Long-term Effects of Simulated Spaceflight Exposure to the Coronary Artery

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Background

The cardiovascular system adapts in extreme conditions, such as spaceflight.

The spaceflight environment includes extreme temperature variations, exposure to deep-space radiation, and changes in gravity. These environmental changes lead to crew adaptations and increased risk developing adverse medical conditions.

This investigation assesses cardiovascular disease risk from the long-term single and combined effects of deep space radiation and microgravity exposure on rats.

Our hypothesis includes spaceflight environmental factor exposure leads to vascular structure and function changes, predisposing astronauts to increased risk of developing cardiovascular disease.

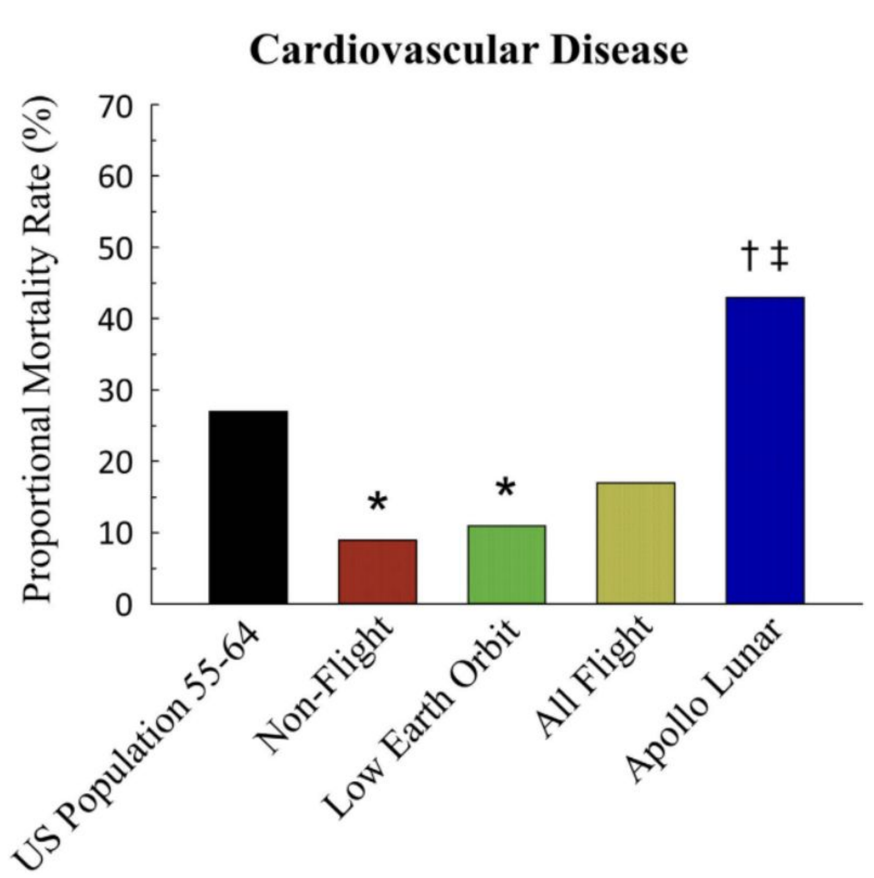


Figure 1. The proportional mortality rate due to Cardiovascular disease of astronauts. (See reference 1).

