BASIC AND APPLIED ALGAL LIFE SUPPORT SYSTEM RESEARCH ON BOARD THE DEEP SPACE GATEWAY. Tobias Niederwieser[1], Luis Zea[1], Jonathan Anthony[1], and Louis Stodieck[1], [1]BioServe Space Technologies (429 UCB ECAE 1B02, Boulder, CO 80309, Tobias.Niederwieser@Colorado.edu).

Introduction: Currently, life support functions are performed with physicochemical systems onboard the International Space Station [1]. These systems require high maintenance [2,3] and are also not capable of producing food. Hence, by definition they are dependent on continuous resupplies and have been identified as insufficient for long term spaceflight missions, as described in NASA's Technology Roadmap area 06 [4,5]. Research is currently being conducted on Bioregenerative Life Support Systems (BLSS) that may address both of these deficiencies. Specifically, the use of algae offers a promising candidate BLSS component due to its potential multifunctional performance in terms of air revitalization, water recycling, food production, and radiation shielding when cultured in a water-based medium [6–8].

One challenge that remains to be solved is the long-term storage of dormant algae. This capability is needed for two reasons: Firstly, to transport inoculum cultures from Earth to the long-term habitat both for initial inoculation but also for backup cultures in case of anomalies. Second, non-continuously crewed habitats require a method to preserve and rapidly restart the algal cultures following dormancy periods. In contrast to the International Space Station (ISS), which is within the protective Van Allen Belts, the Deep Space Gateway (DSG) provides a radiation environment comparable to planetary surfaces and interplanetary travel. Additionally, the DSG is also unique as it is intermittently inhabited and dormant for longer periods of time. These two unique conditions make the DSG well-suited for BLSS research.

The Effect of Long-Term Preservation Methods on DNA Damage of Algal Cultures: The DSG can enable studies to characterize the effect of long-term exposure to radiation on algae-based BLSS. Two strains of photosynthetic algae may be used: *Chlorella vulgaris* Beyerinck (green algae) as a model organism for eukaryotes, as well as the *Nostoc sphaeroides* Kützing (cyanobacteria) as a model organism for prokaryotes. These types of studies can interrogate multiple aspects of future BLSS, including the role of inoculum state (lyophilized vs. in media, e.g. saline solution without carbon source) on cell viability after long-duration stasis in the high-radiation environment of cislunar orbit. A subset of the sample can be shielded to serve as controls of the radiation independent variable. The hardware needed to support these types of investigations would include radiation dosimeters and temperature controlled incubators. Crew time would only be required at the start of the experiment to set it up. Samples can then be automatically fixed at different times during the dormant periods for posterior analyses, including transcriptomics, which would allow us to understand the molecular genetic mechanisms behind any observed phenotypic phenomena. Should there be capabilities on board DSG for full RNA sequencing, gene expression data may be acquired *in situ* by using crew time and only data would need be sent to Earth. Otherwise, fixed samples would return to Earth for processing.

Table 1. Key features required to operate the experiment.

Mass	5 kg
Volume	0.02 m3
Temperature Control	- 20 °C
Crew Time	Start: 2 hours End: 12 hours
Power	100 W
Communication	Data downlink from onboard sequencing
Orbit	No specific requirements

Technology Demonstration of an Algal Photobioreactor as BLSS in Intermittently Occupied Habitats: As the DSG provides uninhabited periods of operation, the results from the basic research are used in a second step, to test the safing of a BLSS demonstrator. A testbed, based on the PBR@LSR experiment on board the ISS, is proposed that is augmenting the primary DSG life support system [9]. A carbon dioxide stream provided by the primary life support system acts as the input to the algal photobioreactor. Through photosynthesis, the algae then produce oxygen that is fed back into the cabin. This system is initially installed during a crewed stay but is from then on automatically controlled. The most promising technique established in the basic research phase of this experiment is implemented into the research reactor so that during the first dormancy stage the algal cells are preserved. Days before the next crew arrives, the culture is reactivated via remote control from the ground and is aiding in preconditioning the habitable atmosphere. As planetary surface bases are intended to employ NASA's proposed exploration atmosphere (8.2 psia, 34 % oxygen) due to the

frequent EVA's, the DSG allows a high-fidelity demonstration, as it is also capable of providing that lower pressure but higher oxygen concentration atmosphere [10]. This is a key enabling technology of the DSG as it is in contrast to current ISS sea level atmosphere and therefore allows a demonstration of intermittent BLSS use in an operational environment.

Table 2. Key features required to operate the experiment.

Mass	60 kg
Volume	0.06m3
Temperature Control	30 °C (operating)
Crew Time	Operations: 4 hours Crew respiration: > 1 week
Power	300 W
Communi-cation	Commanding and data downlink
Orbit	No specific requirements
Fluid Provision	Pure CO2

Conclusions: The proposed experiment both enhances our fundamental understanding of radiation effects on dormant algae but also demonstrates the effectiveness of different storage methods for dormant algal cells in terms of radiation robustness. These results are important for future BLSS design for future long-duration human spaceflight missions. If this technology proves to be successful, algae can be used to rapidly initialize a bioregenerative life support system, which is a major advantage over higher plants. Additionally, algae can be used as a temporary backup system in case of major failures of plant-based bioregenerative life support systems due to contamination or other failure mechanisms.

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