Report of HIMAC experiment 19J432 granted by "Living in Space"

(A03-1) Multidisciplinary Analysis of the Effect of Low Fluence Particle Radiation on Animals and Biological
Adaptations (Living in Space)
Visit duration: 2020/1/28-2/3

HIMAC project 19J432
Title: "Response of probiotic microorganisms to heavy ion radiation (PRO-RAD)"

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Beam time (date and heavy ion):
January 31st, 2020 (23:00–31:00 (11:00 p.m.–07:00 a.m.)): Iron Fe 500 MeV/n (LET 200 keV/µm)

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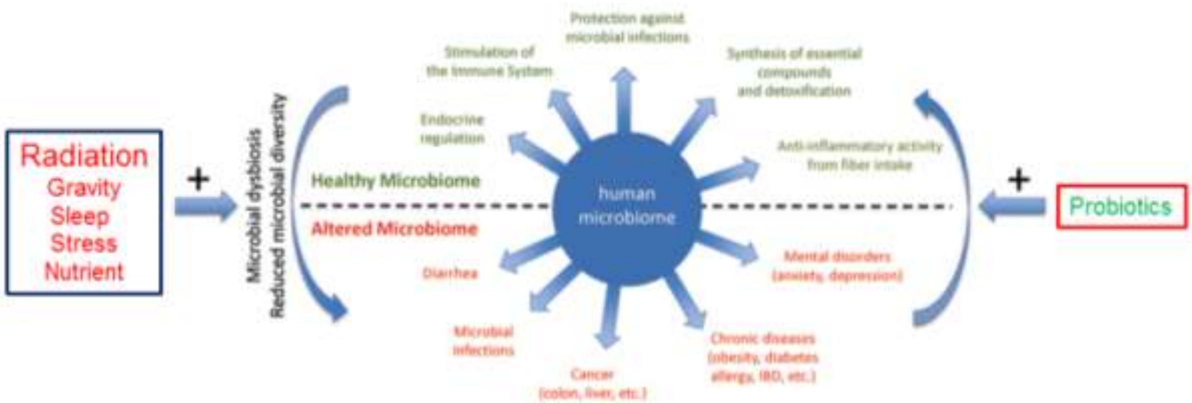
Aim and scope of experiment:
The last decades of space exploration has provided considerable insight into the physiological and psychological effects of radiation and microgravity on humans for short missions, all in low Earth orbit. Conditions such as bone loss, renal calculi, nausea, diarrhea, and depression have been commonly reported by crews during these missions. As several major space agencies (NASA, ESA, JAXA, etc.) plan for longer missions extending beyond LEO, it is critical to fill the gaps in our knowledge on the effects of space radiation of these missions which will encounter on all aspects of crew health, including its effects on the human microbiome.



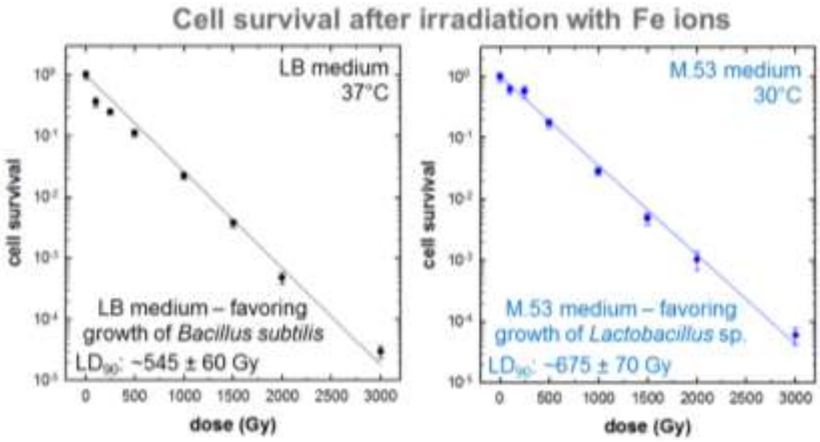
Effects of space travel on the human microbiome. Stressors associated with space travel (blue box) may disrupt the composition of the human microbiome causing dysbiosis. Microbial imbalance could result in the loss of some of its beneficial effects on human health increasing the risk of astronauts of contracting infection or developing human diseases.

These microbial communities are important to human health as they synthesize essential vitamins, retrieve energy from indigestible compounds, limit pathogen colonization, promote maturation and regulation of the immune system, contribute to vascular development and angiogenesis, promote the integrity of epithelial barriers, and even our psychological well-being. These collective traits make the human microbiota a critical target for maintaining astronaut health. Spaceflight can significantly impact microorganisms, altering proliferation rates, physiology, metabolism and virulence. In the case of the species that compose the human microbiome, changes observed during space flights include a decrease in the relative abundance of beneficial microorganisms and an increase in opportunistic pathogens.

Methodology and approach:

A straightforward experimental design will be used to irradiate the biological samples: multi-strain Bio-Kult® capsules (made of hydroxypropylmethyl cellulose) containing 14 probiotic strains (i.e., *Bacillus subtilis, Bifidobacterium bifidum, Lactobacillus acidophilus, L. delbrueckii, L. casei, L. plantarum, L. rhamnosus, L. helveticus, L. salivarius, Lactococcus lactis, Streptococcus thermophiles*) from Probiotics International (Protexin; Somerset, UK) as well as air-dried cells and cells in buffer from individual strains (i.e., type strains of *Bacillus subtilis* (DSM 10), *Bifidobacterium bifidum* (DSM 20456), *Lactococcus lactis* (DSM 20481), and *Lactobacillus salivarius* (DSM 20555) were irradiated.

First / preliminary results:



Cell survival of Fe ion (500 MeV/n) irradiated multi-strain Bio-Kult® capsules containing 14 different probiotic strains. Vitality was determined by strain-specific cultivation methods incl. plate CFU counts

Outlook and expected results:

Because future deep space exploration to the Moon, or to Mars, is a goal, it is essential to establish measures to combat immune system suppression. A manned mission to Mars will present a host of challenges for the astronauts making the long journey, including the difficulty of maintaining a healthy microbiome. Our microbiome helps us break down food, protects us from infection and bolsters our immune system ("*we could not live without it*"). Proactive efforts to establish a healthy microbiome are critical for the physiological and psychological well-being of the crew. Consequently, it is crucial to identify how extended space radiation impacts probiotic microorganisms. Supplementing astronaut diets with microbiota to compensate for the loss of these beneficial bacteria is a potentially viable strategy. However, **very little is known about the resilience and response of these probiotic microorganisms to space radiation**. Filling this 'knowledge gap' is crucial to ensuring astronaut health for long duration space missions, and systematic studies on testing the radiation response of probiotic microorganisms can fulfill this role. **Experimental research at the HIMAC is ideal to**

evaluate the response of a variety of commercially available probiotic microorganisms stored in pharmaceutical-type capsules or prepared individually to major parts of the galactic cosmic radiation.

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