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Astrobiology: Process and Discovery

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1. Introduction

I am very pleased to welcome you to the Fulbright Symposium 2002, Science Education in Partnership, held in conjunction with the Bioastronomy Symposium. I know you will all want to join me in offering our thanks for the beautiful Aboriginal welcoming ceremony. It was particularly meaningful for me. My first trip to this country was in 1966 when I was engaged in medical fieldwork in Western Australia that included members of the Aboriginal community. The ceremony connects this meeting with the earliest human history of this fascinating continent.

2. Education and Outreach

The education of young scientists is one of the most important activities of the astrobiology program and of the NASA Astrobiology Institute. Astrobiology, along with other aspects of space science, takes a very long time to accomplish. For example, at the present rates of speed of spaceships it takes nine months to reach Mars from Earth. For return missions, planetary dynamics require an additional nine months or so sojourn on the planets before the nine-month return trip can be launched. A series of trips will be required in order to test the many hypotheses that have been formulated by the planetary science community and to generate and test new hypotheses. Missions to Europa and other planetary satellites could take even longer. Many of these trips are scheduled for launch several years from now. Therefore, a scientist who is in mid-career when the experiments are first designed and executed will have retired, or died, by the time the data from the missions he or she helped to launch are returned. The sons and daughters of the scientist, or someone else's children, will have to understand the initial experiments and be there to analyze the data and determine if the hypotheses of their scientific parents and grandparents have been supported or rejected. Then, they in turn will come forward with their own ideas in this generational process to carry on the endless quest that is the essence of the scientific enterprise.

It is essential for the perpetuation of space exploration that young people acquire an enthusiasm for space discovery and that they become part of the process at a sufficiently early age so that they survive to see the results after their mentors are no longer able to do so. It is similar to the building of the medieval cathedrals that often took hundreds of years and multiple generations of planners and workers to complete the task. The edifice is often different in its final form than the building envisioned by the original planners; time, events, and personality affect all of human design and discovery.

3. The Astrobiology Mission

The goal of astrobiology is to understand how biology – life – interacts with the planets and other bodies in the universe. The study of the origin, evolution, distribution and future of life on Earth and in the universe is an often-used mission statement. It seeks to explain how life began on Earth and to test the hypothesis that life exists elsewhere in the Universe. There are currently many suggestions that life exists now or may have existed in the past on Mars, Europa, or other places, but there is no convincing proof that it does. Either outcome of the ongoing testing will be interesting. If life does exist, then a whole new universe of ideas and research will emerge. It will be possible to generate a general theory of Biology, as contrasted to the special Biology that, as far as we know, pertains only to our own planet. If the hypothesis of life is not confirmed than we are faced with the possibility that we are the only life in the universe with all the consequences of that reality.

However, it is difficult to reject a negative hypothesis. Even if, in the short run, rejection is feasible, the continued discovery of planets and planet systems orbiting extra-Solar stars elsewhere in our galaxy continues to generate the possibility of life existing in these remote locations.

The Astrobiology Roadmap that has served as the guideline for astrobiology research was formulated at a workshop held at NASA Ames Research Center in California in July 1998. Several hundred members of the astrobiology community as well as leading scientists from other disciplines attended the workshop. From its start, the scientific community set the direction of astrobiology. NASA has funded astrobiology by several mechanisms. One of these is the NASA Astrobiology Institute (NAI) whose operations began in 1998. NASA announced a Cooperative Agreement Notice in 1997 (and again in 2000), to which a large number of research groups applied. The grants provided approximately one million dollars per year for a total of five years for each of the fifteen selected Teams. NAI is a virtual institute; the Teams operate from their own institutions spread throughout the United States. Leadership and management are exercised through NAI Central located at NASA Ames Research Center.

The major mission of the NAI is to conduct basic research. NASA science in general and astrobiology in particular has been and will be a massive source of new ideas. Researches are able to look and measure in places that could not be accessed until the necessary space vehicles and technology became available. NAI is organized to allow the scientists to have a major role in deciding the science they consider most important. They can select the projects they wish to do within the limits of the NASA mission and the Astrobiology Roadmap. Their applications are then judged on scientific merit and the proposed contribution of the Teams to the other NAI missions. The applications are judged by an external committee, and the composition of the committee is changed for each series of applications to prevent the formation of a small group of evaluators who would have an ongoing role in the determination of NAI supported astrobiology science. Further, I have advised the NAI scientists that I do not expect them to do exactly what they said they would when they submitted their proposals. The direction of basic science can change very rapidly and new discoveries that could not have been predicted at the start of the investigation can and should change the direction of research.

