

Fiscal Year:	FY 2023	Task Last Updated:	FY 09/13/2023
PI Name:	Vanapalli, Siva		
Project Title:	Impact of the Gut Microbiome on the Integrative Physiology of Genetically Diverse Invertebrates		
Division Name:	Space Biology		
Program/Discipline:			
Program/Discipline-- Element/Subdiscipline:			
Joint Agency Name:		TechPort:	No
Human Research Program Elements:	None		
Human Research Program Risks:	None		
Space Biology Element:	(1) Microbiology (2) Animal Biology: Invertebrate		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	79409-0001	Congressional District:	19
Comments:			
Project Type:	Flight,Ground	Solicitation / Funding Source:	2020 Space Biology NNH20ZDA001N-SB E.12. Flight/Ground Research
Start Date:	03/01/2022	End Date:	02/28/2026
No. of Post Docs:	1	No. of PhD Degrees:	
No. of PhD Candidates:	2	No. of Master' Degrees:	
No. of Master's Candidates:	1	No. of Bachelor's Degrees:	
No. of Bachelor's Candidates:	1	Monitoring Center:	NASA ARC
Contact Monitor:	Contact Phone:		
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: End date changed to 02/28/2026 per B. Stallsmith/ARC (Ed., 5/20/25) NOTE: End date changed to 02/28/2025 per F. Hernandez/ARC (Ed., 4/25/22)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Driscoll, Monica Ph.D. (Rutgers University, New Brunswick) Samuel, Buck S. Ph.D. (Baylor College of Medicine, Inc) Szewczyk, Nathaniel Ph.D. (Ohio University)		
Grant/Contract No.:	80NSSC22K0250		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	<p>The gut microbiome is a complex community of microbes that exert considerable influence over host physiology, development, metabolism, and predisposition to the disease on Earth. Recent spaceflight investigations in both humans and rodents show that the microbiome community structure is altered under microgravity, posing risk factors for crew health. Thus, understanding the impact of the gut microbiome on long-term physiological changes will be crucial for long-duration space missions to Mars and beyond.</p> <p>The current project is centered around addressing two major knowledge gaps in space biology research. First, fundamental understanding is lacking as to how differences in microbiomes contribute to changes in gut colonization, organ-level physiology, and whole-organism function under microgravity. Second, even though it is recognized on Earth that individual genetic variation can have a large impact when organisms within a species are exposed to new environmental conditions, very little knowledge exists on how genetic diversity within individual species impacts the integrative physiology of organisms when exposed to microgravity since most flight studies to date have focused on genetically homogenous rodent models or cell cultures.</p> <p>To address these knowledge gaps, we plan to use <i>C. elegans</i>, which is an established and low-cost invertebrate model for space biology, microbiome studies, and genetic diversity research. We plan to use recently established gut microbial communities to investigate the impact of the gut microbiome on host physiology. In a parallel advance, using genetically diverse wild isolates of <i>C. elegans</i>, we will study host-microbiome interactions in spaceflight.</p> <p>Our project plan involves testing the following hypotheses in International Space Station (ISS) flight studies with ground study components: (i) Microbial membership of <i>C. elegans</i> gut influences host transcriptional response, tissue-level physiology, and whole-organism function, (ii) Genetic diversity of host influences gut membership of individual microbes, tissue-level physiology, and whole-organism function, and (iii) Insulin signaling pathway play a central role in driving microbiome-induced host response in spaceflight.</p> <p>The proposed studies are aligned with the stated strategic goals of NASA Space Biology, which defines over-arching guiding questions focused on integrated biological approaches to understand physiological and molecular mechanisms in living systems that respond to space exploration environments. Pre-biotic and probiotic therapies could be potentially realized from our investigations to improve crew health, along with the dissemination of new flight-tested protocols and molecular characterization tools for the spaceflight community.</p>
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	<p>The research in this project will quantitate changes in the microbiome as well as in the host in response to space-flight thereby providing detailed understanding of the dynamics of host-microbiome interactions. Additionally, new microfluidic technologies will be developed that facilitate gut-microbiome studies. This new knowledge and capabilities provided by our project can provide significant Earth benefit by contributing to the development of “living medicines” (e.g. probiotics) for treating a variety of human health disorders associated with metabolism, gut, muscle and the nervous system.</p>
Task Progress:	<p>The aims of the CBIOMES spaceflight project are: (1) Determine the effect of spaceflight on different microbiomes; (2) Evaluate the effect of different microbiomes on spaceflight invertebrate standard N2 <i>C. elegans</i> strain; (3) Evaluate the effect of spaceflight on genetically diverse <i>C. elegans</i> fed with the standard <i>E. coli</i> diet; (4) Evaluate the interaction of different microbiomes with genetically diverse <i>C. elegans</i> in spaceflight.</p> <p>To achieve the spaceflight project aims, the science team pursued ground investigations and completed several tasks. We have successfully constructed transgenic <i>C. elegans</i> lines that will permit on-ground elimination of progeny for young adults in spaceflight. Culture experiments were conducted to identify microbial members of the microbiome community, based on their growth and gut colonization capabilities. We evaluated whether polyethylene culture bags can support growth of synchronized populations of <i>C. elegans</i> and the biomes of interest in this project. Finally, we evaluated microfluidic devices in terms of their ability to culture <i>C. elegans</i> in different bacterial diet conditions and found that the locomotory behavior depends on age and diet.</p>
Bibliography Type:	Description: (Last Updated: 10/09/2024)
Articles in Peer-reviewed Journals	<p>Vintila AR, Slade L, Cooke M, Willis CRG, Torregrossa R, Rahman M, Anupom T, Vanapalli SA, Gaffney CJ, Gharahdaghi N, Szabo C, Szewczyk NJ, Whiteman M, Etheridge T. "Mitochondrial sulfide promotes life span and health span through distinct mechanisms in developing versus adult treated <i>Caenorhabditis elegans</i>." <i>Proc Natl Acad Sci USA</i>. 2023 Aug 8;120(32):e2216141120. Online ahead of print. https://doi.org/10.1073/pnas.221614112 ; PMID: 37523525; PMCID: PMC10410709 , Aug-2023</p>