

Fiscal Year:	FY 2020	Task Last Updated:	FY 07/22/2020
PI Name:	Nicholson, Wayne Ph.D.		
Project Title:	Bacillus Spore Probiotics: Evaluation of Survival and Efficacy After Exposure to Deep-Space Radiation Simulating Long-Duration Human Exploration Missions		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		TechPort:	No
Human Research Program Elements:	(1) HHC: Human Health Countermeasures		
Human Research Program Risks:	(1) Food and Nutrition: Risk of Performance Decrement and Crew Illness Due to Inadequate Food and Nutrition (2) Microhost: Risk of Adverse Health Effects Due to Host-Microorganism Interactions		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Comments:	NOTE: Congressional District is for University of Florida (32611-0001)--Ed., 8/17/2012; changed to 3 (Ed., 7/30/13)		
Project Type:	GROUND	Solicitation / Funding	2019 HERO 80JSC019N0001-FLAGSHIP & OMNIBUS: Source: Human Research Program Crew Health. Appendix A&B
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No. of Post Docs:		No. of PhD Degrees:	
No. of PhD Candidates:		No. of Master' Degrees:	
No. of Master's Candidates:		No. of Bachelor's Degrees:	
No. of Bachelor's Candidates:		Monitoring Center:	NASA JSC
Contact Monitor:		Contact Phone:	
Contact Email:			
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Fajardo-Cavazos, Patricia Ph.D. (University of Florida, Gainesville)		
Grant/Contract No.:	80NSSC20K1297		
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Performance Goal Text:			

Task Description:

Background: Probiotics are defined by the World Health Organization as "live microorganisms that confer a health benefit on the host when ingested in adequate amounts." Acquisition of diverse microbes from the environment is important for maintaining a healthy gastrointestinal (GI) microbiome, but astronauts' GI microbiomes change during long-term spaceflight missions. Addition of probiotics to the astronaut diet could provide an effective countermeasure. Current data is limited regarding the shelf life of probiotics during long-duration space exploration, particularly to the radiation environment of interplanetary space. Due to limited onboard refrigerator/freezer space, it would be desirable to store probiotics at ambient temperature as freeze-dried capsules. However, freeze-dried formulations of common probiotic species (e.g., *Lactobacillus*, *Bifidobacterium*) rapidly lose viability at ambient temperatures. In contrast, probiotic formulations containing spores of various *Bacillus* species have very long shelf lives and survive passage through the acidic environment of the stomach and small intestine with high potency. Moreover, recent clinical trials have shown that *Bacillus* spore probiotics are safe, can significantly improve GI symptoms, and stimulate the immune system.

Hypothesis: Exposure of probiotic bacteria to simulated space radiation will result in a decrease in survival and potency, at a rate which can be empirically measured. Probiotics containing *Bacillus* spores will demonstrate enhanced long-term stability and potency compared to traditional *Lactobacillus*- or *Bifidobacterium*-containing probiotics.

Aims: Using the NASA Space Radiation Laboratory (NSRL) at Brookhaven, NY, we propose to evaluate the survival and potency of *Bacillus* spore probiotics vs. traditional probiotic formulations following exposure to simulated Galactic Cosmic Rays (GCRSim) and Solar Particle Events (SPESim) expected to be encountered during NASA Design Reference Missions (DRMs) lasting up to 3 years. Specific aims include: A. Select appropriate freeze-dried, prepackaged probiotic formulations to test. B. Expose samples at NSRL to GCRSim and SPESim at dosages representative of a 3-year DRM, in parallel with matched lab controls and transport controls. C. Measure viability of all samples vs. exposure dose and compare data from exposed vs. control samples.

Methods: DRM-appropriate GCRSim and SPESim exposures will be performed at NSRL. Survival to radiation exposure will be measured by viable counts and live/dead staining. Survival to simulated gastric and intestinal juices will be measured by standard procedures. Comparison of datasets between traditional probiotics and *Bacillus* spore formulations will be performed using appropriate statistical methods.

Deliverables: The proposed study will provide data on survival kinetics of probiotic formulations to GCRSim and SPESim exposures, as well as survival to simulated passage through the upper GI tract before and after irradiation. These results will help mission planners in decisions regarding probiotic inclusion in the food system of upcoming long-duration missions.

Significance: The gut microbiome influences virtually all aspects of human health. Microbiome health and dysfunction have been associated with myriad human health conditions ranging from digestive to cardiovascular, immunological, and psychological. Thus, a healthy GI microbiome is of prime importance to astronaut health during long-duration missions. Inclusion of probiotic supplements to the astronaut diet will promote health and mitigate detrimental effects of chronic exposure to long-term spaceflight.

Human Research Roadmap Gaps addressed: MICRO-01 (We need to determine the efficacy of current countermeasures and the need for countermeasure development based on changes in microbial populations and characteristics), MICRO-02 (We need to determine if spaceflight induces changes in diversity, concentration, and/or characteristics of medically significant microorganisms associated with the crew and environment aboard the International Space Station that could affect crew health), MICRO-03 (We need to determine which medically significant microorganisms display changes in the dose-response profiles in response to the spaceflight environment that could affect crew health), MICRO-04 (We need to determine how physical stimuli specific to the spaceflight environment, such as microgravity, induce unique changes in the dose-response profiles of expected medically significant microorganisms), FOOD-01 (We need to determine how processing and storage affect the nutritional content of the food system), and FOOD-03 (We need to identify the methods, technologies, and requirements that will deliver a food system that provides adequate safety, nutrition, and acceptability for proposed long-duration Design Reference Mission operations).

Rationale for HRP Directed Research:

Research Impact/Earth Benefits:

Task Progress:

New project for FY2020.

Bibliography Type:

Description: (Last Updated: 04/17/2023)