worth, a supposition that some class of objects have intrinsic worth regardless of their utility to humans. Perhaps richness and diversity are inherently valuable, a proposition that has important implications. First, it might be appropriate to alter Mars making conditions on the planet suitable for that indigenous life so as to allow it to develop into a diverse and planetary scale biota. Second, if richness and diversity are valued, then we should feel free to send human life to extraterrestrial destinations. Eventually we may see a religion "of and for life"—a celebration of the richness and diversity of life in the universe.

Impact of Lunar Exploration: Good When We are Doing It, Bad When We Are Not
Del Schuh, Aerospace States Association

The immediate benefits of space exploration are very important. In our efforts to understand our neighbors, the Moon and Mars provide opportunities for students to become involved in learning about science. This interest leads students in middle school and high school to ask "How can I get a career in aerospace?" If we look at the actual enrollment statistics from the University of Indiana, we find that whereas major achievements (such as the landing of humans on the Moon) stimulate enrollments in aerospace, disasters (such as the *Challenger* explosion) decrease involvement. In answer to the question "What has been the impact of lunar exploration?" Schuh concludes that "Recent exploration has stimulated an interest in math, science, and engineering, but history shows that there must be significant,

ongoing events to maintain that interest." Increasing public support for astrobiology and other space-related ventures is a three-step process. First, the public needs to be made aware of current activities. Second, it needs to understand these activities—this requires educational programs based on language that is accessible to the public. The final stage is actual engagement—leveraging whatever resources are available to encourage personal involvement, for example, in a discussion group or some sort of actual research project or helping to educate school children.

Discussion of Tuesday Afternoon Presentations

Astrobiology involves a remarkable confluence of science, technology, and popular culture. All of these are coming together during our current historical period. Many of the issues speak to the fundamental characteristics of people and cultures, and where humanity is going in the future. We are nearing an era when we can manipulate large ecosystem variables, and we can even envision human life off of its native planet. This historical juncture provides a wonderful opportunity for collaborative, indeed synergistic action on the part of scientists and the public. Because of the need for true bi-directional, science-public interaction, perhaps we should recast "Societal Implications of Astrobiology" as "Societal Interactions with Astrobiology." We need to take public opinion into account when formulating policy decisions.

Astrobiology is consistent with fundamental human drives and taps such important ideas as our place and future in the universe. We can stress a combination of exploration, adventure, and science, and recognize that as we proceed we will deepen the mystery as well as find answers to questions. Whereas many people may be attracted by the twin topics of the search for extraterrestrial life and humanity settling elsewhere in the solar system, we cannot expect everyone to become an enthusiastic supporter. There are many people who are very practical or who will be threatened by astrobiological discoveries. Religious fundamentalism, for example, may be a defense against evolution, since fundamentalism suggests that life is patterned and meaningful, rather than random and haphazard. We may be living in an "anti-religious" era where some scientists see only a caricature of religion and miss the underlying values and significance. Religious fundamentalists may be privy to basic wisdom and purveyors of important values for society. We should not think of ourselves as missionaries in the new "Church of Life" who are charged with improving everyone's opinion about astrobiology. We should not think in terms of confrontation but in terms of finding new ways to meld scientific and religious issues through mutual discussion. Simply involving people in discussions of the most profound questions of human life may help break down barriers.

Support for space-related activities varies as a function of the current level of success within the space program. For this reason it is important to maintain a variety of activities, at least some of which will be successful and attract the interest

of the public. A multitude of relatively inexpensive but high profile activities may be more useful for engaging the public than one or two extremely expensive and time consuming “sink or swim” missions. It is particularly difficult to maintain public interest in long term, especially multi-generation, projects. In our efforts to work with the public, scientists can enlist other messengers.

We should develop powerful partnerships with industry, drawing on talented people other than scientists. We should involve educators, industrialists, businesspersons, and service groups as collaborators. We should attempt to reach people of different ages and people who speak different languages. We should be willing to make full use of the Internet and other mechanisms for distributing information; for example, by posting societal implications papers on the Astrobiology Web Site.

WEDNESDAY, NOVEMBER 17, 1999
PLENARY SESSIONS

Astrobiology Outreach Efforts
Rosalyn Grimes

Astrobiology offers great material for cocktail party conversations—and for education. NASA has made good progress developing educational material for teachers and students. This is a two step process: first, determining how to make it interesting for the targeted age group and second, making sure that it meets educational standards and getting it into the K-12 curriculum. There are certain hurdles to some of these efforts. For example, it can be difficult to provide K-12 instructors with the breadth and depth of science that is useful for leading discussions, and not all schools have adequate computer and audio-visual resources.

The NASA Astrobiology outreach effort is web based and incorporates a Brand Name, a Center for Learning, and an Institutional Thread. It promotes a "win/win/win" situation where NASA, teachers, and students all benefit. Efforts targeted at educators include partnerships to develop curriculum, the classroom for the future, a CD-ROM for instructor's use, and a Teacher's Guide. Specific efforts targeted at students include a Poster Series, Space Life Express, and Ask An Astrobiologist. Other efforts are directed towards Native Americans and post-doctoral scholars. Additional efforts establish outreach partnerships with museums and planetaria, Women in Engineering, and university courses. Finally, there is a large public outreach component. This includes brochures, and Internet presence, and working with science interest groups.

WEDNESDAY, NOVEMBER 17, 1999
MORNING PANEL

Question 3. How should we respond to the discovery of life elsewhere?

How should we respond to the discovery of life elsewhere? How have human societies responded to landmark discoveries in the past? What are the societal and psychosocial implications associated with the discovery of life beyond the home planet? What are the social consequences of contact? Of contamination? Of interaction? What recommendations to the Astrobiology Program need to be implemented? What role should governments play? What multi-cultural perspectives are likely to develop? What ethical considerations need to be addressed?

Session Chair:	Steve Dick, Naval Observatory
Session Reporter:	Lynn Harper, NASA ARC
Session Panelists:	John Billingham, SETI Institute
	Steve Dick, Naval Observatory
	Jim Funaro, Cabrillo College
	Albert Harrison, University of California, Davis
	Margaret Race, SETI Institute
	Douglas A. Vakoch, SETI Institute

Responding to the Discovery of Life Elsewhere
John Billingham, SETI Institute

During the last 50 years science has given us an increasingly convincing story of cosmic evolution, and placed theories of simple, complex, and intelligent extraterrestrial life on a firm footing. For approximately forty years scientists involved in SETI have used radio telescopes to search for electromagnetic activity that is of intelligent and extraterrestrial origin. From the beginning of this search, scientists recognized that evidence of extraterrestrial intelligence would be one of the greatest discoveries of all time, and have profound implications for humanity. We can make very few educated guesses about these civilizations, except that they are likely to be much older than our own.

Workshops and symposia convened at NASA Ames and later in conjunction with the annual meetings of the International Academy of Astronautics have sought to explore the cultural aspects of SETI. Some of the products include the International Academy of Astronautics (IAA) SETI Committee's "Declaration of Principles Concerning Activities Following the Detection of Extraterrestrial Intelligence" and other working documents addressing such issues as "active SETI," that is, instead

of passively listening for evidence of extraterrestrial life, boldly announcing our presence in the Galaxy.

A continuing interest within SETI is increasing the contributions of social scientists, including anthropologists, decision theorists, historians, political scientists, psychologists, sociologists, and others. There are several models for doing this. One is establishing "blue ribbon committees" of leading scholars within different social science disciplines. Because eminent scholars serve as models within their communities, their involvement would signal the importance of the effort and encourage other scholars to participate. Social scientists would conduct research aimed at predicting and managing the discovery or extraterrestrial life and its aftermath. Social scientists could make contributions through survey research, informed policy development, education, and media relations.

Response to the Discovery of Extraterrestrial Life
Steven J. Dick, U. S. Naval Observatory

The 1958 National Aeronautics and Space Administration Act encompasses the study of the human response to extraterrestrial life. A broad societal interest in the subject is recognized in Principle 3 of the Astrobiology Roadmap, implying that studies of the impact on society are both prudent and necessary. Changing ideas about the abundance of life in the universe have affected people's worldviews, and the actual discovery of extraterrestrial life will have a phenomenal impact. Human response will be very dependent on the type of life encountered and the way that the discovery unfolds but is sure to change our views of humanity and our place in the universe. Some scenarios have received closer scrutiny than have others; for example, a fair amount of work has been done on the consequences of detecting, by means of radio telescope, an extraterrestrial civilization, but very little work has been done on the consequences of detecting a single-celled life form.