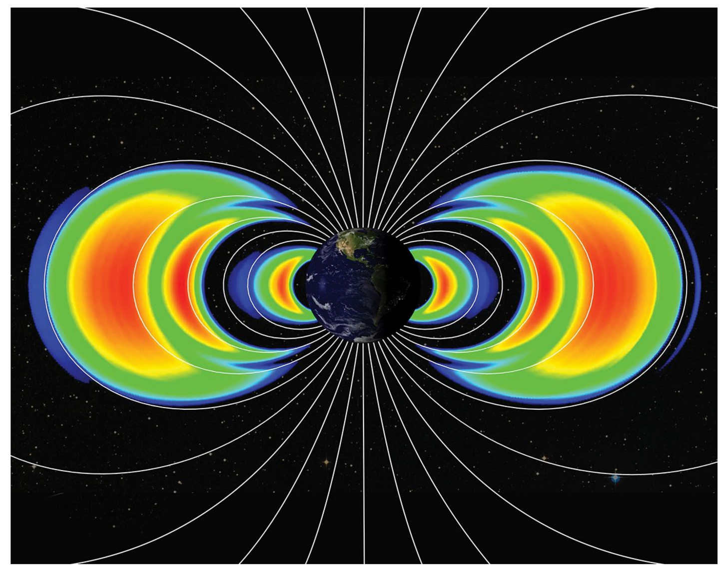


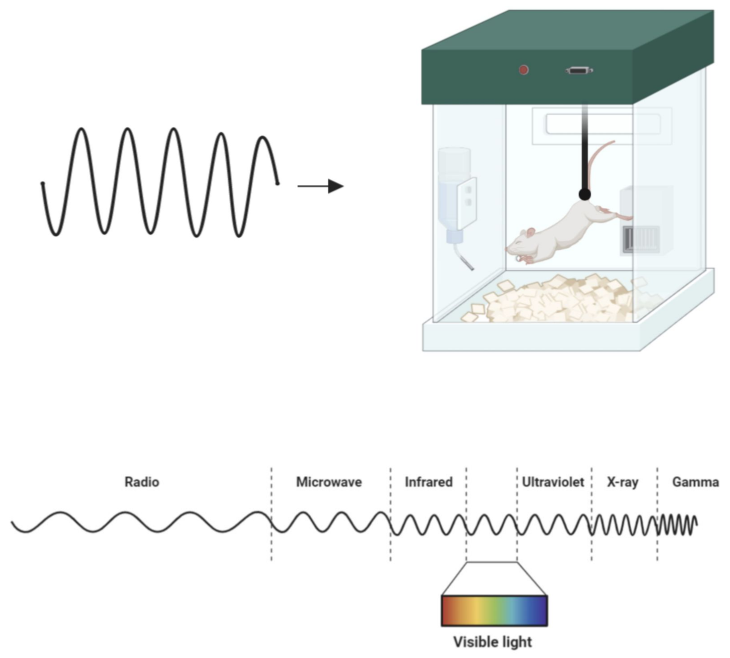
Figure 2. Van Allen Belts, *NASA's Goddard Space Flight Center/Johns Hopkins University, Applied Physics Laboratory*

Figure 3. Brookhaven National Laboratory

Methods

Biospecimen samples were collected and processed from the following groups:

Figure 4. Simulated radiation and hind limb unloading



Cohort 1. EXPERIMENTAL GROUPS	Rats/ Group
Sham Irradiation	18
Hind Limb Unloading Alone	18
Space Radiation Alone 0.75 Gy	18
Space Radiation Alone 1.5Gy	18
Hind Limb Unloading + Space Radiation, 0.75 Gy	18
Himb Limb Unloading + Space Radiation, 1.5 Gy	18
Total Animals	108

Ongoing experiment efforts include cryostat sectioning of coronary arteries for histological sections. These will be further processed, probed and visualized for specific protein markers (e.g. immunofluorescence, see Fig. 5).

