PRINCIPAL INVESTIGATOR	**PROJECT TITLE**
Max Bernstein	Extraterrestrial Ice Chemistry: The Origin of Life and False Biomarkers
Tim Castellano	Ground Based Detection of Transits of Extra-solar Planets
George Cooper	Molecular and Isotopic Analysis of Meteorite Organic Compounds
David Des Marais, Leslie Bebout, Linda Jahnke	Charting The History Of Earth's Earliest Microbial Ecosystems: Flow Dynamics In Microbial Ecosystems and Environmental Effects on Microbial Growth and Biomarker Production.
Jennifer Dungan	Linking Pattern To Process Using Remotely Sensed Imagery Of Vegetation Canopies
Paul Espinosa	Advanced Animal Habitat Centrifuge Project
Tori Hoehler	Biogeochemistry of microbial ecosystems
Peter Jenniskens	Fate Of Organic Matter In Meteor Ablation
David Morrison	Educational Activities in Astrobiology
April Ronca	Hypergravity Effects On The Maternal-Fetal System
Ted Roush	Calibration of the Mars Reconnaissance Orbiter (MRO) Compact Reconnaissance Infrared Spectrometer for Mars (CRISM)
Nancy Searby and Eduardo Alameida	The Influence of Gravity and Mechanical Forces at the Cellular Level
Jeffrey Smith, Richard Boyle, Xander Twombley	Simulation Testbed for Robotic Exploration of a Martian Surface
Carol Stoker	Searching for Life Underground: Experiments with Drilling in Mars Analog Terrains
David Summers	Detection of Biosignatures with highly sensitive radio-labeling techniques The Stable Isotope Fractionation of Abiotic Reactions: A Benchmark in the Detection of Life
Wenonah Vercoutere	Projects in Biophysics
Robert Welch	Adaptation to Overcome Adverse Visual Effects of Small Head-Mounted Displays

Applicants specify their first, second, and third choice project.

EXTRATERRESTRIAL ICE CHEMISTRY: THE ORIGIN OF LIFE AND FALSE BIOMARKERS

Principal Investigator: Dr. Max Bernstein, NASA Ames and The SETI Institute

The tons of organic material that come to the Earth every day on meteorites and dust particles probably helped to make the Earth habitable, and possibly played a role in the origin of life. The organic compounds in meteorites (which are better characterized than those in dust particles) include amino acids (basic components of proteins) purine and pyrimidine bases (basic components of DNA and RNA), as well as a host of other complex organic molecules that resemble those that make up membranes and play key roles in our biochemistry. The origin of many of these molecules remains mysterious, but in recent years we have performed experiments that suggest low temperature radiation chemistry could account for many of these chemicals.

We investigate the formation and distribution of organic molecules in space and consider the impact such molecules may have had on the of origin life on Earth and the search for life on other planets. We perform laboratory experiments to ascertain what kind of chemistry can be done by radiation processing of low temperature ices. These experiments allow us to assess whether extraterrestrial ices of the kind seen in interstellar space and the Solar System (such as on Europa and comets) are the birthplace of organic molecules such as and amino acids (Nature, 2002, 416, 401–403), amphiphiles (Astrobiology, 2003, 2, 371, Proc. Nat. Acad. Sci. 2001, 98, 815), quinones (Science, 1999, 283, 1135) and other functionalized aromatic compounds (Meteoritics, 2001, 36, 351; ApJ., 2003, 582, L25; ApJ., 2002, 576, 1115).

Understanding how components of proteins and DNA could form in sterile space environments is also of relevance to our search for life elsewhere in the Solar System, the great task now ahead for NASA. If we find evidence of Life elsewhere in the Solar System it will probably be in form of chemical biomarkers, quintessentially biological molecules that indicate the presence of micro-organisms. While most people think of molecules, such as amino acids, and nucleo-bases, as good candidate biomarkers, these molecules are produced non-biotically in space and are expected to be present on the surface of other planets, even in the absence of Life. Understanding the range of non-biological organic molecules that could act as false biomarkers in space is a prerequisite for any reasonable search for biomarkers on other worlds.

Highly qualified candidates should combine laboratory experience with a knowledge of, or an interest in, space science applications that relate to astrobiology.

