Fiscal Year:	FY 2021	**Task Last Updated:**	FY 05/10/2021
PI Name:	Smith, Scott M Ph.D.		
Project Title:	Space Biochemistry Profile		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Biomedical countermeasures		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Bone Fracture**:Risk of Bone Fracture due to Spaceflight-induced Changes to Bone (2) **Food and Nutrition**:Risk of Performance Decrement and Crew Illness Due to Inadequate Food and Nutrition (3) **Immune**:Risk of Adverse Health Event Due to Altered Immune Response (4) **Nutrition**:Risk of Inadequate Nutrition (5) **Osteo**:Risk Of Early Onset Osteoporosis Due To Spaceflight (6) **Renal Stone**:Risk of Renal Stone Formation		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	scott.m.smith@nasa.gov	**Fax:**	FY 281-483-2888
PI Organization Type:	NASA CENTER	**Phone:**	281-483-7204
Organization Name:	NASA Johnson Space Center		
PI Address 1:	Biomedical Research and Environmental Sciences Division/SK3		
PI Address 2:	2101 NASA Pkwy		
PI Web Page:			
City:	Houston	**State:**	TX
Zip Code:	77058-3607	**Congressional District:**	36
Comments:			
Project Type:	FLIGHT	**Solicitation / Funding Source:**	2012 Crew Health NNJ12ZSA002N
Start Date:	08/01/2013	**End Date:**	09/30/2022
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:	Stenger, Michael	**Contact Phone:**	281-483-1311
Contact Email:	michael.b.stenger@nasa.gov		
Flight Program:	ISS		
Flight Assignment:	ISS NOTE: End date changed to 9/30/2022 per HRP HHC element and PI (Ed., 7/8/21) NOTE: End date changed to 12/31/2021 per PI (Ed., 2/25/21) NOTE: End date changed to 12/31/2020 per PI (Ed., 5/10/19) NOTE: End date changed to 12/31/2019 per PI (Ed., 6/5/18)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Zwart, Sara Ph.D. (University of Texas Medical Branch/) Heer, Martina Ph.D. (University of Bonn, Germany)		
Grant/Contract No.:	Internal Project		

Performance Goal No.:	
Performance Goal Text:	
Task Description:	As long-duration spaceflights continue and the operational suite of countermeasures is modified, the food system is updated, and the duration of missions lengthens, it will be important to evaluate and monitor a broad set of biomarkers for key physiological systems. The Nutritional Status Assessment Supplemental Medical Objective (aka "Nutrition SMO") was initiated in 2006, and has yielded significant clinical, operational, and research data. This proposal aims to extend the Nutrition SMO, under the guidelines provided in the NRA (NASA Research Announcement). Nutrition SMO data have been used to help identify or explain medical, scientific, and even engineering issues that have occurred during or after International Space Station (ISS) missions. The data have been used by Medical Operations on multiple occasions, to confirm the effectiveness of vitamin D supplementation, to test for nutrient toxicities (secondary to supplement use), to evaluate blood and urine chemistries after instances of kidney stones and gout symptoms in crewmembers, and to evaluate the effects of using a new exercise device on bone and calcium metabolism. The ISS Program Office has used these data to determine factors contributing to the Urine Processor Assembly failure and to make forward operational decisions. Perhaps most striking, the data provided evidence that one-carbon metabolism may be altered in crewmembers who experienced vision changes post flight, the highest Human Research Program risk. The relationship between nutritional status and 1-carbon metabolism would likely never have been discovered if the Nutrition SMO were not being conducted. The impact of the data collected to date provides a strong rationale for continuing with an updated version of this protocol, eliminating some tests while expanding others, to provide a repository of data to other scientific Disciplines. We have extensive experience with these types of analyses, sample and data management, transfer to data archives, and data reduction for medical, management, and research purposes.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The findings from this study will help us better understand physiological adaptation to spaceflight, and will help evaluate countermeasure effectiveness. These results help the ISS Program, the Human Research Program (HRP), Space Medicine, Office of the Chief Health and Medical Officer (OCHMO), NASA engineers, individual astronauts, and other experiments. These results will also inform the general, medical, and scientific communities on human health and physiological issues in an altered gravity environment. There could be significant potential implications of these findings.