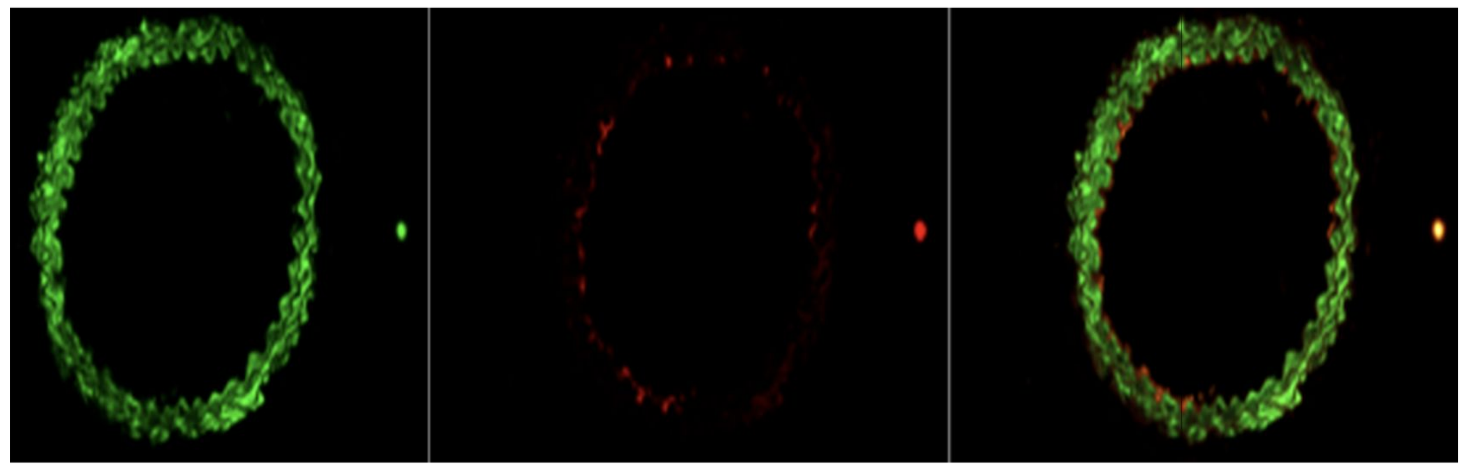


Figure 5. Immunofluorescence staining

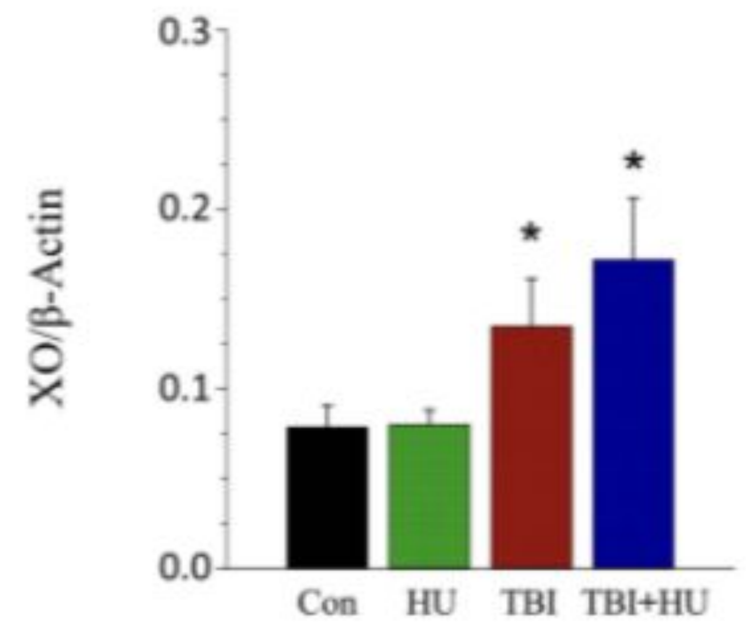


Figure 6. Effects of simulated microgravity and/or radiation on coronary artery biochemical pathways (e.g. oxidative stress, xanthine oxidase) [see reference 1].

Discussion

Our exploration of space now includes more people traveling and residing in space; thus, there is increasing rationale to understand the effects of spaceflight on human physiology.

As a model organism, we studied rats exposed to simulated spaceflight conditions (e.g. radiation and microgravity).

We will show how deep space radiation and/or microgravity exposure leads to specific biomedical adaptations with the cardiovascular system and identify crew risk to developing elevated risk of cardiovascular disease.

Future Directions

We have on-going studies measuring biochemical adaptations of the cardiovascular system, including vascular (e.g. endothelial nitric oxide synthase) and oxidative stress (e.g. xanthine oxidase, superoxide dismutase).

References

1. Delp MD, Charvat JM, Limoli CL, Globus RK, Ghosh P. Apollo lunar astronauts show higher cardiovascular disease mortality: possible deep space radiation effects on the vascular endothelium. Scientific reports. 2016 Jul 28;6(1):1-1.

Acknowledgements

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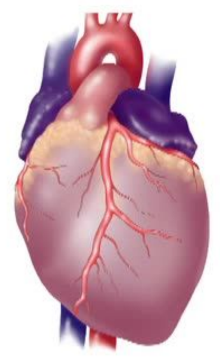

