

Getting ready for Mars:
How will exposure to deep space radiation affect human health?

Egle Cekanaviciute, PhD

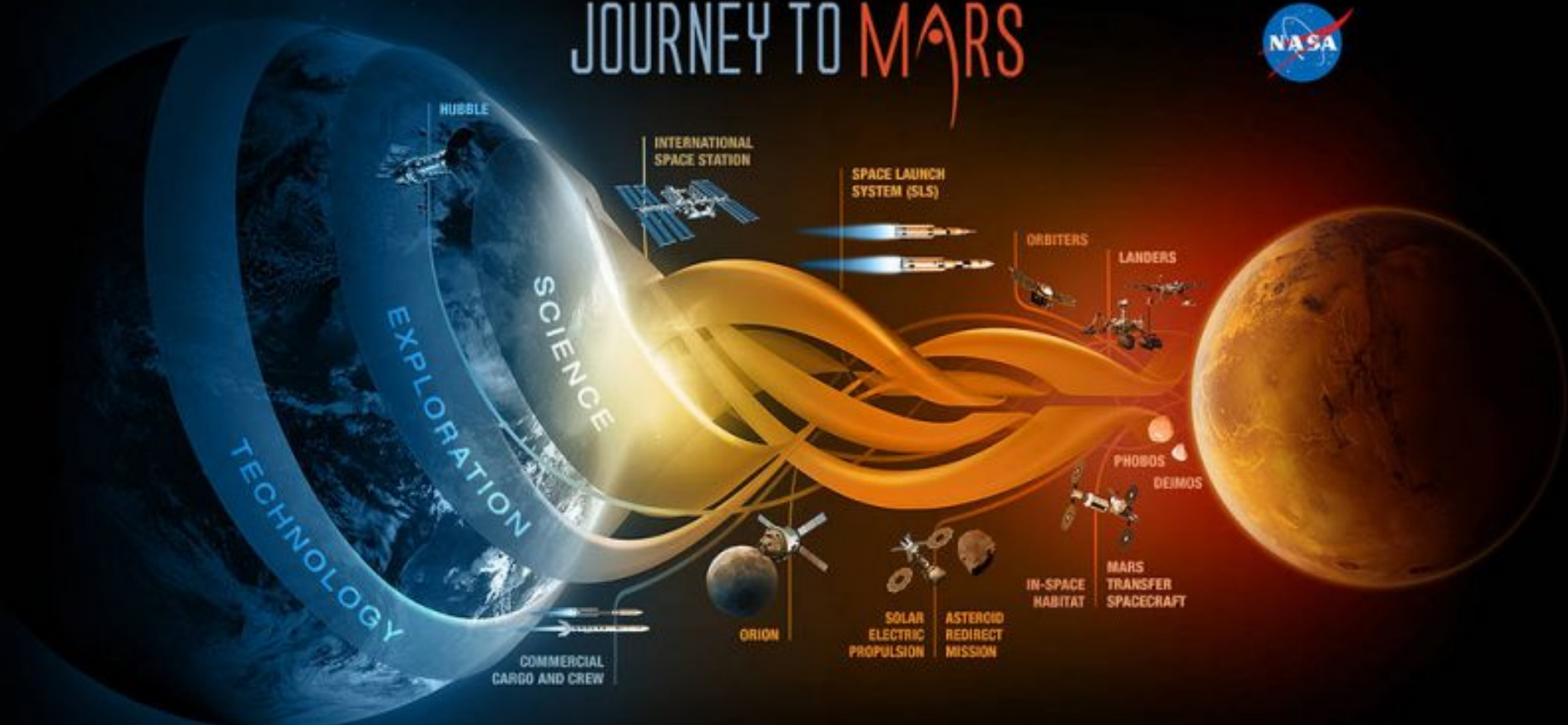
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JOURNEY TO MARS

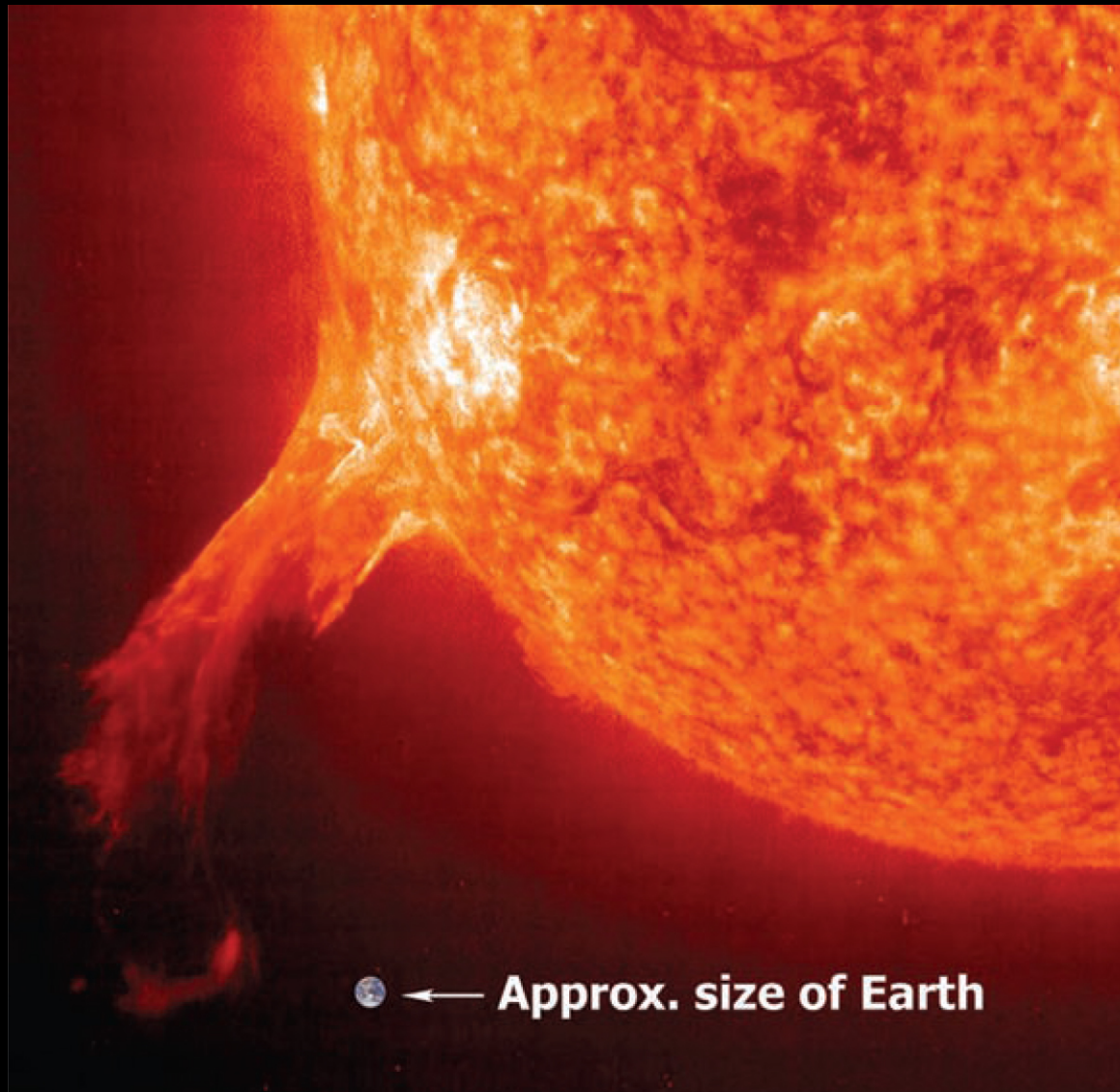


Radiation in human space exploration

- What types of radiation are relevant for human spaceflight?
- How does space radiation affect the human body?
- How to mitigate radiation-associated health risks?

