SSEP

Student Spaceflight Experiments Program

SSEP Mission 13 to ISS: Selected Flight Experiments, Communities, Teams, and Abstracts

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A total of **3,683 proposals** were submitted from student teams across the 38 communities participating in Mission 13 to ISS. Of those **1,354 proposals** were forwarded for review by **Step 1 Review Boards** in each of the communities. Each Step 1 Review Board selected up to three finalist proposals, which were submitted to the **National SSEP Step 2 Review Board**. On November 29-30, 2018 the Step 2 Review Board met at the College Park Marriott Hotel and Conference Center in Hyattsville, MD, reviewed all **121 finalist proposals**, and selected one proposed experiment to fly for 36 communities, 2 proposed experiments for one community and three proposed experiments for another community, for a total of **41 flight experiments**. It is noteworthy that the 3,683 proposals received reflected a total of **23,117 grade 5-16 students fully engaged in experiment design**.

1. Sao Paulo, Brazil

Capillarity versus Gravity in the Filtration Process

Grade 11, Instituto Federal de Santa Catarina – Campus Xanxere

Co-Principal Investigators: Isabela Dalmolin Battistella, Renata Eliza Valentini Müller, Ricardo Vinícius Brum Cenci, Roberta Debortoli Moreira

Teacher Facilitator: Daniel Ecco

Proposal Summary:

This proposal presents a water filtration system that uses activated carbon, based on the Brazilian clay filter's operating method. It depends on gravity to work: the water is stored in its upper part and slowly passes through a candle-type activated carbon filter, leaving impurities behind. In the experiment, the activated carbon will be used as a filter for a solution of methylene blue ($C_{16}H_{18}ClN_3S$) – chosen for its color and apolar characteristic – in distilled water. In the other volume of the FME, there will be a certain amount of cotton placed to absorb the solution to be filtered, due to the need to retain the liquid so that it does not return to the filter. The adapted filter is expected to work in microgravity by capillary action. In this proposal, we seek to adapt the filtration method to the conditions of microgravity environment, in order to find a filtering method that does not rely on gravity, and to observe its effectiveness regarding the same process when developed here on Earth under the action of gravity.

2. Edmonton, Alberta, Canada

The Effect of Microgravity on the Germination of *Nasturtium Officinale* (Watercress)

Grade 9, David Thomas King School, Edmonton Public Schools

Co-Principal Investigators: Lauren Clement, Deeanne Vergara

Co-Investigators: Thea Endols-Joa, Lily Hu

Collaborator: Kyra Lizotte

Teacher Facilitator: Kelsey Wasylenki

Proposal Summary:
Our team is sending *Nasturtium Officinale*(watercress) seeds to the International Space Station to test the effects of microgravity on germination. If germination is successful, the watercress plant would be considered a food source for astronauts in space. If watercress could be added to their daily diets, it would make a big difference in the health of astronauts. Watercress has more Vitamin C than other food nutrition sources such as oranges, provides more iron than spinach, and has more folate than bananas. It also contains calcium, which is essential for bone and tissue growth. In addition, watercress carries vitamins A, B6, B12, as well as magnesium and phosphorous. These nutrients are all required for a healthy body and will be beneficial to astronauts. According to a study done by the University of Ulster, watercress prevents various types of cancer, such as bowel and breast cancer, as well as cognitive disorders, and strokes. In contrast, watercress increases healthy brain activity, acts as an antidepressant, reduces the chances of developing chronic heart disease, reduces oxidative damage to blood cells, and it can help maintain good eye health. If watercress is successfully germinated in microgravity, we would be able to send seeds up to the ISS for astronauts to grow as a food and nutrition source. Another advantage of watercress is the speed of its growth: from seed to mature plant takes between seven to fourteen days, which makes it an excellent choice for missions in space.

3. Qualicum, British Columbia, Canada

Investigating the Growth Patterns of Alfalfa (*Medicago sativa*) Sprouts in Microgravity: a Potential Nourishment for Future Manned Spaceflights

Grades 11-12, École Ballenas Secondary, School District 69
Co-Principal Investigators: Marco Ioffredi, Victor Kamel, Robert Lachance, Alexander Marshall, Filipe Pereira
Teacher Facilitator: Carl Savage

Proposal Summary:
When humans venture beyond Earth’s orbit on to Mars, horticulture will surely follow (Wheeler, 2002). No doubt, plants will have a crucial role in future spaceflights and colonization, both as food and as part of regenerative life support systems. In particular, *Medicago sativa* (Alfalfa) sprouts may be a great resource for astronauts given their nutritional benefits, being a crucial supply of macronutrients for humans in microgravity and in the prevention of microgravity-related diseases (USDA, 2018; Joint, F.A.O & W.H.O., 1998). As one of the most cultivated legumes in the world, Alfalfa is cost effective and easy to obtain. (Bora & Sharma, 2011). The experiment will be performed in a Type 3 FME mini lab: in Volume 1 there will be distilled water, Volume 2 will contain Alfalfa seeds, and Volume 3 a 10% formalin solution acting as a fixative. Comparing germination rate, root length, cross sectional area, volume, and collective mass between the ground control and the experiment in microgravity with a computer aided microscopic imaging device and high precision scale, the experiment will attempt to demonstrate how Alfalfa sprouts react to the conditions in space. Barely any research has been previously done on the behaviour of Alfalfa in microgravity. This experiment could provide the scientific community with data that could allow further investigation into how Alfalfa seeds germinate in microgravity to eventually confirm its potential in future long-term spaceflights and extra-terrestrial settlement. Further, the ISS would serve as a unique laboratory to conduct such research and gather important data.

