Comparison of the Growth Rate & DNA/RNA Quantitation of Microgravity Exposed Microbial Community Samples Collected by the Astronauts Onboard the International Space Station And by Citizen Scientists & Student Scientists at Public Venues

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By

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ABSTRACT

This study has two components. First, it will compare the growth rates of microbes isolated from samples collected from high-touch surfaces at ground-based public venues before and after exposure to the microgravity environment of the International Space Station (ISS). Second, this study will characterize the microbial communities found on surfaces aboard ISS using culture-independent methods. The Molecular Devices Spectra Max M5e Microplate Reader, which is part of the NanoRacks experimental equipment suite available onboard the ISS, will be used to conduct these studies. Additionally, samples from analogous high-touch surfaces within the ISS will be returned to Earth for DNA sequencing and analysis of their growth in the laboratory of Dr. Jonathan Eisen at the University of California Davis (UC Davis).

Data for the ground-based component of this experiment will be collected by citizen and student scientists as a component of ongoing research in the microbiology of the built environment, as well as citizen scientist engagement projects, conducted at UC Davis. The experiment will also be a part ongoing citizen science and Science Technology Engineering & Math (STEM) education programs facilitated and conducted by SciStarter.com, ScienceCheerleader.com, and their affiliated partners. Participation in the experiment by citizen and student scientists will include basic educational information on microbial communities, microbiology of the build environment research, and the ISS itself. It is anticipated that a significant level of citizen and student scientists engagement will occur, thus promoting greater awareness of microbial community science, the science experiments and operations onboard the ISS, and all partnering organizations affiliated with the experiment.

KEY WORDS

Microbial communities, Microbiology of the Built Environment, DNA, Microgravity, International Space Station (ISS), NanoRacks, Microplate Reader, Science Technology Engineering and Math (STEM), Citizen Science, Citizen Scientists, Student Scientists

INTRODUCTION

This study is an extension of research on the microbial ecology of the built environment currently underway at the University of California, Davis (UC Davis), under the direction of Dr. Jonathan Eisen. Dr. Eisen's research focuses on the ecology and evolution of microbial communities, including natural communities in extreme environments, communities found in and on plants and animals (so called microbiomes) and communities found in the human built environment (e.g., buildings, cars, planes).

The study is significant both in the nature of the investigation, the protocols to be used, and the engagement of citizen and student scientists in the execution of the experiment.

The participation of citizen and student scientists is an important goal of this proposal, and has been a long-term goal of our experiment team:

- Our principle investigator, Dr. Jonathan Eisen, is a noted leader both in microbial diversity research and in outreach and engagement of citizen science in microbiology, microbial ecology, community outreach, and public engagement activities relating to the microbiology of the built environment. Community outreach related to the microbiology of the built environment in Dr. Eisen's laboratory is supported by the Alfred P. Sloan Foundation.

- Darlene Cavalier is founder of SciStarter.com, an organization with the mission of engaging citizen scientists in assisting professional scientists from many disciplines with their professional research projects. Ms. Cavalier also founded ScienceCheerleader.com, which aims to promote science, technology, engineering, and mathematics (STEM) education, with a focus on inspiring young women to pursue STEM subject matter and STEM careers. The activities of ScienceCheerleader.com are executed by a volunteer network of STEM professionals with degrees and professional experience in fields across the STEM spectrum, who are also current and former professional cheerleaders.

- Mark Severance, formerly of the NASA Office of Education, is the founding manager of the International Space Station (ISS) National Lab Education Project which engages students in a variety of ISS-based experiments and ISS-related educational activities.

The collection of samples from high-touch surfaces at public venues lends itself to the participation of citizen and student scientists in the collection of these samples. The engagement of citizen scientists is an aim of the microbial research conducted by Dr. Eisen's laboratory.

Leveraging the help of citizen scientists for the collection of samples is an important strategy for maximizing the scientific yield of this experiment. By recruiting a larger number of participants, a larger number of samples will be collected from a broader variety of locations. This will increase the statistical power of the experiment. Additionally, a citizen science approach maximizes the diversity of scientific

perspectives involved in the choice of samples. The different backgrounds, experiences, and opinions of the participants result in a purely additive contribution to the research.

Nevertheless, the citizen science approach used in this experiment is not simply a means to "increase the ***n***" of the data set. The approach also serves important pedagogical and social goals.

The educational benefits of participation in this experiment are considerable. It will foster awareness of microbiology and microbial ecology and promote understanding of scientific research methods and the science experiments which can be conducted in the microgravity environment of the ISS. It will also provide a window into the life and work of the ISS crew, the mission capabilities of the station, and the capabilities of the vehicles that service the station.

