

Indiana Princeton Tennessee Astrobiology Initiative (IPTAI)

Astrobiology

Astrobiology is the study of the living universe. Advances in science and technology are yielding dramatic new knowledge about the origin, distribution, and destiny of life. Scientists have analyzed complex organic chemistry in interstellar clouds of gas and dust and have discovered more than 100 planets outside of our solar system. Life on Earth has been found thriving at environmental extremes such as in Antarctic rocks, boiling hot springs, and aquifers buried kilometers below the land surface. We have found that liquid water, the one essential ingredient for life as we know it, once flowed on the surface of the planet Mars and exists today below the icy crust of Jupiter's moon, Europa. We ponder the implications of baffling physiological and chemical changes induced by the space environment. We are only beginning to probe the adaptability of life to conditions beyond our home planet Earth. This multidisciplinary field brings together the physical and biological sciences to address some of the most fundamental questions of the natural world:

- How do living systems emerge?
- How do habitable worlds form and how do they evolve?
- Does life exist on worlds other than Earth?
- How could terrestrial life potentially survive and adapt beyond our home planet?
- How do rapid changes in the environment affect emergent ecosystem properties and their evolution?
- How have the Earth and its biosphere influenced each other over time?

NASA Astrobiology Institute

In 1998 NASA established the NASA Astrobiology Institute (NAI) as one element of its research program in astrobiology. The NAI is currently composed of 16 Lead Teams, which together represent over 700 investigators across the United States, and it has international partnerships with astrobiology research organizations around the world. The NAI is a virtual organization that represents a partnership between NASA and competitively selected NAI Lead Teams to promote, conduct, and lead integrated multidisciplinary astrobiology research. These and other partnerships are helping to train a new generation of researchers in the discipline of astrobiology and reach out to teachers, students and the general public. NAI Lead Teams involve researchers from multiple disciplines, and they usually include team members from a variety of geographically distributed institutions. Members collaborate with one another, both in person and virtually, using communication and collaboration tools supplied by NAI.

The Indiana Princeton Tennessee Astrobiology Initiative (IPTAI) team will focus on the detection of biosustainable energy and nutrient cycling in the deep-subsurface of Earth and Mars. Geochemists, chemists, microbiologists, and hydrologists on IPTAI team are collaboratively investigating physical and chemical limitations on life beneath the subsurface of Earth. Instrumental detection and monitoring of subsurface ecologies on Earth will be used to design life-detection strategies for the subsurface of Mars. The IPTAI team has recovered microbes (Bacteria and Archaea) from 10- to 100-million-year old, highly saline, fracture water at depths up to 3200 m in South African gold mines. Sulfate reducing bacteria appear to dominate this ecosystem; other indigenous microbial species can be detected, but their pathways of electron transfer are not fully

characterized. We are interested in the identification of specific genes that are critical to the survival of microbes in a wide range of subsurface environments. Life forms in the subsurface of other planets presumably concentrate energy from geological sources similar to those on Earth but the composition and configuration of extra-terrestrial biomolecules could be radically different from those on Earth. In order to design effective life-detection instruments for subsurface planetary probes, we must identify the fundamental elements and behaviors common to subsurface ecosystems on Earth. A combination of field and laboratory experiments will be utilized to search for these unifying characteristics. <http://www.indiana.edu/~deeplife/>

University of Tennessee, Knoxville (UTK)

The UTK team is lead by Dr. S.M. Pfiffner, Research Assistant Professor in the Department of Microbiology and Member of the Center for Environmental Biotechnology Research Center of Excellence. Co-investigators include Ms. K.L. Davis, Assistant Director at the UT Waste Management Research and Education Institute and Dr. D.C. White, and T.J. Phelps Adjunct Research Professor of Geological Sciences and Distinguished Scientist at Environmental Sciences Division at ORNL. Completing the UTK team are the post-docs, graduate students, and undergraduate students at UTK. <http://geomicro.utk.edu>

The UTK team is the IPTAI lead on education and public outreach (E/PO). This role includes organizing and coordinating E/PO activities for the IPTAI and in collaboration with other NAI E/PO groups. E/PO activities include workshops targeting K-12 teachers and minority undergraduate students, internships and mentoring, hands-on experience for K-12 students, and public lectures or poster presentations. An essential responsibility is the assessment and evaluation of the E/PO programs. UTK is also thoroughly involved in the scientific research. The UTK team will participate in laboratory and in situ field experiments using stable isotopes, radiolabeled isotopes, electron donors or acceptors, and selected matrix material that may be used to enrich microbial growth and cultivation, assess metabolic pathways and/or incorporation into cellular materials, and used data analysis tools to interpreting metabolism and relationships with metabolomics. Under the direction of Dr. Phelps, the UTK team will be involved with experiments using the unique high pressure facilities at ORNL. These vessels will examine biogeochemical interactions of subsurface media with hydrocarbons, brines, hydrates, and gases at experimental pressures of 2900 psi for the large 72 liter vessel and up to 5000 psi in the flow through subsurface processor. Many analyses will be coordinated with collaborating IPTAI universities and national laboratories, i.e., functional gene and microarray analyses thereby gaining leverage from the DOE-Genomes to Life (GTL) and similar programs maximizes value in areas of genomic/ proteomic/ metabolomic analysis of microbial species and communities.

UTK Financial Contributions

The CEB-RCE provided a high level of institutional commitment of \$250,000 in matching funds. The matching funds include academic salary, graduate student stipend and tuition, undergraduate salary, travel and supplies for education and public outreach, and computers. These matching funds along with the E/PO lead allowed UTK to be listed as one of the three leading institutes named in the astrobiology initiative.