STEM CELLS IN MICROGRAVITY

The Center for Applied Space Technology in partnership with representatives from the Mayo Clinic Jacksonville, Morehead State University, and the University of Florida Center of Excellence in Regenerative Health Biotechnology (UFCERHB), is creating an opportunity to explore the characteristics of stem cells and stem cell behavior in the environment of space. Preliminary investigation has indicated that stem cells may demonstrate an enhanced rate of expansion when they experience microgravity. This quality, if proven true in actual spaceflight, has tremendous implications for our understanding and perhaps treatment of a wide range of disease including many cancers. Additionally, such characteristics may very well support the growth of specialized human tissues and organs in space. Our team, including a world-class stem cell research scientist, the creator of the CubeSat/CubeLab, and experienced space fundamental biology researchers and engineers, is highly motivated and well-positioned to explore the behavior of non-embryonic stem cells, as well as other significant biomedicine/biotechnology opportunities through the development and flight of the **CELL CULTIVATION AND ORGANOGENESIS IN MICROGRAVITY (CCOM)** module.

Scientific advancement is often marked by the confluence of novel opportunity, advances in technology, and extraordinary innovation. We are currently experiencing such a convergence with the aggressive advancement of the new commercial space industry, the advent of the International Space Station National Laboratory, and the emergence of revolutionary space hardware. The unique environment of space has long held promise as the source of scientific breakthrough in the fields of fundamental biology, biomedicine, and biotechnology, particularly when considering the removal of the gravity vector from the variables affecting research. For the previous sixty years of spaceflight, such investigation has been hampered by the requirement to shape the research to fit the hardware which was often highly complex, relatively expensive, and flown infrequently. Flight campaigns prior to the advent of entrepreneurial space have been measured in years, not months. The ability to conduct simple first order determination, multiple and frequent replications, and to change-out experiment design based upon preliminary findings utilizing existing flight hardware has been either non-existent or comes at an extraordinary cost in time and resources.

The CCOM module has been designed to specifically address each of these historical impediments to the development of the space life sciences and thereby promote universal space access and research capability to the ultimate benefit of mankind.

The use of cells to repair and regenerate tissues and organs in medical practice is growing. These cells are grown and expanded in two-dimensional tissue culture medium. This is an un-natural condition since cells grow in three-dimensional medium tethered by connective tissue and adhesion molecules inside the body. The gravity exerted by the growing cells is counteracted by the tensile forces from the surrounding connective tissues. We therefore hypothesized that microgravity will create the 3D suspense, mimicking the natural growth condition in the body that facilitates cell growth and expansion. We believe with the appropriate scaffolding, organs can be better generated in microgravity than on earth. Studies suggest stem cells grow better in simulated microgravity. We have assembled a multi-disciplinary team that includes scientists and engineers to make this a reality. We plan to conduct experiments in stages. The initial stage is to assess growth of human cells in microgravity at the international space station. The cultured cells will be characterized and evaluated for their regenerative and functional capacities and their safe use in experimental in-vivo models. The next phase is to evaluate if organs can be generated in microgravity. The generated organs will be evaluated in experimental models for their function and safety. We believe with advances in technology and the aggressive advancement of the new commercial space industry, the advent of the International Space Station as a national laboratory, and the emergence of revolutionary space hardware, the timing of our ambitious proposal is appropriate. The CCOM module has been designed to promote universal space access and research capability to the ultimate benefit of the mankind.

Recognizing the opportunity to conduct game-changing biotechnology investigations in the environment of microgravity and realizing the commercial potential inherent in the exploitation of research findings, the CCOM team is focused on maximizing the capabilities provided by the ISS National Laboratory and other emerging space technologies to advance the common good. We are focused on designing ISS-based research infrastructure that builds upon the unique capabilities currently advanced by the entrepreneurial space community, principally technologies that encourage regular, low-complexity, and low-cost access to space research. Key to our infrastructure, the Cell Cultivation and Organogenesis in Microgravity (CCOM) module, is the ability to conduct regular, customized, and replicable investigation with a primary objective of enabling the first order determination, “does microgravity affect the research subject?” The CCOM is built upon the NanoLab concept and is designed to operate within the NanoLab infrastructure on board ISS. This design will enable regular and timely transport to the ISS through a wide range of spacecraft including the Dragon, Cygnus, Soyuz, Progress, ATV, and HTV. The CCOM will be fully self-contained and is designed to enable three-dimensional cell and tissue culture; media replacement; evaluation using onboard sensors; and environmental control for up to thirty days on orbit. The modular design will promote the simultaneous operation of multiple cultures as well as enable rapid test replacement or replication. The three-dimensional growth capability will support the growth of tissue in conditions analogous to development within the body. This hardware will support unprecedented access to flight research opportunities.