Beyond the educational benefits, involvement in this experiment will expose participants to the culture and practice of science itself. Participants will be interacting with researchers in as colleagues, not merely as consumers or observers. We believe that this will help the participants, as well as their friends and families, develop a more active relationship with science as a human, social, and *participatory* undertaking.

Because this experiment blends elements from biology, ecology, engineering, space science, mission planning, and experimental analysis, participating students will encounter a "STEM rich environment" that will be of an extraordinarily unique nature. It is difficult to emphasize enough the impact that this kind of opportunity can have on a person's life, or on the perspectives and beliefs they espouse and choices they make in subsequent years.

SPECIFIC AIMS

Specific Aim 1: *Determine the effects of microgravity on the genotype and growth rate of Earth-collected microbe samples*

Our experimental team plans to use the venues of professional and youth sporting events, as well as homes and school classrooms, for the collection of samples of microbial populations. Such sampling leverages the considerable experience of Dr. Eisen's laboratory in the collection and analysis of samples from the built environment.

Conceptually, citizen and student scientists in attendance at youth or professional football or basketball games would be provided swab sample kits, and at a designated time, asked to sample high-touch or high-microbial activity surfaces of interest. Candidate surfaces include: the front (microphone side) and back (hand side) of cell phones, arm rest or handrails in public seating areas, return air circulation vents, screens or air filters in arenas or classrooms, laptop keyboards in the press box, scorekeepers areas, classroom, or field houses. These collected swabs would be deposited at a central location at the venue and shipped to Dr. Eisen's laboratory at UC Davis where their initial characterization would be performed. After isolation of different

types of microbes within the samples, a subset will be designated for flight to the ISS for subsequent examination after exposure to microgravity.

The number of samples collected at a specific venue and the number and type of venues selected are still to be determined. This number will be based in part on the "throughput capability" and ability of Dr. Eisen's laboratory to perform the characterization, as well as the cost of processing the samples. The resulting sample collection quantity will be statistically significant for all venues and sample types.

Specific Aim 2: *Collect and examine microbial populations found on high-touch surfaces within the ISS*

High-touch surfaces analogous to those sampled in Specific Aim 1 will be sampled by the ISS Astronauts and returned to Earth. The collection and analysis of these samples will be done using identical protocols to those used for Specific Aim 1. This will facilitate the development of analogs between the Earth-based microbiology of the built environment and the microbiology of the built environment of long-duration spaceflight crafts. In addition, this will enable what is believed to be the first use of cutting-edge high-throughput DNA sequencing technology to characterize microbial communities on the ISS.

Specific Aim 3: *Engage citizen and student scientists in this study*

The public participation aspect of this experiment is not merely a means to assemble a large and interesting collection of samples. Our experiment will begin with a prescribed methodology for obtaining the swab samples, and will encompass the full experiment protocol, fundamentals of microbial diversity science as well as educational information on the ISS mission and its use as a U.S. National Laboratory for scientific research. Participants will remain involved in the research after their samples have been delivered to the laboratory, and will see the actual results from their own samples and the methods used to obtain them.

To achieve this aim, the existing partnerships of SciStarter.com and ScienceCheerleader.com will enable this public participation in sample collection, as well as the overall promotion of the experiment. ScienceCheerleader.com has partnered with Pop Warner Little Scholars Inc. to provide STEM educational opportunities through Pop Warner's national youth football and cheerleading programs. ScienceCheerleader.com is scheduled to conduct a nation-wide major STEM engagement initiative at the start of Pop Warner's 2013 season in August. The collection of samples for our proposed study would be ideally suited for this national activity.

ScienceCheerleader.com is also well connected with the National Football League (NFL) and National Basketball Association (NBA). The majority of the Science Cheerleaders are current or former NFL and NBA cheerleaders and their participation in the STEM promotion efforts of ScienceCheerleader.com has been very well received by both leagues and the cheerleaders' respective teams. Previously,

ScienceCheerleader.com co-produced a STEM-oriented educational video series entitled “The Science of NFL Football” with the NFL and NBC Sports. The coordination and scheduling to engage the citizen and student scientist for sample collection at NFL or NBA game venues would begin immediately upon our selection for flight. Samples collection at NFL and/or NBA games could be accomplished early in these leagues’ seasons, in order to process the samples for an October 2013 launch to ISS.

The use of multiple sports venues affords a unique, if not humorous, approach to the microbial diversity characterization: a “microbe playoff” concept. The growth rates and characterization of microbes from different cities, teams, leagues or schools could be seen to be “in competition” with each other based on their ability to hit certain prescribed result markers both onboard the ISS and on the ground. This would be a fun way to keep the interest in the experiment up throughout its duration. The portrayal of results in a competitive manner originating from professional and youth sports venues will undoubtedly enhance the interest of the general public in the experiment, the ISS mission, and the sponsoring organizations.

