UTILIZING THE DEEP SPACE GATEWAY TO CHARACTERIZE DNA DAMAGE DUE TO SPACE RADIATION AND REPAIR MECHANISMS. Luis Zea[1], Tobias Niederwieser[1], Jonathan Anthony[1], and Louis Stodieck[1], [1]BioServe Space Technologies (429 UCB ECAE 1B02, Boulder, CO 80309, Luis.Zea@Colorado.edu).

Introduction: The Deep Space Gateway (DSG) in cislunar orbit will be beyond the protection of the Van Allen Belts, providing an ideal environment for characterizing the DNA damage that can be expected in missions around and on the Moon, and on a journey to Mars. Similarly, these conditions provide a unique setting for the study of different DNA damage repair mechanisms, providing insight into differences in their efficiency in space.

Science Enabled by the DSG: Ionizing radiation (IR) refers to X-rays, gamma rays and cosmic rays, as they can ionize molecules [1]. IR can cause double-strand breaks, which are dangerous to organisms as it does not leave an intact template to use as a basis for repair. This can translate to loss of genes when the cell divides [2]. For repairing IR-derived DNA damage, the two main mechanisms used are (*i*) nonhomologous end joining and (*ii*) homologous recombination. The first one refers to the re-joining of the broken sides via DNA ligation, which usually means the loss of nucleotides. The second, homologous recombination, uses a sister chromatid as template and yields a more accurate, albeit slower, repair.

While humans have lived on the International Space Station (ISS) in low Earth orbit (LEO) for years, the ISS does not provide a representative radiation environment of what is expected beyond LEO, where the Earth's magnetosphere does not provide protection from cosmic and solar radiation [3]. In order to best prepare for future human missions around and on the surface of the Moon, and to Mars, we need to know what magnitude of cellular (DNA) damage can be expected.

Bacteria (e.g. *E. coli*) and humans share DNA repair mechanisms such as the SOS response. DNA double-strand breaks from IR yield single-stranded DNA (ssDNA), which in turn elicits the formation of RecA filaments around these ssDNA regions. The increase in the presence of the RecA protein decreases the amount of LexA, which is a repressor of the SOS response. This makes *recA* and *lexA* (which have homologous genes in the human genome) [4] potential target genes to interrogate under an initial experiment performed on the DSG. While over 1,000 genes are involved in DNA damage response in *E. Coli* [5], target genes can be down-selected by choosing those with human homologs and/or that have corresponding molecular pathways in eukaryotic cells, as described in Ref [6].

Required Instruments: Our group recently proposed the development of the High Altitude Research Pressurized Instrument Enclosure (HARPIE) for implementation on a high altitude Antarctic balloon that operates in a high radiation environment, and it consists of (*i*) the core experiment hardware, and (*ii*) a system that administers power and control/data logging functionalities, as well as provides temperature control.

The core experiment hardware consists several sets of well plates. Each set of plates supporting dozens of samples and capable of providing an initial inoculum, several media changes, and an experiment-terminating fixation/preservation. HARPIE has the ability to autonomously perform media changes to prolong the effective lifetime of the culture, which is critical to performing a multi-generational study to identify effects of radiation exposure. The plates themselves are easy to redesign to support other experiment schedules (e.g. less samples with more media changes) depending on other studies' science requirements.

The experiment can be executed (started or finished) at any point during the mission. The length of the experiment is limited by the number of media changes that occur, the effective dilution ratio between the wells of the inoculum plate and the media/fixative plate, and the growth rate of the selected microorganism or cell. The container includes insulation, heaters, computers, batteries, sensors, and other electronics to operate the core experiment hardware, provide a viable environment for the biology housed within it, and log parameters relevant to the experiment such as temperature, radiation exposure, and HARPIE's health status data. HARPIE's principle of operation is based on hardware we have previously operated on board the Space Shuttle and ISS with updated electronics that are robust against radiation effects.

Needed Resources.

- Mass: 4.1 kg
- Power: average: 7.6W, peak: 11.9W
- Cost: TBD
- Volume: 0.005 m^3
- Crew time: none
- No specific requirement regarding cislunar orbit

Conclusions: The DSG can enable radiation studies, namely DNA damage and repair investigations, in a way that the ISS or Earth laboratories cannot replicate. These type of investigations may serve to determine the likelihood and consequence of the high-radiation risk to human exploration of space beyond

LEO. HARPIE enables the performance of this type of research while consuming minimal resources such as volume, mass, power, and data transmission. This hardware may also enable different types of investigations using unicellular organisms, such as drug effectiveness and multigenerational studies.

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