

Title: Space Biophysics: Accomplishments, Trends, Challenges

Author: Jeffrey D. Smith, NASA Ames Research Center

Abstract:

Physics and biology are inextricably linked. All the chemical and biological processes of life are dutifully bound to follow the rules and laws of physics. In space, these physical laws seem to turn on their head and biological systems, from microbes to humans, adapt and evolve in myriad ways to cope with the changed physical influences of the space environment. Gravity is the most prominent change in space that influences biology. In microgravity, the physical processes of sedimentation, density-driven convective flow, influence of surface tension and fluid pressure profoundly influence biology at the molecular and cellular level as well as at the whole-body level. Gravity sensing mechanisms are altered, structural and functional components of biology (such as bone and muscle) are reduced and changes in the way fluids and gasses behave also drive the way microbial systems and biofilms grow as well as the way plants and animals adapt. The radiation environment also effects life in space. Solar particle events and high energy cosmic radiation can cause serious damage to DNA and other biomolecules. The results can cause mutation, cellular damage or death, leading to health consequences of acute radiation damage or long-term health consequences such as increased cancer risk. Space Biophysics is the study and utilization of physical changes in space that cause changes in biological systems. The unique physical environment in space has been used successfully to grow high-quality protein crystals and 3D tissue cultures that could not be grown in the presence of unidirectional gravitational acceleration here on Earth. All biological processes that change in space have their root in a biophysical alteration due to microgravity and/or the radiation environment of space. In order to fully-understand the risks to human health in space and to fully-understand how humans, plants, animals and microbes can safely and effectively travel and eventually live for long periods beyond the protective environment of Earth, the biophysical properties underlying these changes must be studied, characterized and understood. This lecture reviews the current state of NASA biophysics research accomplishments and identifies future trends and challenges for biophysics research on the International Space Station and beyond.