

Gene Expression Measurement Module (GEMM) – a fully automated, miniaturized instrument for measuring gene expression in space

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The capability to measure gene expression on board spacecraft opens the door to a large number of high-value experiments on the influence of the space environment on biological systems. For example, measurements of gene expression will help us to understand adaptation of terrestrial life to conditions beyond the planet of origin, identify deleterious effects of the space environment on a wide range of organisms from microbes to humans, develop effective countermeasures against these effects, and determine the metabolic bases of microbial pathogenicity and drug resistance. These and other applications hold significant potential for discoveries in space biology, biotechnology, and medicine.

Supported by funding from the NASA Astrobiology Science and Technology Instrument Development Program, we are developing a fully automated, miniaturized, integrated fluidic system for small spacecraft capable of *in-situ* measurement of expression of several hundreds of microbial genes from multiple samples. The instrument will be capable of (1) lysing cell walls of bacteria sampled from cultures grown in space, (2) extracting and purifying RNA released from cells, (3) hybridizing the RNA on a microarray and (4) providing readout of the microarray signal, all in a single microfluidics cartridge. The device is suitable for deployment on nanosatellite platforms developed by NASA Ames' Small Spacecraft Division. To meet space and other technical constraints imposed by these platforms, a number of technical innovations are being implemented. The integration and end-to-end technological and biological validation of the instrument are carried out using as a model the photosynthetic bacterium *Synechococcus elongatus*, known for its remarkable metabolic diversity and resilience to adverse conditions. Each step in the measurement process - lysis, nucleic acid extraction, purification, and hybridization to an array – is assessed through comparison of the results obtained using the instrument with those from standard laboratory protocols.

Once developed, the system can be used with minor modifications for multiple experiments on different platforms in space, including extension to higher organisms and microbial monitoring. A proposed version of GEMM that is capable of handling both microbial and tissue samples on the International Space Station will be briefly summarized.