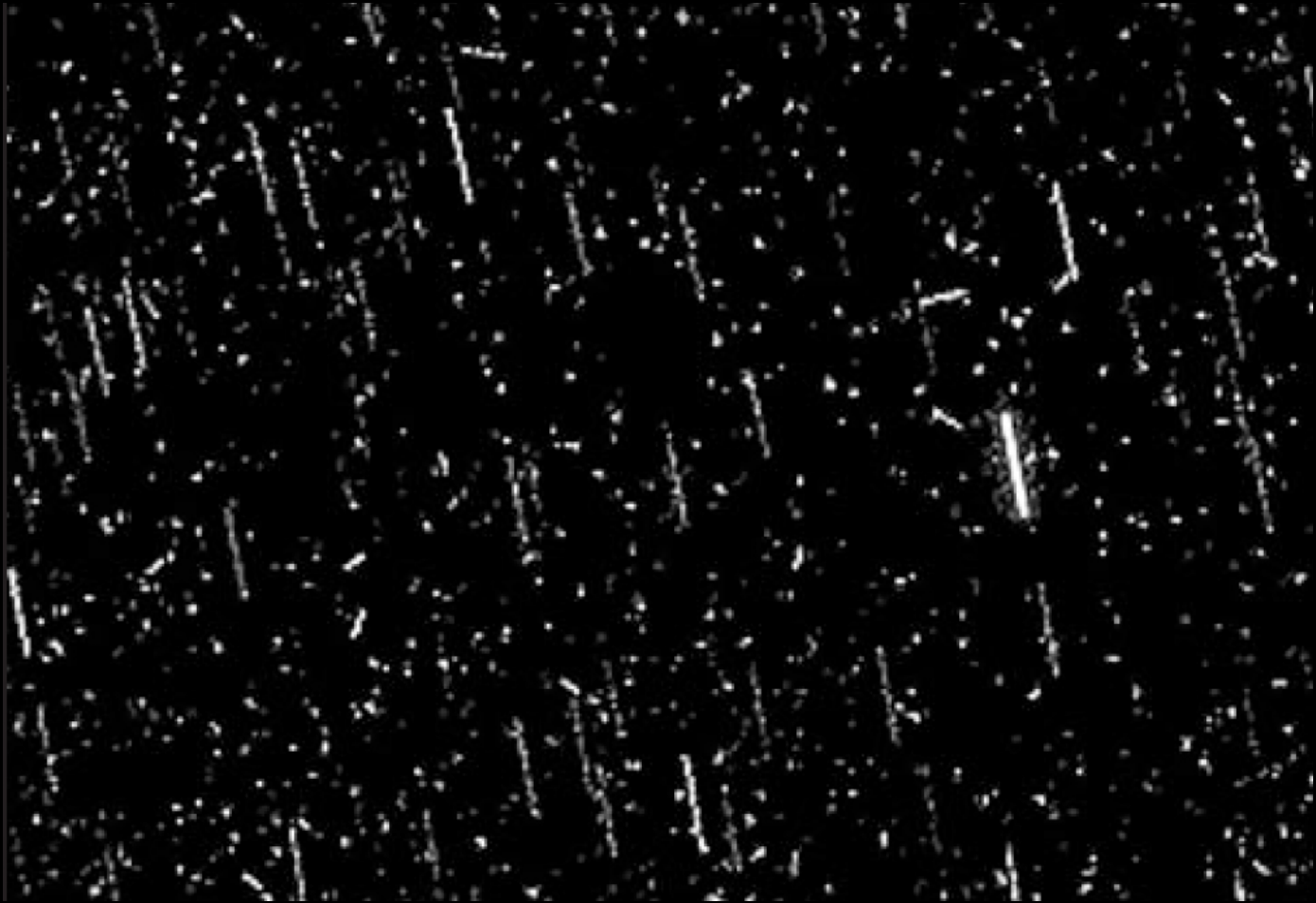


Solar Particle Events



Gamma rays
Protons

Galactic Cosmic Rays (GCRs)

