MOUNTAINEERING; AN ANALOG FOR HUMAN SPACE TRAINING. Scott Matthew Balcao, United States Air Force, University of North Dakota (smbalcao@gmail.com).

Abstract: Astronauts use many analog missions to simulate, train for space exploration, and gather results regarding human factors in a controlled environment. The Human Exploration Research Analog (HERA) at Johnson Space Center is a unique three-story habitat designed to serve as an analog for isolation, confinement, and remote conditions. The Human Exploration Spacecraft Tested for Integration and Advancement (HESTIA) is being developed as a high-fidelity, human-in-the-loop, Lunar/Mars surface analog in support for next generation human exploration missions. NASA's Extreme Environment Mission Operations (NEEMO) is an underwater habitat that sends groups of astronauts, engineers, and scientists for up to three weeks at a time to allow trainees to experience some of the same challenges that they would on a distant asteroid, planet, or a moon. BIOS 1, 2, 3 tests the efficiency of a closed recycle system. The MARS 500 simulated a Martian mission by confining participants to severe habitats that simulated Mars' atmosphere and surface. There are many more analog missions that astronaut trainees use to experience and simulate the harsh environment of space. I believe mountaineering is another analog that would be beneficial as it is an extreme environment that stresses the human body both physically and mentally.

RADIATION EFFECST ON PLANTS IN LONG-DURATION SPACE FLIGHT. Scott Matthew Balcao, United States Air Force, University of North Dakota (smbalcao@gmail.com).

Abstract: Plants are quite persistent and can grow in less than optimum conditions. One external environment that has a profound impact on a plant's life cycle is radiation. Radiation can either improve or hinder a plant's ability to flourish. From the research gathered it has been concluded that plant's ability to tolerate radiation and still grow is determined by four conditions: (1) When in the plant's life cycle the radiation is emitted, (2) The duration of the exposure, (3) the type of radiation being emitted, (4) The type of plant that is being exposed to the radiation. Under the right conditions plants could grow faster, yield more, and create a newer generation of radiation resistant plants.

EPIGENETICS AND HUMAN SPACEFLIGHT PHYSIOLOGY. Lindsey Berger, University of North Dakota (lindsey.d.berger@und.edu).

Abstract: Space travel is taxing on the human body. Physiological changes are noted in every body system and can arise quickly. New studies are revealing that these changes go down to the molecular level and affect the DNA of astronauts. Epigenetics is the study of changes in gene expression, or the "on" or "off" switches in our genetic code that control physiological responses. A prominent study in the emerging field of space epigenetics is the twin study, which placed one twin in space for a long duration mission of one year. The results showed changes in the epigenetic responses of the immune system during long duration spaceflight. These changes, combined with other stressors (such as radiation, workload, and microgravity), can and will have consequences on the health of future astronauts. For future long duration spaceflight, methods to examine on-going epigenetic changes as the crew travels will be needed. This poster presentation aims to give an analysis of known effects of epigenetic changes on the immune and nervous systems, along with study methodology.

Keywords: epigenetics, spaceflight, physiology

Dinoflagellates (Bioluminescent Phytoplankton): A Study of Enzyme Kinetics in Microgravity.

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Biochemical pathways evolved under Earth gravity conditions. A growing number of studies are revealing how changes at the cellular level occur in response to the microgravity environment. However, a comprehensive understanding of these changes and their effects remain a long way off and detailed study on how the microgravity environment affects enzyme kinetics remains largely undetermined. Some longer duration studies have revealed upregulation of proteins and even production of enzymes that were never demonstrated to be present in the proteome of the model organism on Earth. Other studies have shown that protein conformations can alter in microgravity. Understanding these cellular shifts and their physiological effects on organism health and viability is crucial to transitioning from short duration to long duration spaceflight missions.

The objective of this study is to clarify how microgravity influences biochemical processes by investigating the alteration of the luciferin-luciferase bioluminescent pathway of the Dinoflagellate species *Pyrocystis fusiformis*. Dinoflagellates are non-motile, photosynthetic microorganisms which live in marine environments and produce bioluminescence.

Here, we investigate enzyme kinetics of the bioluminescent pathway in Dinoflagellates. The Dinoflagellates are stimulated to trigger their bioluminescent pathway involving their luciferin-luciferase reaction during a microgravity flight. The intensity and wavelength of the light is measured and compared to a ground control. Bioluminescence was chosen for this study both to elucidate enzymatic pathway changes during microgravity exposure and as it pertains to a growing number of fields including biomedical, biotechnical, and spaceflight applications.