4. Winfield, Alabama

Purification of Water in Microgravity

Grade 12, Winfield City High School, Winfield City Schools
Co-Principal Investigators: Luke Clark, Tanner Edmond, Davis Holdbrooks, Luke Jungels, Savannah Williamson
Teacher Facilitator: Jennifer Birmingham

Proposal Summary:
The recent discovery of water on Mars has opened a possibility of new ways that the life sustaining liquid can be obtained in space travel. This new method would rely on collecting water from space bodies that are not our own. The only problem with this method is determining if this water would be safe to drink. Our team is proposing to study if microgravity has any effect on the purification of water. We would collect water from a non-sterile source, like a pond and mix it with purification tablets. Next, we would test the water to see if anything harmful survived.

5. Corcoran, California

The Brine Shrimp Study

Grade 7, John Muir Middle School, Corcoran Unified School District
Co-Principal Investigators: Luz Angelica Medina, Anneliese Trevino
Co-Investigators: Carolina Leal Aceves, Rozalynn Yang-Garza
Collaborator: Mariana Moreno
Co-Teacher Facilitators: Jonathan Sorrick and Jari Stokes

Proposal Summary:
In this proposed study, we will be experimenting with Brine shrimp eggs in microgravity. We will send dried Brine shrimp eggs into space to observe and study their hatching and maturation rate. We have found throughout our research that Brine shrimp are very similar to Krill. Krill produces a powerful antioxidant called astaxanthin; that helps avoid spoiling in your stomach. Krill oil also contains EPA and DHA, which helps the body absorb Omega 3. Omega 3 has multiple health benefits such as helping with blood fat, Rheumatoid Arthritis, stiffness in joints, depression, ADHD, Alzheimer’s disease, and dementia. Due to Krills´ size, it would not be able to fit into the FME tube. Instead of sending Krill to space, we will be using Brine shrimp as a test subject. Brine shrimp can also possibly be the food source for other aboard animals. According to an article we found, it states that brine shrimp can be a food source for other sea predators or any other animal that can consume brine shrimp. The exact steps are: 1: compress gas glass cleaner into FME tube, 2: Put in the 1st plug, 3: Place 0.0002 oz Brine shrimp eggs in the tube, 4: Add 1 ml of yeast into the tube, 5: Snap on clamp A, 6: Pour in the 6.3 ml of our saltwater mixture, 7: Snap on clamp B, 8: Pour in 1 ml of Formalin, 9: Put in the 2nd plug. After the necessary steps are conducted, the mini labs will be ready for data observations. As soon as the experiment arrives back to Earth, we will analyze the results, comparing the two mini labs. Without this experiment going to space, our questions are not put to rest.

6. La Verne, California

***Flammulina velutipes* Growth in Microgravity**

Grades 11-12, Damien High School, Archdiocese of Los Angeles
Co-Principal Investigators: Anthony Ebiner, Curtis Lin, Dylan Mckenzie, Kotoi Wu
Teacher Facilitator: Charity Maricic

Proposal Summary:
The experiment being proposed is studying the effect of microgravity on fungi growth patterns. The two main objectives of this experiment will be to see how these observed growth patterns can help in the propagation and cultivation of mushrooms in space and to see if the results will prove or disprove two theories on how fungi can detect gravity: 1. David Moore's theory on mushroom gravimorphogenesis: the apex of the stem is the part of the organism that sensitively responds to gravity's effets and 2. Jan Monzer's theory on fungi gravitropism: the nucleus of fungi's hyphal cells act like an otolith, responding to the direction of the gravitational forces. Each theory defines an independent set of detection systems. Monzer's theory defines the system by which the fungi detects gravity while Moore's defines the system by which the fungi reorients itself. By finding out which one, or both, is controlling the growth of the fungi, future experiments on the fungi will be able to better understand the optimum conditions in which to grow fungi. These theories will be tested by growing Enokitake mushrooms both aboard the ISS and on the ground as a control. The growth patterns of the samples will be studied and either Monzer's theory, Moore's theory, neither, or both will be confirmed. The most likely scenario is that both theories will be correct and thus allow a complete law of mushroom microtropism and gravimorphogenesis be established under Moores' and Monzer's names.