Task Progress:	The Biochemical Profile study continues to deliver on what it was designed to do: provide a broad swath of biochemical data from a large number of astronauts to help assess the effects of space flight on the human body. Continued data analysis yields primary papers, along with data supporting other NASA investigators, including both Human Research Program (HRP) and Space Biology program (SBP).
Bibliography Type:	Description: (Last Updated: 05/24/2023)
Articles in Peer-reviewed Journals	Gabel L, Liphardt A-M, Hulme PA, Heer M, Zwart SR, Sibonga JD, Smith SM, Boyd SK. "Pre-flight exercise and bone metabolism predict unloading-induced bone loss due to spaceflight." Br J Sports Med. 2021 Feb 17;56:196-203. http://dx.doi.org/10.1136/bjsports-2020-103602 ; PMID: 33597120 , Feb-2021
Articles in Peer-reviewed Journals	da Silveira WA, Fazelinia H, Rosenthal SB, Laiakis EC, Kim MS, Meydan C, Kidane Y, Rathi KS, Smith SM, Stear B, Ying Y, Zhang Y, Foox J, Zanello S, Crucian B, Wang D, Nugent A, Costa HA, Zwart SR, Schrepfer S, Elworth RAL, Sapoval N, Treangen T, MacKay M, Gokhale NS, Horner SM, Singh LN, Wallace DC, Willey JS, Schisler JC, Meller R, McDonald JT, Fisch KM, Hardiman G, Taylor D, Mason CE, Costes SV, Beheshti A. "Comprehensive multi-omics analysis reveals mitochondrial stress as a central biological hub for spaceflight impact." Cell. 2020 Nov 25;183(5):1185-201.E20. https://doi.org/10.1016/j.cell.2020.11.002 ; PMID: 33242417; PMCID: PMC7870178 , Nov-2020
Articles in Peer-reviewed Journals	Luxton JJ, McKenna MJ, Taylor LE, George KA, Zwart SR, Crucian BE, Drel VR, Garrett-Bakelman FE, Mackay MJ, Butler D, Foox J, Grigorev K, Bezdan D, Meydan C, Smith SM, Sharma K, Mason CE, Bailey SM. "Temporal telomere and DNA damage responses in the space radiation environment." Cell Rep. 2020 Dec 8;33(10):108435. https://doi.org/10.1016/j.celrep.2020.108435 ; PMID: 33242411 , Dec-2020
Articles in Peer-reviewed Journals	Luxton JJ, McKenna MJ, Lewis A, Taylor LE, George KA, Dixit SM, Moniz M, Benegas W, Mackay MJ, Mozsary C, Butler D, Bezdan D, Meydan C, Crucian BE, Zwart SR, Smith SM, Mason CE, Bailey SM. "Telomere length dynamics and DNA damage responses associated with long-duration spaceflight." Cell Rep. 2020 Dec 8;33(10):108457. https://doi.org/10.1016/j.celrep.2020.108457 ; PMID: 33242406 , Dec-2020
Articles in Peer-reviewed Journals	Gertz ML, Chin CR, Tomoiaga D, MacKay M, Chang C, Butler D, Afshinnekoo E, Bezdan D, Schmidt MA, Mozsary C, Melnick A, Garrett-Bakelman F, Crucian B, Lee SMC, Zwart SR, Smith SM, Meydan C, Mason CE. "Multi-omic, single-cell, and biochemical profiles of astronauts guide pharmacological strategies for returning to gravity." Cell Rep. 2020 Dec 8;33(10):108429. https://doi.org/10.1016/j.celrep.2020.108429 ; PMID: 33242408 , Dec-2020