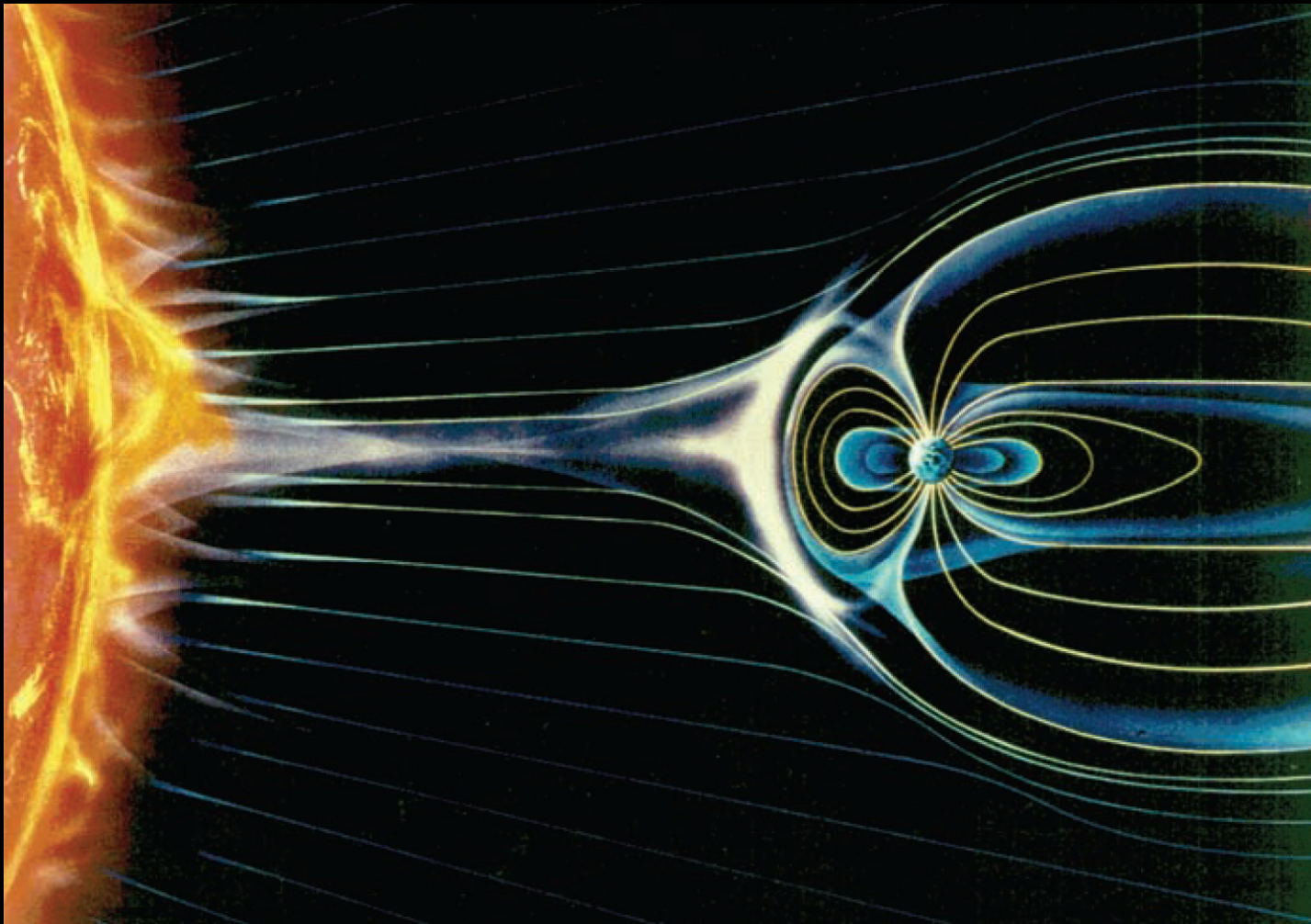


90% protons

9% helium nuclei

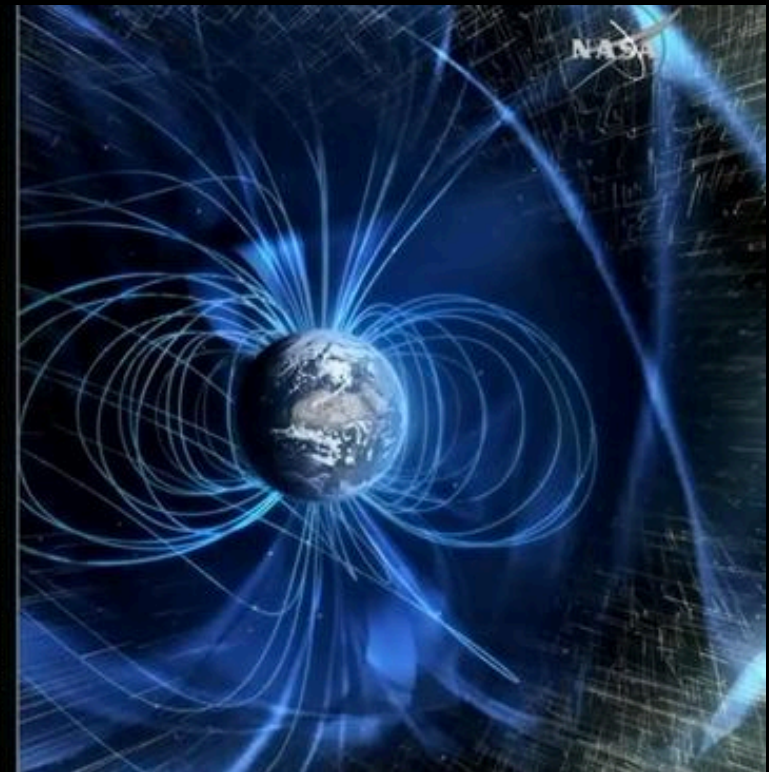
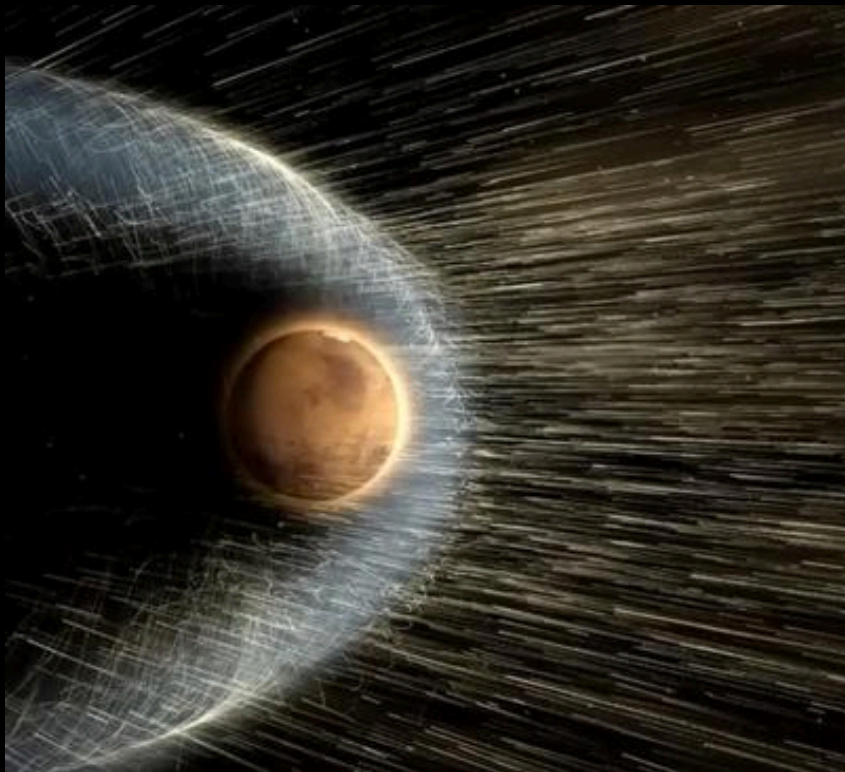
1% high energy-high charge particles (oxygen, iron, titanium...)

Magnetic field protects the Earth from cosmic radiation



Radiation on a trip to Mars:

- Passing through Van Allen belts (concentrated radiation)
- Lack of magnetic field
- Long duration