The SciStarter.com partnership with the National Science Teachers’ Association (NSTA) will also be leveraged to provide awareness of, and engagement in, the experiment by science teachers nation-wide. Ms. Cavalier’s currently scheduled speaking engagement at the NSTA National Conference in April 2013 will provide an excellent venue to introduce the experiment to middle school and high school science teachers from around the country. The SciStarter.com and SciCheerleader.com partnership with Discover magazine will enable promotion of the experiment, while spotlighting ISS and the sponsoring organizations. Discover can also facilitate a wide public dissemination of the experimental results through their on-line and magazine publications.

In addition to implementing the above concepts in conjunction with our partners, SciStarter.com and ScienceCheerleader.com are planning the following activities to engage citizen and student scientists and the general public:

- Create a special content section on our sites, comprising a dedicated landing page and secondary pages, as well as links and connections into existing areas of both sites
    - These sections will have multiple purposes: to promote microbe-related citizen science activities; to highlight the specific activities of this ISS initiative; and to enable participants to upload data and view results (Earth-based and aboard the ISS)
    - We will incorporate http://www.microbe.net/citizen-science-sampling-protocols/ messaging and context, as well as promotion for partner organizations’ events and activities, into all content
    - This content area will live on as a permanent part of SciStarter.com and would form the basis for an ongoing citizen science community around microbe matters
    - Profiles of select participants (teachers, “average” citizens, etc.)

- Provide Science Cheerleaders' expertise and promotional power to represent and promote the project at events associated with the initiative and other events

- Work with Science Cheerleaders and our partners to promote the initiative and recruit participants and distribute kits

- Promote the experiment through our social media channels and on the home page of SciStarter.com

- Create and print "take home" materials to share at events

- Syndicate all content to all partners, through feeds, widgets, or links

- At the conclusion of the experiment, make available to UC Davis all relevant blog posts, as well as measurements of user participation and site traffic

SIGNIFICANCE

Perhaps the best metric for determining the significance of our experiment would be to examine it in the context of the published judges' criteria. We address our ability to meet each criterion in the paragraphs below.

a. That the Proposal offers a reasonable return on investment and that is has clear viability and application for commercial research

Our proposal offers a reasonable return on investment given its ability to provide an unprecedented characterization of the microbes onboard the ISS through cutting-edge, ultra high-throughput DNA sequencing, while using a similar characterization of the microbial environment in public spaces as a ground based analog. These results could have commercial implications for the products and techniques used in the management of both types of environments. On the ground-based building side, the experiment will provide a DNA based characterization of the microbial environment of high touch/high microbial activity surfaces which would be applicable to optimizing techniques and products to control that environment. On the space side, such data may have applicability to the levels of cleanliness required to limit the introduction of microbes onto spacecraft surfaces, spacecraft cargo, and payloads prior to launch, in addition to providing insight into new techniques or products which may control microbes within the existing orbital spacecraft environment.

b. That the research detailed in the Proposal proposes benefits mankind if and when it is successfully developed and implemented

A general benefit to mankind is provided through the further understanding of the microbial environments within built spaces occupied by humans, by examining that environment at the DNA level. At the core of the study is the engagement of citizen

scientists and student scientists directly in this research. This will promote a greater understanding and appreciation of microbial diversity science. More expansively, it provides a highly visible means by which citizens and students can participate in scientific research, thereby promoting greater involvement in science by the general public and further promoting STEM subject matter among students.

c. That the Proposal is a viable and logistical proposal of research that will neither impede nor endanger the mission to/or onboard the ISS

By vetting our concept at the tactical level with the NanoRacks, and leveraging the expertise of Dr. Eisen and his laboratory team, we can affirm the logistic feasibility of all aspects of the experiment. All proposed use of the ISS Program resources have been confirmed to be reasonable and within scope. All support provided by UC Davis will be directed by Dr. Eisen to ensure that the scale of that support preserves the experiment's ability to provide verifiable, quality results. Dr. Eisen's team will ensure that no toxins or biohazards will be introduced into the ISS environment through their isolation of the microbial communities to be flown. Similarly, they will ensure that no toxins or biohazards will be present in the selected surface swab kits to be flown to ISS.

d. That the Proposal may offer technical opportunities and benefits for future space travel, aerospace research and the survival of astronauts travelling far from Earth

The experiment will be one of the first operational uses of the NanoRacks microplate reader and will provide operational experiment techniques applicable to the use of this device for future experiments. The unprecedented characterization of the ISS microbial environment through DNA characterization will provide greater insight into the environment of current and future spacecraft on long duration missions. As noted above, the examination of similar ground-collected samples after exposure to the microgravity environment could have implications for the cleanliness levels required to limit the introduction of microbial communities onto spacecraft surfaces, spacecraft cargo, and payloads prior to launch. Insight into new techniques or products which may control microbes in existing within the orbital spacecraft environment may also be obtained.

e. The professional credentials and experience of the applicant(s)

The development, promotion, execution and data analysis of this experiment is well within the experience base of the experiment team. Highlight excerpts from some of team member's experience have been provided above. Additional information on all team members is provided in the About Our Experiment Team section at end of this proposal.

