

<b>Fiscal Year:</b>	FY 2020	<b>Task Last Updated:</b>	FY 09/20/2019
<b>PI Name:</b>	Mancinelli, Rocco Ph.D.		
<b>Project Title:</b>	Elucidating The Nitrogen Cycle of Eu:CROPIS (Euglena: Combined Regenerative Organic-food Production In Space)		
<b>Division Name:</b>	Space Biology		
<b>Program/Discipline:</b>			
<b>Program/Discipline--Element/Subdiscipline:</b>	SPACE BIOLOGY--Cellular and molecular biology		
<b>Joint Agency Name:</b>	<b>TechPort:</b>	No	
<b>Human Research Program Elements:</b>	None		
<b>Human Research Program Risks:</b>	None		
<b>Space Biology Element:</b>	(1) Cell & Molecular Biology (2) Microbiology		
<b>Space Biology Cross-Element Discipline:</b>	(1) Reproductive Biology		
<b>Space Biology Special Category:</b>	(1) Cell Culture (2) Translational (Countermeasure) Potential (3) Bioregenerative Life Support		
<b>PI Email:</b>	<a href="mailto:mancinelli@baeri.org">mancinelli@baeri.org</a>	<b>Fax:</b>	FY
<b>PI Organization Type:</b>	NON-PROFIT	<b>Phone:</b>	(650) 604-6165
<b>Organization Name:</b>	Bay Area Environmental Research (BAER) Institute		
<b>PI Address 1:</b>	Mail Stop 239-4, NASA Ames Research Center		
<b>PI Address 2:</b>			
<b>PI Web Page:</b>			
<b>City:</b>	Moffett Field	<b>State:</b>	CA
<b>Zip Code:</b>	94035	<b>Congressional District:</b>	18
<b>Comments:</b>			
<b>Project Type:</b>	FLIGHT	<b>Solicitation / Funding Source:</b>	Space Biology Unsolicited
<b>Start Date:</b>	10/01/2013	<b>End Date:</b>	10/31/2020
<b>No. of Post Docs:</b>	0	<b>No. of PhD Degrees:</b>	0
<b>No. of PhD Candidates:</b>	0	<b>No. of Master' Degrees:</b>	0
<b>No. of Master's Candidates:</b>	0	<b>No. of Bachelor's Degrees:</b>	0
<b>No. of Bachelor's Candidates:</b>	0	<b>Monitoring Center:</b>	NASA ARC
<b>Contact Monitor:</b>	Griko, Yuri	<b>Contact Phone:</b>	650-604-0519
<b>Contact Email:</b>	<a href="mailto:Yuri.V.Griko@nasa.gov">Yuri.V.Griko@nasa.gov</a>		
<b>Flight Program:</b>	Small Satellites		
<b>Flight Assignment:</b>	NOTE: End date changed to 10/31/2020 per F. Hernandez/ARC (Ed., 8/13/18) NOTE: End date changed to 9/30/2018 per F. Hernandez/ARC (Ed., 3/23/17)		
<b>Key Personnel Changes/Previous PI:</b>			
<b>COI Name (Institution):</b>	Hauslage, Jens Ph.D. ( DLR (German Aerospace Center) ) Richter, Peter Ph.D. ( Friedrich-Alexander-Universität - Erlangen, Germany ) Lebert, Michael Ph.D. ( Friedrich-Alexander University Erlangen-Nürnberg ) Strauch, Sebastian Ph.D. ( Friedrich-Alexander University Erlangen-Nürnberg )		
<b>Grant/Contract No.:</b>	Coop Agreement via NNX12AD05A		
<b>Performance Goal No.:</b>			
<b>Performance Goal Text:</b>			

**Task Description:**

Editor's Note (12/2/2013): Funding is for Dr. Mancinelli's participation as Co-Investigator on the German Aerospace Center (DLR)'s Eu:CROPIS (Euglena with Combined Regenerative Organic-food Production In Space) mission and the Principal Investigator of the nitrogen cycling portion of the mission, entitled "Elucidating The Nitrogen cycle of Eu:CROPIS (Euglena: Combined Regenerative Organic-food Production In Space)."

The objective of the proposed study is to determine the effect of different gravity levels on the nitrogen cycle leveraging experiments to be flown on DLR's Eu:CROPIS mission. This is of importance to NASA because The National Research Council's Plant and Microbial Biology Decadal Survey (2011) states that there is a need for understanding the role of gravity on microbe-microbe interactions and microbe-plant interactions. The research proposed here will do just that. Nitrogen is an essential element for life. It is present in all living systems, occurring in several important molecules including proteins and nucleic acids. Without nitrogen life as we know it could not exist. Thus, the nitrogen cycle is important to supporting life whether it is on Earth, in space, or on other planets or moons. Because only Earth has a 1 x g environment understanding how the nitrogen cycle operates as a function of gravity is key to sustaining life off of Earth. To change the gravity levels the spacecraft will be maneuvered (by spinning) to produce three different gravity regimes during the course of the mission. The three gravity regimes will be 0.01 x g - 0.1-x g (essentially microgravity); 0.16 x g (Moon gravity); and 0.38 x g (Mars gravity). Each gravity regime will last for six months. Eu:CROPIS will be used in reducing organic waste and in the development of efficient life support systems. Its core element is a microbiological trickling filter of lava rock – the habitat of a multitude of microorganisms that purify and decontaminate water. The development aims at a wet composting system that may be used in closed life support systems such as waste water recovery. A key component of the system is the nitrogen cycle. So, modeling the nitrogen cycle of the system is essential to understanding how the system functions. It will be the first time nitrogen-transformation reactions will be measured as a function of gravity. NASA has an excellent opportunity to participate in the DLR's Eu:CROPIS mission that allows us to obtain data by leveraging their laboratory work and hardware at a fraction of what it would cost if funded/supported solely by NASA.