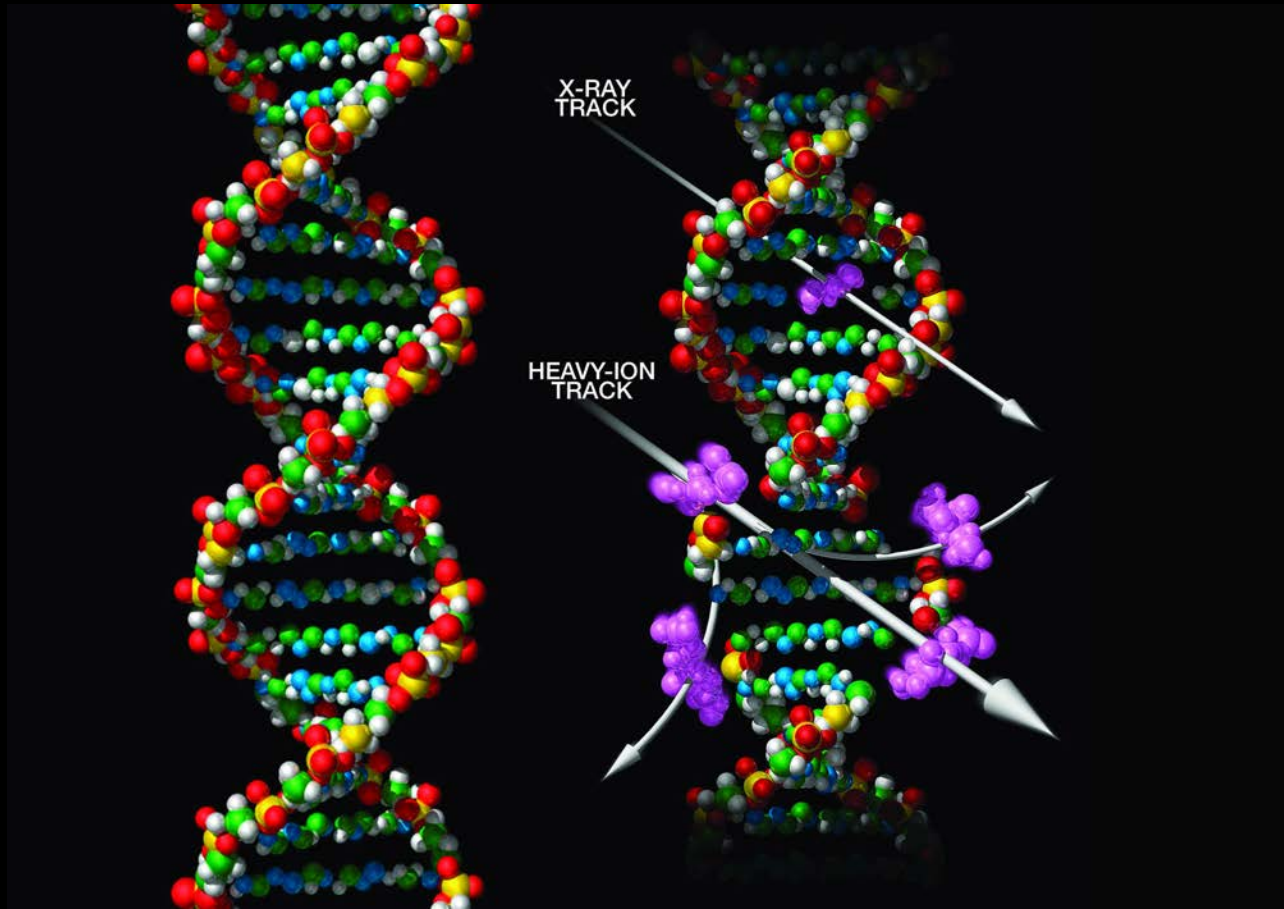


Radiation in human space exploration

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 - Low Earth orbit: gamma rays and solar flares
 - Moon/Mars: solar particle events, Galactic Cosmic Rays
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Radiation-induced DNA damage → mutations, carcinogenesis



Each cell on a way to Mars (3 years): ~ 1 proton/3 days, 1 He nucleus/3 weeks, 1 high mass and charge particle / 3 months (Dr. Susanna Rosi, UCSF)

Health risks of chronic exposure to space radiation

Neuroinflammation:
cognitive decline

Carcinogenesis

Tissue degeneration:

Cataracts

Pulmonary damage

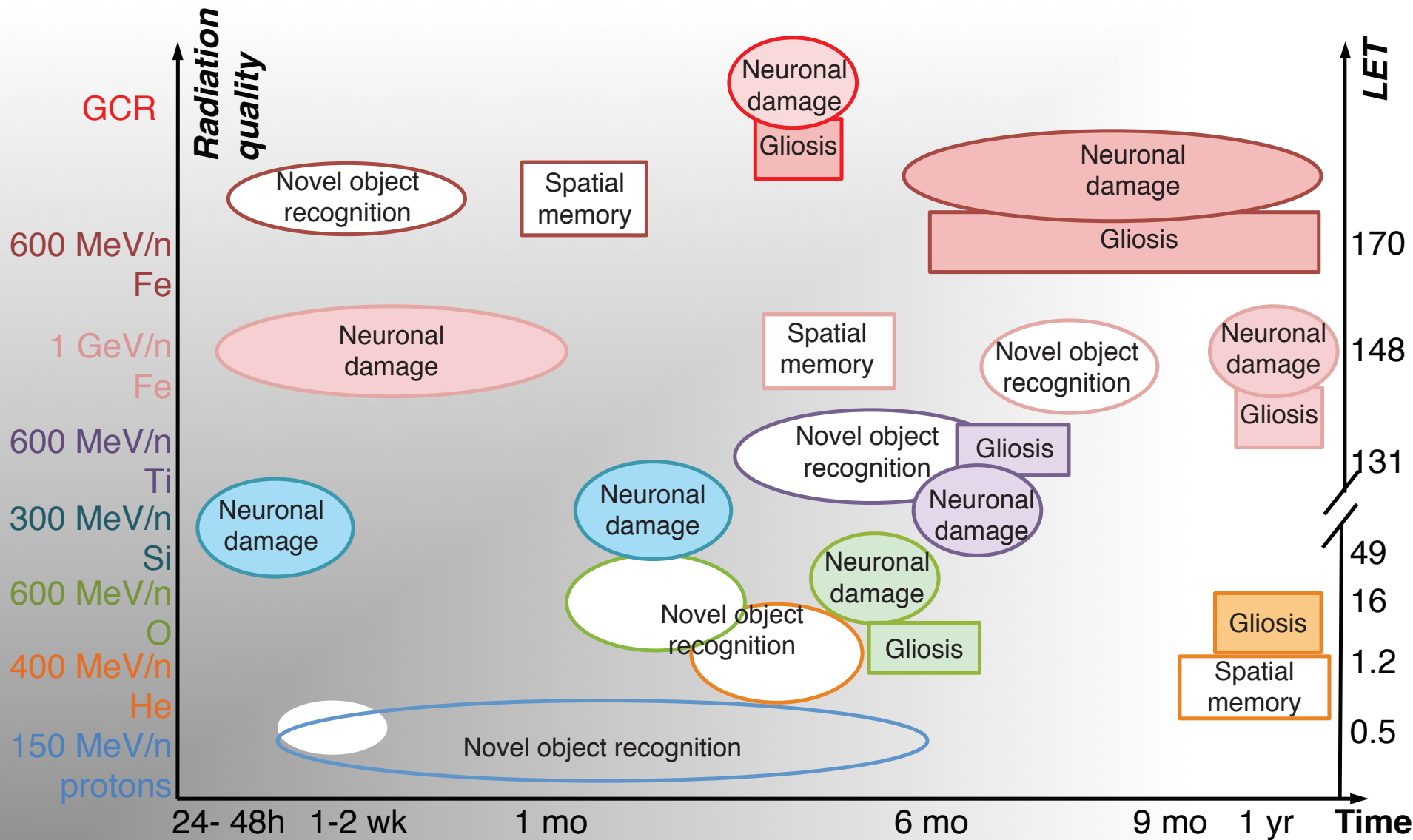
Cardiovascular impairment

Digestive diseases

Also: acute radiation exposure

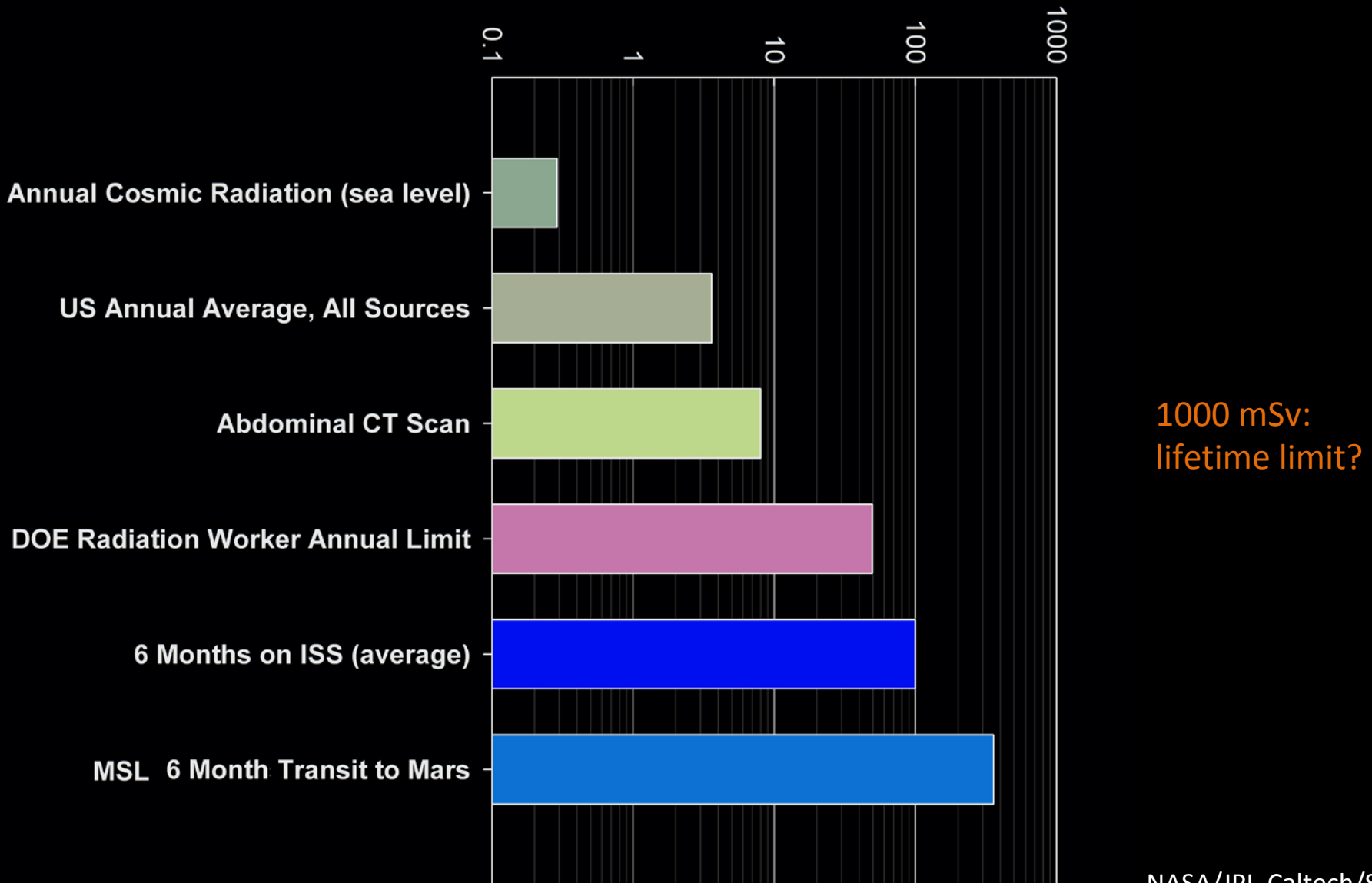


Effects of simulated space radiation on the central nervous system



Radiation exposure

Dose Equivalent (millisieverts)



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 - DNA damage, oxidative stress
 - CNS damage, tissue degeneration, carcinogenesis, acute radiation risk
- How to mitigate radiation-associated health risks?



Spaceflight studies: *in vitro* and *in vivo*



Simulated space radiation: *in vitro* and *in vivo*



SCIENTIFIC REPORTS



OPEN **Temporary microglia-depletion after cosmic radiation modifies phagocytic activity and prevents cognitive deficits**

Received: 9 January 2018

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Published online: 18 May 2018

Karen Krukowski^{1,2}, Xi Feng^{1,2}, Maria Serena Paladini^{1,2}, Austin Chou^{1,2}, Kristen Sacramento^{1,2}, Katherine Grue^{1,2}, Lara-Kirstie Riparip^{1,2}, Tamako Jones³, Mary Campbell-Beachler³, Gregory Nelson³ & Susanna Rosi^{1,2,4,5,6}

SCIENTIFIC REPORTS



OPEN **Epigenetic determinants of space radiation-induced cognitive dysfunction**