The demonstrated ability of the Principle Investigator and the SciStarter.com and ScienceCheerleader.com organizations to engage citizen scientists and student scientists while leveraging existing grant funding and partnerships with a variety of organizations is very significant. These relationships will ensure a broad

engagement and raise the awareness of the general public on microbial community science, the ongoing ISS mission and the ISS scientific research program.

f. The proposed timeline for the development of the payload and whether the timeline can be adhered to and will be met by the applicant(s)

This experiment does not require the development of new experiment hardware, but will be one of the first users of a new existing capability onboard the ISS. Therefore, we do not have potential schedule threats associated with the development and certification of new flight hardware. Consultations with Dr. Eisen and NanoRacks have confirmed the viability of the experimental timeline within the execution phase. Furthermore, the planned execution time of the experiment in autumn 2013 provides an optimum opportunity for participation by our key partnering organizations.

INNOVATION

The experiment will be the first to examine how the growth and DNA/RNA quantization of Earth-originated microbes (on the ISS) compares to their Earth-based control group over time.

This experiment is the first to provide high throughput DNA sequencing of microbe samples returned from the ISS.

The experiment will be one of the first applied uses of NanoRacks microplate reader onboard the ISS. By doing so, our team will develop experimental techniques applicable to the future use of that device.

The participation of citizen and student scientists from across the United States in professionally-lead, space-based microbiology experiments is an unprecedented opportunity that was not possible only several years ago. The individuals participating in sample collection will surely follow the experiment's results as they are published on the experiment's website and will engage deeper into the scientific principles and concepts driving the experimental protocol. They will also gain an increased understanding of the ISS, its capacity and capability as a U.S. National Laboratory, and its continuing mission. In a very real sense, these individuals will become part of the ISS mission and will be bona-fide co-principle investigators for an experiment flown in space onboard the ISS.

RESEARCH STRATEGY & TECHNICAL DESCRIPTION OF METHODS

The strategy for the experiment encompasses experimental protocols for the ground-based microbe samples and the ISS based microbe samples. To be operationally viable, ISS Astronaut time estimates and Ground Control Center operational requirements must be considered, along with onboard storage requirements for transportation to and from the ISS and storage while onboard the ISS. Each of these strategic elements are described at a tactical level in the following sections and are illustrated in Figure 1 below.

Hypothesis 1: *Microbes found under earth normal gravity will exhibit different growth rates under microgravity conditions.*

Hypothesis 2: *Microbial community profiles from the ISS will differ in composition and exhibit ecological features that are unique to microgravity environments compared with samples collected from similar public, workplace, and residential surfaces under earth normal gravity.*

Additionally the DNA sequencing of ISS-originated microbe samples will demonstrate a new technique for establishing the microbial community baseline environment of the ISS.

In addition to providing fundamental insight into microbial community behavior, such data may have applicability to the levels of cleanliness required to limit the introduction of microbial communities onto spacecraft surfaces, spacecraft cargo, and payloads prior to launch. Characterization of a baseline of the microbial community on the ISS may also lead to the establishment of new methods to control the microbial communities onboard long-duration space missions.