An additional mission of the NAI is education and public outreach and a significant part of our budget is allocated to this purpose. Later in this symposium you will hear from members of the NAI staff who will discuss the details of the education program. A broad education, both general and specific is important for astrobiology research. Astrobiology deals with many social, intellectual, philosophical, and even spiritual concepts that are best appreciated from a broad general knowledge and experience. It also requires a broad scientific training. The field encompasses astronomy, cosmology, geology, paleontology, various forms of chemistry, field biology, microbiology, cell and molecular biology, information technology, robotics and a variety of other subjects. Contemporary science education emphasizes specialization in a particular discipline and, often, specialization within that discipline to a narrow area of expertise. Astrobiology is heading in a different direction; although scientists in the field usually hold graduate degrees in a conventional academic discipline they have to be open to other fields and to develop a comprehension, not only of the subject matter, but their style of scientific process.

Astrobiology includes historical sciences such as geology, paleontology, field biology, and astronomy, where the event has happened and the scientist attempts to understand the phenomenon using, primarily, observational methods. It combines this with contemporary biological research that is primarily experimental and hypothesis-driven; the scientist designs an experiment, that is meant to duplicate a natural phenomenon, and then studies the world that he or she has created with the expectation that it will provide insights into the real world of phenomenon. Historical sciences depend strongly on the inductive phase of science, that is, the observations are made first, and the hypotheses are derived from them. Modern biological sciences, particularly medical sciences, are primarily deductive, that is the hypothesis is formulated first, and then the experimental and other data is collected to test it. The fascinating feature of astrobiology as a scientific endeavor is that it combines these two essential approaches. It is also a reason why astrobiology and similar subjects has become an attractive undergraduate course. (More than 150 such courses are offered in Colleges and Universities in the USA.) It offers to the beginning undergraduate a broad range of sciences and the binary scientific process described above, combined with a fascinating and contemporary scientific adventure. It is basic science, linked to the demands of space technology.

Public outreach is essential to astrobiology as it is to all of modern science. In a democratic society the citizens, through their elected representatives, fund most basic research. Scientists have the responsibility to inform the public about their work and, when necessary, explain it to them to facilitate their making appropriate choices on which areas of science to support. It is necessary to include all elements of society in the scientific pursuit and in making these decisions. NASA and the NAI are dedicated to programs to include genders equally and to assist minorities and others to take part in space related research. NAI has started a program to include traditionally minority colleges and universities in our research programs. We provide funds for research sabbaticals for faculty members of these institutions to work at NAI laboratories on subjects selected by mutual agreement with the teams and institutions. It is expected that these collaborations will lead to joint research projects that will further engage the minority institutions with the astrobiology community.

Astrobiology has a great appeal to the public. It is a generator of new ideas that could not have been imagined before we had the facilities to venture into space, and occupy it. For example, the ice on earth is viewed much differently after the ice on Europa was seen and studied. Impact craters on Earth have a different meaning now that those on the moon have been partially explored and their significance will even be greater after the craters of Mars are explored and, perhaps, visited. Astrobiology is a great quest setting out, as it does, to the planets and beyond, serving the human need for discovery and adventure.

4. Organization of the NASA Astrobiology Institute

The NAI includes 15 Teams spread across the United States located at Universities, Research Institutes, and NASA Centers. Different kinds of expertise flourish in different Teams and it is a mandated mission of NAI to develop methods to enable the members of this "virtual" institute to effectively work together. The Principal Investigator of each of the Teams determines membership in his or her Team. There are about 740 members including about 150 senior investigators; they are engaged in a total of 96 projects. There are many distinguished scientists in the Teams; 15 are members the National Academy of Sciences of the US. There is an impressive list of publications many in leading scientific journals. These are given in our annual scientific reports, available on our website (www.nai.arc.nasa.gov).

There are also five foreign associate and affiliate institutions; Spain, the United Kingdom, Australia, France, and the European astrobiology group. We have developed excellent collaborative interactions with our international colleagues. It is particularly gratifying to attend this international meeting organized by our affiliate, the Australian Centre for Astrobiology and its Lead Dr. Malcolm Walters.

The virtual format has great advantages in that it combines many scientists, working in their own laboratories and supported by their own institutions to work on a national program that does not require the cost of constructing and maintaining building and facilities. But, how can they communicate and collaborate at a distance? This is a common problem in the contemporary era of large national and international organizations.

Fulfillment of this mission requires the selection of appropriate electronic, video, telephone, internet and other facilities. But, it also requires an understanding of the sociology and even the psychology of scientists and how they interact with each other in a scientific and personal mode. Dr. Lisa Faithorn, The Collaborative Research Manager of NAI will address these issues later in the Symposium. Her training and experience has been in anthropology and management - her fieldwork was with the Highland people of Papua New Guinea – skills that she has used in developing an extensive survey and analysis of the collaboration needs of the NAI.