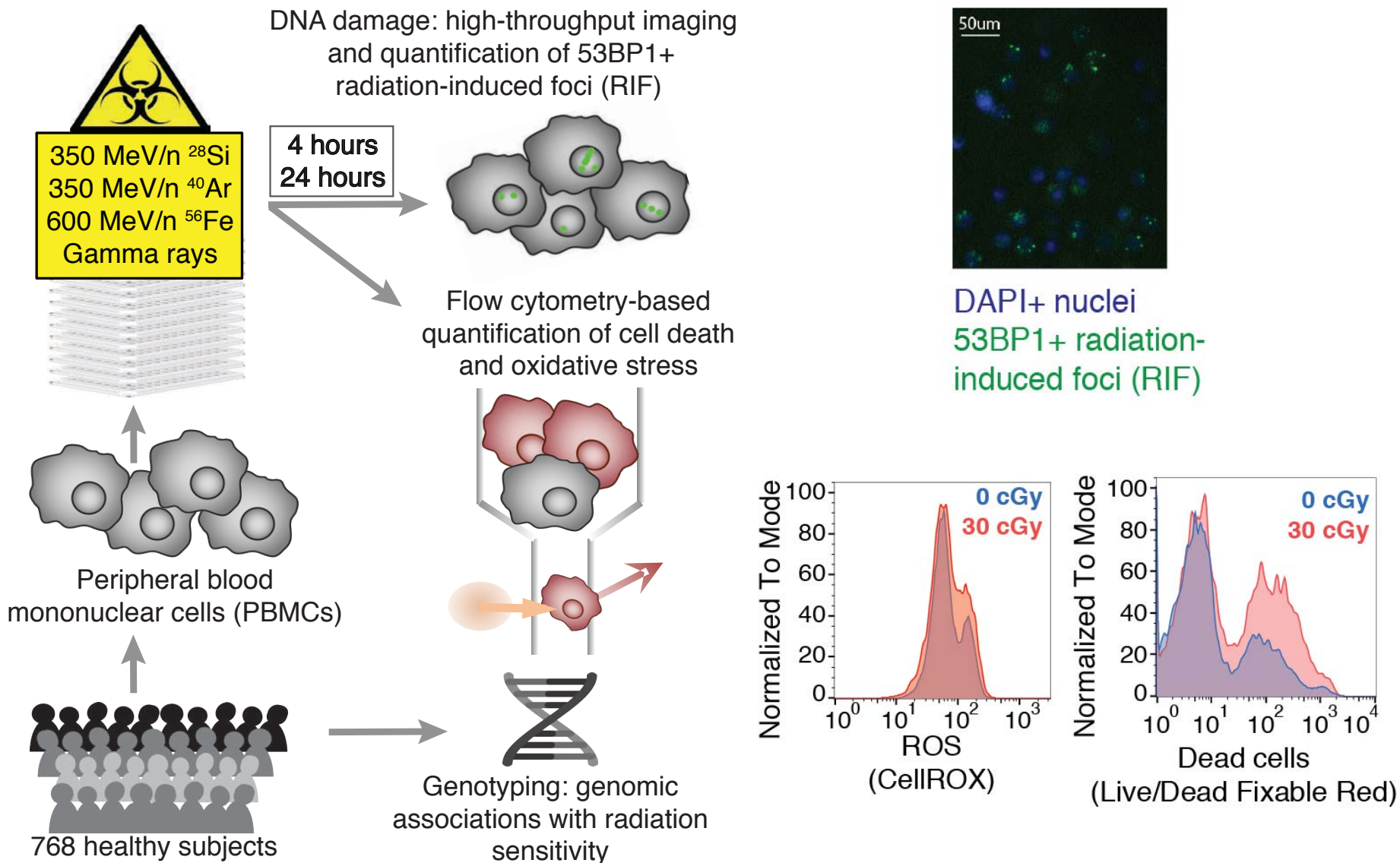
Received: 24 August 2016

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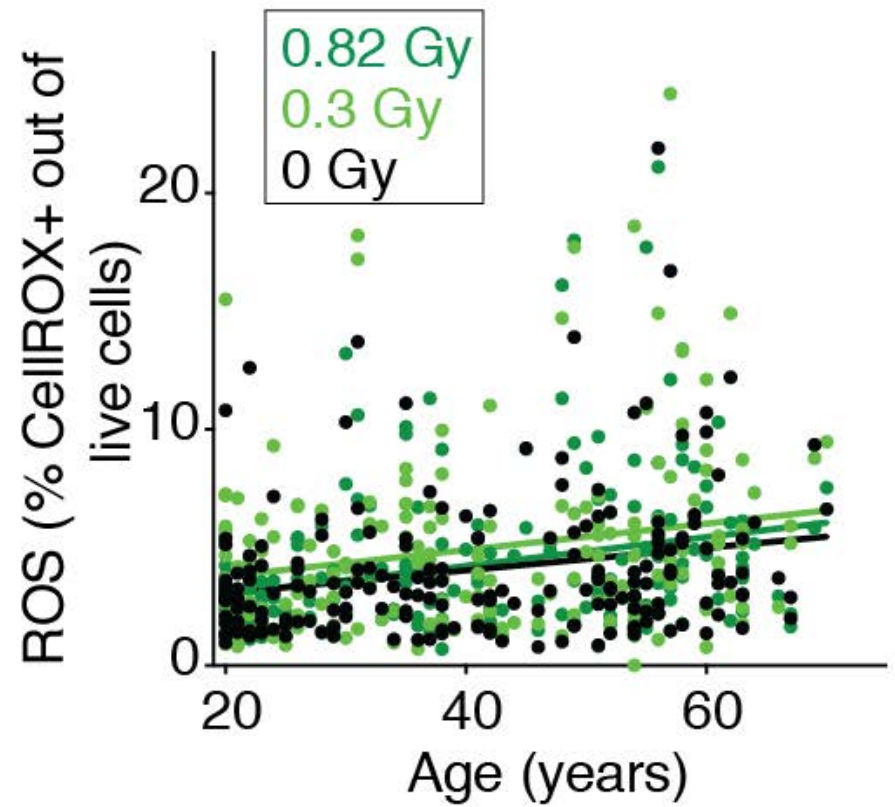
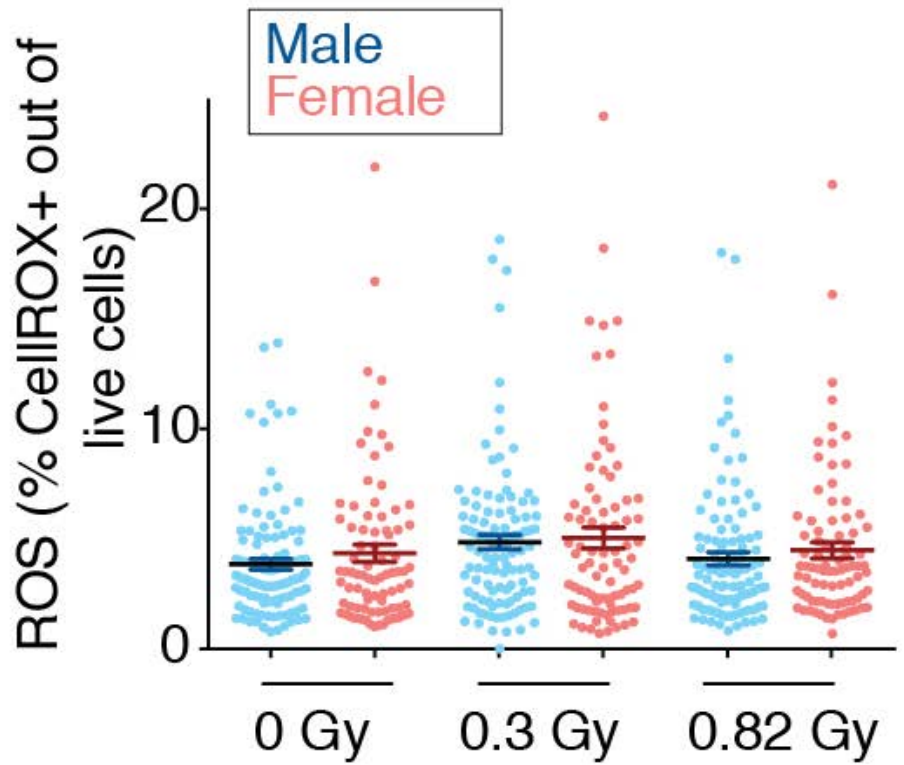
Published: 21 February 2017

Munjal M. Acharya, Al Anoud D. Baddour, Takumi Kawashita, Barrett D. Allen, Amber R. Syage, Thuan H. Nguyen, Nicole Yoon, Erich Giedzinski, Liping Yu, Vipin K. Parihar & Janet E. Baulch