GROUND BASED DETECTION OF TRANSITS OF EXTRASOLAR PLANETS

Principal Investigator: Dr. Tim Castellano, NASA Ames

Small telescopes and commercially available charge coupled device cameras are capable of achieving the necessary photometric precision to detect transits of short period Jovian sized extrasolar planets. Only 1 of the 100 or so extrasolar planets currently known has been extensively studied during its transits. Tim Castellano of NASA Ames and collaborator Greg Laughlin of The University of California at Santa Cruz have developed a collaboration with amateur astronomers, students and teachers, in order to continuously measure the brightness of many stars that harbor short period extrasolar planets. A small robotic observatory was developed last summer with the help of undergraduate physics students from the NSF REU and NAFEO programs.

Summer 2004 work will concentrate on refining the observatory in order to improve its ability to measure small changes in the brightness of stars indicative or an orbiting planet, surveying promising candidates, and communicating techniques and procedures to amateur astronomers, teachers and students nationwide. A website that facilitates remote collaboration with amateurs, teachers and students worldwide: www.transitsearch.org

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MOLECULAR AND ISOTOPIC ANALYSIS OF METEORITE ORGANIC COMPOUNDS.

Principal Investigator: Dr. George Cooper, NASA Ames

Our principal research involves the molecular and isotopic analysis of organic compounds found in carbonaceous meteorites. Carbonaceous meteorites are of great interest in the study of early solar system organic chemistry and the origin of life. These meteorites were formed at the very beginning of the solar system, approximately 4.6 billion years ago, and thus contain a record of the earliest Solar System chemical processes. Meteoritic material was subsequently delivered to the Earth and other solar system bodies. Therefore, the study of the molecular and isotopic nature of meteorite organic compounds provides information about extraterrestrial organic chemistry and what compounds were present on the early Earth and available for prebiotic chemistry.

In this research students use various techniques of analytical organic chemistry that include gas-chromatography-mass spectrometry and ion chromatography. Synthesis of compounds to be used as standards is critical and students would use methods of organic synthesis.

CHARTING THE HISTORY OF EARTH'S EARLIEST MICROBIAL ECOSYSTEMS

Co-Investigators: David Des Marais, Dr. Leslie Prufert-Bebout, and Linda Jahnke, NASA Ames Research Center

Microorganisms are the primary engines of our biosphere, and so they play major roles in the biogeochemical cycles of carbon, oxygen, nitrogen, sulfur and metals. The hierarchical organization of microbial ecosystems determines the rates of processes that shape Earth's environment, create the sedimentary and atmospheric signatures (biosignatures) of life, and define the stage upon which major evolutionary events occurred. To learn how microbes fulfill these roles on Earth and, potentially, other worlds, we must therefore understand the structure and function of microbial ecosystems. Photosynthetic microbial mats have been major players for billions of years. They are self-sustaining, complete ecosystems in which light energy that is absorbed over part of a diel (24 hour) cycle drives the synthesis of spatially organized, diverse biomass. Thus microbial mats offer an opportunity to study how microbial populations associate to control the biogeochemical cycles.

This project involves experiments with cyanobacterial microbial mats that are maintained in a simulated natural environment. We will explore various conditions that represent stages in the long-term (billion-year) evolution of Earth's environment. The effects of seawater composition, oxygen and dissolved inorganic carbon contents will be measured for ecosystem properties such as population sizes, elemental cycling and gas production. We will seek a better understanding of how the environment influences biosignatures such as atmospheric gases and also chemicals and minerals preserved in sedimentary rocks.

The student will participate in experiments with microbial mats as part of a team. He/she will measure rates of growth and migration, as well as the production and consumption of various key chemical compounds using microelectrodes and chromatographs. These measurements will be interpreted as components of ecosystem processes that can vary in response to changing environmental conditions. The student will thereby contribute to an improved understanding of how ancient photosynthetic ecosystems interacted with changing environments and recorded their legacy.

#1 FLOW DYNAMICS IN MICROBIAL ECOSYSTEMS
This project will focus on looking at the dynamics of water flow on the physical integrity and structure of microbial communities (microbial mats and stromatolites). Focus will be on the effects of physical flow dynamics on sedimentation, diffusion, microbial growth and gas flux in microbial systems.