7. Moreno Valley, California

The Growth and Development of Sustainable Brine Shrimp in Microgravity

Grade 7, Palm Middle School, Moreno Valley Unified School District
Principal Investigator: Aidan Alvarez
Co-Investigators: Dorian Arias, Vince Mora
Collaborators: Vincent Ruiz, Andre Portlock
Teacher Facilitator: Gayle DiCarlantonio

Proposal Summary:
Our project will examine the response to microgravity of brine shrimp and possibly contribute to the further use of these animals as a resource in a food chain for raising fish on the International Space Station or another planet. Our goal is to do what we can to make sure that our experiment is successful and can be used to further research in this area. We believe that the shrimp may show a response to microgravity perhaps in their physical appearance or their rate of development. We will examine how the brine shrimp hatch and develop while in microgravity compared to on Earth. Both experiments will be done the same way including the time span, procedure, feeding, and fixation using 10% buffered formalin to preserve them. Also, we will ask the following questions as we analyze both brine shrimp populations: Are there any differences in the percent of shrimp hatched, their appearance, and in the types of developmental stages or the percent of shrimp at these stages? How can our findings contribute to using these animals as part of a marine aquaculture in microgravity?

8. North Hollywood, California

The Effects of Microgravity on Cell Recognition
Grades 10-11, Oakwood School
Co-Principal Investigators: Monie Choi, David Storm
Teacher Facilitator: Andrew Miller

Proposal Summary:
We propose to answer the question: How effective are pathogen associated molecular patterns in microgravity? We are measuring protein recognition receptors ability to signal immune responses in the presence of an *Escherichia coli* infection while under the influence of microgravity and comparing their functionality to similar receptors on Earth. The purpose of this experiment is to see if cell recognition is less efficient in space than in a gravitational setting. It was predicted that with the seemingly endless increased interest in space travel, there have been multitudinous investigations conducted studying the effects of microgravity on the immune system. Results from many of these studies concluding that the immune system is severely weakened by microgravity (Graham, 2018). Cell recognition plays a crucial role in the effectiveness of the immune system as the body's immune response is stimulated after recognizing specific antigens on the surfaces of pathogens (Marshall, 2017). Our experiment aims to investigate a possible reason as to why the functions of the immune system vary in an environment subjected to microgravity. We hope that the results from this investigation will be cause for increased scientific questioning in the biomedical world about protein recognition receptors and open new doors to treat unique diseases that are caused by faults in their capabilities. Alternatively, we hope to pinpoint the cause of weakening immune systems in microgravity to inch closer to the future of prolonged space explorations.

9. Riverside, California

The Effects of Microgravity on Saturated Copper Sulfate Crystals
Grades 4-5, John F. Kennedy Elementary School, Riverside Unified School District
Co-Principal Investigators: Ranteg Bajwa, Aiden Grover
Co-Investigator: Ivan Hughes
Collaborators: Olivia Guastella, Loc Andre Olea, Cheri Thompson
Teacher Facilitator: Carla Yawney

Proposal Summary:
The purpose of our experiment is to find the effect of microgravity on the growth and structure of saturated Copper Sulfate crystals. We are examining whether these crystals will grow differently in microgravity than on Earth. We are proposing that microgravity can make the Copper Sulfate crystals grow extra slowly and therefore the crystals will have minimized flaws. In our experiment, we will be comparing the speed of growth and the structure of crystals in gravity and microgravity by observing the optical clarity, color distributions, and the crystal surfaces. Our hypothesis is that the crystals in the microgravity environment will be smaller, will have less flaws, and may grow somewhat slowly. This is because we think that the crystal will not settle to the bottom of the tube because it will float in the solution due to microgravity. This could be a better way to grow crystals for many uses, for example for new medical applications such as improving radiation detection for medical imaging, helping to make antidotes for nerve agents, and other technology and agricultural uses. The experiment includes Copper Sulfate, Ethanol, filtered purified Superhydrophobic foam, filtered purified water, and jelly crystals.

Effects of Microgravity on Radish Seed Germination
Grade 7, STEM Academy, Riverside Unified School District
Co-Principal Investigators: Adani Ahmad, Aliyah Zuwayed
Teacher Facilitator: Megan Harns

Proposal Summary:
We propose to answer this question: Will radish seed germination be affected by microgravity? Last year we conducted an experiment in which different colors of light were used to test the effect on the germination of bean sprouts, so this new experiment will help further our research about the germination of seeds. We found out that on Earth, the roots of a seed start to grow downwards because of gravity, but seeds in space will be in microgravity, so they may sprout differently. We are looking for a radicle (baby root) to show that the seeds sprouted. Research based off two previous experiments gives evidence that there wasn't a dramatic difference in germination between Earth and microgravity seeds (Briarty, 2004; Millar, 2011). However, these tests were on *Arabidopsis thaliana* seeds. We propose to use radish seeds, or *Raphanus raphanistrum subsp. sativus*, which take about three to four days to start to germinate depending on the conditions. This will be effective seeing as the experiment will be carried out for only 12 days. Our experiment will consist of two of the Type 3 FME Mini-Labs, whereas one test tube will be on ISS, and the other here on Earth. This way, we can compare the seeds in each tube once the ISS tube is returned to Earth. We hypothesize that the resulting amount of germinated seeds on ISS will be greater than the number of germinated seeds on Earth because microgravity will put fewer constraints on seed growth.