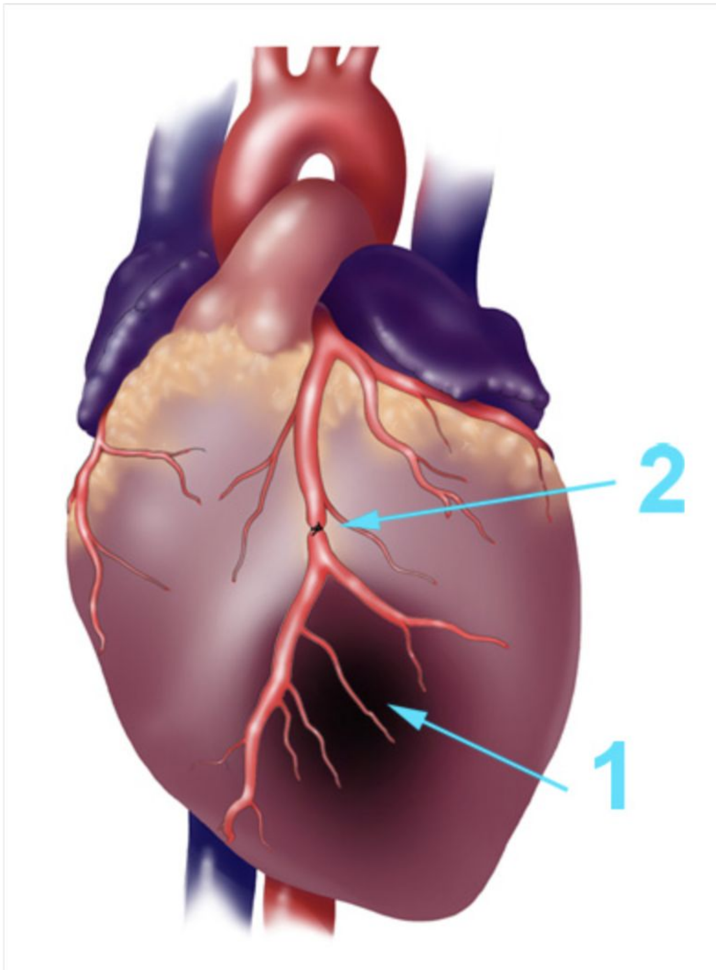
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