#2 ENVIRONMENTAL EFFECTS ON MICROBIAL GROWTH AND BIOMARKER PRODUCTION.
This project will examine the effects of various growth conditions (irradiance, nutrients, temperature, flow conditions) on motility and biomarker production in cyanobacteria.

Coursework in chemistry and/or biology, and a working knowledge of word processing and spreadsheets, is necessary.

LINKING PATTERN TO PROCESS USING REMOTELY SENSED IMAGERY OF VEGETATION CANOPIES

Principal Investigator: Dr. Jennifer Dungan

The NASA Ames Code SGE Ecosystems Science and Technology Branch uses images of the Earth's surface collected from space to research natural processes of plant life as well as human activity. A few of our current projects include observing fires across North America, making real-time measurements of agricultural productivity and modeling the seasonal greening of the biosphere. The summer research associate will assist with a project on vegetation canopies as depicted by satellite images. The project is concerned with what explains the spatial patterns seen in images of vegetation canopies and whether these patterns are unique or can be summarized using metrics that would enable the measurement of biomass amount or extent. Students with backgrounds in any Earth or environmental science such as ecology or geography would be well-suited to this work. In addition, student should have computer programming experience.

ADVANCED ANIMAL HABITAT CENTRIFUGE PROJECT

Principal Investigator: Dr. Paul Espinosa

Astronauts exposed to long periods of microgravity experience harmful physiological effects. To develop countermeasures, NASA conduct research to improve understanding of how bones and muscles change in space and after return to Earth, and how hormones and the immune system respond to long exposure to microgravity. Because of the similarity of animal and human physiological systems, the most effective way to obtain large amounts of data is by using animals and flying them in microgravity. The Space Station Biological Research Project (SSBRP) has contracted out the development of the Advanced Animal Habitat-Centrifuge (AAH-C) to fly rats and mice on the International Space Station (ISS) beginning in 2009. The AAH-C will allow both scientists on Earth and astronauts in space to view the animals and monitor their physiology and behavior while the rodents live in space. The rodents will be exposed to microgravity conditions or to different levels of artificial gravity created when the hardware is attached to the Space Station's centrifuge. In addition to acting as a scientific instrument, the habitat must include all the basic facilities to support the animals for up to 90 days onboard the ISS.

These habitats, designed by highly skilled engineers and scientists, can also be attached to an on-orbit glovebox, allowing astronauts to reach into the cages to retrieve animals and perform experiments. Each habitat can house up to 6 rats or 12 mice and must be able to support the rodents on the station for up to 90 days. The habitats must provide air, water, food, waste management, light and dark cycles and temperature control for the rodents and must also contain all waste and odors generated inside the cage and meet the stringent hardware fabrication requirements imposed by the space station.

BIOGEOCHEMISTRY OF MICROBIAL ECOSYSTEMS

Principal Investigator: Dr. Tori Hoehler, NASA Ames

For more than 75% of its history, Earth's biosphere consisted exclusively of microorganisms. During all of this time, microorganisms represented the sole biological agents of chemical change on Earth's surface, and they continue to play a preeminent role in global chemical cycles into the modern day. If Earth's history is any guide, our searches for fossil or extant life on other worlds are more likely to encounter evidence of microbial life than of "higher" organisms. The farther from home we look for life, the more our search will depend on exclusively chemical forms of evidence. With this context, our group seeks to better understand the way in which microbial life affects the chemistry of its host planet. The systems we study must, of necessity, be terrestrial and modern. Wherever possible, however, we focus on systems that provide useful analogs of Earth's microbially-dominated past, and seek to guide our studies and place our results in the context of astrobiological search strategies.

The summer researcher will aid in examining the factors controlling production and flux of potential biosignature gases from one or more systems including: hypersaline microbial mats (as analogs of the vast "reefs" of cyanobacteria that dominated biological productivity on Earth for as much as two billion years); anoxic sediments (as the ultimate biological buffer on Earth's oxidation state, and the ultimate filter on material passing into the rock record); chemosynthetic, anaerobic communities (as potential analogs of Earth's earliest, pre-photosynthetic life forms). Daily activities will consist largely of analytical characterization of gas fluxes from these communities, using a variety of modern analytical tools. Significant time will also be spent discussing the general scientific and astrobiological context for the specific systems under study. Because much of our focus is on understanding the thermodynamic controls on biogeochemistry, a strong background in chemistry, including lab work, would be beneficial for a prospective summer researcher in our group.

