

<b>Fiscal Year:</b>	FY 2020	<b>Task Last Updated:</b>	FY 05/29/2020
<b>PI Name:</b>	Kaplan, David L. Ph.D.		
<b>Project Title:</b>	Silk Composite Biomaterials for Shielding Medications in Space		
<b>Division Name:</b>	Human Research		
<b>Program/Discipline:</b>			
<b>Program/Discipline--Element/Subdiscipline:</b>	TRISH--TRISH		
<b>Joint Agency Name:</b>		<b>TechPort:</b>	Yes
<b>Human Research Program Elements:</b>	None		
<b>Human Research Program Risks:</b>	None		
<b>Space Biology Element:</b>	None		
<b>Space Biology Cross-Element Discipline:</b>	None		
<b>Space Biology Special Category:</b>	None		
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<b>Zip Code:</b>	02155	<b>Congressional District:</b>	5
<b>Comments:</b>			
<b>Project Type:</b>	Ground	<b>Solicitation / Funding Source:</b>	2018 TRA BRASH1801: Translational Research Institute for Space Health (TRISH) Biomedical Research Advances for Space Health
<b>Start Date:</b>	01/01/2019	<b>End Date:</b>	12/31/2020
<b>No. of Post Docs:</b>	1	<b>No. of PhD Degrees:</b>	0
<b>No. of PhD Candidates:</b>	1	<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>	TRISH
<b>Contact Monitor:</b>	<b>Contact Phone:</b>		
<b>Contact Email:</b>			
<b>Flight Program:</b>			
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<b>COI Name (Institution):</b>	Kluge, Jonathan Ph.D. ( Vaxess Technologies )		
<b>Grant/Contract No.:</b>	NNX16AO69A-T0411		
<b>Performance Goal No.:</b>			
<b>Performance Goal Text:</b>			

<b>Task Description:</b>	<p>The goal is to utilize silk protein, an US Food and Drug Administration (FDA) approved protein biomaterial, in composite material formats, to shield and protect a range of medications -- addressing topic #5 in Biomedical Research Advances for Space Health (BRASH) 1801 - New materials for shielding medications. We will utilize novel formulations of the silk protein in composite formats with inorganic particles, as both pouch and as part of the material, to demonstrate broad protection of a range of drugs during exposure to environmental extremes using accelerated testing, mechanistic insights and modeling, and functional assessments. The outcome will be new composite material systems that provide broad-ranged protection, a preliminary model for predictive outcomes, and publications.</p>
<b>Rationale for HRP Directed Research:</b>	
<b>Research Impact/Earth Benefits:</b>	<p>Silk and the additives have potential to provide protection for medications against environmental stresses, such as elevated temperature and radiation. Such protection would ensure that medications retain bioactivity and are safe to use by the space crew during long duration mission missions. Silk also provides a versatile material that can be morphed into useful applications (e.g., other material formats) for space missions, while also serving as a backup protein source if needed.</p>
<b>Task Progress:</b>	<p>[Ed. note May 2020: Report submitted by TRISH to Task Book in March 2020; covers reporting as of November 2019.]</p> <p>The medications needed to keep a crew healthy during a deep space exploration missions must remain effective while enduring more than a year in deep space, which includes exposure to space radiation. Medications must be stored in containers that are resilient to such conditions, which is the goal of our project. The objective is to utilize silk protein composite materials to protect these compounds. Silk protein is a biomaterial that has previously been approved by the US Food and Drug Administration for various medical products. In the study for NASA, formulations including silk proteins will be used with inorganic particles and additives to shield a variety of drugs from exposure to environmental extremes. The protective ability of the materials and mechanisms underlying this protection will be explored and optimized through a combination of experimental testing and molecular modeling. The specific objectives are: 1. Preparation and Characterization of Protective Silk-Based Composite Materials; 2. Assessment of Stability of Medications in the Protective Materials; 3. Mechanisms of Stabilization Past Work Related to the Project.</p> <p>Previously, silk materials have been shown to be effective at stabilizing a number of drugs and complex antibodies, as well as providing protective functions for otherwise labile biological materials (e.g., foods). Further, in neat forms and as silica composites, silk films were flown for 18 months on the International Space Station (MISSE-6) to assess the impact of space radiation on structure and function. Of the material formulations tested, it was observed that silk composites (silk-silica) remained mainly intact in morphology and size. Based on these finding, we are working on the design of formulations including silk proteins with inorganic particles to shield a variety of drugs from exposure to environmental extremes.</p> <p>Experimental Approaches -- We designed two different silk formulations for our experiments; the first being silk films with medications embedded inside the films, while in the second format, the medication is loaded as powder or tablet inside silk pouches. The films and pouches were subjected to incubation at elevated temperature and humidity as accelerated aging experimental conditions (e.g., 40oC and 75% relative humidity). High Pressure Liquid Chromatography (HPLC) is being used to quantify the recovery and to analyze the stability of the medications being studied, while several other instrumental analyses such as Fourier Transform Infrared Spectroscopy (FTIR) and Scanning Electron Microscopy (SEM) are used to evaluate changes in the silk structure and morphology, respectively. Films are being modified with the addition of inorganic or organic compounds to further enhance their protective properties, such as to increase mechanical toughness and free radical scavenging capabilities. Examples of drugs being used initially include ciprofloxacin, tetracycline, and ampicillin. Other drugs known to be susceptible to space radiation, such as clavulanate and levothyroxine, will be included after designing suitable silk formulations. The type of radiation that will be initially tested includes gamma rays and X-rays, while we will also subject the samples and the drugs to different ions and energy at the Brookhaven National Lab to simulate Galactic Cosmic Radiation, more relevant to deep space radiations.</p> <p>Modeling Approaches -- Density Functional Theory (DFT) calculations of commonly-used drug molecules, the amino acids and sequences in silk with different lengths are being performed. We used the energy and electron density obtained from the DFT results to calculate conceptual DFT reactivity descriptors, which allow us to evaluate the tendency of each molecule to transfer electrons and to identify the locations of reactive sites in the chemical structures.</p> <p>Next Steps -- For the next year, we will with the two device designs, films and pockets, focusing on improvements in production efficiency, mass balance assessments, and additions of inorganic particles such as silica and antioxidants such as Vitamin C and Trolox to enhance protective capabilities. We plan to irradiate samples with gamma rays, x-rays, and heavy ions to simulate Galactic Cosmic Radiations (GCR). All-atom and/or coarse-grained molecular dynamics simulations will be used to investigate the mechanisms of radiation effects on the silk films at the molecular level.</p>
<b>Bibliography Type:</b>	Description: (Last Updated: 02/01/2019)