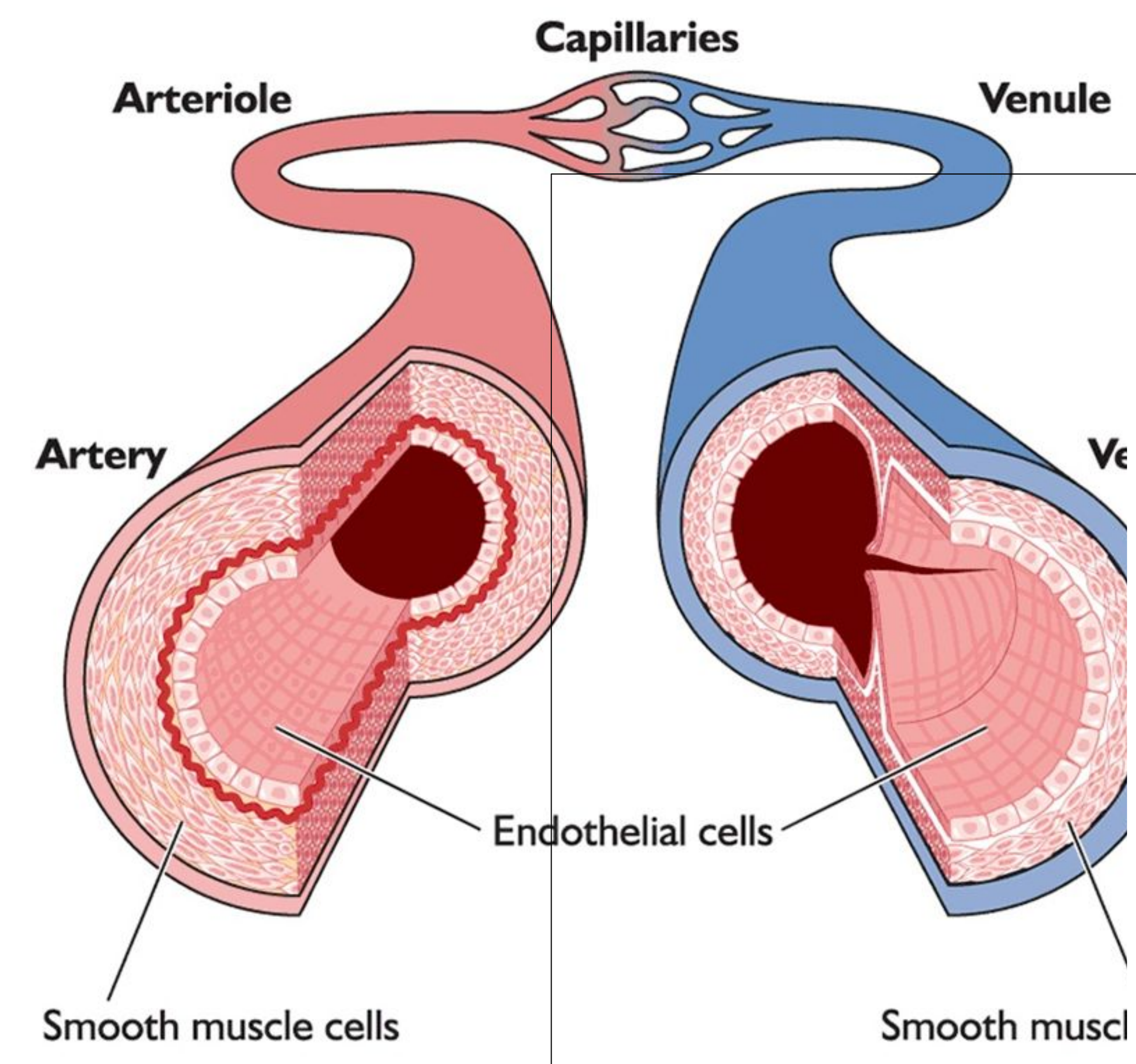
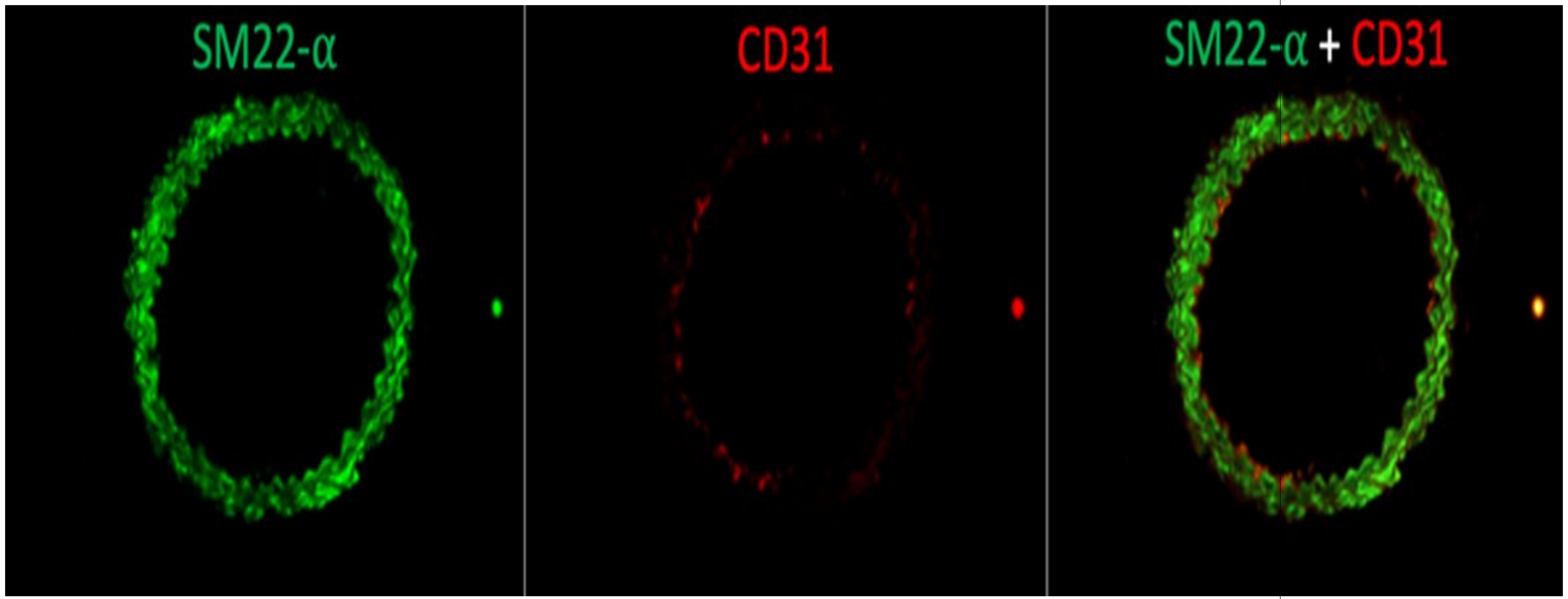