***Chenopodium quinoa* Cell Development in Microgravity**
Grades 11-12, John W. North High School, Riverside Unified School District
Co-Principal Investigators: Karen Cortina, Audrey Cui, Alejandra Robles, James Rohde, Hannah Terao
Teacher Facilitator: Adam Quaal

Proposal Summary:
We are attempting to answer the question: How does microgravity affect the cell development of *Chenopodium quinoa (C. quinoa)* sprouts? Studies of *C. quinoa* development in microgravity may indicate whether the organism could provide a valuable food source for a long-term duration in space. *C. quinoa* contains a desirable combination of amino acids and secondary metabolites that can typically be achieved only through a blend of multiple food sources. Physiological characteristics of the plant, such as cell size, chloroplast count, cell wall dimensions, and overall sprout size are indicative of a plant's current metabolism and stress resistance. We hypothesize that in a microgravity environment, the *C. quinoa* cells will grow larger than on Earth, with a greater number of chloroplasts and a thinner cell wall, because they will be exposed to a gravitational acceleration that is less than that on Earth. To test this hypothesis, we will send *C. quinoa* seeds up onto the International Space Station (ISS) and activate the seed germination with water. Once the *C. quinoa* seeds have sprouted, we will fixate the *C. quinoa* and its cellular structures using a formaldehyde buffer and examine them back on Earth to determine any changes in sprout size, cell size, chloroplast count, and cell wall thickness, as compared to a parallel experiment set on Earth. If this experiment is selected, astronauts and biologists will gain a valuable understanding of agricultural cultivation and may allow access to fresh nutritious food in long-term space exploration.

10. Ashford/Willington, Connecticut

How Microgravity Effects Beetroot Seed Germination

Grades 6 and 8, Ashford School and Hall Memorial Middle School, Ashford School District
Co-Principal Investigators: Alison Bean, Anna Dietz, Skylar Garrison, Parker Perosky
Co-Investigators: Adam Dunham, Thaddeus Kelly
Teacher Facilitator: Dory Moore

Proposal Summary:
We are proposing to study the effect of fertilizer on a beetroot seeds from Hart Seed Supply in a microgravity environment and compare to a seed growing with the same fertilizer on Earth. Specifically, we chose beetroot seed due to its health benefits such as lowering blood pressure, improving memory and helping muscles when you exercise. Beetroot helps your blood pressure do down, it also helps people with diabetes and contains high levels of fiber. This experiment is important because we would be able to find a new way to provide faster growing and nutritious food for astronauts. Having the plant in a microgravity environment could also help us discover an innovative process to grow abundant plants for those on Earth. If it appears that microgravity has a positive effect on plants, we would be able to not only provide food for astronauts, but also average people and animals as well. For example, if in the future we face a world hunger crisis, we could grow nutritious produce in space when expansion in technology and infrastructure has not left room for growing plants and crops.

11. Hillsborough County, Florida

Mung Bean Project 2018

Grades 6-7, Randall Middle School, Hillsborough County School District
Co-Principal Investigators: Riana Basista, Payton Hardy, Sydney Jacobson, Alexander Januario
Teacher Facilitator: Mary Vaughn

Proposal Summary:
Mung Beans will allow an advancement in space travel by providing a food source that will keep astronauts healthy on long term space mission. They are full of nutrients and are simple to grow. The Mung Beans are sourced from Sprouts grocery store. According to hunker.com, the germination period can be 4-5 days depending on the amount of water that is present during germination. Inside the volume 1 of the FME of the tube we have water for watering the Mung beans. The water is from our local water source at our school. In volume 2 we have the Mung beans and felt, which is going to act as a medium for the beans to root into. In volume 3 of the FME there is formalin. Formalin is a fixative and will be used to stop the growth of the Mung Beans. Through experimentation with the pilot tests we have determined to put 5 Mung Beans in the FME. If we could grow Mung Beans astronauts would have a great food source, since Mung Beans contain plenty of nutrients like vitamins K, B2, B9, B5, B6, C, and B1 thiamine. They can keep astronauts healthy on long flights to other planets such as Mars. Mung Beans can also be eaten raw, which means there will not be a need to send extra supplies to prepare the Mung Beans. Mung Beans would help astronauts stay healthy since they’re great at fighting heart disease, cancer, and diabetes.

12. Port St. Lucie, Florida

The Effects of Microgravity on the Germination of Culinary Lavender

Grade 8, Renaissance Charter School at Tradition, St. Lucie County Schools
Co-Principal Investigators: Jolina Jofors, Marcella Melo
Co-Investigators: Brooklyn Brandt, Deidra Gurin
Teacher Facilitator: Danielle Bisaccio

Proposal Summary:
The question that we are focusing on is how microgravity will affect the germination of culinary lavender. Lavender (Specifically Culinary Lavender) is commonly used for its convenience here on Earth. In fact, it can be put in pretty much anything. Lavender can be used in teas, essential oils, as a seasoning in food, or just for the aroma. Also lavender oil can help with anxiety or depression, which is a major struggle that astronauts deal with. We are seeking to discover what effect microgravity has on the germination of the lavender. We decided to use culinary lavender because this can be used for the astronauts. We believe that this will give us a greater understanding on how microgravity will affect germination of plants.