There are many sources of ideas about human response including historical prototypes involving cultural contact and the speculations of science fiction writers. It may be impossible to predict how people will actually react, but we can take a step forward by systematically considering various alternatives. 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.

Proximity, System Level, and Human Response to Extraterrestrial Life
Albert A. Harrison, University of California, Davis

Whereas the Astrobiology Program and SETI share interests in life in the universe, they also have important differences. Astrobiologists lean heavily towards the preliminary terms in the Drake Equation (stars, planets, habitability, initiation of life) and tend to search for life's precursors and simple life forms within our solar system.

SETI scientists' interests extend to the final terms of the Drake equation (evolution of intelligence, longevity) and seek advanced technological civilizations elsewhere in the Galaxy.

Thus, astrobiology and SETI vary along two major dimensions: where they concentrate their search (proximal or distal locations) and the level of the living system that they seek (recognizing that everything is relative, "simple" or "complex"). Combining the two levels of the two dimensions yields four detection scenarios assigned the working titles of Space Visitors (high proximity and complex system), Microbes on Mars (high proximity and simple system), ET Calling (low proximity and complex system) and Distant Dust (low proximity and simple system). These scenarios are not equally probable. The unfolding of any of these detection scenarios would represent a great scientific discovery and could have a profound effect on humanity, but it should be more challenging easing humanity through some scenarios (Space Visitors and ET Calling) than others.

Decades ago, NASA commissioned the Brookings Institute to grapple with issues of contact and its aftermath, and the Institute's report was presented to the 82nd US Congress on April 18, 1961. It noted that the discovery of intelligent life in other parts of the universe could occur at any time. It stressed that although this evidence is likely to be discovered by radio telescope, it could occur in other ways, such as the discovery of artifacts left on the Moon or on other planets. The consequences for people's attitudes and values are unpredictable, potentially profound, and likely to differ from group to group. In spite of these recommendations written nearly 40 years ago there have been few attempts to gauge the consequences to our society of unambiguous evidence of extraterrestrial life. If, in fact, we are increasingly convinced that contact will come about, it is time to invest in appropriate research.

Ethical Considerations in Astrobiology: A Proposal for Guidelines Applicable to the Discovery of Non-Intelligent Extraterrestrial Life
Margaret S. Race, SETI Institute
Richard Randolph, Center for Theology and the Natural Sciences

For decades, international treaties have guided space-exploring nations and policies aimed at avoiding harmful cross contamination, but there has been little attention paid to the ethical dimensions of exploration itself. While formal principles have been proposed for the eventuality of detecting intelligent life in our Galaxy, no such guidelines exist for the discovery of non-intelligent life within our solar system. In light of our advancing capabilities, it is prudent to consider not only how we undertake space exploration but also the implications of invasive activities on planets where life is encountered. Based on an analysis of applicable ethical principles and consideration of the likely encounter scenarios, we should develop interim guidelines applicable to the discovery of non-intelligent life. Like the SETI principles, these guidelines should serve as operating protocols at the point and moment of discovery, until longer-range plans for the handling and treatment of

extraterrestrial life can be developed through international consultation. There is growing scientific confidence that the discovery of extraterrestrial life in some form is nearly inevitable. It is appropriate to encourage comprehensive discussion of the issues prior to an event of such historical significance.

Predicting Reactions to the Detection of Life beyond Earth
Douglas A. Vakoch, The SETI Institute

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. Carefully planned studies may help anticipate sources of skepticism about, or opposition to, bona fide reports of the existence of extraterrestrial life. Such studies may help guide strategies for productive public outreach programs that could address people's concerns about detection of extraterrestrial life. These studies can help us identify sources of resistance to astrobiology, identify sources of support for Astrobiology and develop a database that will help us develop intelligent policies. To be of maximal benefit, such studies should be cross-cultural, quantitative, and have high explanatory power.

Studies should be initiated prior to the detection of extraterrestrial life, so we can perfect questionnaires and other instruments for immediate application after detection occurs. The timely access to relevant data shortly after detection of extraterrestrial life could be of considerable use in planning appropriate policies as well as educational and media initiatives specific to the circumstances of the actual detection. Empirical studies conducted prior to detection of life beyond Earth are particularly encouraged, because they could identify a basic battery of well-designed questionnaires and other research instruments. Such advanced preparation could facilitate the collection of high quality empirical data about people's reactions to an actual detection mere days or weeks after detection, rather than months or years later if there were no advanced planning. The timely access to relevant data shortly after detection of extraterrestrial life could be of considerable use in planning appropriate policies as well as educational and media initiatives specific to the circumstances of the actual event.

Societal Impact of the Discovery of Extraterrestrial Life: How Will Humans Adapt?
James Funaro, Cabrillo College

Some scientists may assume that if extraterrestrial life is discovered science will be validated while religion will suffer irreconcilable difficulties and perhaps even collapse. If so, these scientists are underrating religion's survivability and its usefulness as an adaptive tool. The discovery may stimulate a worldwide resurgence in religious activity. Religion may have an advantage over science as

we attempt to adapt to strong and widespread emotional impact. Some of the advantages of religion include: (1) Religion has already had considerable experience dealing with ETs; (2) Religion can answer questions that science cannot; (3) Religious hypotheses may be strengthened by disproof; and (4) Religion provides a built-in, self-activating mechanism for responding to widespread societal stress. In the actual event of encountering extraterrestrial life, some of the needs of humanity as a whole may require the kind of non-scientific solutions provided by religion. Given the number of unknowns in the contact equation, we should not ignore the potential value of any of our adaptive resources.

Discussion of Wednesday Morning Presentations

As we contemplate the human response to extraterrestrial life we must adopt a very broad perspective. We can conduct research to help us forecast and manage the human response to extraterrestrial life. Indeed, research on societal implications of astrobiology should be incorporated into core science initiatives as well as education and outreach activities. We may not be able to make specific predictions of reactions to extraterrestrial life, but we can explore the possibilities in a systematic way.

The human responses to extraterrestrial life have long been an interest in SETI and, in their discussion of this question; many of the panelists drew on their involvement in this effort. John Billingham described how the physical and biological scientists who led SETI realized that the endeavor had important societal consequences. Over the years a number of symposia and workshops, including many staged by the International Astronautical Federation, addressed the psychological and cultural aspects of the search for extraterrestrial intelligence. In Billingham's view, it is important to involve top-level scholars in the discussion. This is more than a way to bring good ideas to the table; it gains acceptance for our new enterprise within conservative academic disciplines.

Confirmation of extraterrestrial life could occur in any of a number of ways. Thusfar, most of the attention has been directed towards discovery of intelligent life in a distant solar system. Less attention has been spent on potential human reactions to the confirmation of relatively simple forms of extraterrestrial life, such as single-celled fossils on Mars or simple life forms on Europa. Such detections could have profound effects on world-views and religious beliefs, and will raise many ethical and practical issues. Advanced planning should encompass a range of detection scenarios, with more emphasis on the kinds of discoveries that might be made through astrobiological research.

Workshop participants developed a strong case for a high level of research and outreach efforts before the fact. Research efforts should include the development of survey instruments to provide accurate quantitative measures of people's current beliefs and expectations. This will provide us with a better understanding of

people's likely reactions to discoveries and a reference point for evaluating attitudes in the post-detection world. By developing sound research strategies and measurement devices early on, we will be able to mount prompt research efforts following any announcement of the confirmation of extraterrestrial life. At that point we will not have to undertake lengthy preparations before we can collect the information that we need to "manage" contact and plan for the post-contact world.

NASA's Astrobiology Outreach efforts are a laudable multi-pronged effort to reach the public both directly and through museums and schools. Outreach efforts are a staple also of the SETI Institute, which has an education office and has developed instructional materials for use in schools. Currently, some of these materials are undergoing translation into foreign languages for distribution internationally. Education is an objective of SETI Australia, and in concert with NASA-Ames the CONTACT organization (a loose knit aggregation of scientists and science fiction writers) has developed materials for an integrated series of art, literature, and science courses. These have been offered for the past two years at the Oroville, California High School. The NASA-contracted Aerospace Educational specialist program could be a unique asset in outreach efforts.