FATE OF ORGANIC MATTER IN METEOR ABLATION

Principal Investigator: Dr. Peter Jenniskens

The bulk of extraterrestrial matter falling in on Earth today ablates in Earth's atmosphere as a meteor. In the process, organic matter can be chemically changed to produce prebiotic molecules. In recent years, the Leonid Multi-Instrument Aircraft Campaigns have produced a wealth of data on how dust from comets ends up on a collision course with Earth, on the unusual physical conditions in meteors, and on the fate of organic matter during ablation. The Research Associate will help develop a meteor fragmentation and ablation model to interpret light curve and spectroscopic data and help develop new AIM-IT technology during the August 13 Perseid shower in an effort to expand the spectroscopic data set to include ablation conditions and parent bodies other than that of the Leonids.

EDUCATIONAL ACTIVITIES IN ASTROBIOLOGY

Principal Investigator: David Morrison

Astrobiology is a new, multidisciplinary field, whose intellectual content is still evolving. Since astrobiology draws upon several disciplines and utilizes a variety of approaches (such as exploration science, field work, and hypothesis-driven experimentation), it is difficult for any one person to decide "what is an astrobiologist" or "which topics belong in astrobiology". The NASA approach has been to convene many scientists from different backgrounds to jointly produce a NASA Astrobiology Roadmap. The Roadmap is formulated around research questions, and so far it has been very effective in defining this research field. However, there is an alternative approach based on education in astrobiology. For those teaching an introductory undergraduate course (of which more than 100 are now offered in American universities, mostly by astronomy departments), the question is which topics to include in a one-semester overview. For those planning graduate programs, the question is what knowledge to require for admission to, and completion of, a graduate certificate in astrobiology. The PI led in the original formulation of the NASA Astrobiology Roadmap and is currently investigating college-level education in American universities. This project is primarily a library (and web) research effort to intercompare current educational programs and courses in astrobiology at the graduate level to help address the questions of "what is astrobiology" and "what is an astrobiologist".

The student will collect information on the content of courses and on the requirements of graduate degrees in astrobiology. It will also be useful to interview selected teachers and students to get their impressions directly. The contents of these education programs can be compared with the research efforts in astrobiology, as described by the NASA Astrobiology Roadmap, the current NASA PI grants programs in astrobiology, and the projects of the NASA Astrobiology Institute. The product will be a snapshot in time of the meaning of astrobiology as interpreted by its participants (researchers, teachers, students) and perhaps some insight into the future evolution of this new discipline.

HYPERGRAVITY EFFECTS ON THE MATERNAL-FETAL SYSTEM

Principal Investigator**:** Dr. April E. Ronca

Life on earth, and thus the reproductive and ontogenetic processes of all extant species and their ancestors, evolved under the constant influence of the earth’s 1-g gravitational field. Opportunities to observe biological processes under gravitational conditions that deviate from earth-normal are infrequent and have historically been dedicated predominantly to understanding adult processes. Research in my laboratory focuses on the role(s) of gravity in reproductive and developmental processes in mammals with particular emphasis on effects of increased *(hyper-)* and decreased *(hypo-)* gravity on pregnancy, birth and the transition from prenatal to postnatal life. Studies of mammalian development are dynamic and complex. The mother plays crucial roles in offspring's development, providing necessary resources that promote and foster growth and development. Offspring, in turn, provide stimulation that helps maintain and regulate maternal responses. We focus on bi-directional linkages within the *maternal-offspring system* and therefore, analyze the effects of altering the gravitational field on both mothers and neonates. Our approach is multidisciplinary, performing integrative analyses in conjunction with other laboratories at Ames and several universities.

The Astrobiology Academy student will participate in projects in we will measure intrauterine pressure in late pregnant female rats exposed to hypergravity using the Ames 24-ft centrifuge. We previously found that exposure to hypo- and hypergravity alters the frequency of labor contractions in pregnant rats. Our projects focus on changes in the force of contractions measured by telemetric (wireless) biosensors in addition to changes in maternal uterine connexin proteins and in abdominal muscle. Correlated changes in neonatal neurodevelopmental outcome will also be studied.