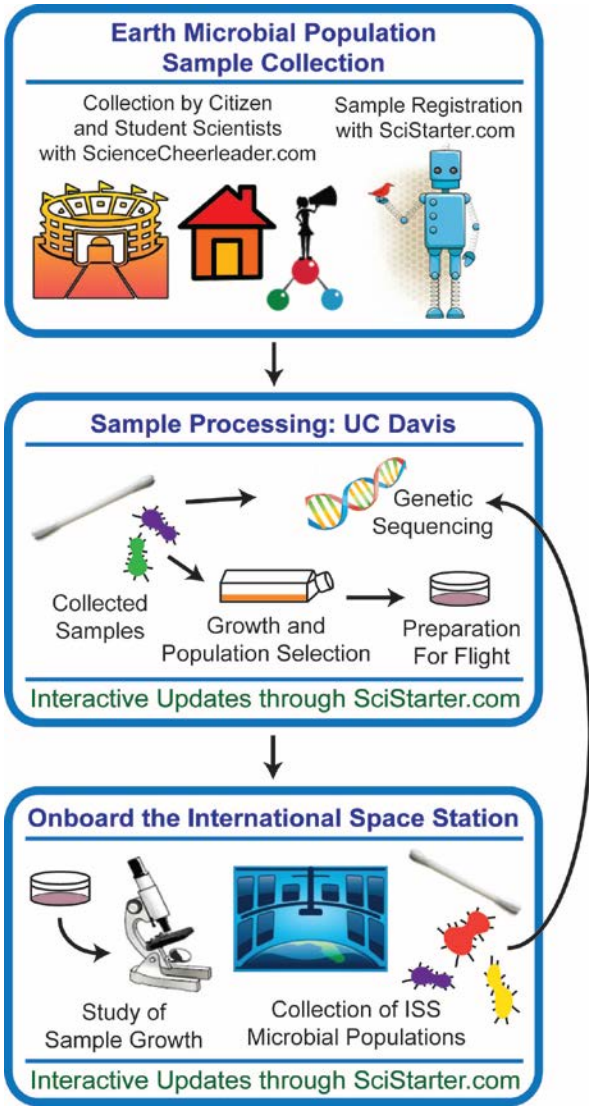

Figure 1: Research Strategy Overview

Ground-Based Microbial Population Sample Experiment Protocol

Swabs of ground-based high-touch surfaces will be acquired using swab kits provided through Dr. Eisen's laboratory at UC Davis. A statistically significant number of samples will be provided to each organization or venue participating in the ground sample collection portion of the experiment. Examples of surfaces to be sampled are: laptop keyboards, the front (microphone side) and back (hand side) of cell phones, arm rest or handrails in public seating areas, and return air circulation vents, screens or filters. The swab and its post-sample containment will be treated with a non-hazardous buffer to ensure pH stabilization of the samples. Instructions for how to properly obtain the swab and contain the swab after sampling will be provided with the kit. Users will also be asked to provide metadata on the surface the sample was taken, the type and location of venue and the observed environmental conditions at the time the samples were

taken. The contained samples will then be returned to Dr. Eisen's laboratory at UC Davis for initial characterization. In the laboratory, swabs will be initially categorized by the location of the sample venue and the sample surface type. Half of the samples from a given venue and surface type will be isolated for DNA/RNA quantitation and DNA sequencing using established laboratory protocols. DNA/RNA quantitation will be performed using a microplate reader that is functionally identical to the NanoRacks microplate reader onboard the ISS.

The remaining half of the microbe samples will be placed into growth media. Sample growth will be monitored at prescribed intervals through fluorescent characterization methods which will be functionally identical to those to be used with the NanoRacks microplate reader onboard ISS.

The DNA sequencing and growth results will be used to isolate and cull the microbes best suited for study onboard the ISS. The prime criterion for this selection will be the elimination of any toxins or biohazards that may be contained in the samples acquired from the public venues. Those microbes that are designated for flight will be identified by their sampling venue location and the type of surface sampled. At a specified time in their growth, the various microbe specimens will be transferred to the designated wells of microplates compatible for use with the NanoRacks microplate reader and then frozen in growth media. The microplates designated for flight will remain frozen until the examination of the samples onboard the ISS.

Initial discussions with Mr. Mike Johnson of NanoRacks confirmed that maintaining the microplate in a frozen state prior to onboard examination is within the logistical capabilities of NanoRacks and the cargo transportation spacecraft of the ISS Program. Specifically, this will require the frozen microplates be flown to the ISS on the Space X Dragon cargo vehicle with a powered NASA provided GLACER freezer unit onboard. Manifesting on the Dragon cargo vehicle and use of the NASA-provided GLACER freezer unit is within the scope of NanoRacks, as they are a commercial participant in the ISS U.S. National Laboratory. Notionally the microplates would be manifested on the Space X-4 cargo supply mission, presently scheduled for launch from Cape Canaveral in October 2013. This provides perfect alignment with the planned October-December 2013 launch and execution timeframe of the Space Florida International Space Station Research Competition. The launch date is also optimal for planned activities with SciStarter.com and ScienceCheerleader.com and our education partners.

ISS-Based Microbial Population Sample Experiment Protocol

The ISS based portion of this experiment has two distinct components. The first is the examination of the frozen microbe samples from ground-based public venues. The second is the collection of microbe samples onboard the ISS for return to Earth and subsequent examination in Dr. Eisen's laboratory at UC Davis.

As noted above, the microplate samples should remain in a frozen state both onboard the Dragon cargo vehicle and after transfer to the ISS. The number of microplates to be

flown is currently under review by the Principle Investigator. However, to provide a minimal stowage impact and minimize the required ISS Astronaut time, it has been decided that the number of microplates to be flown will not exceed four (4) microplates with a maximum of ninety six (96) wells per microplate.