WEDNESDAY, NOVEMBER 17, 1999
AFTERNOON PANEL

Question 4. What is the evolutionary fate of human societies and cultures beyond the home planet?

Will there be a migration of entire populations off the home planet? If so, how will such human migration affect global, national, group, and individual perspectives, as well as values, expectations, and policies? What has been the effect of emigration and migration of people in the past? What will be the social effect, role, and impact of migration to space-based orbital platforms? To the Moon? To Mars? And beyond? What will be impact of alien environments on human cultural evolution? What should be the resulting public policies? Will new cultures be created? Will there be radical genetic manipulation of existing peoples so that they may successfully migrate off the home planet? What are or will be the ethical considerations associated with such genetic manipulation? What multi-cultural forces will determine who will remain on the home planet and who will go? And in what direction? How will societies and cultures interact with the cosmos?

Session Chair:	Kenneth Jon Rose, Author, Scientist, and Attorney
Session Reporter:	Scott Hubbard, NASA ARC
Session Panelists:	Ben Finney, University of Hawaii
	Charles L. Harper, Jr., Templeton Foundation
	Howard McCurdy, American University
	Allen Tough, University of Toronto

Space Futures
Ben Finney, University of Hawaii

In these "confessions of a would-be astro-anthropologist," Finney stressed the linkages between human migration into space and the search for extraterrestrial life. Astrobiology is not simply a Western concept. Russian rocket scientist Konstantin Tsiolkovsky (like his better known German counterparts Oberth and Von Braun) was a futurist and a visionary who saw humankind leaving the cradle of Earth to populate the Galaxy. Only now, in the new Russia, are Tsiolkovsky's philosophical and spiritual writings becoming available so we can trace the scope and depth of his vision. In effect one of the "fathers of astrobiology," Tsiolkovsky saw emigration from Earth as a landmark along humanity's path to perfection. The crucial turning point will come when we view our home as the cosmos, not as the Earth. At that time we will not be one species, we will be many, and given the varied ecological niches in space, our diversity will be a virtue.

If we continue to refer back to past human experience to think ahead about the coming human expansion into space, we should do so by critically examining the human record over the entire globe, as well as our own myths about that record. Such an exercise should be coordinated also with a serious consideration of what key technologies lie over the horizon. Then mix these together to simulate not one rigid path to be followed, but a number of possible scenarios for expansion beyond Earth. There is no single future to predict, only alternative futures to model.

Interplanetary Evolution in Popular Imagination
Howard E. McCurdy, American University

A discrepancy between realities and expectations may be one of the reasons that will keep the public from full engagement in astrobiology. In an effort to build support for space exploration, scientists such as Herman Oberth and Werner von Braun oversold the potential accomplishments of the space program. To make their visions seem plausible, they relied on familiar metaphors such as opening up the Wild West and Space as the high ground for winning the cold war. These efforts led to high expectations that were not matched by reality. Spaceflight is neither cheap nor easy, a fact that discouraged support for specific endeavors and caused some people to become cynical.

Drawing on the metaphor of terrestrial expeditions, advocates also offered the promise of extraterrestrial life. Earthly explorers returned from terrestrial expeditions with tales of weird beasts and exotic civilizations; space advocates argued that close examination of other heavenly bodies would reveal strange creatures as well. Advocates were assisted in this regard by purveyors of a popular culture increasingly preoccupied with extraterrestrial life, from the flying saucer phenomenon to movies like ET. Once again, this has the potential to breed public disappointment and cynicism. It could happen in SETI, for example, if enthusiasts oversell the idea that intelligent life would be friendly and share wisdom with humanity. It could occur if scientists find no life in the rest of the solar system. Alternatively, extraterrestrial life may be difficult to understand, or have characteristics not to our liking. The gaps between expectations and reality that cloud the history of space exploration could affect the search for extraterrestrial life soon. Optimism may generate public enthusiasm that rapidly declines in the face of unanticipated events, so we would do well to encourage realistic expectations.

What is the Evolutionary Fate of Human Societies and Cultures beyond Earth?
Charles L. Harper, Jr., The John Templeton Foundation

Astrobiology promises a practical, coherent approach to scientific mission planning to address some of the scientific questions of the 21st Century. Does life arise frequently under a certain range of physical conditions? Does life tend to generate intelligent life? If so, what is intelligent life like “out there?” Are their generic aspects of the exploration of “meaning” in advanced forms of life, if such exist? What kind of

cosmos do we inhabit? By initially examining potentially life-bearing (or fossil) sites within our solar system, this new field of inquiry provides a realistic scientific basis for beginning to address such interesting possible insights. Astrobiology begins in our solar system but has an "endless frontier" horizon through exoplanetary astronomy in exploring the vastness of the cosmos and the "other worlds" outside our own.

The Templeton Commission on the Future of Planetary Cosmology has mounted a strategic planning initiative that explores constructive ways to encourage broad public interest in discovering whether we exist within an "infinite ocean" of life-bearing worlds. A working premise of the Commission is that, in addition to its scientific virtue, astrobiology is a spiritually substantive and enriching endeavor, but that communicating such a view presents important and significant cultural challenges. Although science fiction writers and the entertainment industry have produced speculative tales about "aliens" and human life among the stars, the wider significance remains elusive. The exploration of the biological aspect of the cosmos is a deeply meaningful, magnificent, scientifically directed spiritual quest made possible by technological advances. Preparing for future developments in space exploration requires establishing clear ways to address issues of meaning, religious identity, and God concepts while inspiring society's appreciation of the cosmos as a possible infinite sea of living worlds.

We need to determine cogently and strategically how a small group of people can generate major reforms favorable to the future of extra-solar planetary astronomy. Including the challenging task of funding highly ambitious new interferometric space observatories to image planetary worlds in other solar systems and in this way support the search for extraterrestrial intelligence. Forming a set of worthwhile and practical goals requires considering what levers of change are available, what barriers might need to be overcome, and what strategies might be pursued to implement changes successfully, and cost-effectively. Our core goal for the next century is proactively to link humanity's ongoing deep moral and spiritual traditions with the cosmological perspectives evolving from astrobiology. The idea is to help generate the degree of broad cultural enthusiasm that the endeavor deserves.

Living Far From Earth
Allen Tough, University of Toronto (Emeritus)

Human emigration into space is likely to yield five major benefits. Tomorrow's spacefarers are likely to enjoy: (1) mining, low-gravity manufacturing, tourism, power satellites, interstellar beam propulsion, and other material benefits; (2) a new frontier, a destination for pioneers and adventurers; (3) greatly reduced chances of human extinction from a worldwide war or other catastrophe; (4) the flourishing and evolution of an instructive diversity of cultures, societies, ideas, perspectives and worldviews; and (5) a suitable off-Earth meeting ground if needed for interaction with intelligent extraterrestrial beings or robots.

These, in turn, have four major policy implications. (1) Major resources should be devoted to all of the next steps necessary for eventually enabling small groups of people to live far from Earth. (2) Each group living in space should be somewhat diverse, quite different from our current conception of astronauts, and should have as much freedom as possible. This will enhance the evolution of ideas and cultures. (3) Within the rapidly developing field of genetic engineering, some research should focus on the feasibility and desirability of producing individuals uniquely suited to living in space. (4) Because space settlements increase the likelihood of finding microbial life or making contact with extraterrestrial intelligence, disciplined thought and creative simulations should be utilized to prepare for such an event. Carefully prepared plans should be in place very soon, because the discovery of microbial or intelligent extraterrestrial life could occur at any time.

Discussion of Wednesday Afternoon Presentations

This panel reminds us of the diversity of issues that fall under the umbrella of societal implications of astrobiology. We believe that we will eventually encounter extraterrestrial life, and we believe that we will migrate towards the stars. These beliefs raise many philosophical, religious and ethical issues. Although we cannot envision all of these in their specifics, we can conduct careful research and think through various alternatives. A relatively small group of people will have to take the lead, conduct the necessary research, and devise strategies for working with the public. It would be helpful to find allies and develop partnerships for this venture.

