NASA Ames Astrobiology Academies (1997-2003)
Group Research Projects

2003 Microbiologically Induced Corrosion at Hydrothermal Vents

Deep-sea vents are host to a variety of extremophilic microbial life including thermophilic (heat loving) and chemoautrotropic (extracting energy from chemicals) bacteria and archea. These microbes are considered to be the earliest forms of life on Earth. Extremophilic microbes may thrive in a wide range of conditions within the solar system, expanding the "Habitable Zone." Microbes similar to those found around hydrothermal vents may be found in liquid water oceans beneath the ice of Europa or subsurface hydrothermal systems on Mars. Future solar system exploration will have strict sterilization requirements to insure that probes do not contaminate other worlds. Sterilization requirements are critical for identifying new life on other planets instead of stowaway microbes.

An apparatus comprised of multiple metal and tile plates with varying compositions was engineered and assembled to be sent to a deep-sea hydrothermal vent aboard the MIR deep-sea submersible. The apparatus will spend one to seven days on the ocean floor in the Menez Gwen area (along the Mid-Atlantic rift zone near the Azores) accumulating biological material and corroding. After a retrieval dive, the apparatus will be returned to the surface and preserved for study by the NASA Academy research team at Ames.

The goals of the group project are to produce a sound scientific experiment with potential for publication and outreach. The project draws on the diverse talents of all thirteen-academy students and the resources of the Academy infrastructure.

2002 "Human to Mars: The Political Initiative and Technical Expertise Needed for Human Exploration of the Red Planet"

We describe how a human mission to Mars would not only create a unified goal for NASA but would also unite and strengthen the entire nation. We show how a human Mars mission is an investment, not only in basic scientific knowledge to unravel the mysteries of our neighboring planet, but also in strengthening our nation. The benefits of such a mission are outlined. We show why, given the current state of our nation, a Mars mission is a necessity. We explain the feasibility of a human mission, presenting an overview of existing technology and current research that, when integrated, could make a mission to Mars both physically possible and safe for our astronauts.

Since last summer, the NAABA2K2 group stayed motivated to continue our group project. Several of us made presentations to our respective space grant offices as well as to schools. Several of us participated in a poster presentation of

our project at the February 2002 NASA Astrobiology Institute (NAI) Astrobiology Conference at Arizona State University. We followed this up with an oral presentation at the Humans in Space Symposium in Banff, Canada sponsored by the International Association of Astronautics (IAA) in May 2003 and a presentation at the Astrobiology Colloquium at Ames in July 2003. We are now waiting to see if the IAA in Acta Astronautica may publish the manuscript. We were proud that nine of the original twelve authors were present for the symposium. Ultimately, we hope to send our document to members of Congress at the time of the MER landings when we feel that public interest in Mars will be at its peak. Our goal is to play a small part in driving the initiative to get humans to Mars.

Working on this project was a very rewarding experience — broad in scope, requiring our group to bring diverse talents and viewpoints to the table. Surprisingly, though we learned much about Mars and human spaceflight, we learned even more about the motivation for the entire space program. This study gave us insight into how and why things have happened in the human spaceflight program in the past, and how we can learn from these past experiences as we push forward with our careers in the space program and hopefully on to Mars.

2001 "Variations in growth, metabolism, and reproduction of iron-processing bacteria in a low pressure environment"

The purpose of this research project was to investigate the viability and metabolic activity of terrestrial iron oxidizing microorganisms under Mars-like pressures. Assessing the possibility of microorganisms thriving on the surface of Mars would help to direct future astrobiological missions searching for life on the red planet. Given the experimental nature of this research project, it was necessary for our group to collaborate with scientists not only at NASA Ames, but also throughout the United States. After deciding to study the iron oxidizing bacteria *Shewanella oneidensis*, our group collaborated with Dr. Ken Nealson and the Life Detection Group at NASA JPL to obtain this organism, and to learn the biological techniques necessary for our experiment. The NASA Ames Astrobiology Academy of 2001 came from a variety of scientific and engineering backgrounds. This research project allowed each of us to gain valuable skills working as an interdisciplinary team within the NASA system.

We investigated how symbiotic microbial systems respond to changes in atmospheric pressure. A number of different bacterial pairs were considered. Of particular interest to this study was an iron redox pair, given its possible implications in Mars terraforming, and understanding possible life on early Mars.

