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AUTOMATED, MINIATURIZED INSTRUMENT FOR SPACE BIOLOGY APPLICATIONS AND THE MONITORING OF THE ASTRONAUT'S HEALTH ONBOARD THE ISS

Abstract

Human space travelers experience a unique environment that affects homeostasis and physiologic adaptation. The spacecraft environment subjects the traveler to noise, chemical and microbiological contaminants, increased radiation, and variable gravity forces. As humans prepare for long-duration missions to the International Space Station (ISS) and beyond, effective measures must be developed, verified and implemented to ensure mission success. Limited biomedical quantitative capabilities are currently available onboard the ISS. Therefore, the development of versatile instruments to perform space biological analysis and to monitor astronauts' health is needed.

We are developing a fully automated, miniaturized system for measuring gene expression on small spacecraft in order to better understand the influence of the space environment on biological systems. This low-cost, low-power, multi-purpose instrument represents a major scientific and technological advancement by providing data on cellular metabolism and regulation. The current system will support growth of microorganisms, extract and purify the RNA, hybridize it to the array, read the expression levels of a large number of genes by microarray analysis, and transmit the measurements to Earth. The system will help discover how bacteria develop resistance to antibiotics and how pathogenic bacteria sometimes increase their virulence in space, facilitating the development of adequate countermeasures to decrease risks associated with human spaceflight.

The current stand-alone technology could be used as an integrated platform onboard the ISS to perform similar genetic analyses on any biological systems from the tree of life. Additionally, with some modification the system could be implemented to perform real-time in-situ microbial monitoring of the

ISS environment (air, surface and water samples) and the astronaut's microbiome using 16SrRNA microarray technology. Furthermore, the current system can be enhanced substantially by combining it with other technologies for automated, miniaturized, high-throughput biological measurements, such as fast sequencing, protein identification (proteomics) and metabolite profiling (metabolomics). Thus, the system can be integrated with other biomedical instruments in order to support and enhance telemedicine capability onboard ISS.

NASA's mission includes sustained investment in critical research leading to effective countermeasures to minimize the risks associated with human spaceflight, and the use of appropriate technology to sustain space exploration at reasonable cost. Our integrated microarray technology is expected to fulfill these two critical requirements and to enable the scientific community to better understand and monitor the effects of the space environment on microorganisms and on the astronaut, in the process leveraging current capabilities and overcoming present limitations.