CONCLUSIONS

The field of astrobiology is incredibly exciting and significant, for the general public as well as for the scientists. Few fields rate as high in this regard. Participants in this workshop shared this enthusiasm and welcomed the opportunity to participate in this multidisciplinary and interdisciplinary discussion of the far-ranging implications of astrobiology. They embraced the invitation to collaborate in the overall effort, and look forward to drawing upon their expertise to make sustained contributions. They conclude that it is absolutely essential to attend to the philosophical and social psychological dimensions of astrobiology, and hope to secure support for future efforts. Keys to success include close coordination with researchers who undertake the actual searches and developing research and outreach proposals that are at once excellent and compatible with NASA's charter, interests, and funding capabilities.

One of the enormous intellectual contributions of SETI, the search for extraterrestrial intelligence, has been to combine the efforts of scientists from many fields, not just the physical and social sciences, but also the humanities. A continuation of this trend under the even broader mantle of astrobiology may help pave the way for "consilience," or the unification of knowledge. Continuation of these efforts should involve scholars from a very wide range of fields; not just those represented at this initial workshop. Theologians, media personnel, and artists are among the groups that came to mind.

Although this workshop addressed both the searches for extraterrestrial life and humanity's future in space, the former topic tended to dominate the discussion. One of the reasons for this is a sense of urgency: confirmation of extraterrestrial life could occur at any time and in any of a number of ways. When it occurs, we may have only limited control over the situation. Our future in space, on the other hand, rests on human policy, human resource allocation, and human technology. Our expansion into the solar system and beyond is likely to occur in a phased fashion with major developments, such as space settlements and space tourism, still in the distant future. Another reason for the emphasis on the search for extraterrestrial life is that many of the participants in the workshop have been involved in SETI and have already given substantial thought to the societal implications of their endeavor. To what extent can work previously done on the societal implications of SETI help inform work on the societal implications of astrobiology? Margaret Race's work—which compares post contact protocols for both extraterrestrial civilizations and single-celled organisms—is an example of relevant work applying ideas from SETI to astrobiology. Although NASA is not including SETI in any of its "missions" at present, it is important to think about and discuss SETI within NASA and give careful consideration to some of SETI's pioneering activities—some of which occurred when SETI was still located at NASA-Ames.

Despite preconceptions, we have no real knowledge about extraterrestrial life forms and civilizations, if such exist. This has two profound implications. First, ultimate findings about life in the universe may be unexpected, strange, and fit very poorly with some of our theories (as is happening already in the field of extrasolar planets). Actual extraterrestrial life could strike us as improbable, strange, or even bizarre. If we are deeply ignorant about whatever exists out there, we should not limit ourselves to a narrow range of search strategies. Whether the first confirmed detection is microbial or intelligent, it is extremely important for us to be highly knowledgeable about the likely reactions of different constituencies (the press, various religious groups, political leaders around the world, the general public). We would be foolish and negligent if we did not study such reactions well ahead of time and make state-of-the art preparations for major discoveries.

Much of the workshop focussed on two issues: research to better understand the societal implications of astrobiology, and outreach to prepare the public for the discovery of extraterrestrial life and our possible future as a spacefaring civilization. Participants developed an almost endless array of relevant research topics. These include the theological, sociopolitical and psychological implications of extraterrestrial life; the ethical aspects of human activity on various planets and moons; changing conceptions of ourselves as we redefine our position in the universe, and the implications of astrobiology for literature and the arts. A satisfactory overall research program would be broad, multidisciplinary, structured in such a way as to permit meaningful quantitative comparisons, and enable cogent explanations of findings.

Survey research will be useful for identifying the relative prevalence of different attitudes towards extraterrestrial life, and understanding how these attitudes are affected by cross-cultural and psychological variables. Survey research can help us identify sources of resistance to astrobiology and sources of support for astrobiology. In addition to helping us understand people's beliefs and expectations and therefore predicting reactions to various types of discoveries, survey research would be useful also for making informed policy decisions. By putting in "front time" now, we will be able to rapidly mount research efforts close on the heels of major discoveries.

The twin pillars of astrobiology—searching for evidence of extraterrestrial life and preparing for a future where men and women will live far away from their native planet—have profound implications for the future of humanity. Astrobiology provides an excellent opportunity to captivate the interest of the public and initiate a broad dialogue on humanity's future. Astrobiology offers a magnificent opportunity to raise the level of public discourse, to involve people in discussions of the major issues of the cosmos.

As a multidisciplinary endeavor, astrobiology may move us in the direction of consilience, or the unification of knowledge. Ultimately, Astrobiology's success or

failure will depend on public support. Not everyone is interested in astrobiology, and there may be strong resistance from people whose religious beliefs or worldviews are challenged by the assumptions or findings of the emerging field.

In our attempts to engage the public in astrobiology, we must foster mutual respect and build a true dialogue. We should present our ideas, but also listen. Because of the complex multidisciplinary nature of astrobiology and because of its profound implications we must be attuned to society. Rather than avoiding controversy we should engage controversy rapidly and fully. We must also recognize that for many people science does not have all of the answers. Religion shapes many people's worldviews and helps them adapt to changing conditions.

Although we think that astrobiology is based on fundamental human drives, we have very little, if any, understanding, of views of people from different cultures and subcultures. Our discussion has focused on (primarily contemporary) western society. Yet, astrobiology has implications for all of humankind. One urgent requirement is to extend our explorations to people from radically different cultures: Asian, African and South American as well as North American and European. As we proceed, we must be mindful to avoid arrogance and show sensitivity to cultural differences.

Much remains to be done. The consequences for society of the discovery of extraterrestrial life will depend very much on the nature of that life, where it is found, and how the discovery unfolds. Whereas we cannot with any certainty predict this response, we can systematically review some of the possibilities. This will require further discussions involving representatives of disciplines and viewpoints that were not present at this workshop, empirical research, and efforts to tie research to policy recommendations.

RECOMMENDATIONS

Research and outreach activities bearing on the societal implications of astrobiology are consistent with the NASA charter and with the Astrobiology Road Map. Participants applaud the aims of Societal Implications of Astrobiology Workshop and hope that it is but the first step on a long road. In the course of this workshop, we identified many important research topics.

Recommendation 1: Establish a Steering Committee

First, we recommend establishing a Steering Committee to chart our future course. This group would consist of a relatively small but diverse group of astrobiologists, social scientists, and scholars in the humanities. The Steering Committee would develop a long-range plan. Once this was done, the Steering Committee would implement the plan, coordinating and guiding research and outreach activities.

Recommendation 2: Establish a Circle of Consultants

Empanel a circle of consultants to assist the Steering Committee. Comprised of known leaders within various fields, members of the circle would draw the attention of the Steering Committee to pertinent high quality research within the group members' scholarly discipline. In addition to keeping the Steering Committee apprised of cutting-edge research, the membership of circle would validate the importance of research on the Societal Implications of Astrobiology and, by example, encourage their colleagues to participate in his kind of research.

Recommendation 3: Ensure Close Coordination among Scientists, Social Scientists, and Scholars in the Humanities

Scientists who work on the physics and biology must be closely articulated with those who work on the societal implications. The two efforts are deeply and irrevocably intertwined, and a mutual appreciation of the close relationship is vital to the integrity of both fields.

Recommendation 4: Establish an Electronic Forum

Participants in this workshop look forward to continuing the dialogue. As a relatively low cost and quick measure, we recommend establishing an electronic forum on the World Wide Web.

In addition to these specific action items, participants encourage basic and policy-related research in each area embraced by this workshop:

1. What are the biological, psychological, and cultural factors that compel humankind to envision life beyond our planet's surface? Why do we seek evidence of extraterrestrial life and intelligence, and why do we strive to establish a continuing human presence off of our home planet? Is there an "extraterrestrial imperative" that pushes us towards the stars?

2. What are the ethical principles and issues involved in exploring other planets? How might these lead to policies that define appropriate and inappropriate life-altering interventions? What practical steps could we take to implement these policies?

3. How can we formulate a cohesive plan of action for short- and long-term response to ETI? Possible strategies include:

    - Developing scenario-contingent strategies for managing discovery and its aftermath;
    - Undertaking studies based on analogues in the humanities and history; the social and behavioral sciences, and science fiction to determine likely reactions;
    - Undertaking carefully planned cross-cultural polls and other empirical studies;
    - Exploring the capacity of religion as a resource to absorb impact of discovery and to maintain beneficial relations with ETI.

4. What are the implications for humans of different strategies for robotic and piloted missions within our solar system and beyond? What are possible biological, psychological, and cultural consequences of human migration beyond our home planet? How might we envision interplanetary and interstellar humanity?