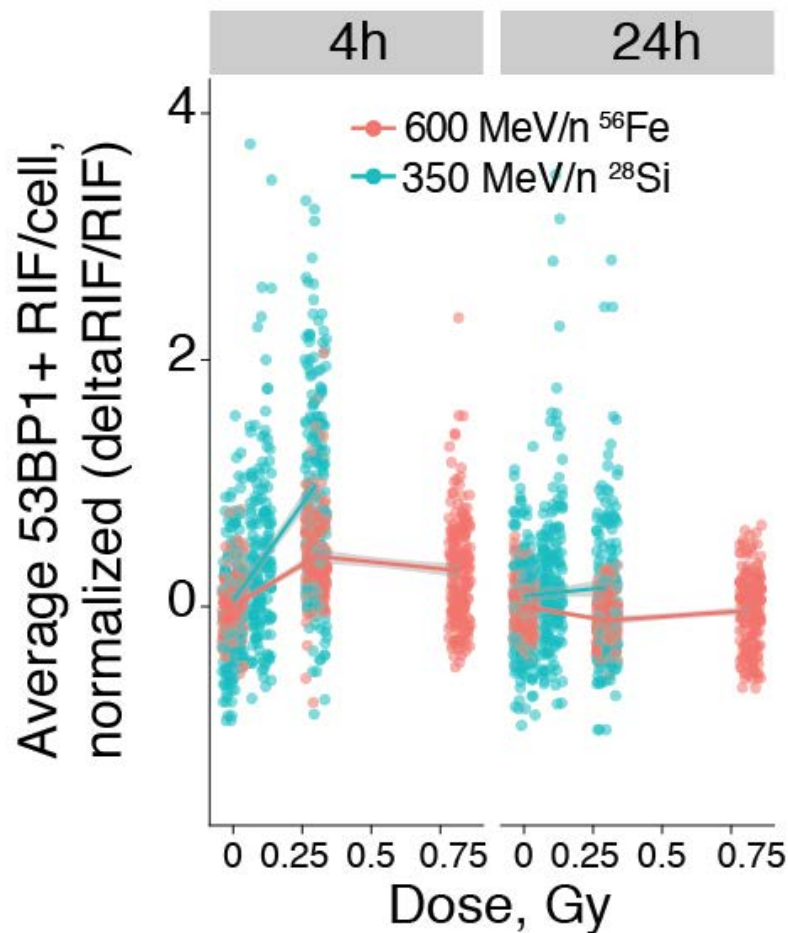
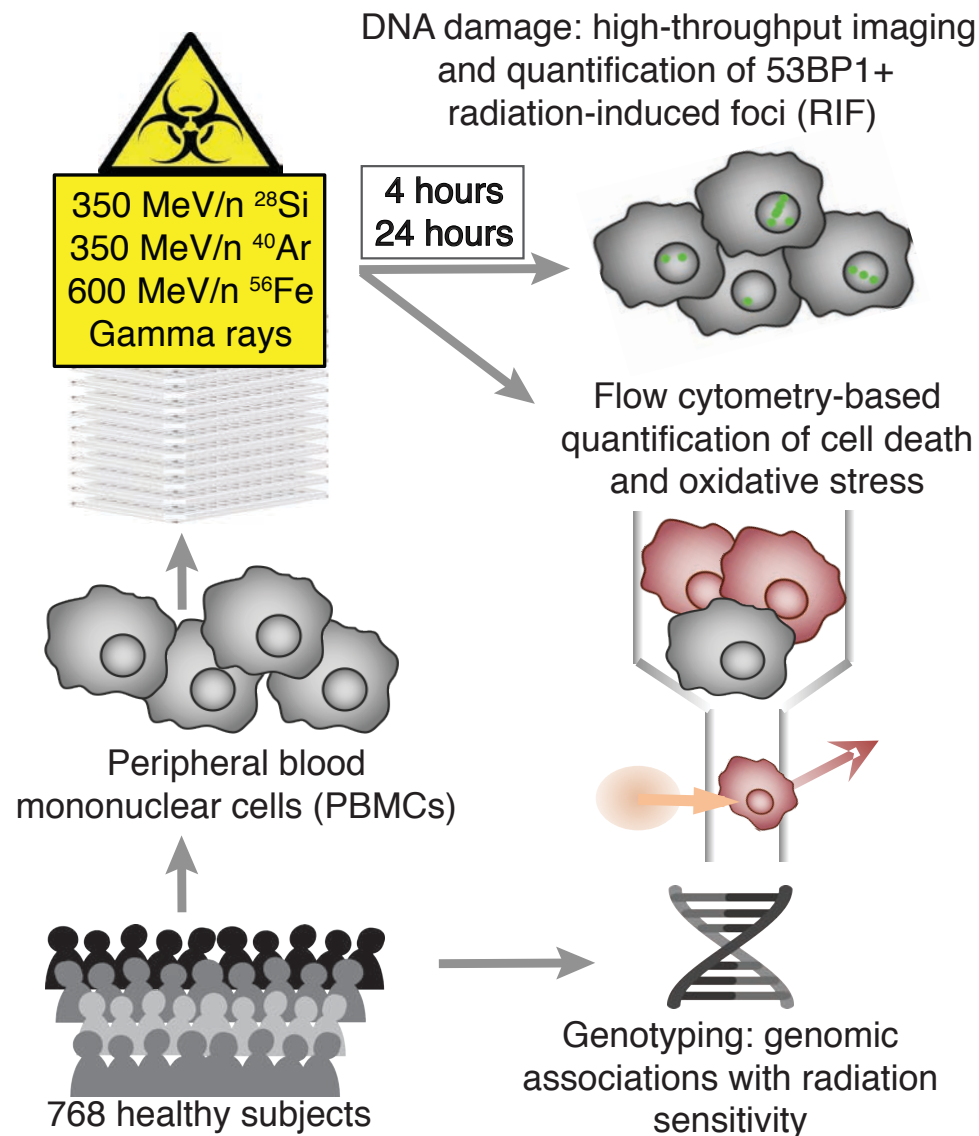
Human studies: what determines radiation sensitivity?



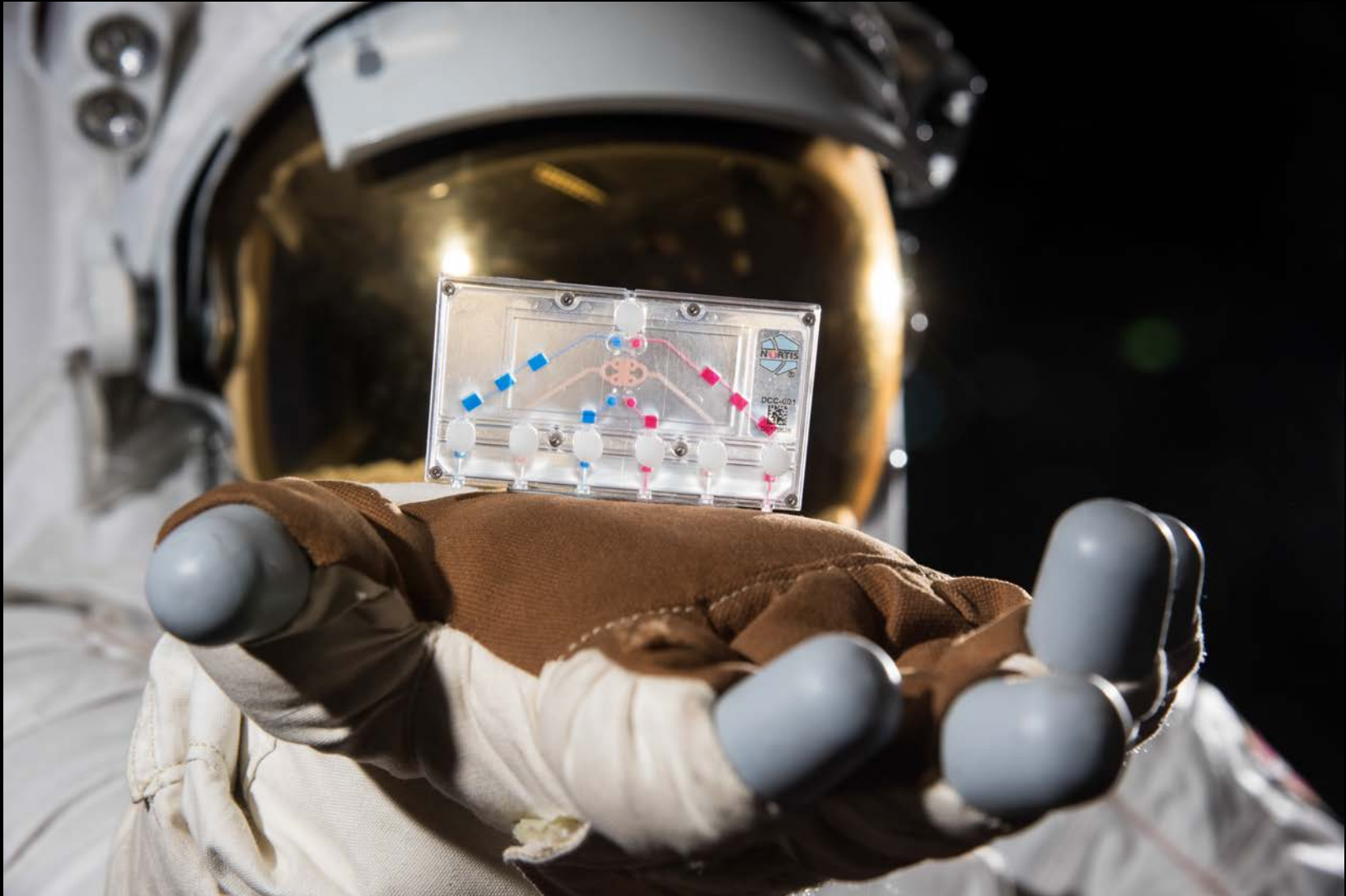
Human studies: what determines radiation sensitivity?