Capillaries
Arteriole
Venule
Artery
Endothelial cells
Smooth muscle cells


SM22-α
CD31
SM22-α + CD31

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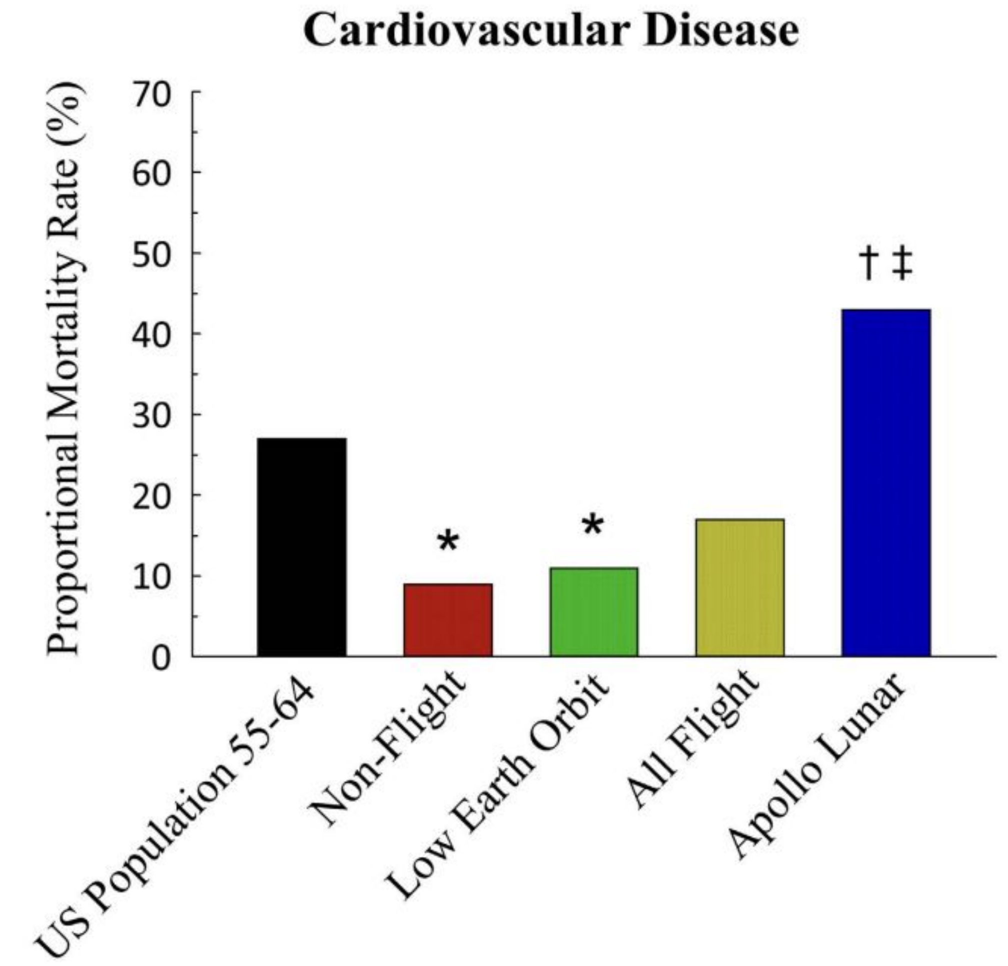
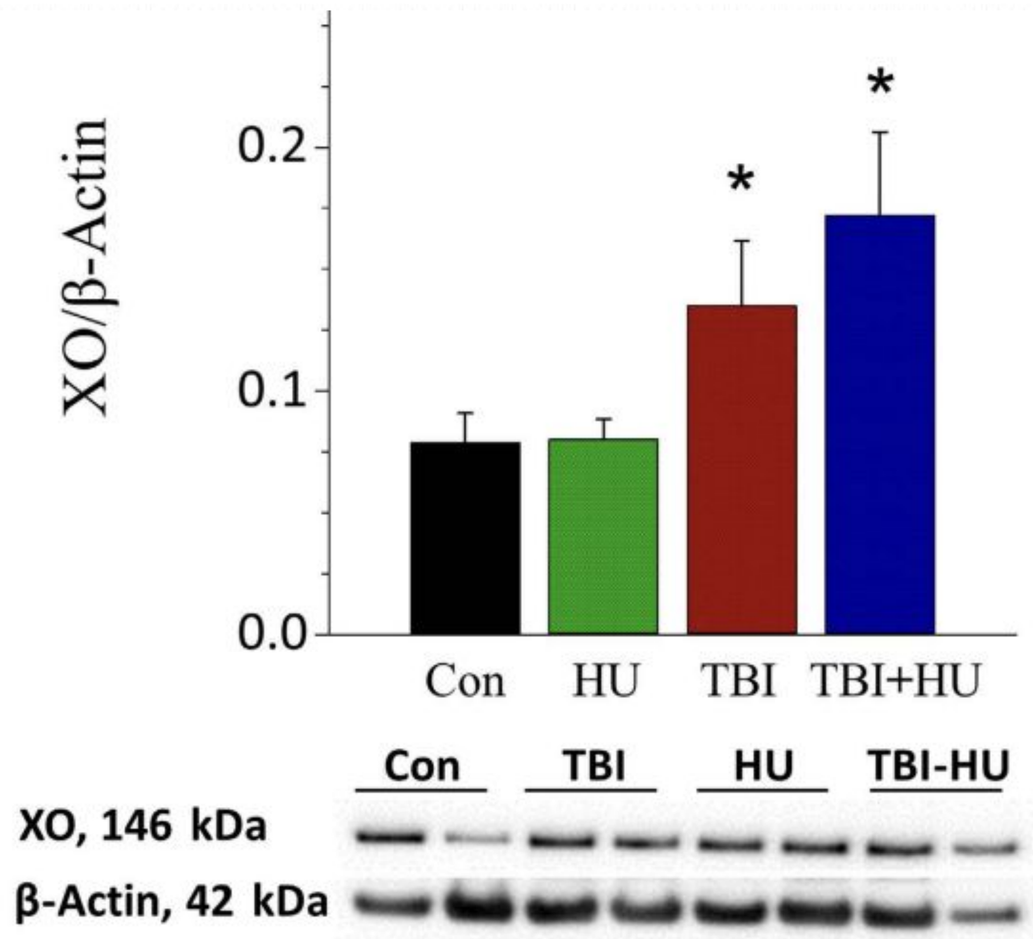


Figure 1. The proportional mortality rate due to cardiovascular disease in the United States among individuals age 55–64 years, non-flight astronauts, astronauts that flew only low Earth orbit missions, all flight astronauts, and Apollo astronauts that flew missions to the Moon. *Significantly different from the US population 55–64 years of age at the time of death, $P \leq 0.05$. †Significantly different from the non-flight astronaut group, $P \leq 0.05$. ‡Significantly different from the low Earth orbit astronaut group, $P \leq 0.1$.