5. How can we use astrobiology to develop powerful educational tools to engage the interests of contemporary students and broaden their understanding of physical, natural and social science?

Appendix I

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APPENDIX II

WORKSHOP ABSTRACTS

The Visionaries: Toward A Cultural History of Astrobiology.

Mark Adams
University of Pennsylvania

Astrobiology embodies a longstanding dream of Western culture, and has deep roots within it (Kepler's "Somnium," the Enlightenment debate over "the plurality of worlds," Leibniz, Voltaire, Darwinism, genetics.) A century ago, these interests assumed a modern form in the great furor over the possibility of life on Mars (Schiaparelli, Lowell, and H.G. Wells). With the emergence of a new "experimental biology" early in this century, however, members of a new generation born around 1890 (J. Huxley, J.B.S. Haldane, H.J. Muller) "updated" the gloomy futurism of H. G. Wells into a remarkable visionary "creed" concerning the human evolutionary future—one that contemplated not only immediate biological manipulations (a la Brave New World), but also the engineering of both humans and other species to live on other worlds. Interwar publications by leading biologists and writers (Olaf Stapleton, C. S. Lewis, and Robert Heinlein) gave considerable attention to this vision, its moral and cultural implications, and its significance for the long-term survival and evolutionary destiny of humankind. This "visionary biology" provides the field with a legacy whose riches are yet to be fully understood or exploited.

How Should We Respond to the Discovery of Life Elsewhere?

John Billingham
SETI Institute

For many centuries scholars have considered the possibility of the existence of extraterrestrial life, whether it be simple, complex or intelligent. In the last fifty years science has given us an increasingly convincing story of cosmic evolution, and placed theories of extraterrestrial life on a firm footing. In 1959, Joshua Lederburg coined the term "exobiology" to describe the new science, and Philip Morrison suggested we might exchange messages with other civilizations by interstellar radio communication. Frank Drake carried out the first search for radio signals of extraterrestrial origin in 1960. Since that time there has been seventy-five SETI searches. It has been also been apparent, over these last fifty years, that the unequivocal detection of ETI would have profound consequences for our society on Earth. It is statistically likely that any civilization we discover will be much older than we are, perhaps a billion years, and many feel that they will have evolved into an advanced society whose capabilities we cannot even imagine. So what would the consequences of detection be? Recognizing that the implications for our society would be profound, attempts have been made to conduct the first serious studies of what these implications would be. 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. The title of question 3 is "How should we respond to the discovery of life elsewhere?" This is actually only one among all the questions. It is pointed to policy issues, that is, the formulation of a cohesive plan of action somehow representative of humankind. This is important. It does not exist today. Attempts have been made by the International Academy of Astronautics, with the support of the International Institute of Space Law, to draw up some guidelines on the immediate sensible steps to be taken by a group that makes the discovery. It is called the "Declaration of Principles Concerning Activities Following the Detection of Extraterrestrial Intelligence", and has the force only of endorsement by six international professional space societies and informal agreement among most of those carrying out SETI. More profound questions are "Should we transmit communications from Earth to ETI, either de novo or after having detected ETI?" and if so "what should we say?" and "who decides?"

These are the subjects of a second document, which is a formal Academy Position Paper, also endorsed by the International Institute of Space Law, entitled "A Decision Process for Examining the Possibility of Sending Communications to Extraterrestrial Civilizations". This document is being submitted to the Committee on the Peaceful Uses of Outer Space of the United Nations in the summer of 2000. It contains a draft "Declaration of Principles", says a consensus should be achieved if possible, and recommends extensive further studies. The SETI Institute has recently published, in the SETI Press, the report of a blue-ribbon team, which met to discuss the "Cultural aspects of SETI". It is entitled "Social Implications of the Detection of an Extraterrestrial Civilization", and has 236 references. Its Executive Summary, together with the two Academy documents described above, can be found on the Institute web site.

Life and Human Exploration beyond the Home Planet

Ben Bova

The observation of life and human exploration off the home planet will have a plethora of far-reaching implications that may not appreciated fully by today's humanity. Studies of the heavens were practical to ancient man because such studies helped them plant their crops and entered into their religious systems. Astronomical studies in the Renaissance led directly to the rise of science, the attenuation of Church authority, and indirectly to an era of global European domination. Science fiction whetted people's interests in topics that are central to Astrobiology. Unfortunately, while science fiction opens people's minds to new possibilities, science fiction does not always present an accurate picture.

People may see the search for extraterrestrial life, space exploration and similar activities as personally irrelevant since they are undertaken by an arcane group of specialists and seem to have little or no obvious bearing to the common person and to everyday life. Astrobiology may be particularly remote to people from subsistence societies. As astrobiological research accelerates, we will "raise the ante" earning more accolades but also giving rise to more fears. Many people still fight the concept of Darwinian evolution, and some people may be truly fearful of extraterrestrial life. Some of these people may use their political clout to deter astrobiology. For people who believe that they were created in God's image, discoveries of other life forms could prove devastating and perhaps lead to violent reactions. Astrobiology could replace the Cold War as a source of ideas and controversies. This could continue for decades.

Actual discovery of life elsewhere may force us to rethink what it means to be human. Perhaps religious thinkers will gain new insights, and conclude that we were not created in God's physical image, but in other ways reminiscent of our images of a Supreme Being.

Response to Discovery of Extraterrestrial Life

Steven J. Dick,
U. S. Naval Observatory

The study of the human response to the discovery of extraterrestrial life [ETL] is a complex problem that falls within the 1958 National Aeronautics and Space Act objective for "the establishment of long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful scientific purposes." A broad societal interest in the subject is recognized in Principle 3 of the Astrobiology Roadmap, implying that studies of the impact on society are prudent and necessary. NASA has carried out only a very few such studies (Billingham, 1999); they also have precedent in the Human Genome Project, and should be part of the effort to increase communication between science and society. The problem of the human response to discovery of ETL is tractable only when divided into its constituent parts: microbial vs. intelligent life; the circumstances of discovery of microbial life or contact with ETI, the varying responses among different cultures, different segments of each culture, and so on. It should be noted that the question of how we "should" respond is quite different from how we "will" respond. One of the justifications for the studies recommended here is to inform policy and to inform the public response based on knowledge rather than ignorance. Given these distinctions, there are several approaches to the problem of social impact of the discovery of ETL (Dick, 2000).

From human history one can find many analogues to physical or intellectual contact with other cultures, using all the proper precautions when invoking analogues. One can study the reception of major new ideas and worldviews by various societies and segments of societies. One can use a variety of approaches from the social and behavioral sciences, including Living Systems Theory (Harrison, 1997). Empirical approaches involving polls will inform us about current attitudes. One should also not discount the serious thought that has gone into the subject by the best science fiction writers. Future studies are recommended using these approaches and others to be determined. The idea that life is abundant in the universe is a worldview that will have implications for all areas of human thought. Just as the Copernican, Darwinian and Freudian world views triggered a broad rethinking of our place in nature, the "biological universe" or "biophysical cosmology" may lead to what Lupisella (1998) has called cosmocentrism, in which human concerns are finally seen in the context of our true place in the universe. Moreover, as a multidisciplinary science, astrobiology is in a prime position to foster what E. O. Wilson has called "consilience", the unity of knowledge. An actual discovery of extraterrestrial life will also foster consilience.

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Space Futures

Ben Finney
University of Hawaii

In these “confessions of a would-be astro-anthropologist,” I stress the linkages among human migration into space and the search for extraterrestrial life. Astrobiology is not simply a Western concept. Russian rocket scientist Konstantin Tsiolkovsky (like his better known German counterparts Oberth and Von Braun) was a futurist and a visionary who saw humankind leaving the cradle of Earth to populate the Galaxy. Only now, in the new Russia, are Tsiolkovsky’s philosophical and spiritual writings becoming available so we can trace the scope and depth of his vision. In effect one of the “fathers of Astrobiology,” Tsiolkovsky saw emigration from Earth as a landmark along humanity’s path to perfection. The crucial turning point will come when we view our home as the cosmos, not as the Earth. At that time we will not be one species, we will be many, and given the varied ecological niches in space our diversity will be a virtue.