At the scheduled date and start time of the 30 day experiment period (i.e. Day 1 of the experiment period), the ISS Astronauts will be requested to remove the microplates from the onboard freezer and temporarily stow them at a location of their choosing to allow for a gradual 24-hour thaw in ambient conditions prior to the first examination with the NanoRacks microplate reader. After the thaw period is completed each microplate will be sequentially loaded into the NanoRacks plate reader by the crew and automated studies for growth rate and DNA/RNA quantization initiated. The microplates will require change out after completion of the preceding plate's examination. This change out will be required no more than four (4) times, but all microplate reads and change out should be accomplished within the same day. After the change out, the crew is requested to return the microplates to their temporary stow location and allow them to remain there until the next examination period. After the last microplate reader run, the crew will transfer data from the plate reader to the ISS Express Rack laptop for later downlink to the ground. This downlink will be accomplished through a simple file transfer upon command by Payload Controllers at the ISS Payload Operations and Integration Facility (POIF) located at the NASA-Marshall Space Flight Center in Huntsville, Alabama. POIF personnel will then transfer the downlinked data files to the NanoRacks Control Center. NanoRacks personnel will initiate the transfer of these data back to UC Davis and SciStarter.com for dissemination to the citizen scientists and student scientists participating in the experiment, as well as the general public.

Notionally, microplate examination periods will be requested at 7 day intervals, on days 2, 9, 16, 23 and 30 of the experiment period. Less frequent microplate examinations could be accommodated if required due to unanticipated crew time requirements resulting from unplanned events on the ISS. Once the 30 day experiment period has been completed, the microplates can be discarded. Microplate return to Earth is not required.

The second component of the experiment is the collection of microbial community swabs from high-touch surfaces onboard the ISS. This microbe collection would be a one-time event for collection from several surfaces. This collection will be conducted using swab kits identical to those provided to the citizen and student scientists for use at the public venues. A total of six (6) surface swab kits will be provided. The onboard surface swabs can be accomplished at any time during the 30 day experiment period. However, it is requested the swabs be performed at least one week after any of the target surfaces have undergone the periodic "wipe down cleaning" which is conducted onboard the ISS. Candidate high touch surfaces for swabbing, which are analogous to those swabs taken on the ground are: laptop keyboards, hand held microphones, Express Rack hand rails or similar hand holds. The ISS Astronauts should make the final determination of which surfaces to swab based on their knowledge of the "touch traffic" of these candidate areas. Sample swabs are only being

requested from the US Operational Segment (USOS) of the ISS. Additionally, collection of lint from the air filters of the NanoRacks Platforms 1 or 2 is highly desirable. However, this collection is requested only if it can be easily accommodated, such as during a planned filter cleaning activity.

The collected swab samples should be placed in the provided containment and then stowed in a freezer unit. The samples should remain in a frozen state until their return to Earth. This requirement will mandate their return on the Space X Dragon return capsule, while contained in a powered NASA-provided GLACER freezer unit onboard the return capsule. As with our requirement to launch the frozen microplates to the ISS, return of frozen samples via the Dragon spacecraft is within the logistical capabilities of NanoRacks and within scope of their participation in the ISS U.S. National Laboratory. It is anticipated that the returned swab samples can be delivered to the Dr. Eisen's laboratory at UC Davis within 72 hours after splashdown of the Dragon capsule, given nominal recovery conditions.

After sample thawing at UC Davis, a protocol similar to that used on the microbial communities sampled from the public venues will be followed. DNA sequencing will be conducted on all samples obtained. Additional growth studies may also be conducted pending the results from the DNA sequencing.

<u>ISS Astronaut Time Estimates & Ground Control Center Operational Requirements</u>
This experiment has been designed with the judicious use of ISS Astronaut crew time in mind. Our experiment team is fully aware of the acute demands on crew time and has built in flexibility into the experiment's protocol should unforeseen demands on crew time arise.

Based on consultation with Mr. Mike Johnson of NanoRacks, our initial time estimates for all crew activities associated with both components of the experiment over the 30 day period are as follows:

1. Initial removal of the microplates from the freezer and temporary stowage for thawing: 10 minutes
2. Initial set up of the microplate reader for sample runs: 30 minutes
3. Change Out and Re-stow of microplates (up to 3 additional microplates): 20 minutes
4. Repeat of Steps 1-3 for Day 9 microplate examination: 60 minutes
5. Repeat of Steps 1-3 for Day 16 microplate examination: 60 minutes
6. Repeat of Steps 1-3 for Day 23 microplate examination: 60 minutes
7. Repeat of Steps 1-3 for Day 30 microplate examination: 60 minutes
8. Conduct one-time microbial surface swabs and NanoRacks Platform filter lint collection (if feasible) at any time during the 30 day experiment period: 30 minutes

Cumulative 30 day experiment time: 330 minutes (5 hours 30 minutes).

It should be noted that these time blocks are believed to be conservative (higher than anticipated), particularly once the ISS Astronauts gain operational familiarity with the NanoRacks microplate reader. However, it should be noted that the total crew time in this estimate is slightly less than one full workday, dispersed over a period of one month. Our experiment team believes this is a reasonable investment of ISS Astronaut time given our experiment's potential scientific and technical results, the anticipated level of involvement of citizen scientists and student scientists and overall public engagement.