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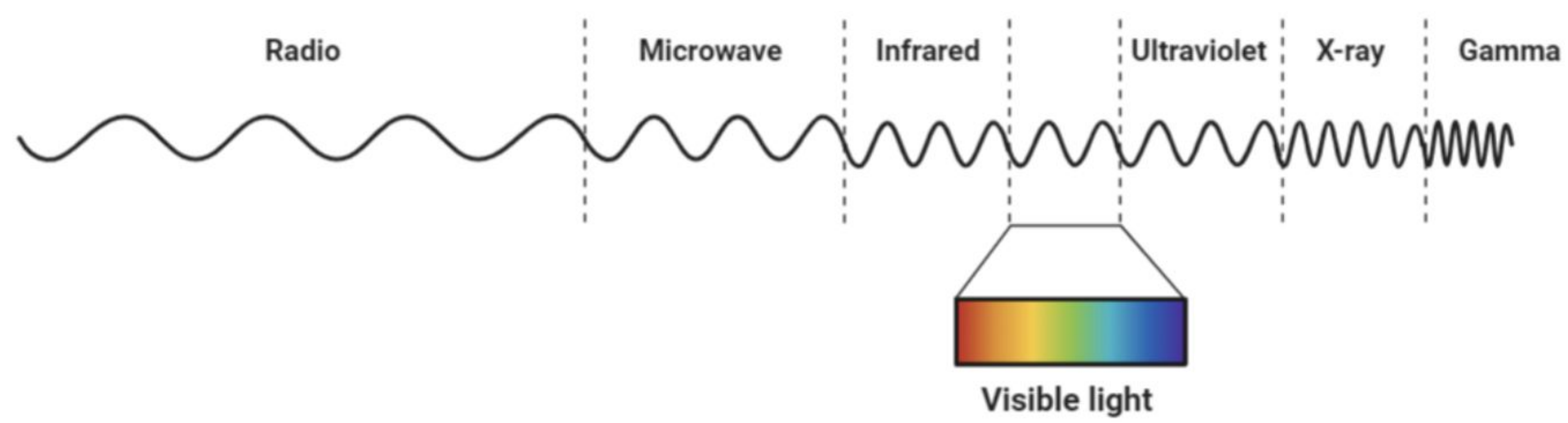

