NASA SBIR 2004 Phase I Solicitation

B2.03 Understanding and Utilizing Gravitational Effects on Molecular Biology and for Medical Applications

Lead Center: JSC

Participating Center(s): ARC

Microgravity allows unique studies of the effects of gravitational effects on cell and tissue development and behavior. These studies use novel and advanced technologies to culture and nurture cells and tissues. Additionally, the ability to manipulate and/or exploit the form and function of living cells and tissues has significant potential to enhance the quality of life on Earth and in space through novel products and services, as well as through new science knowledge generated and communicated. This capability may lead to new products and services for medicine and biology. Current space research includes the development of space bioreactors for culturing fragile cells, which has applications in biomedical and cancer research; tissue engineering systems which take advantage of microgravity to grow 3-D tissue constructs; testing the effectiveness of drugs and biomodulators on growth and physiology of normal and transformed cells, and methods for measuring specific cellular and systemic immune functions of persons under physiological stress. Biotechnology research systems also are being developed for microgravity research on the International Space Station and future space-based laboratories. Studies of this nature are critical to our understanding of how the space environment affects astronaut health, and for maintaining a healthy environment for astronauts during missions of exploration.

Specific areas of interest are:

- New methods for culturing mammalian cells in bioreactors, including advanced bioreactor design and support systems; microprocessor controllers; and miniature sensors for measurement of pH, oxygen, carbon-dioxide, glucose, glutamine, and metabolites. Neural fuzzy logic network systems for the control of mammalian cell culture systems. Methods to minimize biofilm formation on fluid-handling components, sensors and bioreactors. Spectroscopic and biochemical analysis of biofilm formed in bioreactors. Microscale bioreactors for biomonitoring of radiation and other external stressors.

- Technologies that allow automated biosampling and bio-specimen collection, handling, preservation/fixation, and processing in cellular systems. Methods for separation and purification of living cells, proteins, and biomaterials, especially those using electrokinetic or magnetic fields that obviate thermal convection and sedimentation, enhance phase partitioning, or use laser light and other force fields to manipulate target cells or biomaterials.
• Techniques or apparatus for macro-molecular assembly of biological membranes, biopolymers, and molecular bio-processing systems; bio-compatible materials, devices, and sensors for implantable medical applications including molecular diagnostics, *in vivo* physiological monitoring and microprocessor control of prosthetic devices.

• Methods and apparatus that allow microscopic imaging including hyperspectral fluorescent, scattering and absorption imaging, and biophysical measurements of cell functions; effects of electric or magnetic fields, photoactivation, and testing of drugs or biocompatible polymers on live tissues. Integrated instrumentation for separation and purification of RNA, DNA, and proteins from cells and tissues.

• Quantitative applications of molecular biology, fluorescence imaging and flow cytometry, and new methods for measurement of cell metabolism, cytogenetics, immune cell functions, DNA, RNA, oligonucleotides, intracellular proteins, secretory products, and cytokine or other cell surface receptors. Small scale mass spectrometers. Means to enhance and augment genomics/proteomics techniques, including molecular and nano-scale tools. Development of novel fluorophores that tag proteins mediating cellular function, particularly those that can be excited using solid-state lasers.

• Micro-encapsulation of drugs, radiocontrast agents, crystals, and development of novel drug delivery systems wherein immiscible liquid interactions, electrostatic coating methods, and drug release kinetics from microcapsules or liposomes can be altered under microgravity to better understand and improve manufacturing processes on Earth.

• Miniature bioprocessing systems that allow for precise control of multiple environmental parameters such as low level fluid shear, thermal, pH, conductivity, external electromagnetic fields, and narrow-band light for fluorescence or photoactivation of biological systems.

• Novel low temperature sample storage methods (-80°C and -180°C) and biological sample preservation methods. Methods to reduce launch/return mass of biological samples and support reagents.

• DNA template for molecular wiring that permits macro- to nanoscale connectivity. Nanoscale electronics based on self-assembling protein-based molecular structures.

• Computer models and software that better handle large numbers of coupled reactions in cell science systems.

• Tools and techniques to study mechanical properties of the cell: subcellular rheology, cell adhesion, affect of shear flow, affects of direct mechanical perturbation. Tools and techniques to facilitate multiple simultaneous probing and analyzing of a cell or sub-cellular region (examples include atomic force microscope coupled with microelectrode or micro-Raman, Optical trap)

• Nanosensors for sub-cellular measurements: ultra-microelectrodes with less than 1µ diameter including cladding, nanoparticle reporters that provide spectroscopic information, and other novel intracellular sensor devices to provide spectroscopic data on intracellular processes.