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SLS AND FH PROGRAM MANAGEMENT COMPARISON
Lisa Brake
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Abstract

Did the entrepreneurial culture of SpaceX enable the earlier success of the Falcon Heavy over an arguably more risk-averse government culture present in the NASA Space Launch System (SLS) program? Although Falcon Heavy and SLS will provide similar heavy lift capabilities, there is a noticeable difference between the implementation of Falcon Heavy and the implementation of SLS, which has not yet been achieved. To resolve the question of why the two similar programs are working under such different timelines, this research effort compares the program management schemes of NASA's SLS and SpaceX's Falcon Heavy vehicle. Several assumptions are considered during this study: (1) that there is enough similarity between SLS and Falcon Heavy to make a feasible program management comparison; (2) that NASA, as a government entity, is not driven by profit but SpaceX, as a private organization, is focused on profit; and (3) that NASA, as a government entity, may be more constrained by political and funding pressures than SpaceX. Peer reviewed articles are analyzed to include topics such as: the history of risk aversion at NASA (very extensive history) and of SpaceX (questionable history of risk aversion); and the goals of each organization (NASA may be more science-oriented, while SpaceX could be more focused on profit). In order to ensure a thorough analysis, SpaceX and NASA are compared against the criteria for mechanistic and organic organizations as described by Burns and Stalker (1961). These criteria, considered along with the results of Thematic Content Analysis conducted on SpaceX and NASA leadership, are intended to illuminate the differences between SpaceX and NASA that allowed SpaceX to launch its Falcon Heavy vehicle first.

LIPID DECONTAMINATION PROCEDURES FOR LIFE DETECTION MISSIONS

D. K. Buckner, University of North Dakota, Department of Space Studies

Introduction: Molecular biosignatures are key targets for current, proposed, and future life detection missions. With the high accuracy and low limit of detection (LOD) that new and future instruments require (e.g., <ppb range), decontamination of life detection hardware (especially instruments that handle or process sample) is necessary to prevent false positives for in situ life detection missions.

Fatty acids, a class of lipid ubiquitous in the cell membranes of all terrestrial life as we know it, are a primary molecular target for astrobiology missions. Fatty acids (and other lipids) are of interest because of this biological ubiquity, ability to form through both biotic and abiotic processes, and ability to persist unaltered in the geologic record for millions of years (compared to other biomolecules, which degrade in <thousands of years). Fatty acids have been found in meteoritic material, suggesting they may be common on planetary bodies, including ones that could support life (i.e. Mars, Enceladus, Europa, etc). For these reasons, it is expected that fatty acids could be a key molecular component of extraterrestrial life.

Traditional methods of decontamination for life detection instruments (i.e., cleanroom cleaning techniques and NASA-approved methods for Planetary Protection (PP) compliance, including dry heat microbial reduction [dhmr] and vapor phase hydrogen peroxide treatment [vph]) primarily clean hardware by removing/flushing contaminants off instrument surfaces. However, while these methods are effective at removing the bulk of viable microbes, research suggests these techniques are ineffective at removing dead cells, thus unable to reduce lipid contamination to the ~ppb level required by ultra-sensitive life detection instruments. Laboratory standard cleaning methods are highly effective at removing fatty acid contamination, but impractical for instrument decontamination, as they utilize high temperatures and/or chlorinated solvents that are often incompatible with sensitive instrument materials. To accommodate these materials while reducing contamination to ultra-low levels, a new solution is needed.

Knowledge Gap

There is a knowledge gap in quantifying the effects of decontamination techniques (both traditional and new/non-traditional) on lipid contamination. Newly developed cleaning techniques, such as electron beam irradiation (EBI), show promise for reducing lipid contamination below the ~ppb level mandated by new analytical instrumentation, but additional testing is required to assess EBI decontamination effects on lipid molecules. EBI is especially attractive because it breaks the bonds of molecular contaminants present, as opposed to wiping or flushing contaminants away. Further, though EBI can destroy some organic molecules and biomolecules, it can be applied to many of the synthetic materials used to construct life detection instruments (i.e. polymers, epoxies, electronics, etc) without destroying or seriously degrading those materials. This provides potential application for efficient whole-instrument decontamination following fabrication.