2000 "Characterization of Biomass in an Alluvial Feature at Haughton Crater - An analog for Future Manned Sample Return Mission to Mars"

Haughton Crater, located on Devon's Island, Nunavut in the Canadian high arctic contains a Mars-like alluvial feature ideally suited for testing protocols that could be adapted for future missions to Mars. A goal central to a Mars mission is the characterization of any biomass that associated with a landing site. In address of this goal, the Academy group developed a novel protocol for manned sample return of rock and soil samples using commercially available materials. A member of the Haughton-Mars Project implemented the sampling protocol, and materials with the biological-signature of the site were successfully acquired and returned to the Academy. Phospho-Lipid Fatty Acid Analyses of these samples revealed specific trends in the distribution of biomass across the elevation and depth of the feature. These data provide suggestions for locations of highest probability for fruitful detection of bio-signatures at an analogous alluvial feature on Mars.

We characterized the relative biomass within a Mars-like alluvial feature, creating a novel protocol for manned sample return. Through implementation of this protocol, biomarkers samples could be acquired, analyzed, and sample trends revealed.

1999 Scouting for Lunar Resources: Local Confirmation of Inferential Data via a Lander and Rover Combo

With lunar Prospector's confirmation of a strong hydrogen signature at both lunar poles, the next step is to send a robotic explorer into the shadowed craters of these regions to determine the chemical structure of the material retaining (or "binding") this hydrogen. The proposed group project proposed sending a Discovery type robotic mission to the lunar pole to verify both the existence of water ice (and possible organics within the ice) and ^{3}He.

Following the combined group effort of the summer of "99, this project was presented orally at the 2000 Space and Robotics Conference and presented as a poster at the First Annual Astrobiology Conference at Ames Research Center. In addition, the group project leaders were invited to present the paper to the ESA ESTEC meeting in Amsterdam in the summer of 2000.

1998 KC 135 potential flight - Autogenic Feedback System (AFS)
Dr. Patricia Cowings

Since the beginning of manned space flight, effects of microgravity on the human nervous system have been studied. Until recently only Intramuscular Promethazine was prescribed as a means of alleviating "space sickness." In collaboration with Dr. Patricia Cowings and her Autogenic Feedback System (AFS), we proposed a series of tests and exercises that could acclimate astronauts to the rigors of space travel. The AFS is a system that can measure in real-time skin conductivity, body temperature, pulse rate, ECG, and respiration. The AFS then correlates that data with an accelerometer attached to the subject's head to

measure head movement and determines the effects of motion on the body. We proposed that a suite of exercises that would train a person to become less affected by motion sickness while in microgravity.

To this end, two flights on the KC135 Reduced Gravity Research platform separated by several weeks of our designed exercises would be necessary to study both pre- and post-conditioned human physiological responses to microgravity. The results of our study ended in a feasibility study and proposal to the KC135 program office.

1997 Student Shuttle Flight Experiment - Neurolab Dream Study Proposal

STS - 90 flight
Dreaming differs in space as compared to dreaming on Earth. The objectives of this effort were to determine if dream frequency differs during space flight; to determine if dream content and themes are influenced during space flight; and to assess the effects of melatonin on dreaming

Life events, body chemistry, and environments have an effect on sleep and dream cycles. Melatonin has been studied for its effects on sleep. It is likely that the extreme environment of outer space influences the sleep and dreams of crewmembers. The crew of the Neurolab mission (STS-90) wore SleepNets (to record EEG readings) and participated in a double-blind study on the effects of melatonin on sleep. The existing sleep study included a questionnaire the astronauts filled out daily. The objective of the 1997 Astrobiology Academy's group project was to determine if dreams differ in space. The proposed study was to be in the form of approximately five questions added to the existing sleep questionnaire. Questions would focus on the emotion, setting, content, sensations, and vividness of the dreams. The study would incorporate pre-, post-, & in-flight testing with the questionnaire. Unfortunately, the study has not yet been approved because time constraints did not allow a scientific peer review before STS-90 took flight. However, the academy participants communicated with various researchers and personnel associated with NASA and sleep/dream research, including the crew of Neurolab and the sleep study PI’s. The 1997 Astrobiology Academy received the shuttle crew award in 1998.