13. Berea, Kentucky

Rate of Rust Formation in Microgravity
Grade 11, Berea Community High School, Berea Independent School District
Principal Investigator: Michael Mecham
Co-Investigators: Lucas Hannon, Brent Robinson, Breanna Smith
Collaborators: Julia Kilgore, Carlyn Mcdonald
Teacher Facilitator: Christopher Preece

Proposal Summary:
Our group's experiment is testing the question of what the rate of rust formation is in microgravity. This experiment could potentially be important to NASA because if microgravity does affect how quickly something rusts in space then knowing the data collected from our experiment could help in the development of future space equipment depending on the results. This experiment would only require 12 days and will also be done on Earth in a classroom setting simultaneously to compare rusting rates. The needed procedure for this experiment would be to have the tube consisting of 3 different chambers, salt water, steel nails, and sodium polyacrylate. You unclamp Clamp A between the Steel Nails and the salt water and let it sit for a period of 12 days. After 12 days you would unclamp Clamp B between the sodium polyacrylate and the salt water (The polyacrylate will soak up all of the salt water in the tube and stop it from continuing to rust). When the sample returns back to us, we will put isopropyl alcohol in the tube, loosening the sodium polyacrylate so the nails can be removed easily. After the nails are extracted from the sodium polyacrylate, the nails will be put into acetic acid for 3 days, removing any remaining rust and leaving only the steel. The rust particles removed from the acetic acid can then be taken and analyzed using a microscope, allowing us to see any differences there may be in the formation of the rust. Then the two samples will be weighed, and the difference in weight will determine which sample rusted more, as rust takes away from the mass of an object. You could then see the rate at which rust was able to form in microgravity and compare it to the rate it forms on Earth. The results of this experiment will allow us to see and gain data about how rust forms in a microgravity setting compared to how it forms on Earth.

14. Anne Arundel County, Maryland

Effect of Microgravity on the Structural Strength of Concrete
Grade 6, Magothy River Middle School, Anne Arundel County Public Schools
Co-Principal Investigators: Gabby Munoz, Ethan Shellem, Gavin Wildberger, Caleb Young
Teacher Facilitator: Lauren Ebersberger

Proposal Summary:
Our project title is "The Structural Integrity of Concrete in Microgravity." We are testing if concrete can still hold it's natural structural integrity in microgravity. Our definition of structural integrity is the ability of an item to hold together under a load without breaking or deforming. We

are testing this to see if we could build on Mars or other neighboring planets and moons the same way we can on Earth. We found that concrete is made of 60% limestone, 25% silica, 5% alumina, iron oxide, and gypsum or Portland cement, pebbles, and sand. We believe that we will need a Type 2 Mini Lab, half filled with 3.2 grams of *Quikrete* powder and half filled with 1 mL of water. When we have both tubes of concrete back to us, we will have our teacher help us use a razor blade to remove the concrete to measure how much weight the concrete can hold to see if the concrete will have the same structural integrity when hardened in microgravity as it does when hardened on Earth. The main thing that our team will be testing is whether concrete hardened in microgravity can hold the same amount of force as concrete hardened on Earth. Without testing this, we would be unable to narrow down the list of building materials that could be used in microgravity.

15. Montgomery County, Maryland

Mixing Cement with Steel Shavings

Grade 7, Parkland Magnet Middle School, Montgomery County Public Schools
Co-Principal Investigators: Emran Ali, Nayeli Alonzo, Suhani Aryal, Jack Bozarth, Beniam Tekie
Teacher Facilitator: Zachary Johnson

Proposal Summary:
We are going to see if the cement and steel shavings will mix in microgravity the same way they do on Earth. We will conduct an experiment on Earth first to see how the steel shavings and cement react in the normal atmosphere. Then, we would do our experiment in space and see if through microgravity the cement and steel shavings will mix, or if the steel and cement mixture from space becomes stronger than the steel and cement mixture on Earth. We will see which one is stronger by using weights, and we would keep on adding weights until one cement steel mixture cracks. We are making reinforced concrete. The way we will do this is by adding steel shavings in our cement. We will make the cement by adding aggregate and sand with Portland cement. We will see if microgravity affects this in any way such as harden it or mixing it. It will hopefully make reinforced cement. We believe that the microgravity will affect the mixing. The mixing of the steel shavings and the Portland cement will make stronger cement.