Alternatives do exist to adapt the experimental protocol to use less crew time if required. As an example, if there are no other users of the Microplate Reader during the 30 day experiment, an alternative protocol could have the crew load one plate at a time directly from the freezer into the microplate reader, and after thawing, run continuous measurements for a week. The crew could conduct the transfer of data to the Express Rack laptop during thawing of the next sample instead of making that a separate step for the crew.

Stowage Requirements

Our maximum of 4 standard 96-well microplates can be accommodated within a 1.5U NanoRacks stowage volume. Their estimated weight while containing frozen samples would be below 0.5 kg. The 6 microbe surface swab kits can be contained in a standard flight certified Ziploc-type bag. The surface swab kit bag weight is also less than 0.5 kg. Mr. Mike Johnson of NanoRacks informed us that flying the surface swab kits in a Ziploc-type bag not contained in a NanoLab module is permitted for this experimental competition.

CONCLUSIONS

This proposal describes an innovative approach to examination of the microbial environment through the use of the NanoRacks microplate reader and the DNA sequencing of microbe samples from the ISS after their return to Earth. The resulting data will be applicable to the study of microbiology of the build environment for Earth based dwellings and long-duration space missions. This data is necessary starting point for the development of model systems which could help uncover features relevant to the understanding of built environments both on earth and in space.
The experiment leverages the experience of a recognized leader in microbial genomics, who's noted research is followed world-wide.

The engagement of citizen and student scientists in this study provides an unprecedented opportunity to further public engagement in microbial science and raise the awareness of the myriad of research possibilities onboard the ISS. Through their "hands on" participation, these individuals will become part of the ISS scientific research program. The implementation of this public engagement through SciStarter.com, ScienceCheerleader.com and their partners such as Pop Warner, NSTA, Discover magazine, the NFL, and the NBA will promote a broad public awareness of the ongoing ISS mission, Space Florida, NanoRacks and NASA.

ABOUT OUR EXPERIMENT TEAM

Jonathan Eisen (Principle Investigator):

Jonathan A. Eisen, Ph.D., is a Full Professor at UC Davis. His lab is in the UC Davis Genome Center and he holds appointments in the Department of Medical Microbiology and Immunology in the School of Medicine and the Department of Evolution and Ecology in the College of Biological Sciences. In addition he holds an Adjunct appointment at the Department of Energy Joint Genome Institute in Walnut Creek, CA.

Dr. Eisen's research focuses on communities of microbes and how they provide new functions – to each other or to a host. His study systems have included boiling acid pools, surface ocean waters, agents of many diseases, and the microbial ecosystems found in and on plants and animals. He is also coordinating the largest microbial sequencing project to date – a Genomic Encyclopedia, being done at the Department of Evolution Joint Genome Institute where he holds an Adjunct Appointment. The overarching goal in all of his research is to create a "Field Guide to the Microbes" much as exists for birds and trees.

In addition to his research, Dr. Eisen is a vocal advocate for "open science," especially "open access" to scientific publications and is the Academic Editor-in-Chief of PLoS Biology. He is also an active and award-winning blogger and microblogger.

Prior to moving to UC Davis he was on the faculty of The Institute for Genomic Research in Rockville, Maryland and held an Adjunct Appointment at the Johns Hopkins University. He earned his Ph.D. in Biological Sciences from Stanford University and his undergraduate degree in Biology from Harvard College.

Blog: http://phylogenomics.blogspot.com/
Lab Web Page: http://phylogenomics.wordpress.com
Twitter: @phylogenomics

Russell Neches (Co-Principle Investigator):

Russell Neches is a PhD student in the Microbiology Graduate Group at UC Davis, advised by Jonathan Eisen. He studies the way microbes migrate around the planet by sequencing their DNA in bulk directly from the environment. Russell studies microbes that live in extreme environments, such as those with extreme heat, high concentrations of salt, and extreme pH. His other research interests include microbial ecology, software, Open Hardware, Open Access, DNA sequencing, evolution, and genomics. He holds a BS in Physics from Northeastern University in Boston, Massachusetts.

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Wendy Brown (Co-Principle Investigator):

Ms. Brown is a PhD student in the Biomedical Engineering Graduate Group at UC Davis. Her research interests include the development of biologically functional, autologous, tissue-engineered osteochondral grafts for treatment of cartilage degeneration, and the use of dermis-isolated adult stem cells for cartilage tissue engineering. She holds a BS degree in Biomedical Engineering with minors in Spanish and Organizational Leadership from the Georgia Institute of Technology in Atlanta, Georgia.

