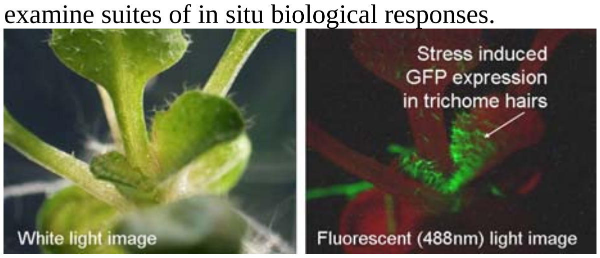
IN SITU BIOLOGICAL RESPONSE: SCALABLE ASSAY OF COMPLEX BIOLOGICAL PHENOMENA USING GENETICALLY ENGINEERED PLANTS.

A-L. Paul[1], A. Schuerger[2] and R. J. Ferl[1], [1]University of Florida, Horticultural Sciences, Program in Plant Molecular and Cellular Biology, Gainesville, FL 32611. alp@ufl.edu , robferl@ufl.edu, [2]University of Florida, Plant Pathology, SLSL, Kennedy Space Center, FL 32899.

Science and Exploration Rationale:

As complex eukaryotic organisms, plants share basic metabolic and genetic processes with humans, yet their sessile nature requires that plants deal with their environment by adaptation in situ. Thus plants have evolved to deal with environmental change and stress by responding with changes in metabolism in order to meet the challenge, making them ideal reporters of the biological impact of their surroundings. Plants are therefore ideally suited for biological experimentation during near-term missions to the moon and other extraterrestrial environs [1]. Further, plants can make the journey within the stasis of the seed, under complete vacuum and extremely low temperatures. Given current and continued emphases in eukaryotic genomics, developmental and molecular biology, truly insightful experiments that address fundamental molecular questions about biological adaptation and responses to extreme extraterrestrial environments can be answered using plants.

A plant growth experiment is scalable over a wide range of variables that should be examined for biological impact. Such variables include atmospheric composition and pressure, transit and in situ radiation, gravity, and exposure to local resources. A plant growth payload is also scalable over a wide range of engineering and mission profile constraints. In a serriously constrained scenario, a few watts of power and a few cubic centimeters would allow examination of growth, development over several critical stages and gene expression in 10-20 plants - all within the course of a single lunar day. In a less constrained scenario, plants could be exposed to lunar regolith and a variety of mitigation technologies to enhance survivability and examine suites of in situ biological responses.



The plants to populate a Lunar or Mars lander experiment would be genetically engineered to be biological sensors (biosensors) of their environment. Plants engineered with Green Fluorescent Protein (GFP) reporter genes can be designed to respond to a variety of stimuli, they can be monitored telemetrically, and biological data can be collected in the form of digital images. Switching between normal lighting and that which facilitates the observation of GFP expression, will enable observation of both the general condition of the plants as well as monitoring of the development of fluorescent signals that cue a response to a specific feature of the environment [2-4].

In practice the plant growth payload would have a series of modules in which plants would be exposed to various aspects of the planetary environment as appropriate, with the size and number of modules being determined by the engineering trade space and mission profile [5]. Gravity would be an inherent component of the lander environment, as would be the incident radiation that penetrated the lander hull. Regolith collected by a robotic arm and returned to the growth space is a potential experimental variable that offers tremendous potential returns. Although there has been some experimentation with the effects of minute amounts of lunar regolith on plant growth in a neutral matrix [6], never has there been a test of its efficacy as a growth substrate and certainly not within the suite of conditions that exist in the in situ lunar environment.

A plant biology payload is both a fundamental test of biological survival outside the terrestrial environment as well as a technical and programmatic step in the development of advanced plant-based life support systems to support human exploration. Potential biotoxicity issues will be addressed directly. If plants can be grown safely in Lunar or Mars regolith, then the use of regolith within human rated habitats (whether as “soil” or simply as building material) becomes much more tenable and plants can then be used for the capture of in situ resources and the movement of those resources into the habitation environment [7].

References: [1] Ferl R. et al. (2003) *Curr Opin Plant Biology* 5:258-263 [2] Paul A-L. et al. (2003) *Plant Physiology* 134: 215-223. [3] Paul A-L. et al. (2003). *SAE Technical Paper* 2003-01-2477. [4] Manak M.S. et al. (2002) *Life Support Biosph Sci* 8:83-91. [5] Schuerger A.C. et al. (2002) *Life Support Biosph Sci* 8: 137-147. [6] Walkinshaw C.H. et al. (1970) *BioSciences*. 20:1297-1302. [7] Ming D.W. and Henninger D.L. (1994) *Adv Space Res*. 14:435-443.