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GENE EXPRESSION MEASUREMENT MODULE (GEMM) – A FULLY AUTOMATED, MINIATURIZED INSTRUMENT FOR MEASURING GENE EXPRESSION IN SPACE

Abstract

One of the central, long-standing goals of the astrobiology program that holds promise for both major scientific discoveries and exciting the general public is to understand life in outer space and on other celestial bodies. One strategy towards achieving this goal is to determine the potential for terrestrial microbial life to adapt and evolve in space environments. Identifying the limits of terrestrial life in space and the accompanying molecular adaptations is a prerequisite for developing predictions and hypotheses about life on other worlds. The ability of microorganisms to survive in a wide range of conditions encountered in space would support the hypothesis that terrestrial life might not be a local planetary phenomenon, but instead could expand its evolutionary trajectory beyond its planet of origin. This would, in turn, support the notion that terrestrial life may not be unique and similar life forms might exist elsewhere in the Universe.

To facilitate studies on the impact of the space environment on biological systems we are developing the Gene Expression Measurement Module (GEMM), a fully automated, miniaturized, integrated fluidic system for nanosatellites capable of in-situ measurement of expression of thousands of microbial genes from multiple samples. Because of these capabilities GEMM represents a major technological and scientific advancement in space biology. The instrument, supported through the NASA Astrobiology and Exobiology Programs, is scheduled for completion later this year. It will be capable of autonomously (1) lysing bacterial cells, (2) extracting/purifying RNA, (3) hybridizing it on a microarray and (4) providing electrochemical readout of thousands of genes, all in a microfluidics cartridge format.

Once developed, the system can be used with minor modifications for multiple experiments on different platforms in space, including extensions to higher organisms and microbial monitoring on the International Space Station (ISS). The first target application is to cultivate and measure gene expression of the photosynthetic bacterium a cyanobacterium known for its remarkable metabolic diversity and resilience to adverse conditions, exposed to light and dark cycles on a nanosatellite for a period of 6 months in a high-altitude, high-inclination low Earth orbit.

The integration and end-to-end technological and biological validation of the instrument will be discussed. A proposed version of the GEMM that is capable of handling biological samples on the ISS will be briefly summarized.