16. University System of Maryland, Maryland

Biofilm Adhesion of *E. coli* to Annealed Porous and Smooth Aluminum in Microgravity

Grade 13, University of Maryland, College Park, University System of Maryland
Co-Principal Investigators: Debbie Adam, Michelle Fang, Niki Gooya, Pali Keppertipola, Apurva Raghu
Teacher Facilitator: Natasha Ivanina

Proposal Summary:
Biofilms are communities of microorganisms with complex physiologies which can facilitate the development of diseases like atherosclerosis and leptospirosis. This poses a risk for health and wellness of astronauts in confined environments, meaning that deterring biofilm growth is of extreme importance on long haul missions. The great structural diversity of these microbial systems contributes to its acquisition of resistance towards antimicrobial substances through generational selection. In addition to illness, biofilms in space may obstruct the function of critical equipment. Such equipment is often constructed of aluminum alloys, as its low production costs combined with high malleability facilitate the formation of a wide range of innovative designs. We propose an experiment that analyzes the adhesion of *Escherichia coli* on porous and smooth aluminum surfaces to determine if smoother surfaces of aluminum garner more bacterial adhesion in a microgravity setting than a porous one. Research indicates that *E. coli* is capable of biofilm formation, and known for microbial surface colonization. Earlier

inquiries into biofilm formation on porous surfaces show reduced microbial attachment and formation. We intend to see whether or not these results are analogous or contingent in a weightless environment. In the event we observe elevated microbial formation on annealed smooth aluminum, our experiment will suggest concurrence with current research findings. Additionally, it would be recommended that the equipment used on the International Space Station be made of porous materials. Following mission completion, biofilm growth on both the annealed porous and annealed smooth aluminum samples will be analyzed via confocal microscopy.

17. Fitchburg, Massachusetts

How is the Growth of the Bacteria *Frankia alni* Affected by Microgravity?

Grade 10, Montachusett Regional Vocational Technical High School
Co-Principal Investigators: Camille Haas, Elizabeth Moylan
Co-Investigators: Abigail Floyd, Jacob Hollowell, Jason Martin
Teacher Facilitator: Paula deDiego

Proposal Summary:
Our project proposal is designed to answer one question: How is the growth of *Frankia alni* affected by microgravity? *F. alni* is a nitrogen-fixing bacterium that forms a symbiotic relationship with many actinorhizal plants. By inducing the formation of root nodules, it is able to provide all of the nitrogen requirements of the plant in environments where nitrogen is a limiting factor to the plant's growth. In addition, *F. alni* is one microbe that dwells within activated sludge in wastewater treatment plants. While the bacterium isn't harmful in controlled quantities, the excessive growth that tends to occur causes operational problems, hazardous working conditions, and effects on solid separation in wastewater treatment plants. In order to test the growth of *F. alni* in microgravity, we will be using a growth medium to instigate bacterial growth for fourteen days, before unclamping the protozoal growth inhibitor, Puromycin. The insight gained from conducting our experimental design will greatly increase our understanding of the growth of *F. alni* in microgravity, allowing us to take greater advantage of the benefits of *F. alni* in regards to the growth of valuable actinorhizal plants while minimizing the potential risks concerning wastewater treatment.

18. Redford, Michigan

Can Peppermint Seeds Germinate in Space?

Grade 8, Hilbert Middle School, Redford Union School District
Co-Principal Investigators: Destinee Chaney, Joseph Clark, Ethan Cuevas, Ada Mahar, Dontez Robison
Teacher Facilitator: Maureen Lemon

Proposal Summary:
In microgravity, astronauts' muscles will grow weak and we think peppermint will help them. Peppermint is a very useful plant. It helps indigestion, anxiety, muscle pain, stomach pain, headaches, and also helps coughs and colds. Also in space, peppermint, peppermint tea, and regular peppermint leaves can help keep astronauts' muscles healthy. Astronauts also suffer from depression and anxiety. Sometimes it is from the fact that they are in space, or because of not seeing their family. We thought of helping astronauts and learned that peppermint is good for depression, even by having a small garden people can become less lonely. We will take a test tube and have two clamps. Each section will have:

- Bottled spring water, 1.4 ml

- 5 organic Peppermint seeds and peat soil, 2.8 ml
- 10% neutral buffered formalin fixative, 2.8 ml

To perform this experiment on the ground, the only thing that would be different would be the gravity. This activity will examine how gravity may affect the growth of peppermint. If this projects works, it can help many people, including people living on Earth.

19. Traverse City, Michigan

The Growth of *Bacillus Subtilis* on a Substrata Material in Microgravity
Grade 9, Traverse City West Senior High School, Traverse City Area Public Schools
Co-Principal Investigators: Hattie Holmes, Langley Nelson
Co-Investigators: Kale Cerny, Lainey Wickman
Teacher Facilitator: Patrick Gillespie

Proposal Summary:
We are testing the effect that microgravity has on biofilm growth of *Bacillus Subtilis* on a substrata material. We will be measuring biofilm mass, thickness and architecture. Control experiments will be performed on Earth to replicate those performed on the International Space Station (ISS).