Ms. Brown is an active member of the Science Cheerleaders and is a professional cheerleader, formerly with the Atlanta Falcons of the NFL, Sacramento Kings of the NBA, and currently with the Sacramento Mountain Lions of the UFL. Ms. Brown was featured in a recent NBC Today Show segment on the Science Cheerleaders which can be seen here:
http://www.sciencecheerleader.com/2012/09/science-cheerleaders-on-the-today-show-heres-the-awesome-segment/

Twitter: @ProCheer_Wendy

Darlene Caviler (Co-Principle Investigator):
Ms. Cavalier is the founder of Science Cheerleader.com, a site that promotes the involvement of citizens in science and science-related policy featuring the Science Cheerleaders, current and former NFL and NBA cheerleaders-turned-scientists and engineers. The Science Cheerleaders perform at events across the nation to playfully challenge stereotypes, inspire the 3 million cheerleaders in the U.S. to consider careers in science, math, and engineering, and encourage “regular” people to tap into their inner scientists and get involved in “citizen science” projects (research projects in need of volunteers). She is also the founder of SciStarter.com, a web site, named one of Philadelphia’s Top Ten Tech Start Ups with a Social Good that connects everyday people to science through recreational activities as well as formal research.

Ms. Cavalier held executive positions at Walt Disney Publishing and worked at Discover Magazine for more than a decade. She was the principal investigator of a $1.5 million National Science Foundation (NSF) grant applied to promote basic research through partnerships with Disney and ABC TV and more recently collaborated with the NSF, NBC Sports and the NFL to produce the Science of NFL Football series.

Ms. Cavalier is a former cheerleader with the Philadelphia 76ers of the NBA and holds a BA in Communications from Temple University in Philadelphia and a Master of Liberal Arts degree from the University of Pennsylvania, Philadelphia, where she studied the role of the citizen in science. She is a writer and senior adviser to Discover Magazine, serves on the Steering Committee for Science Debate, and organized an effort to launch the first-of-its-kind network to support citizen engagement in technology assessments. In addition to Science Cheerleader, founding partners of that effort

include the Woodrow Wilson Center for Scholars, Boston Museum of Science, and Arizona State University. Her dedication, impact, and innovative approaches have been featured in Science, The Scientist, the Chronicle of Higher Education, Newsweek.com, Forbes.com, Discover Magazine, Fox National Headline News, CNN, NPR and even ESPN, and many other national media outlets in the U.S. and internationally.

Blog: Scistarter.com/blog
Twitter: @scistarter and @scicheer

Summer Williams (Co-Principle Investigator):
Ms. Williams is an aerospace engineer at the NASA-Johnson Space Center (JSC) in Houston Texas, employed by Jacobs Technology. She currently manages several laboratories in the Avionics Systems Division of NASA-JSC responsible for the development and processing of flight hardware used on the International Space Station. Ms. Williams holds a BS in Aerospace Engineering from Wichita State University, Wichita, Kansas. She is also a licensed private pilot and is pursuing pre-med course work at the University of Houston - Clear Lake. Ms. Williams is an active member of the Science Cheerleaders and is a former professional cheerleader with the Houston Texans of the NFL. Additionally, Ms. Williams is the reigning Ms. Texas-United States, and uses this role to further promote the engagement of young women in STEM-related studies and career paths.

Mark Severance (Co-Principle Investigator & Experiment Proposal Point-of-Contact):
Mr. Severance is a NASA engineer at the Johnson Space Center (JSC) in Houston, Texas. He has spent most of his career in Mission Control Center-Houston as a Flight Controller in several technical disciplines for the Space Shuttle and International Space Station. In addition to his work as Space Shuttle and Space Station Flight Controller, he was also a NASA Operations Lead in Mission Control Center-Moscow early in the ISS program and when NASA had Astronauts performing long-duration science missions onboard the Russian space station Mir. He previously worked in NASA's Office of Education where he started a project to develop educational activities and experiments for the International Space Station. He is currently an engineer and manager of a space communications lab in the Avionics Systems Division of NASA-JSC.

Mr. Severance has had a life-long interest in spaceflight and views the space program as a catalyst for engaging minds of all ages in a deeper understanding of science, engineering, technology, and mathematics. As a teenager he was invited to be a student member of the Kettering Group, an international network of student and adult amateur observers who studied Soviet and Chinese satellites and space missions through radio tracking and analysis of telemetry & Cosmonaut voice signals. His satellite tracking proved to be a life directing force, launching his interest and studies in Electronics, Physics and Russian language.

Mr. Severance holds BS degrees in Electrical Engineering & Physics, with minors in Russian and Math from Southern Methodist University in Dallas, Texas and an MS in Physical Science with a concentration in orbital mechanics from the University of Houston. He is active with ScienceCheerleader.com and SciStarter.com as their "Space Guy", developing space related projects and subject matter for both sites.

All experiment team members are U.S. Citizens.