If we continue to refer back to past human experience to think ahead about the coming human expansion into space, we should do so by critically examining the human record over the entire globe, as well as our own myths about that record. Such an exercise should be coordinated also with a serious consideration of what key technologies lie over the horizon. Then mix these together to simulate not one rigid path to be followed, but a number of possible scenarios for expansion beyond Earth. There is no single future to predict, only alternative futures to model.

Societal Impact of the Discovery of Extraterrestrial Life: How Will Humans Adapt?

Jim Funaro,
Anthropologist, Cabrillo College

Science and religion are among the many intellectual resources that have evolved to stock humanity's toolkit. Should unequivocal evidence of life elsewhere in the universe be discovered, it is often assumed that, whereas science will be validated, religion will suffer irreconcilable difficulties and perhaps even collapse under the burden of ultimate disproof. This may be an underestimation, due to our secular society's distrust of "organized religion" and its lack of experience with religion in evolutionary and cross-cultural perspectives as an active mechanism for change. The discovery, in fact, may stimulate a worldwide resurgence in religious activity. In dealing with new phenomena, especially those involving strong and widespread emotional impact such as encountering alien life forms, religion may provide our species with a more powerful adaptive tool than science. Some of its advantages: [1] Religion has already had considerable experience dealing with ETs. [2] Religion can answer questions that science cannot. [3] Religious hypotheses may be strengthened by disproof. [4] Religion provides a built-in, self-activating mechanism for responding to widespread societal stress. Human biological success has been secured by an arsenal of resources that deal with the full range of human experience. Natural selection will judge those adaptive mechanisms -- not by their ability to acquire accurate knowledge of the universe -- but by their ability to ensure the survival of the species.

As a scientist, I agree that science is the most reliable method so far devised for understanding objective phenomena and should be utilized to the utmost in dealing with the problems of contact within its expertise. However, in the actual event of encountering extraterrestrial life, some of the needs of humanity as a whole may require the kind of non-scientific - and even non-objective - solutions provided by religion. Given the number of unknowns in the contact equation, we should not ignore the potential value of any of our adaptive resources in establishing and maintaining successful and mutually beneficial relations if we meet others who share the universe with us.

What is the Evolutionary Fate of Human Societies and Cultures beyond the Home Planet?

Charles L. Harper, Jr., D. Phil.
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John Templeton Foundation
Radnor, Pennsylvania

The programmatic concept of "astrobiology" promises a practical, coherent approach to scientific mission planning to address the big questions of 21st-century "planetary cosmology": Does life arise frequently under a certain range of physical conditions? Does life tend to generate intelligent life? If so, what is intelligent life like "out there"? By initially examining potentially life-bearing (or fossil) sites within our solar system, this new field of inquiry provides a checkpoint for exploring the vastness of the cosmos and the "other worlds" outside of our own solar system. My focus is based on the vision and aims of the Templeton Commission on the Future of Planetary Cosmology (TCFPC), which recently held its first conference at the Harvard-Smithsonian Center for Astrophysics. This strategic planning initiative explored constructive ways to encourage broad public interest in discovering whether we exist within an "infinite ocean" of life-bearing planetary worlds. A working premise of the TCFPC is that the future of space science is potentially a spiritually substantive and enriching endeavor, but that communicating such a view presents significant cultural challenges in the United States. Overall, the scientific discoveries of the 20th century have greatly expanded human understanding of our Earth's place within an unimaginably vast cosmos of infinite stellar worlds. The entertainment industry has used these insights to produce speculative tales about "aliens," inspiring the human imagination about life among the stars. Yet the wider significance of an infinite cosmos remains elusive. It clearly has not affected religious thinking in any substantial way, although the spiritual domain enshrines what people hold to be most essential to their worldview. The new cosmology presents a potentially potent opportunity for "science and religion" to work together constructively for change. We need to determine cogently and strategically how a small group of people can generate major reforms favorable to the future of extra-solar planetary astronomy, primarily by developing new observatories to image planetary worlds in other solar systems and supporting the search for extraterrestrial intelligence (SETI). My particular concern is to generate public enthusiasm for exploring the magnificent cosmic vista by considering such a venture as far more than just another scientific project. In my view, cosmic exploration is a deeply meaningful, magnificent, scientifically directed spiritual quest made possible by technological advances. Can we cultivate such a view in our society? Forming a set of worthwhile and practical goals requires considering what levers of change are available, what strategies might be pursued to implement changes successfully and cost-effectively, and what barriers to success might exist. This critical task includes marshalling public support to inspire political, cultural, and space science leadership to create high-impact, high-efficiency, competitive funding mechanisms

that could generate a wide range of highly innovative, cost-effective projects. If success is at root a cultural challenge, our greatest opportunity may be in developing projects to persuasively communicate an inspiring new "vision of possibility" about the potential significance of extrasolar planetary astronomy in expanding humanity's vision of the cosmos and its place within it. Our core goal for the next century is to proactively link humanity's ongoing deep moral and spiritual traditions with the cosmological perspectives evolving from astrobiology. Preparing for the cultural impact of future discoveries of extraterrestrial life requires establishing clear ways to address issues of meaning, religious identity, and God concepts while whetting society's appreciation of the cosmos as a potential infinite sea of living worlds.

Proximity, System Level, and Human Response to Extraterrestrial Life

Albert A. Harrison
University of California, Davis

The NASA Astrobiology Program and SETI share interests in life in the universe but also have important differences. Astrobiologists lean heavily towards the preliminary terms in the Drake Equation (stars, planets, habitability, initiation of life) and tend to search for life's precursors and simple life forms within our solar system. SETI scientists' interests extend to the final terms of the Drake equation (evolution of intelligence, longevity) and seek advanced technological civilizations elsewhere in the Galaxy. Thus, Astrobiology and SETI differ along two major dimensions: where they concentrate their search (proximal or distal locations) and, drawing on James Grier Miller's seminal work Living Systems, the level of the living system that they seek (low or high). There are many, often conflicting predictions of how individuals, societies and cultures will respond to the confirmation of extraterrestrial life. Some of these anticipated effects are generic, but others are contingent on the way that extraterrestrial life is confirmed. We can impose greater order on these hypotheses if we can link them, in a systematic way, to specific detection scenarios. Combining two levels of the two dimensions that differentiate Astrobiology and SETI yields four detection scenarios. These are assigned the working titles of Space Visitors (high proximity and high system level), Microbes on Mars (high proximity and low system level), ET Calling (low proximity and high system level) and Distant Dust (low proximity and low system level). The unfolding of any of these detection scenarios would represent a great scientific discovery and could have a profound effect on our intellectual and emotional lives. Nonetheless, it should prove more challenging easing humanity through some of these scenarios (Space Visitors and ET Calling) than others (Microbes on Mars and Distant Dust). Each scenario has different implications for our science and technology, our religion and arts, and our everyday lives. The fourfold table with cells which include both Astrobiology and SETI offers a logical and convenient framework for organizing various hypotheses about short-term and long-term human reactions to extraterrestrial life. This framework will help us develop scenario-contingent strategies for managing discovery and its aftermath.

Exploration and the Role of Science in Society

Bruce M. Jakosky
University of Colorado

Planetary science and astrobiology are fields for which the practical applications (if any) are not commensurate with the tremendous public interest.
This suggests that "exploration" is the real driver behind them. Instead of wanting to learn specific results, we as a society are, more generally, trying to learn about the boundary conditions surrounding our existence. By understanding the evolution of the universe, the formation of stars and planets, the potential for Earth-like planets, and the possibility of life or intelligent life elsewhere, we are finding out who we are and how we got here. By learning about the universe, we are learning about ourselves. In this context, exploring the universe is the same sort of endeavor as exploring the arts, literature, and the humanities. This aspect of science is especially important now, as the end of the Cold War brings to a close the post-World-War-II Vannevar-Bush era of "good science and good technology". We are in the middle of a transition to an era in which even basic research has to be justified on some grounds. If we are not able to find a reason that the public and Congress can continue to support, astrobiology runs the risk of becoming a marginal activity. Exploration is just such a reason. In addition, we can use the tremendous interest in fields such as astrobiology, planetary science, and cosmology to help the public understand the nature and role of science in society today. We usually teach science as a collection of facts, for example. However, science plays its most important role in the underlying concept that the world is inherently understandable, and we can understand how it works by observing it. The ongoing debate about creationism versus evolution indicates that the public either does not understand this view of science or does not accept it.