The duties of an Astrobiology Academy student will include assisting in hypergravity experiments of the pregnant rats and their offspring and conducting data analysis using statistical programs. He/she would also be expected to attend weekly research meetings to discuss research progress and results. Background in biology and neuroscience and experience with general laboratory equipment is desirable.

CALIBRATION OF THE MARS RECONNAISSANCE ORBITER (MRO) COMPACT RECONNAISSANCE INFRARED SPECTROMETER FOR MARS (CRISM)

Principal Investigator: Dr. Ted L. Roush

The CRISM instrument on MRO is intended to map the mineralogy of the martian surface by measuring the reflected/emitted energy in the 0.3-4.0 micrometer wavelength region. Such information can address the climactic and geologic history of Mars and hence is directly relevant for assessing if conditions conducive to the development of life on Mars ever existed. To achieve this objective a calibration of the instrumental response function is required. This project will involve the Research Associate in the final pre-flight instrumental calibration process. The Associate's participation will include any or all of the following: 1) characterization of the instrumental response to varying levels of light intensity; 2) influence of scattered light; 3) wavelength response; and 4) point spread function. Efforts may include data collection, reduction, and/or analysis. A background in electrical and/or mechanical engineering would be beneficial. Knowledge of IDL and/or ENVI would be desirable.

THE INFLUENCE OF GRAVITY AND MECHANICAL FORCES AT THE CELLULAR LEVEL

Principal Investigators: Dr. Nancy D. Searby and Dr. Eduardo Almeida, NASA Ames

Humans are made up of many cells that perform a wide variety of functions while being subjected to the mechanical loads of daily living. For example, daily activities such as walking and running subject bone-forming osteoblasts to cyclic tension and compression via the cell-to-bone attachment points called focal adhesions. Bone continually remodels and adapts to these mechanical loads. In addition, bone-forming osteoblasts are sensitive to changes in gravity, from microgravity to hypergravity; this sensitivity may be the key reason astronauts lose bone. The objective of our research is to examine the cellular response to these changes in mechanical loading. Cells may respond by activation of key structural and signaling elements within the cell. Likely candidates for mediating cellular responses to mechanical loads include the cell's skeleton, or cytoskeleton, cell surface adhesion receptors, and a complex array of intracellular signaling molecules regulated by tyrosine phosphorylation.

The Research Associate will participate in a project in which mechanical loads are altered and the cellular response studied. The project may involve development of experiment unique hardware necessary to complete the investigation, such as customized cell chambers or automated devices for use on the centrifuge. The Research Associate will assist in hardware development, perform cell biology experiments, and analyze data. The specifics of the project will depend on the Research Associate's background. Background in cell biology and/or engineering, and general laboratory experience is desirable.

SIMULATION TESTBED FOR ROBOTIC EXPLORATION OF A MARTIAN SURFACE

Principal Investigators: Dr. Jeffrey Smith, Dr. Richard Boyle, Dr. Xander Twombley

This Research Associate(s) will develop a computer simulation testbed for robotic exploration of the Martian surface. With this physically-based software simulation, the student(s) will test a variety of design options for future Mars rovers, including walking and wheeled locomotion systems to search for potential evidence of life. The overall goal is to develop a realistic simulation of biological exploration using autonomous tools at remote sites. To accomplish this goal requires a diverse team of theorists, engineers and biologists. This mission supports the Astrobiology goal to search for life, or the building blocks of life, beyond Earth.

One or two Research Associates will be chosen for their potential contribution to the team effort, which aims to produce publishable results in a ten-week period. The team will consist of a Research Associate(s) and NASA Ames staff with an appropriate skill mix that spans three major areas: 1) knowledge of biology and the search for life and its building block on Mars, 2) engineering of Mars rover systems and 3) software development of physically-based computer simulations. The investigators will look for a Research Associate(s) with expertise in any of the following areas:

- Computer Science: develop C++ software for robotic simulation using current tools available at the BioVIS Technology Center;
- Mechanical Engineering/Robotics: work with real robotic systems and provide input to simulation system with validated robotic data results;
- Neuro-Engineering: develop evolutionary robotics control systems based on genetic algorithms for navigation of simulated terrain and completion of mission objectives;
- Geology/Chemistry/Biology: develop sensor/detector requirements of a targeted mission, such as a sample return mission to Mars. Use these scientific objectives to define success criteria for simulated robotic systems.

