BioSentinel: developing a space radiation biosensor

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Ionizing radiation presents a major challenge to human exploration and long-term residence in space. The deep-space radiation spectrum includes highly energetic particles that generate double strand breaks (DSBs), deleterious DNA lesions that are usually repaired without errors via homologous recombination (HR), a conserved pathway in all eukaryotes. While progress identifying and characterizing biological radiation effects using Earth-based facilities has been significant, no terrestrial source duplicates the unique space radiation environment.

We are developing a biosensor-based nanosatellite to fly aboard NASA's Space Launch System Exploration Mission 1, expected to launch in 2017 and reach a 1AU (astronomic unit) heliocentric orbit. Our biosensor (called BioSentinel) uses the yeast *S. cerevisiae* to measure DSBs in response to ambient space radiation. The BioSentinel strain contains engineered genetic defects that prevent growth until and unless a radiation-induced DSB near a reporter gene activates the yeast's HR repair mechanisms. Thus, culture growth and metabolic activity directly indicate a successful DSB-and-repair event. In parallel, HR-defective and wild type strains will provide survival data. Desiccated cells will be carried within independent culture microwells, built into 96-well microfluidic cards. Each microwell set will be activated by media addition at different time points over 18 months, and cell growth will be tracked continuously via optical density. One reserve set will be activated only in the occurrence of a solar particle event. Biological measurements will be compared to data provided by onboard physical dosimeters and to Earth-based experiments.

BioSentinel will conduct the first study of biological response to space radiation outside Low Earth Orbit in over 40 years. BioSentinel will thus address strategic knowledge gaps related to the biological effects of space radiation and will provide an adaptable platform to perform human-relevant measurements in multiple space environments. We hope that it can therefore be used on the ISS, on and around other planetary bodies as well as other exploration platforms as a self-contained system that will allow us to compare and calibrate different radiation environments.

BioSentinel's results will be critical for improving interpretation of the effects of space radiation exposure, and for reducing the risk associated with long-term human exploration.