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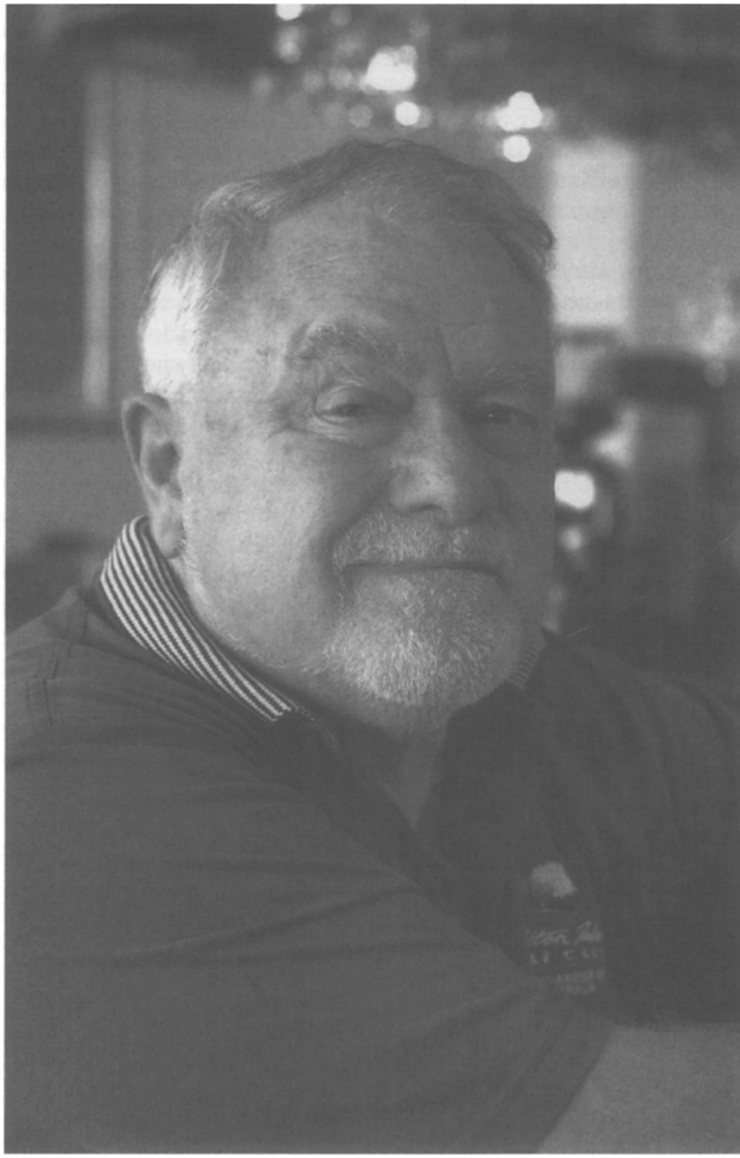
We supply videoconferencing capability to the Teams and are now supplementing this with personal computer based methods for conferencing, data exchange and storage. We have started other programs to enhance the collaboration that is essential to the institute concept. NAI Focus Groups are organized on a research theme. Members of the NAI Teams, as well as scientists from outside NAI are welcome to join these programs. Some are focused on planets and their satellites; Mars, Europa, and Titan. Others deal with concepts and processes: Astromaterials (i.e., meteorites), Ecogenomics (genes and the environment), Mission to Early Earth (geology, paleontology and molecular biology), Evogenomics (the population genomics of early organisms), and, the proposed Virus Focus Group. These bring together scientists in a cross Team effort, often using the video conferencing capabilities for the design and in some cases execution of experiments.

We also have an NAI Fellowship program for postdoctoral training conducted by the National Research Council. Fellows are encouraged to interact with more than one Team and to travel between them to convey personal knowledge of the science from one location to another. They also can be funded to attend field trips conducted by their Team or another. In a program initiated at the University of California at Los Angeles, students at several of the Teams have founded student astrobiology clubs that provide interaction at the home and other institutions. The NAI General Meetings, held every other year, allow all team members to meet in person to supplement the electronic means of communication. These and other mechanisms both formal and informal have enriched the concept of an Institute that is bigger than the simple sum of its parts. Time will be required to evaluate how successful this has been but it is fair to say that it's much better now than it was at our beginnings several years ago.

5. Conclusion

Astrobiology is a young scientific field that has attracted an enthusiastic interest. These Symposia are a further step in its growth and emphasize the important role that Australian science has and will take in its development.



Ray Johnston, resident astronomer on Hamilton Island, who contributed so much to the success of this Symposium (*photo: Seth Shostak*)

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