Proposed Solution

To explore solutions for lipid decontamination, I propose to study techniques that decontaminate by destroying contaminants through molecular bond breaks. I will study both traditional/PP approved and non-traditional/recently developed decontamination techniques for application to life detection instruments, measuring effects on lipid molecules. I hypothesize traditional techniques will be either 1. ineffective at reducing lipid contamination to meet LOD limits, and/or 2. incompatible with instrument hardware. After assessing percent reduction in lipid contamination following traditional treatment, I will explore EBI for 1. ability to eliminate lipid contamination, and 2. material compatibility with instrument components. I hypothesize that EBI will be 1. highly effective at reducing lipid contamination, and 2. compatible with instrument materials, thus a viable decontamination method for application to life detection missions.

An Overview of Sleep Deprivation and its Relationship to Mental Performance. Clift, Joseph[1], [1]University of North Dakota.

Introduction: The environment encountered by astronauts and cosmonauts poses unique challenges to human health. Sleep deprivation has been a problem for the proper execution of space and terrestrial operations. This research discusses the work done on predicting the effects of sleep deprivation on mental performance based on length of sleep deprivation and mental acuity exercise baselines.

CLASSIFICATION OF A CHONDRITIC METEORITE FOUND NEAR COLGATE, NORTH DAKOTA.

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Introduction: Meteorites are classified by multiple criteria including; chemistry, mineral structure and mineral abundance. The meteorite studied was found in 1999 in Colgate, ND during a home construction. The main mass of the meteorite weighs 39 Kg making it the largest yet found within North Dakota. The meteorite is a chondritic stone, which is the most common type of meteorite making up 86% of falls [1]. This study determined the class, clan, and the petrological type, which measures the aqueous alteration or metamorphism experienced by the meteorite.

Methods: Whole rock geochemical analysis of the meteorite was determined by X-ray Fluorescence, and X-ray Diffraction. The chemical composition of individual mineral grains was determined with a scanning electron microscope and energy dispersive x-ray spectroscopy. The petrologic structure and optical properties were determined with a polarizing microscope using three thin sections. All equipment used is located either at Leonard Hall, or Upson Bld. 1 at The University of North Dakota.

Results: The meteorite has a SiO2/MgO ratio of 1.5, a FeO/SiO2 ratio of 0.71, and a Fe(metallic)/FeO ratio of 0.72. Total metallic Fe is 19.8%, and the olivine Fa (fayalite) composition is 20.27 mol%. The meteorite has good olivine grain homogeneity with less than 5% average deviation. The meteorite's matrix contains crystalline properties with mostly well segregated chondrules with an average diameter of 0.3mm, and a little igneous glass. With these measurements the meteorite was determined to be H clan meteorite within the ordinary chondrite class, and a petrologic type of 4. Commonly expressed as an H4 Chondrite. Currently the classification is under review by the meteoritical bulletin, and the Colgate Meteorite should be officially added to the bulletin in the coming months.

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Acknowledgments: I'd like to give a huge thank you the Erickson family, for first bring in the meteorite to UND, and later generously allowing me to cut a sample from the meteorite and providing great descriptions of the discovery of the meteorite. I'd also like to thank my academic advisor Dr. Nels Forsman for giving me the opportunity to classify the meteorite and always being available for discussion and guidance at any time of the day. Dr. Xiaodong Hou, Dr. Michael Spilde, and Dr. Mike Gaffey all provided helpful advice and training both with the technical equipment and understanding the geochemistry. Finally, I'd like to thank Darin Buri for all his help and expertise with the rock cutting equipment and remembering to take photos during the process.

PILOT-SCALE DESIGN OF A LUNAR ILMENITE BENFICIATION PLANT. P. Henson, University of North Dakota (UND), Space Studies Department, Clifford Hall Room 512, 4149 University Ave Stop 9008, Grand Forks, ND, 58202, peter.henson@ndus.edu

Introduction: As we settle on the Moon, it would be ideal if we could live the off land, using in-situ resource utilization (ISRU). Since launch costs are substantially dependent on payload mass, any payload mass we can avoid launching from Earth will save us in orders of magnitude on costs at the launchpad and will also reduce launch risk. This research is focused particularly on ISRU at the lunar surface. A suite of the Moon's ISRU chemical processes available is reported, and a deeper investigation into lunar mineral beneficiation is studied.

We now understand the Moon offers resources to support the major life support commodities. Lunar scientists have characterized the basalts, anorthites, and other minerals that make up the lunar surface. Likewise, a prestigious community of researchers has also demonstrated processing techniques for the extraction of oxygen, hydrogen, He^3, and metals from lunar materials.

However, pilot-scale development and demonstration programs of these processes have been limited by a combination of lack of national commitment to lunar development and a lack of large quantities of feedstock materials.

