MitoMars: Targeted Mitochondria Replacement Therapy to Boost Deep Space Endurance

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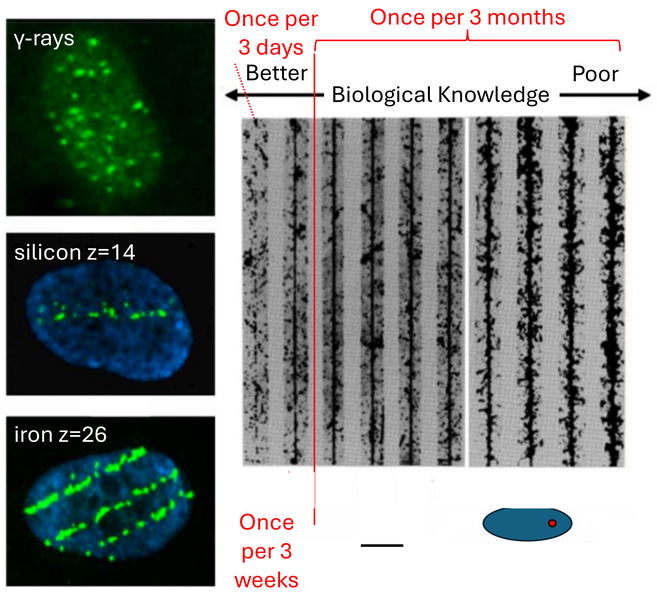
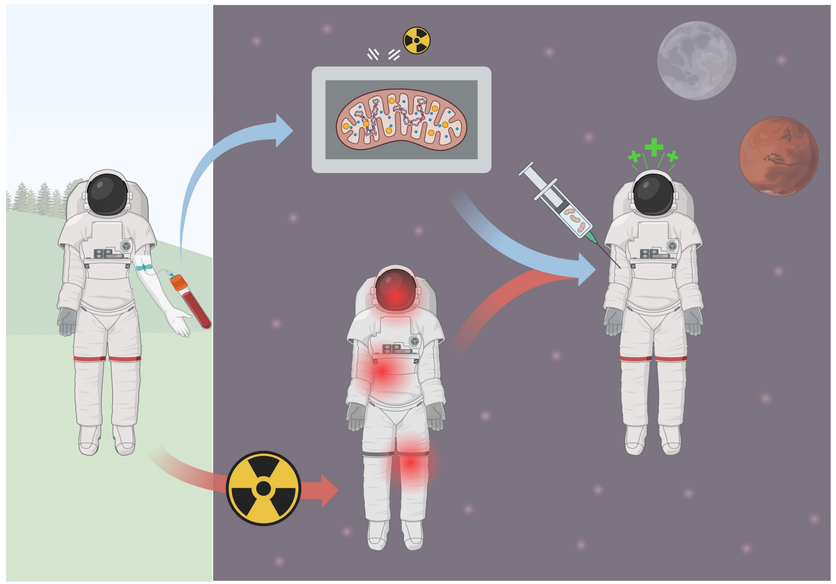
Context

- Radiation threatens the health of astronauts especially on extended deep space missions. Recent research suggests mitochondrial dysfunction is a common damage pathway.
- NASA's most current and realistic plan for landing humans on Mars, the DRM5, would exceed astronauts' *whole career* radiation dose limits. Current shielding technology is insufficient.



Left: DNA damage tracks illustrating concentrated breaks with higher mass particles. *Right*: Ionization tracks of particles of increasing mass. Red text denotes frequency of traversals through a cell nucleus-sized volume in deep space. Adapted from "Space Radiation Cancer Risk Projections and Uncertainties" 2012. Cucinotta, Kim, Chappell



Conceptual schematic of the MitoMars approach to mitochondrial replacement to heal astronauts from radiation damage in flight.

Overview

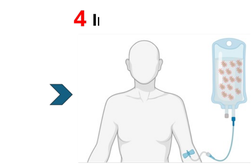
MitoMars aims to bank healthy mitochondria to be shielded in flight and administered back to crew during extended deep space missions to replace radiation-damaged mitochondria thus preserving crew health.

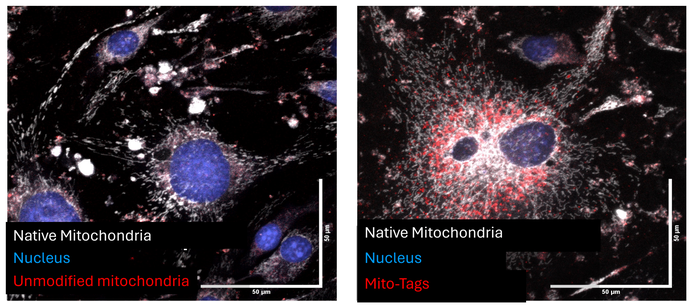
Impact

Restoring mitochondrial function may improve radiation tolerance - enabling new classes of crewed deep space missions. This technology may also improve terrestrial treatment for many age-related diseases.

Approach

- New animal research shows mitochondrial replacement therapy can restore function in aged immune cells.
- We will test for restoration of human immune and stem cell function after radiation exposure.
- We will investigate acute and chronic doses of gamma radiation, high energy high mass (HZE) particle radiation, and multiple treatment schedules.
- We will also evaluate the efficacy of cryopreserved mitochondria for use in treatment.





Top: Conceptual schematic of Mito-Tags, the technology underlying MitoMars. *Bottom:* Immunofluorescence images showing Mito-Tags (right) compared to unmodified mitochondria (left) integrating into target cells.

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