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Interactive Presentations - 20th IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (IPB)

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APPLICATION OF EMERGING INNOVATIONS IN MICROBIOME SCIENCE TO SPACE DEVELOPMENT AND SETTLEMENT SYSTEMS

Abstract

Future human spaceflight beyond low-Earth orbit will bring substantial changes and new requirements to the development of fully sustainable, healthy indoor human environments across a range of gravitational, radiation, and thermal conditions. One key aspect is understanding (and potential leveraging) of microorganisms that must coexist with humans, plants, and animals in enclosed habitats (their microbiota or microbiomes). Modern, genome-resolved microbiome science provides an opportunity to better understand how we can utilize microbes to optimize space missions and protect human health and well-being long-term. Microorganisms will be critical to mission success due to their direct or indirect interactions with 1) humans, 2) other living systems (e.g., plant and animal life as a food source and for experimentation), and 3) the built environment. For example, the human gut microbiome is a complex community that has important implications for human health and performance that include mental health, nutrition intake, and immune system function. The health of plant microbiomes is also critical for sustainable, dependable, and nutritious food production. Humans, plants, and other living systems (e.g, animals used in experimentation) will also shed microbes into the built environment, which may impact human exposure, plant health, system integrity, and planetary protection from microbial contamination in both forward and reverse directions. Microbes from all three systems will interact, resulting in potentially important 'non-linear' system implications that must be understood for the overall long-term sustainability of hardware, crew, and other living systems. This paper discusses recent advances in technology that expand measurement capabilities to ultra-low-biomass samples and now allow for better understanding of microbial taxa, community structure and drivers, and their functional capacity, which together will empower microbiome-optimized deep-space human exploration missions. We propose and discuss on-ramps for these technologies to inform the successful design, operation, and long-term sustainability of deep-space habitats, space development, and settlement systems, as humans venture beyond low-Earth orbit.