The mineral ilmenite has been found to be a valuable mineral for its chemistry; including iron, titanium, and oxygen. For optimized efficiency, ilmenite should be separated from the gangue, or waste material, of the bulk lunar regolith. This research proposes a prototype beneficiation plant for the separation of the mineral ilmenite from a lunar regolith simulant by a means of electrostatic separation, using parallel plate electrodes.

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Rover Localization and Analog Astronaut Detection Using Machine Vision

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Abstract — Human robotic teams in space exploration are becoming ever prevalent. Autonomous robotics can prove beneficial during human spaceflight and crewed planetary missions by offsetting task loads. A platform to aid in technology development regarding human-robotic interactions can be found through current crewed mockups and analog habitat mission studies. In this study the test bed of an Inflatable Lunar/Mars Analog Habitat (ILMAH) is utilized to develop and test an object detection machine vision algorithm for analog astronaut identification and rover localization using horizon features.

By applying Speed Up Robust Features (SURF) techniques for feature extraction in tandem to camera triangulation, accurate descriptions of an analog space suit, fiducial markers and the horizon have been identified. Through the use of SURF features and Random Sample Consensus (RANSAC), image stitching techniques were created to generate a 180° panoramic image of the analog habitat environment. Correlation of feature matching and object detection allowed for successful identification of an analog astronaut within the panoramic view of the habitat. A zero-horizon line was detected within the panorama allowing interpolation between the matched horizon pixel position. A corresponding pixel position value of the detected analog astronaut is quantified within the environment correlated to the 0 to 180° view. This angle will be used in future studies for autonomous rover movement.

Potential of Short-Arm Human Centrifuge for Mitigating Spaceflight induced Cardiovascular Deconditioning.

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Performance of the human physiological system, on a day-to-day basis, is dependent on gravity. The absence of gravity, such as during long-duration spaceflight, causes a series of physiological changes (spaceflight adaptation). Change in posture from supine to standing challenges blood pressure homeostasis due to the gravity-induced displacement of blood volume away from the heart. However, via a series of reflex mechanisms, of which cardiovascular system is a key component, blood pressure is regulated. The cardiovascular adaptation to microgravity has a detrimental effect on blood pressure regulatory mechanisms. Accordingly, astronauts find maintaining blood pressure quiet challenging during upright stance on return to earth, which adversely affects their mobility. The success of future interplanetary missions is contingent on our ability design pertinent countermeasures to mitigate cardiovascular deconditioning to ascertain healthy life for astronauts on return to Earth. In this regards, short-arm human centrifuge (SAHC) can be promising given its capability to create artificial gravity and compact design which makes its application feasible during long-duration space flight. We compared the regulation of blood pressure during standing and artificial gravity (1-g and 2-g) created via short-arm human centrifuge. From 13 healthy participants continuous blood pressure was recorded, from which beat-by-beat heart rate and systolic blood pressure were derived. The statistical analysis highlighted that blood pressure regulatory mechanisms during standing was similar to 2-g created via SAHC. The findings of the study underscored the potential of SAHC towards mitigating the adverse effects of microgravity on cardiovascular performance.

Electrodynamic Dust Shield Performance on Highly-Convex Surfaces. T. I. Wang, University of North Dakota (taren.wang@ndus.edu)

Abstract: Lunar regolith is an important target for in-situ resource utilization, potentially providing future space missions with propellant, life support consumables, and building material. However, excavating and working with lunar dust presents several challenges. First, the regolith is extremely abrasive and adhesive: it clings to every exposed surface, obscures lenses and solar panels, impairs thermal control, and wears down moving parts. [1] Second, the lesser gravity of the lunar surface reduces the effectiveness of terrestrial-style excavators, which use their weight to penetrate soil. [2]

The electrodynamic dust shield (EDS) was developed to clean regolith off a spacecraft via an array of wire electrodes embedded in the craft's surface and charged in sequence, causing dust particles to be lifted and carried away. [3] This technology potentially allows a novel method of regolith excavation: a rolling robot with no external moving parts that collects regolith passively by adhesion, and deposits its cargo by cleaning itself via EDS. The amount of dust collected would be proportional to the excavator's surface area. In the interests of efficiency, it should have a surface area-to-mass ratio as high as possible. This can be accomplished by two methods: by making it as small as possible, and by covering it in finger-like structures.

Thus far, EDS has been tested extensively on a wide variety of surfaces, including flexible fabric. [4] However, no literature was found on the effectiveness of EDS when applied to highly-convex shapes, such as the previously-mentioned fingers. The purpose of this project is to fill this research gap and determine what variables affect EDS performance on such shapes, with the intention of eventually developing a prototype electrodynamic excavator.

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