The Criticality of Biology's Second Data Point

Mark Lupisella
NASA Goddard Space Flight Center
University of Maryland Department of Biology and Philosophy

If the discovery of a "cosmically local" independent origin of life suggests a distribution of life that further implies life is necessary, that is, that life is a "cosmic imperative", then finding and understanding that second data point is clearly critical, not only for biology, but for what it will tell us about the nature of the universe and our relationship to it. Worldviews could range from being centered on a deeply meaningful universe to a completely meaningless universe, with many other interesting interpretations in between. Navigating our way through these possible interpretations will be challenging and will depend on many factors. Interestingly, however, the meaning and value of life can be inferred from perhaps all implications associated with whether or not extraterrestrial life exists. It is the kind of meaning and value of life that will be directly informed by the details. This is likely to be very important for how we understand and experience our existence in a larger context, and as history has demonstrated, perceptions of how we fit within a larger context can often act as strong motivation for our behavior. This places a very high premium on the second biological data point we are in search of. It will be important to communicate to the public (which probably already thinks extraterrestrial life exists) precisely what could be at stake. So that informed policy measures, perhaps such as careful exploratory approaches to ensure the integrity of possible extraterrestrial life, and measures that ensure the long-term survival of our species and the biosphere of Earth, can be realized.

Interplanetary Evolution in Popular Imagination

Howard E. McCurdy
American University

All of the early advocates of space flight envisioned a time when rocket technology would be used to move humans to other spheres. The reasons offered for interplanetary migration followed historically familiar themes. Robert Goddard predicted that survival of the human race would require interplanetary migration, just as terrestrial migration on the Earth allowed humans to thrive in different settings. Works of imagination, like the science fiction movie "When Worlds Collide," reinforced this theme. Other advocates offered interplanetary migration as a means for spurring innovation and change. The history of human migration on Earth confirms that societies change when people settle new lands. Historians have traced the distinctive social and political culture of the United States to conditions that existed on the American frontier. Exploration advocates believe that this process will occur on other worlds.

Interplanetary migration may create challenges unanticipated by people wielding historical analogies. Gravity affects the development of bone and muscle mass, and has played a significant role in the evolution of species. Following the publication of War of the Worlds, H. G. Wells speculated on the way in which creatures evolving on a lighter-gravity world would appear. It is doubtful that humans born on Mars would be able to return to Earth without specially engineered walking aids.

This presentation will explore various perceptions about space travel and extraterrestrial life, which have appeared in popular science and works of fiction.

The Environmental Ethics of Bringing Mars to Life

Christopher P. McKay
NASA Ames Research Center

Current knowledge of Mars suggests that it is possible to transform that planet into one that would be habitable by plants and microorganisms from Earth. This could be done over time-scales of a hundred years or so using technologies that we are already demonstrating, probably to our detriment, on the Earth. Should we do so? It is interesting to pursue this question within the scope of environmental ethics. If Mars has no life today and we are proposing to introduce life there then this is a situation novel in environmental ethics, which has heretofore only considered human interactions with systems that were biologically complete prior to human activity. On Earth the status quo ante and a living world are the same. Environmental principles that place value on life do not conflict with environmental principles that attempt to restrain human activity. For Mars the situation is the obverse: there the status quo, nature as humans first found it, is lifeless and we have the possibility of introducing (or re-introducing) life there. I have proposed that the normative principles of environmental ethics are based on some combination of three fundamental axioms: 1) Anti-humanism, the notion that human action is inevitably harmful; 2) Stewardship, a requirement that humans must use nature wisely for their own benefit; and 3) Intrinsic worth, the supposition that some class of objects have intrinsic worth regardless of their utility to humans. It is interesting therefore to consider each of these as applied to the question of making Mars a home for life. It may be useful to note there is little support from philosophy for the assumption that what is (e.g. Mars today) can be defended as what ought to be simply because it is. It is important to note that it is possible that life forms—different from Earth life—are dormant on Mars within the permafrost or have found refuge in some cryptic niche. It might then be appropriate to alter Mars making conditions on the planet suitable for that indigenous life so as to allow it to develop into a diverse and planetary scale biota.

Social Impact of Lunar Exploration: Good When We're Doing it; Bad When We're Not

Del Schuh
Executive Director
Aerospace States Association

In the 1960's, America was challenged by Presidential Order to achieve leadership in the exploration of space. The industrial complex responded to the challenge and eventually achieved that leadership role, culminating with the 11th and 12th men (Americans) walking on the Moon. This achievement was not driven by the desire to explore and to understand the origin of life, but rather to achieve and maintain superiority in a dark, threatening Cold War. At the end of Apollo, the nation's focus moved from conquering Earth's oldest satellite, having firmly established American technology as superior to that of the Soviet Union, to the economic utilization of space and scientific investigations through the means of short duration shuttle flights. The Apollo program stimulated an interest in math, science and engineering education. During that time, heroes were made—and remembered—careers in aerospace were viewed as exciting, and America was treated to life off the planet, both on the nightly news and in film (and this feeling was rejuvenated in the mid-90's by a simple piece of cinema—*Apollo 13*). Then America turned away from lunar exploration. Experimentation in microgravity, living and working in space and exploration of our universe became paramount. Russian and American flights into orbit became numerous and heroes became commonplace without memorable names. Although the world was being treated to visions of other galaxies and superb vistas of our planet from orbit, there arose a focus on exorbitant costs, unfulfilled contract obligations, downsizing and cost reduction. Slowly, the excitement of scientific and technical education wore off and math, science and engineering became too tough and fell from the curriculum requirements. The social impact from lunar exploration was lost. Twenty-five years after Apollo, America ventured to the Moon again. In January 1998, the Lunar Prospector mission was launched. As a part of the program's visibility, data retrieved from orbit over the lunar surface would be made publicly available via the Internet. This time there would emerge a scientific collaboration effort involving societies around the world. The Lunar Prospector program not only conducted scientific experiments while in orbit, but allowed thousands of educators and student to access real-time data and see what scientists see, simultaneously. This program alone has peaked the interest of our future workforce to consider the fields of math, science and engineering. The current effort to better know our satellite neighbor has provided some insight to the creation of the universe and has provided significant educational opportunities for our youth. Missions to the Moon and now to Mars and other planets and asteroids, have captured the excitement of America again. Engineers and scientists are working on unprecedented numbers of missions and technologies for scientific exploration of space. We see a sparkle in the eyes of middle school and high school students and we are responding to questions about

"how do I get a career in aerospace?" So, in answer to the question "what has been the impact of lunar exploration?" we conclude that recent exploration has stimulated an interest in math, science and engineering, but history shows that there must be significant, ongoing events to maintain that interest.

Ethical Considerations in Astrobiology: A Proposal for Guidelines Applicable to the Discovery of Non-Intelligent Extraterrestrial Life

Margaret S. Race,
SETI Institute

Richard Randolph
Center for Theology and Natural Sciences (CTNS), Berkeley, CA, and Saint Paul School of Theology, Kansas City, Missouri

Integral to NASA's Astrobiology Program are four operating principles that touch on important societal issues, including the notion of planetary stewardship, emphasizing protection against biological cross contamination and recognition of ethical issues surrounding the search for extraterrestrial life. For decades, space-exploring nations have been guided by international treaties and policies aimed at avoiding harmful cross contamination, but there has been little attention paid to the ethical dimensions of exploration itself. Moreover, while formal principles have been adopted for the eventuality of detecting intelligent life in our galaxy (SETI Principles), no such guidelines exist for the discovery of non-intelligent extraterrestrial life within the solar system. In light of our advancing capabilities to explore far beyond Earth, it is prudent to consider not only how we undertake exploration, but also the implications of making and maintaining future contacts or planning deliberate, invasive activities on extraterrestrial bodies where life may be discovered. Since scientists are actively planning missions to Mars, Europa and other bodies with biological potential, it is timely to consider the many implications of discovering microbial life in the solar system. Based on an analysis of applicable ethical principles and consideration of the likely encounter scenarios, we believe there is a need for interim guidelines applicable to the discovery of non-intelligent extraterrestrial life. Like the SETI principles, these guidelines should serve as operating protocols at the point and moment of discovery, until longer-range plans for the handling and treatment of extraterrestrial life can be developed through international consultation. There is growing scientific confidence that the discovery of extraterrestrial life in some form is nearly inevitable. It is appropriate to encourage comprehensive discussion of the issues prior to an event of such historical significance.