Articles in Peer-reviewed Journals	Paul AM, Cheng-Campbell M, Blaber EA, Anand S, Bhattacharya S, Zwart SR, Crucian BE, Smith SM, Meller R, Grabham P, Beheshti A. "Beyond low-Earth orbit: Characterizing immune and microRNA differentials following simulated deep spaceflight conditions in mice." iScience. 2020 Dec 18;23(12):101747. https://doi.org/10.1016/j.isci.2020.101747 ; PMID: 33376970 ; PMCID: PMC7756144 , Dec-2020
Articles in Peer-reviewed Journals	Douglas GD, Zwart SR, Smith SM. "Space food for thought: Challenges and considerations for food and nutrition on exploration missions." J Nutr. 2020 Sep 1;150(9):2242-4. https://doi.org/10.1093/jn/nxaa188 ; PMID: 32652037 , Sep-2020
Articles in Peer-reviewed Journals	Lee SMC, Ribeiro LC, Martin DS, Zwart SR, Feiveson AH, Laurie SS, Macias BR, Crucian BE, Krieger S, Weber D, Grune T, Platts SH, Smith SM, Stenger MB. "Arterial structure and function during and after long-duration spaceflight." J Appl Physiol (1985). 2020 Jul 1;129(1):108-23. https://doi.org/10.1152/japplphysiol.00550.2019 ; PMID: 32525433 [Associated Letter to the Editor and response: J Appl Physiol (1985). 2020 Nov 1;129(5):1111-1113.] , Jul-2020

Articles in Peer-reviewed Journals	Crucian BE, Makedonas G, Sams CF, Pierson DL, Simpson R, Stowe RP, Smith SM, Zwart SR, Krieger SS, Rooney B, Douglas G, Downs M, Nelman-Gonzalez M, Williams TJ, Mehta S. "Countermeasures-based improvements in stress, immune system dysregulation and latent herpesvirus reactivation onboard the International Space Station – Relevance for deep space missions and terrestrial medicine." Neurosci Biobehav Rev. 2020 Aug;115:68-76. https://doi.org/10.1016/j.neubiorev.2020.05.007 ; PMID: 32464118 , Aug-2020
Articles in Peer-reviewed Journals	Afshinnekoo E, Scott RT, MacKay MJ, Pariset E, Cekanaviciute E, Barker R, Gilroy S, Hassane D, Smith SM, Zwart SR, Nelman-Gonzalez M, Crucian BE, Ponomarev SA, Orlov OI, Shiba D, Muratani M, Yamamoto M, Richards SE, Vaishampayan PA, Meydan C, Foox J, Myrrhe J, Istasse E, Singh N, Venkateswaran K, Keune JA, Ray HE, Basner M, Miller J, Vitaterna MH, Taylor DM, Wallace D, Rubins K, Bailey SM, Grabham P, Costes SV, Mason CE, Beheshti A. "Fundamental biological features of spaceflight: Advancing the field to enable deep-space exploration." Cell. 2020 Nov 25;183(5):1162-84. Review. https://doi.org/10.1016/j.cell.2020.10.050 ; PMID: 33242416 , Nov-2020
Articles in Peer-reviewed Journals	Patel ZS, Brunstetter TJ, Tarver WJ, Whitmire AM, Zwart SR, Smith SM, Huff JL. "Red risks for a journey to the red planet: the highest priority human health risks for a mission to Mars." npj Microgravity. 2020 Nov 5;6(1):33. https://doi.org/10.1038/s41526-020-00124-6 ; PMID: 33298950; PMCID: PMC7645687 , Nov-2020
NASA Technical Documents	Smith SM, Zwart SR, Douglas GL, Heer M. "Human adaptation to spaceflight: The role of food and nutrition. Second edition." Houston, TX: NASA Lyndon B. Johnson Space Center, 2021. 255 p. NP-2021-03-003-JSC. https://www.nasa.gov/sites/default/files/atoms/files/human_adaptation_2021_final.pdf , Apr-2021