Objectives of this project:

- Identify current and future walking and wheeled rover designs under consideration for future robotic exploration of Mars. Focus on a future Mars Sample Return mission.
- Identify Astrobiology mission objectives that rovers must accomplish, focusing on a future Mars Sample Return mission.
- Modify existing Mars rover designs in simulation software to include current design considerations.
- Develop self-guided control mechanisms with the simulation environment.
- Identify and design specific sensors for navigational control and for data collection.
- Explore new, original design options considered by the team.
- Perform validation testing of appropriate design options in a Mars-terrain mock-up using design options that have existing hardware to test.

SEARCHING FOR LIFE UNDERGROUND:
EXPERIMENTS WITH DRILLING IN MARS ANALOG TERRAINS

Principal Investigator: Dr. Carol Stoker, NASA Ames

The strategy for searching for water and evidence of life on Mars requires access to the subsurface. The Martian surface is bathed in ultraviolet radiation, which decomposes organic compounds, destroying possible evidence for life. The Viking lander experiments also imply the presence of several strongly oxidizing compounds at the surface, which may play a role in destroying evidence for life at the surface. While water ice is unstable over most of the Martian surface, recent results from the Mars Odyssey Gamma Ray Spectrometer experiment indicate that water ice exists in many locations near the surface under a thin cover of dry soil. Organic compounds created by an ancient Martian biosphere might be preserved in such ice-rich layers. Furthermore, accessing the subsurface provides a way to identify unique stratigraphy, such as small-scale layering associated with lacustrine sediments. Subsurface access might also provide new insights into the Mars climate record that may be preserved in the Polar Layered Deposits. Recognizing the importance of accessing the subsurface of Mars to the future scientific exploration of the planet, Mars Surveyor 2007 Science Definition Team has called for drilling beneath the surface soils.

Autonomous robotic systems for drilling subsurface, and retrieving and analyzing samples, have had relatively little development. Our group is developing several new technologies of relevance to searching for life in the subsurface. These include: (1) Deep core drilling system: we plan a study of a subsurface biosphere in Rio Tinto in Spain by obtaining samples from underground using a drilling system designed for drilling on Mars. We are conducting field experiments at the Rio Tinto to search for a subsurface biosphere living on chemical energy as an analog to searching for life on Mars. The drilling system will be instrumented and samples extracted from underground will be sensed by an array of remote sensing instruments on the surface. (2) Mars Underground Mole: a novel device for subsurface access has been developed for the European Beagle 2 mission. This device is called a subsurface penetrometer or mole. It is designed to burrow its way underground to depths up to 1 m. Building on the Beagle 2 design, we plan to develop a more capable, larger device carrying a suite of sensors capable of measuring subsurface properties.

Astrobiology students could contribute to any of these projects at a variety of levels depending on background. At this phase of the projects, engineering students are particularly needed. Students with mechanical or electrical engineering background could assist with design, development, hardware building and testing. Students with computer science background could assist with software development for controlling the devices. Students with physics or geology background could assist with data analysis of data collected in field work related to these projects. Bilingual students with Spanish language skills are encouraged to apply.

#1 DETECTION OF BIOSIGNATURES WITH HIGHLY SENSITIVE RADIOLABELING TECHNIQUES

Principal Investigator: Dr. David P. Summers, NASA Ames and The SETI Institute

One question of interest in the study of microbes from ancient samples, considering transit of materials between planets, and general studies of microbes in extreme environments, is how long microbes can remain viable when they are dormant. Are the totally dormant? Or can they, under some conditions (such as frozen in ice), repair damage that occurs while “dormant”? For the search for life, some similar questions are… What are the biomarkers that life can leave behind? At what levels can we detect the presence of organisms (both living and dead)?

One project seeks develop tools to investigate the lower limits of metabolic activity. The procedure is to take tyrosine that has been radiolabeled with 125 I and feed it to microbes to test their metabolic activity. Any radiolabel taken up can then be measured by MultiPhoton Detection, a technique that allows the detection of radioiodine at below background levels. This work would involve handling microbes, preparation of radiolabeled materials, measurement of labeling, and possibly biochemical techniques (such as polyacrylamide gel electrophoresis). A candidate ideally should have a background in biological or chemical work and be willing to work radioisotopes.