Living Far From Earth

Allen Tough
University of Toronto

Within 100 years, various groups of people will likely be living far from Earth. People (or robots that are even smarter than the people of today are) will probably live on the Moon, Mars, asteroids, and perhaps in large self-contained space settlements at the Lagrange points. BENEFITS. The existence of groups living far from Earth will produce at least five major benefits: (1) Mining, low-gravity manufacturing, tourism, power satellites, interstellar beam propulsion, and other material benefits. (2) A new frontier, a place for pioneers and adventurers to move to. (3) Greatly reduced chances of human extinction from a worldwide war. (4) The flourishing and evolution of an instructive diversity of cultures, societies, ideas, perspectives, and worldviews (less encumbered by entrenched norms and massive governments than their counterparts on Earth). (5) A suitable off-Earth meeting ground if needed for interaction with intelligent extraterrestrial beings or robots.

Implications for Policy. Several powerful implications for policy arise immediately: (1) Major resources should be devoted to all of the next steps necessary for eventually enabling small groups of people to live far from Earth. It will likely happen, one way or another, so we might as well provide beneficial leadership and guidance to the process. Flexible partnerships among space agencies, industry, governments, universities, and entrepreneurs could be especially valuable. Adequate support for nanotechnology (molecular manufacturing) and advanced computer intelligence is particularly important because of their likely role in enabling life in space. (2) Each group living in space should be somewhat diverse, quite different from our current conception of astronauts, and should have as much freedom as possible. This will enhance the evolution of cultures and ideas mentioned above in #4. To prepare for this eventual goal, we should soon study historical analogues and create simulations on Earth. (3) Within the rapidly developing field of genetic engineering, some research should focus on the feasibility and desirability of producing individuals uniquely suited to living in space. (4) Because space settlements increase the likelihood of finding microbial life or making contact with extraterrestrial intelligence, disciplined thought and creative simulations should be utilized to prepare for such an event. Carefully prepared plans should be in place very soon, ready for the news that we have confirmed detection of microbial or intelligent life that arose somewhere far from Earth. Such preparations can avoid the worst catastrophes and maximize humanity's benefits. (5) Social science research should study the important role that will be played by deep-seated human attitudes. In particular, it should study (a) common attitudes toward living far from Earth and toward life in the universe, and (b) the impact that success in either venture will have on our conception of our place in the universe and our sense of meaning and purpose. (6) Some serious thought and discussion should be devoted to the possibility that humans traveling farther and farther from

Earth will eventually trigger a response from an extraterrestrial civilization or probe that is monitoring our society.

Predicting Reactions to the Detection of Life beyond Earth

Douglas A. Vakoch
SETI Institute

We have many commonsense notions about how people will respond to the discovery of extraterrestrial life, but these beliefs may not all be accurate. For example, it has been suggested that people will react to news of signal detection from extraterrestrial intelligence somewhere along a continuum from extremely negatively to extremely positively. However, empirical research suggests that responses may be more complicated. It seems that this pattern may fit well for American respondents (with any given individual tending to have either positive or negative expectations), but not for Chinese individuals (with the same person more often imagining both positive and negative consequences of signal detection) 1) To cite a case applicable to the detection of either microbial or intelligent life beyond Earth, it has often been noted that discovering extraterrestrial life would highlight the fact that we are not at the center of the universe, and may provide a challenge to our self-image comparable to that produced by the Copernican and Darwinian revolutions. In short, we might expect to find anthropocentric assumptions shaken once again. One way to assess the plausibility of such predictions is to see whether, in fact, there is an empirically verifiable relationship between personal characteristics and specific beliefs. In this example, is there a relationship between 1) how anthropocentric people are and 2) how open they are to the possibility of life beyond Earth? Indeed, it seems there is. Recently, we found that more anthropocentric individuals are significantly less likely to endorse statements such as "The origin of life occurs naturally on planets with favorable environments" and "There are so many stars in the universe that there must be life around some of them." We discovered the same relationship between anthropocentrism and beliefs about the likelihood of extraterrestrial intelligent life existing. Moreover, there were statistically significant relationships between beliefs about extraterrestrial intelligence and such personal characteristics as degree of religiosity and feelings of alienation [1]. Carefully planned studies may help anticipate sources of skepticism about or opposition to bona fide reports of the existence of extraterrestrial life. Such studies may help guide strategies for productive public outreach programs that could address people's concerns about detection of extraterrestrial life. Empirical studies conducted prior to detection of life beyond Earth are particularly encouraged, because they could identify a basic battery of well-designed questionnaires and other research instruments to be used in additional studies immediately after detection of extraterrestrial life. Such advanced preparation could facilitate the collection of high quality empirical data about people's reactions to an actual detection mere days or weeks after detection, rather than months or years later if there were no prior planning.
This timely access to relevant data shortly after detection of extraterrestrial life could be of considerable use in planning appropriate policies as well as educational and media initiatives specific to the circumstances of the actual detection scenario. [1]

Vakoch, D. A., & Lee, Y-S (2000)., Reactions to receipt of a message from extraterrestrial intelligence: A cross-cultural empirical study, Acta Astronautica, in press

Appendix III

Workshop on
THE SOCIETAL IMPLICATIONS OF ASTROBIOLOGY
Agenda

Day One: Tuesday, November 16, 1999

Morning

8:00 Registration and Continental Breakfast

8:25 Introductions
Greg Schmidt, NASA ARC

8:30 Welcome to the Meeting
Director, NASA ARC

8:35 Overview of Astrobiology
David Morrison, Director, Space, NASA ARC

8:45 The Mission of the Workshop
Baruch Blumberg, NASA Astrobiology Institute
Director

8:55 Break

Question One: Why Do We Search for Life or its Beginnings?
Session Chair, Baruch Blumberg
Session Reporter, Kathleen Connell, NASA ARC
Session Introduction

9:05 Panel Reports
Mark B. Adams, University of Pennsylvania
Bruce M. Jakosky, University of Colorado
Mark Lupisella, NASA Goddard

10:10 General Discussion

11:00 Recommendations to the Astrobiology Program

12:00 Lunch
Speakers: Greg Schmidt and Scott Hubbard, NASA ARC
Education and Outreach: "Astrobiology and Mission Opportunities."

Afternoon

1:00 Question Two: What are the implications of observation of life and human exploration off the home planet?

Session Chair: Lynn Harper, NASA ARC
Session Reporter: Greg Schmidt, NASA ARC
Session Introduction

1:05 Panel Reports
Ben Bova, author
Christopher P. McKay, NASA ARC
Del Schuh, Aerospace States Association

2:10 General Discussion

3:05 Recommendations to the Astrobiology Program

3:50 Break (Session Reporters convene)

4:20 Reconvene with report-out session with findings.

4:50 Adjourn

Day Two: Wednesday, November 17, 1999

Morning

8:30 Continental Breakfast

9:00 Question Three: How should we respond to the discovery of life elsewhere?

Session Chair: Steve Dick, Naval Observatory
Session Reporter: Lynn Harper, NASA ARC
Session Introduction

9:05 Panel Reports
John Billingham, SETI Institute
Steve Dick, Naval Observatory
Jim Funaro, Cabrillo College
Albert Harrison, University of California, Davis
Margaret Race, SETI Institute

Douglas A. Vakoch, SETI Institute

10:15 General Discussion

11:00 Recommendations to the Astrobiology Program

12:00 Lunch
David Morrison, NASA ARC, and panel
Education: "Communicating our Vision of Society and Astrobiology"

Afternoon

1:00 Question Four: What is the evolutionary fate of human societies and cultures beyond the home planet?

Session Chair: Kenneth Jon Rose, author, scientist, and attorney
Session Reporter: Scott Hubbard, NASA ARC

Session Introduction

1:05 Panel Reports
Ben Finney, University of Hawaii
Charles L. Harper, Jr., Templeton Foundation
Howard McCurdy, American University
Allen Tough, University of Toronto

2:10 General Discussion

3:00 Recommendations to the Astrobiology Program

3:45 Break (Session Reporters convene)

4:10 Reconvene with report-out session with findings.

4:30 General Discussion and Wrap-up
Kathleen Connell, NASA ARC

4:40 Adjourn