20. Kansas City, Missouri/Kansas

The Growth of Mint in Microgravity
Grades 7-8, Coronado Middle School, USD 500
Co-Principal Investigators: Uhunoma Amayo, DaQuon Cheadle, Jimenez Reyes, Daleshone Sharkey
Teacher Facilitator: Erin Henry

Proposal Summary:
We propose to answer the following question: Can mint successfully grow as well in space as it does on Earth? We want to see the growth process of mint in space. We would like to see this happen because we want to make life on the International Space Station more comfortable for the astronauts. Mint is a calming herb that has been used for thousands of years to help people with stomach problems (LD, 2017). Mint is very good for people's health. We also know that mint can help in other ways, such as reducing fevers and producing better cholesterol health. Mint is rich in nutrients and also helps gas and indigestion (LD, 2017). Mint is great for soothing sore throats when combined with tea. Mint can improve Irritable Bowel Syndrome and it has also been known to improve brain functioning (LD, 2017). Our hypothesis is based on the experiment where astronauts proved that crystals grow better in space, so we are conducting a similar experiment using mint. We believe that mint will grow as well in space as it does on Earth because we already know that mint can grow with little to no sunlight. We think that mint will grow better in microgravity.

21. Clark County, Nevada

Will Quinoa Grow in Microgravity?
Grade 5, J. Marlan Walker International School, Clark County School District
Co-Principal Investigators: Colin Brandel, Hunter Dodds, Spencer F., Roman Medina, Baron Petersen
Teacher Facilitator: Pam Locascio

Proposal Summary:
Our proposal question is "Will Quinoa Grow in Microgravity?" Quinoa (*Chenopodium quinoa*) is high in protein and nutrients. Quinoa is additionally high in fiber, phosphorus, magnesium, iron, potassium, calcium, B vitamins, vitamin E, and many other beneficial antioxidants. It is very full of protein, loaded with fiber, and has a lot of iron. Quinoa has a lot of riboflavin (B2). B2 can help with muscles and brain cells. This seed also will help prevent cardiovascular disease. Quinoa is gluten-free which will definitely help in a case where someone is gluten intolerant. There are many ways quinoa can be beneficial. If quinoa can be grown in microgravity, it would be an extremely healthy food for the astronauts to eat. In our experiment, we will be using the type 3 FME mini-lab with 10 quinoa seeds embedded in rockwool, spring water, fertilizer, and a liquid to stop the growth. We will be looking for a similarity between quinoa germination in space and germination down on Earth. We will compare how many seeds germinated.

22. Galloway, New Jersey – Stockton University

Analysis of Double-stranded Break Repair in Haploid *Saccharomyces cerevisiae* Under Spaceflight Conditions

Grades 13-16, Stockton University
Co-Principal Investigators: Matthew Elko, Joseph Romanowski, Daniel Stoyko
Teacher Facilitator: Dr. Michael Law

Proposal Summary:
With the advancement of space age, humans spend increasing amounts of time in spaceflight. To ensure their well-being, all health-risks associated with spaceflight conditions have to be studied in great detail. Arguably, the most concerning of such risks is DNA damage which may contribute to cancer. Double-strand breaks in DNA (DSB) are well known to be causes of chromosomal aberrations that result in carcinogenesis. One of the pathways responsible for the repair of such DSBs is non-homologous end joining (NHEJ). Although NHEJ generally prevents cancer, there is sufficient data suggesting that NHEJ is the cause of carcinogenesis in certain conditions. For this reason, it is important to study the mechanics of NHEJ under microgravity and space radiation (spaceflight conditions). This project will use type 3 FME NanoRacks mini-lab to expose actively dividing *Saccharomyces cerevisiae* to bleomycin, a DSB inducing agent, for two days. The experiment will then be stopped by fixation using a final concentration of 4% paraformaldehyde. Once the sample returns to Earth, DSB repair will be quantified using a combination of cytological and molecular assays that can measure unresolved DSBs. The data from these methods will provide information regarding rate of DSB repair, expression of NHEJ related genes, and rate of mutations induced by NHEJ in spaceflight compared to on Earth.

23. Ocean City, New Jersey

The Effect of Microgravity on the Hatch Rate and Development of *Artemia salina*

Grades 10-11, Ocean City High School, Ocean City School District
Co-Principal Investigators: Abigail Craige, Alexia Schmidt
Collaborators: Steven Myers, Madison Morgan
Teacher Facilitator: Catherine Georges

Proposal Summary:
Brine Shrimp, *Artemia salina*, have been found to be reliable subjects when experimenting in orbital space and microgravity. *A. salina* can be easily transported into space as a dormant cyst, and then reactivated by saltwater in space. It is theorized that *A. salina* can be an important link in a space-based food chain. Fecal waste produced by astronauts can be broken down and ingested by algae. The algae is then eaten by the *A. salina* which can then either be eaten by astronauts or a larger predator, like a fish. B.S. Spooner et al showed that the exoskeleton of *A.*

salina grows at a faster rate in a microgravity situation, but to the same size as on Earth. Therefore, we ask how many *A. salina*will be activated, what stage in their life cycle are they at and, the ratio between male and female *A. salina*. Upon arrival in the International Space Station, the *A. salina* cysts will be exposed to synthetic saltwater and will then hatch and grow. After twelve days, the experiment will be terminated with the application of a fixative, formalin. Formalin will kill the *A. salina* and stop any growth or decomposition, so the sample will be analyzed in the condition as terminated in space. The information collected in this experiment could be helpful to improve our knowledge of space-based food production for future extended space missions.