**Rationale for HRP Directed Research:**

The need for fundamental research to understand the role of gravity on microbe-microbe interactions microbe-plant interactions and microbe human interactions in space is recognized in the National Research Council's Plant and Microbial Biology Decadal Survey (2011) on Biological and Physical Sciences in Space (chapter 4). Through the proposed work, data from the Eu:CROPIS mission will address microbe-microbe and microbe plant interactions through cycling of key nutrients, specifically nitrogen, oxygen, and carbon.

Eventually, space travel will require the ability for self-sufficiency. Once mission profiles extend beyond short trips to the lunar surface, the duration of each mission will mean it will no longer remain cost-effective -- or indeed feasible -- to dispose of all waste and resupply oxygen, water, and food to crew members from Earth. NASA has acknowledged this reality for more than two decades with programs exploring the development of both physicochemical and bioregenerative life support systems. The program on bioregenerative capabilities arose from observations that the only truly long-term, self-sustaining life support system that has a demonstrated stability and efficacy relies upon biological systems for its function; that system is the life support afforded by Earth. Since bioregenerative life support systems are not high on the NASA priority list at this time it was stated in the report: Because international collaborations will be essential to make rapid progress with these aims, NASA should support collaborations, where appropriate, with partners that are already pursuing these goals, such as European scientists....

**Research Impact/Earth Benefits:**

Eu:CROPIS is a clear example that fits in with this statement. It allows NASA to obtain this data at little cost by using the laboratories, the hardware, and the spacecraft paid for by the DLR. The Eu:CROPIS (Euglena: Combined Regenerative Organic-food Production In Space) experiment will test the feasibility and technology in the areas of life support systems and gravitational biological research. The mission offers for the first time the opportunity of analyzing coupled biological life support systems under different levels of gravity (space, moon, Mars) utilizing state-of-the-art methods for image and molecular analysis. It combines the C.R.O.P. system plant growth water purification system developed at the DLR in Cologne, Germany with the well studied *Euglena gracilis* space flight system.

*Euglena gracilis* is a motile, photosynthetic, unicellular flagellate living in ponds and lakes. It uses gravity and light as hints to reach and stay in regions of the water column optimal for photosynthesis and growth. At low light irradiances, *Euglena* swims toward and at higher irradiances cells swim away from a light source (positive and negative phototaxis). In addition, *Euglena* typically orients away from the center of acceleration (negative gravitaxis). *Euglena* is considered a 'professional gravi-sensing organism,' a term that was coined by ESA (European Space Agency). In the past 15 years, *Euglena* has been established as a model organism for studying gravity perception of single cells. A model for gravitaxis was created by the combination of physiological, biochemical, and molecular biological methods. In this context substantial contributions came from microgravity experiments in space.

**Task Progress:**

At 19:34 CET on 3 December 2018, the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) Eu:CROPIS mission was launched into space from Vandenberg Air Force Base in California. A Falcon 9 from the US aerospace company SpaceX carried two biological life support systems comprising greenhouses, dwarf tomato seeds, single-celled algae, and synthetic urine on a satellite up to a near-Earth orbit at an altitude of 600 kilometres. The aim is for the seeds to germinate in space and continue to grow due to the successful conversion of urine into a fertiliser solution. The mission is intended to show how biological life support systems can be used to supply food on long-term missions. The Eu:CROPIS satellite, which is approximately one cubic metre in size and weighs 230 kilograms with its biological payload, was designed and built by DLR and the Friedrich Alexander University (FAU) in Erlangen-Nuremberg.

The satellite was successfully placed in orbit at an altitude of 600 kilometres. First radio contact with the satellite to the German Space Operations Center (GSOC) in Oberpfaffenhofen took place about one hour and 15 minutes after the launch. Two weeks after launch the SOC commissioned the satellite in space and tested all functions. Seven weeks after launch, the first of two greenhouses was scheduled to go into operation. However, a software malfunction occurred and communication with the payload was lost. Since then diagnostic tests were made from the ground to the satellite and on the ground using the ground simulation facility. The ground control is working perfectly. During the week of October 23rd 2019 new software will be uploaded and the mission restarted soon thereafter.

Bibliography Type:	Description: (Last Updated: 02/22/2023)
Abstracts for Journals and Proceedings	Mancinelli RL, Cortesao M, Mowller R. "Microbes in Space: An overview." Presented at the International Symposium on Fungi/Microbes Under Stress, San José de Los Campos, Brazil, May 18-26, 2019. Abstract book. International Symposium on Fungi/Microbes Under Stress, San José de Los Campos, Brazil, May 18-26, 2019. , May-2019