Another project is the study of “biomarkers” that living organisms possess and leave behind as they die. This is important for the search for life and detecting contamination by bacteria. This project involves the use of MPD and radiolabeling to detect proteins as a marker for the presence of organisms. It seeks to be able to detect proteins that may be present in samples and to also detect the presence of living organsims. This work involves preparation of radiolabeled materials, measurement of labeling, and possibly biochemical techniques (such as polyacrylamide gel electrophoresis). A candidate ideally should have a background in biological or chemical work and be willing to work with radioisotopes.

#2 THE STABLE ISOTOPE FRACTIONATION OF ABIOTIC REACTIONS: A BENCHMARK IN THE DETECTION OF LIFE

Principal Investigator: Dr. David P. Summers, NASA Ames and The SETI Institute

One of the important biomarkers that life can leave behind is the carbon and nitrogen isotope fractionation that remains in the organic matter it produces. However, this implies a comparison with the fractionation that would be expected with any alternate sources of organics for a sample being studied. To be able to establish that an isotope signature observed is indeed characteristic of life, one needs to know what signature to expect from such processes as the abiotic formation of organics. Abiotic carbon isotope fractionation has only been studied for a few reactions and that work has been done assuming a reducing atmosphere. There is a lack of data for processes under the non-reducing atmosphere now thought to have been likely on the early Earth and other terrestrial planets, or data for the nitrogen stable isotope fractionation of abiotic reactions under any conditions.

This work will measure the carbon and nitrogen stable isotope fixation for a series of abiotic reactions that would have occurred in a non-reducing atmosphere. We will study reactions that span the sources of prebiotic organics from shock heating, to photochemistry, to hydrothermal reactions. The work would involve the running of chemical reactions, work up of samples and separation of products, and development of chromatographic methods. A candidate should have some background in chemical experimentation. Unlike the other work, this project does *not* involve the use of radioisotopes.

TWO PROJECTS IN BIOPHYSICS

Principal Investigator: Dr. Wenonah Vercoutere, NASA Ames

#1 CELLULAR BIOPHYSICS:

In this first project, the goal is to elucidate how the structure of DNA influences its molecular dynamics and how this may affect genomic responses to the mechanical stimuli that occur because of gravity. The hypothesis is that gene expression in mechanosensitive adherent cells is in part regulated directly by mechanical force transduction from the extracellular matrix to the nuclear matrix and protein-packaged DNA. This work will improve the context in which we understand the ability of adherent cells to detect, filter and respond to the mechanical stimulation of gravity.

#2 SINGLE MOLECULE BIOPHYSICS:

In this second project, the objective is to elucidate how the dynamics of DNA structure are altered by damage caused by radiation or oxidation at the single molecule level, and determine ways to ameliorate this damage. The chemical changes to DNA caused by ultraviolet radiation are expected to alter the molecular structure and/or dynamics sufficiently to be individually identifiable using an aqueous ion-conducting nanopore detector. This hypothesis is based on previous work has shown that single nucleotide differences can be discriminated using such a nanopore detector. This technique will vastly improve the ability to assess damage to DNA, and provide a simple means to help characterize the risks of radiation exposure in space. It may also provide a method to test radiation protection.

ADAPTATION TO OVERCOME ADVERSE VISUAL EFFECTS OF SMALL HEAD-MOUNTED DISPLAYS

Principal Investigator: Dr. Robert B. Welch, NASA Ames

The use of virtual environment (VE) technology for space flight training and other purposes should, ideally, involve lightweight, energy-efficient head-mounted displays (HMDs). However, in order to preserve pixel resolution, current commercial HMDs are forced to provide users with a very narrow field of view (FOV). This visual restriction is known to disrupt visual perception and visual-motor coordination, with potentially serious consequences for task performance. The goals of our research project are to (1) systematically quantify the deleterious effects of reduced FOVs on perception and performance in the context of the fields of view found in currently available HMDs, (2) determine the role of adaptation as a response to — and as a countermeasure for — these effects, and (3) identify the underlying basis for this adaptation and its response to variables known to influence adaptation to visual distortions in general. The results should indicate whether the problems caused by reduced FOV warrant its increase in future HMDs and will provide the necessary guidelines and specifications for such a redesign.