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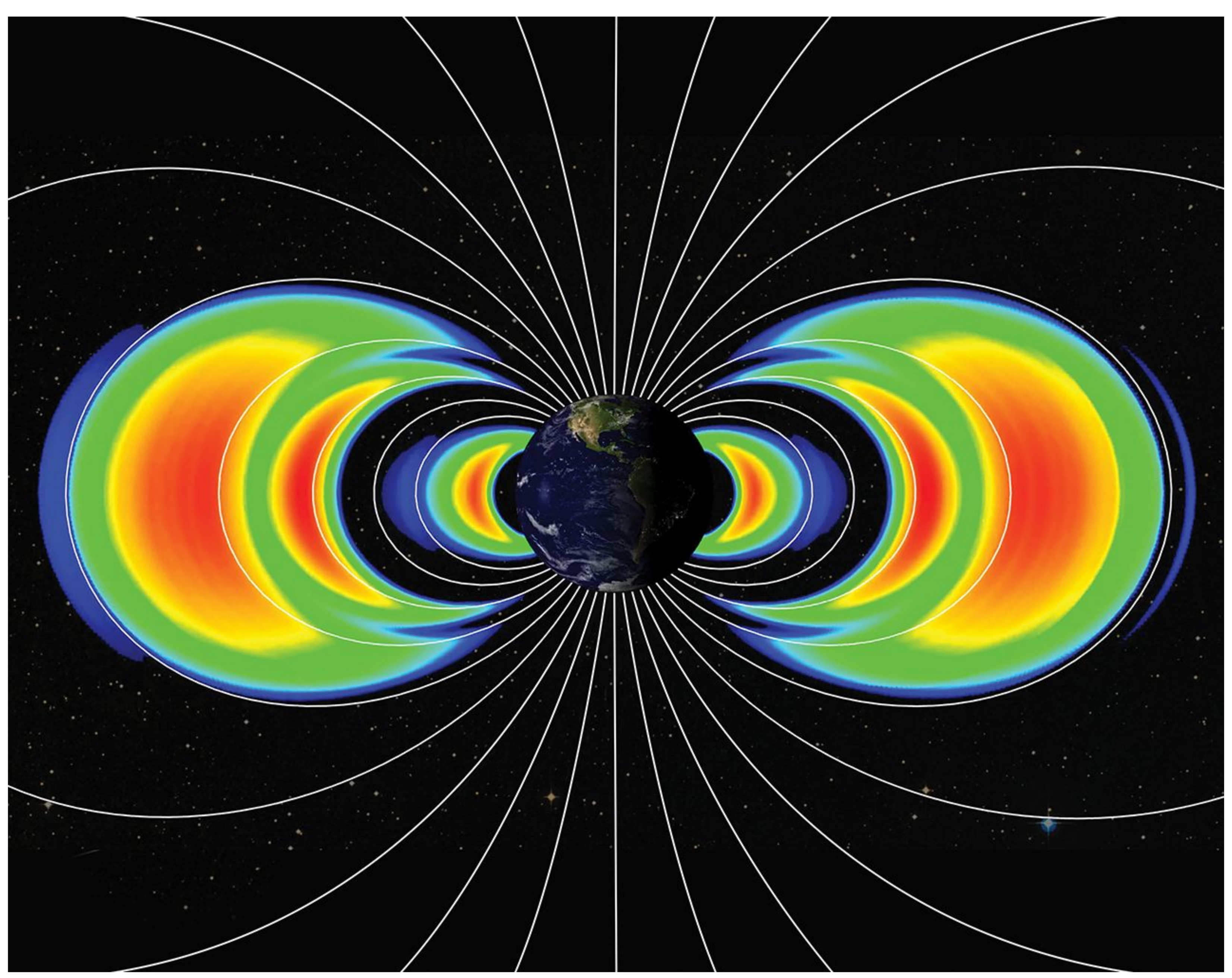
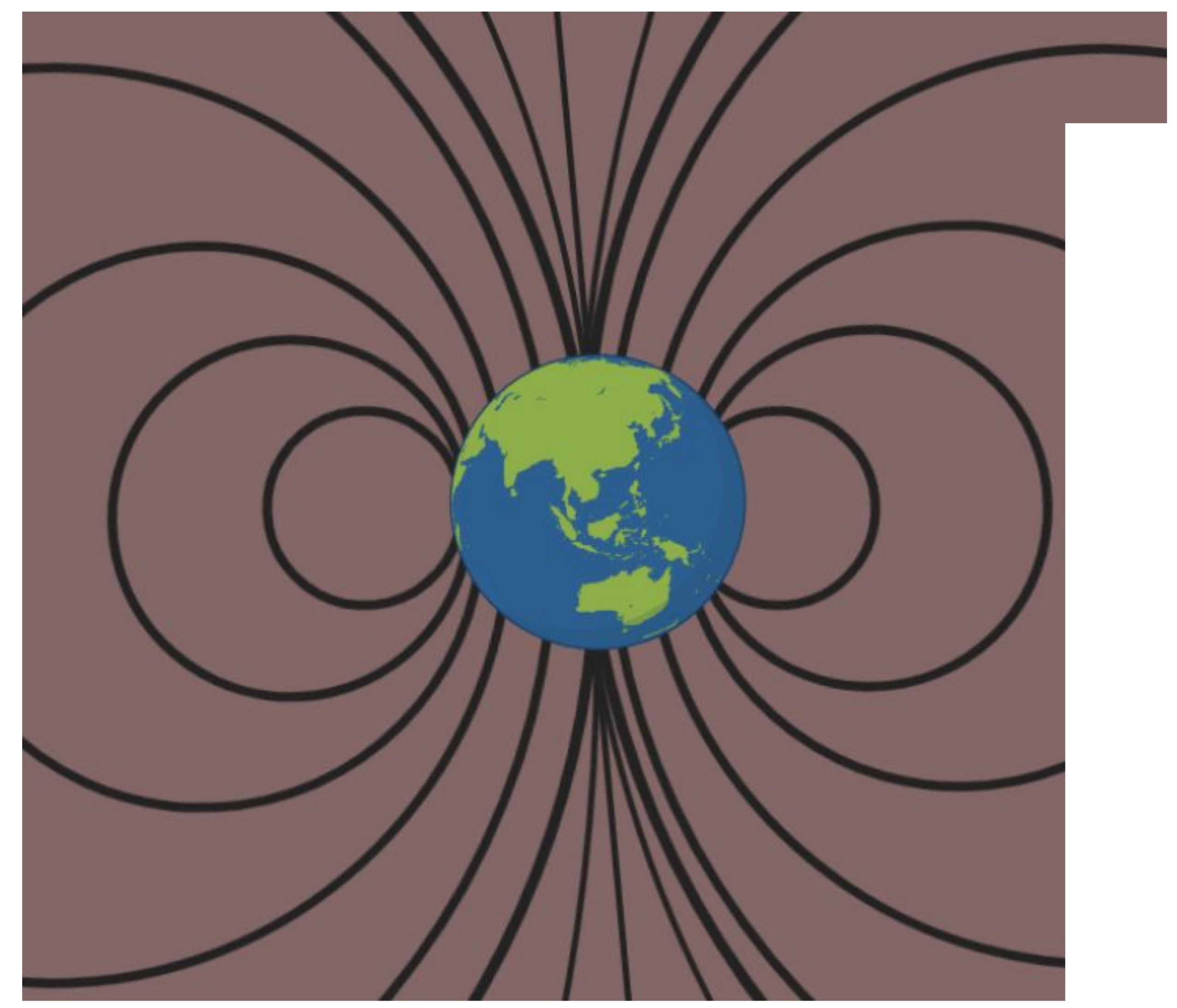
are mean ± SE. *Denotes significant difference from Con



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