A proposal for a comprehensive database of space flight radiation measurements relevant to life sciences

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Radiation data from crewed missions and biology payloads are collected in independent or loosely coupled databases (*e.g.* SRAG, ESA, BAS-Liulin)

NASA collects space flight biology data :

- Life Sciences Data Archive (LSDA)
- Ames Life Sciences Data Archive (ALSDA)
- GeneLab

GeneLab has environmental data (*e.g.* temp, humidity CO_2) and **radiation absorbed dose data** for studies in its database (Shuttle, ISS labs, Bion, Foton, SZ-8)

Radiation data include spacecraft, experiment start/end dates, duration, dosimeter, location within spacecraft (e.g. habitat, ISS module/rack), average and cumulative absorbed dose

Environmental Data for Spaceflight Experiments

Any and all data regarding the conditions under which an experiment is conducted may have bearing on how the data produced during the experiment are interpreted; these conditions, explicitly documented or not, are a part of the experiment design. Therefore, GeneLab is taking actions, where possible and policies and available resources permit, to collect and publish data on these conditions. We have grouped these conditions into the areas listed below.

Space Radiation Dosimetry

Dosimetry techniques vary depending on the particular experiment environment. To date, most flight experiments have not employed "dedicated" dosimeters (i.e. dosimeters integrated into experiment platform housing). Therefore, doses to which study samples are exposed frequently must be interpolated and/or extrapolated from nearby dosimeters. Two qualities of radiation were considered: low-LET (photons and electrons) and high-LET (charged nuclei). Both passive (thermoluminescent dosimeters: TLD, or plastic nuclear track detectors: PNTD) and active (solid state, tissue equivalent proportional counters) have been used. For passive dosimeters, TLD are sensitive to low-LET charged particles (< 10 keV/µm) and PNTD to high-LET (> 10 keV/µm). Active dosimeters are sensitive to a wider range in LET and, depending on the detector, can provide time resolution, LET spectra and some particle identification. By integrating the dose from the time-resolved data over the duration of the experiment, the total absorbed dose can be calculated. Depending on the configuration of dosimeters in the vicinity of the samples, absorbed dose may be reported as averaged with other detectors, or individually.

Datasets in the GeneLab repository with samples flown in space have corresponding metadata which includes the exposure duration, and the average, minimum and maximum absorbed dose received, broken out into low LET and high LET charged particles (when LET resolution is available). The duration of the exposure is defined as the time a sample was in space and biologically active, i.e. when the sample has returned to Earth or when it is chemically fixed or frozen in space. It is important to note that the absorbed doses we provide in these metadata are an approximation, due to several factors. First, the sensitivity in charge and LET for each detector being used. For example, even though TLDs detect low-LET radiation, the detected dose also includes some contribution from charged nuclei depending on the charge and speed of the nuclei traversing the detector. Similarly, active detectors even if sensitive to specific energies and charges, can still have contributions to dose from low-LET particles and neutrons. Second, reported dosimetry does not take into account the shielding provided by the sample enclosure. For low energy or low-LET particles this material could have effects unique to each mission and experiment, modifying both the dose and radiation quality.

Abbreviations: LET = Linear Energy Transfer, TLD = Thermoluminescent Dosimeters, PNTD = Plastic Nuclear Track Detectors.

STS (Space Shuttle) Radiation Dosimetry
For STS (Space Shuttle) experiments, three passive dosimeter packages were fixed in locations on the shuttle middeck, where biological samples were located.

BION-M1 Radiation Dosimetry
Both passive and active dosimeters were used.

Foton-M4 Radiation Dosimetry
Passive dosimeters were used.

ISS Radiation Dosimetry
Both passive and active dosimeters were used.

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Proposal:

Extend the GeneLab radiation database to include all space flight radiation data from crewed missions and biology payloads

Database to include:

> measurements taken by all of the scientific and operational radiation detectors, both active and passive, used on ISS and other crewed and uncrewed space missions with relevance for human space exploration, including future missions beyond low Earth orbit.

Possible applications:

- allow users to generate time-dependent radiation maps within and across multiple ISS modules (à la DOSIS-3D)
- facilitate intercomparisons between detectors with a variety of ranges and sensitivities
- extension to Artemis, Gateway and lunar surface operations

Radiation database features:

- Searchable by date, vehicle, detector, location
- Source agency controls level of detail that is publicly available
- Linked to other relevant databases (SRAG, ESA, BAS-Liulin)

Space Radiation Analysis Working Group

- GeneLab Analysis Working Groups (AWGs) investigate specific subsets of omics data from experiments conducted onboard the International Space Station, the Space Shuttle, as well as ground-based research with relevance to space flight

- The primary activity of the AWGs is to establish analytical processes to generate higher order data from data contained in the GLDS

- Current AWGs focus on animals, plants, microbes and multi-omics strategies

Space Radiation AWG:

- **Provide a forum for collaboration between space biologists and the space radiation measurement community**

- **Provide input on design, content and user interface of space radiation DB**

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