OVERCOMING LIMITATIONS OF ORGAN-ON-CHIP (OOC) TECHNOLOGIES TO ADVANCE THE CHARACTERIZATION AND MEDICAL MANAGEMENT OF CHEMICAL AND BIOLOGICAL (CB) THREATS

Establishing An Astronaut Gut On A Chip To Develop Countermeasures Against Gut Microbiome Dysbiosis In Space

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Long term space travel for scientific and defense related missions is inevitable. Those who serve our nation under either of these operations are exposed to various environmental factors considered extreme and contradict terrestrial factors influencing human health. During relatively short-term flight missions, increased exposure to radiation and microgravity has resulted in observed physiological changes to astronauts. The development of an “astronaut gut-on-a-chip” would provide the means to test the impact of space flight and evaluate efficacy of countermeasures to mitigate debilitating gut microbiome dysbiosis. This chip would provide rapid, high throughput testing capable of protecting and supporting mission readiness prior to the projected rise in defense related space travelers. To directly characterize alterations in human gut microbiome in space environment, Rhodium Scientific and Los Alamos National Laboratory (LANL), supported by DTRA, launched a prototype investigation named “Rhodium Space Microbiome” to the International Space Station in 2020.

Previous space-based investigations have shown that commonly nascent bacterial species increased their mutation rates and virulence due to exposure to microgravity conditions. Thus, the science team hypothesized that certain members of the normal human microbiota would increase in pathogenicity or increase in abundance to become a host threat. While this scenario entails an enrichment of pathogens due to microgravity exposure, the converse postulate was also hypothesized stating that microgravity would pose selective pressure on the human microbiome that could decrease the abundance of beneficial populations. In this scenario, certain key bacterial species normally keeping opportunistic pathogens in check or providing valuable nutrients may become depleted; thereby negatively impacting host health. Whatever the case may be, it is evident our understanding of the mechanisms affecting microbiome composition in microgravity leading to reduced health for the host is not fully understood.

The overall goal was to establish rapid and reproducible flight preparation processes to increase capabilities for identify shifts in bacterial community structure patterns posing threats to human health in space. The central hypothesis was ISS-based cultivation of gut microbiome samples from healthy individuals will result in community population shifts and reveal potential pathogens previously below detection limits during terrestrial cultivation. Well established terrestrial techniques for gut microbiome cultivation developed in the Dichosa Labwere were adapted by Rhodium for use within the Rhodium Science Chamber Facility, an ISS Science Facility capable of supporting all cultivation needs of this experiment. Rhodium’s DoD spaceflight prototype “Quality, Industry Compatible (QuIC) Space Process™” was used to complete all pre-flight requirements efficiently and effectively for launch on SpaceX-20. This prototype process provided rapid flight certification and launch in less than 2 months from NASA kickoff. In addition, the process was vetted by the DoD for quality assurance standards necessary for producing and maintaining products of regulated industries. Post-flight analysis detected microbial community shifts, supporting both hypotheses showing a rise in pathogenic lineages and a downshift in beneficial lineages. A second ISS mission has been funded to isolate key members of the gut population to further understand and predict these shifts, develop countermeasures and establish the “astronaut gut-on-a-chip”.

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