Human studies: what determines radiation sensitivity?



Tissues/organs on a chip

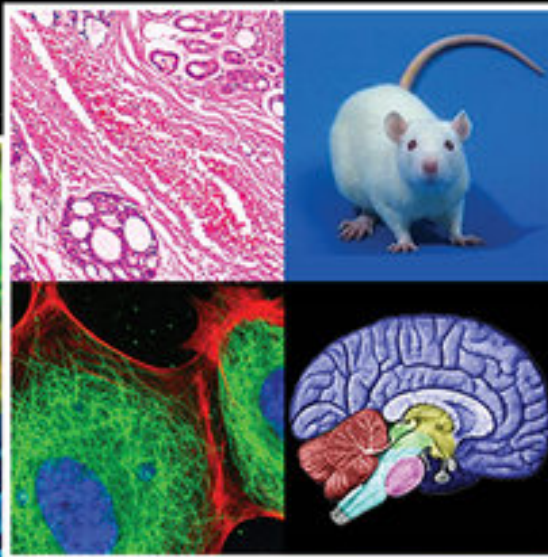
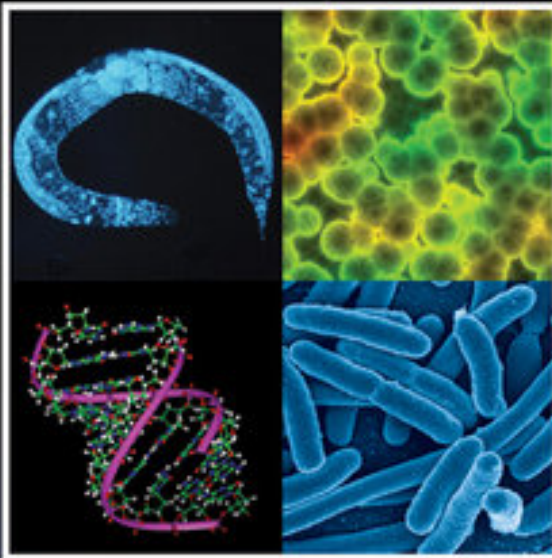


Sensitivity / Dosimetry / Prevention / Repair

Human Exploration

Human Health

Biological Systems



- Model Organisms
- Cell and Microbial Biology
- Biomolecules

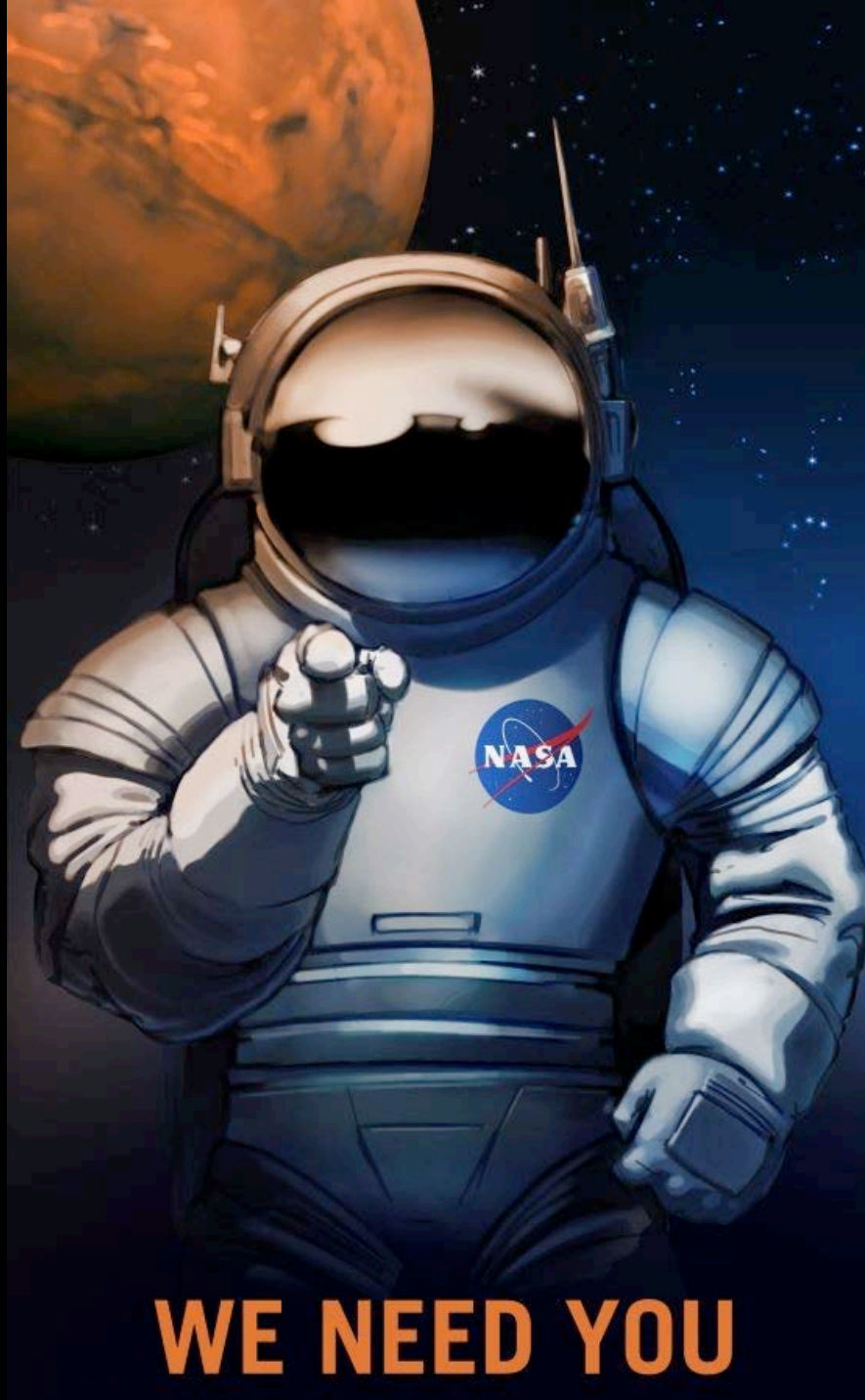
- Mammalian Cells
- Model Organisms

- Exploration Subsystems
- Bioregenerative Life Support

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Image credit: NASA

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- How to mitigate radiation-associated health risks?
 - CNS: reduce inflammation and neuronal damage by depleting immune cells or changing the signaling patterns
 - Cancer: reducing DNA damage and oxidative stress
 - Ongoing research: spaceflight; simulated space radiation
 - New directions: personalized medicine, tissues on a chip

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