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AUTOMATED, MINIATURIZED INSTRUMENT FOR MEASURING GENE EXPRESSION IN SPACE - THE DOORS TO NEW BIOLOGY IN SPACE

Abstract

Is terrestrial life sufficiently flexible and robust to move beyond its planet of origin to adapt to and thrive in space? To facilitate astrobiological missions on the survival and adaptation of microorganisms and mixed microbial cultures to the space environment, we have been developing a fully automated, miniaturized system for measuring their gene expression on small spacecraft. This low-cost, multi-purpose instrument represents a major scientific and technological advancement in our ability to study the impact of the space environment on biological systems by providing data on cellular metabolism and regulation orders of magnitude richer than what is currently available. The system supports microbial growth, lyses the organisms to release the expressed RNA, reads the expression levels of a large number of genes using microarray analysis, and transmits the measurements to Earth. To measure gene expression, we use microarray technology developed by CustomArray, Inc, which is based on an array of 12.544 electrodes on a semiconductor substrate. The CMOS circuitry supports both the electrochemical synthesis of unique DNA probes on each electrode as well as enzyme-enhanced electrochemical detection of complementary nucleic acid binding. The arrays can be sectored to allow multiple samples per chip. Hybridization is carried out using reporter probe technology, which avoids prior labeling of the extracted RNA. The arrays have been integrated into an automated microfluidic cartridge that uses flexible reagent blisters and pinch pumping to move liquid reagents between chambers. The accuracy of this system in comparison with the accuracy of similar instruments in the laboratory will be discussed.

The proposed instrument will help us to understand adaptation of terrestrial life to conditions beyond the planet of origin, identify deleterious effects of the space environment, develop effective countermeasures against these effects, and test our ability to sustain and grow in space organisms that can be used for life support and in-situ resource utilization during long-duration space exploration. The instrument is suitable for small satellite platforms, which provide frequent, low-cost access to space. It can be also used on many other platforms in space, including the ISS. It can be replicated and used with only small modifications in multiple biological experiments with a broad range of goals.