24. Springfield, New Jersey

***Triops longicaudatus* Growth and Development in Microgravity**
Grade 7, Florence M. Gaudineer School, Springfield Public School District
Co-Principal Investigators: Ava Fidalgo, Sarah Lumas, Miriam Pereira, Lakela Whitney
Teacher Facilitator: Alison Gillen

Proposal Summary:
Triops longicaudatus are aquatic crustaceans that live in small bodies of water. Their eggs can live without water for long periods of time. We would like to send *T. longicaudatus* eggs to the International Space Station to see if their eggs will hatch in microgravity and if they do hatch, how will they develop. *T. longicaudatus* eggs are easy to send to space because they are so small and are dormant for long periods of time. Once water is introduced, the eggs are activated and can start their growing process. Our plan is to put the *T. longicaudatus* in the type 3 FME mini lab with 2 clamps. Section 1 will have 10 *T. longicaudatus* eggs and 1 pellet Triops food to feed them once they start growing. The second section will have 5 ml of Poland Spring water that will be added once they reach space. The *T. longicaudatus* will have about a month to hatch and develop. Our expert told us that only a fraction of the eggs in each batch will hatch. We expect 20-25% of the eggs to hatch. The third section will have 1 ml of 10% Neutral Buffered Formalin to stop them from further development. Understanding how organisms develop and grow in microgravity will help us as we attempt to establish colonies in space. Dr. David E. Cowley says “Imagine if the secret of suspended development in Triops someday enables people to explore another solar system or galaxy!”

25. Jefferson County, New York

Rust Investigation
Grade 6, Harold T. Wiley School, Watertown City School District
Co-Principal Investigators: Ryan Arca-Steel, Agnika Ghatak, Alexander Higginbotham, Skyye Mee-Thomas, Mallary Williams
Teacher Facilitator: Ann Fillhart

Proposal Summary:
We propose to answer the question: Is rust removed faster under microgravity or on Earth? Rust can be anywhere, on cars, nails, or even structures. The more that our apparatuses rust the more we have to try things to remove rust. We need to know safe ways to remove rust in microgravity. In the FME, volume 1, we will pour distilled white vinegar. In volume 2, we will place a rusted screw. In volume 3, we will place distilled water. The distilled white vinegar will remove the rust from the screw. The distilled water will dilute the vinegar and slow down the rust removal process while the experiment is being shipped back to us. We will run this investigation on the ISS and on Earth. We will test the difference in the speed of how fast the rust is removed after the experiment by comparing the differences in weight of the two rusted screws. In the future, if mankind has to live in space, they will still need oxygen, which can cause items to rust.

This experiment will test how rust removal works in microgravity. If an important piece of machinery rusts everyone on board can be in danger. If we know how best to remove rust in microgravity, we can work our way to a safer future in space.

26. Suffolk County, New York

Effect Of Microgravity On Effectiveness On Probiotics
Grade 5, Birchwood Intermediate School, South Huntington School District
Co-Principal Investigators: Gianni Balanos, Jacianna Chiechi, Aguedo Romano, Christina Rosploch, Jancarlos Silva
Teacher Facilitator: Barbara Wright

Proposal Summary:
Our question is: How does microgravity affect probiotics? Our group has found out that astronauts get space sickness. Space sickness includes diarrhea and anything that is brought up from Earth. On Earth we have researched that probiotics kill bad bacteria in your stomach. We have read in our research that when you add probiotics to milk, they grow microorganisms. This is the same thing that happens when a person takes probiotics. We want to find out if shelf stable milk with Blue Biology Bluebiotics will make the probiotic grow microorganisms in space. Using the type 3 FME miniature laboratory, we will test what happens to milk when probiotics are added. We will have 5.0 ml of shelf stable milk (brand is Parmalat) in volume 1. In the middle volume (volume 2) we will have contents of one capsule of Blue Biology Bluebiotics Ultimate Care. This particular brand has a wide spectrum and is used for digestive health. In volume 3 we will have Isopropyl alcohol 91% (2.8 ml). On A=0 of arrival we would like clamp A to be removed and probiotics to be shaken gently with the milk. On A+2 of arrival we would like clamp B to be opened and shaken gently.

27. WNY STEM – Buffalo/Niagara, New York

The Effect of Microgravity on *Bacillus subtilis* on Subsequent Terrestrial Behavior
Grades 7-9, PS 198 @ 202 International Preparatory at Grover, Buffalo School District
Co-Principal Investigators: Alejandro Arrigo, Joanne Everett, Joy Elaine Everett, Solé Witt
Teacher Facilitator: Andrew Franz

Proposal Summary:
Bacillus subtilis is an extremely useful species of bacteria found in our digestive tracts, but used for industrial and medical chemical production. Whether humans do so willingly or not, this bacterium is coming to any place we venture in the universe. Our experiment, poses to study the behavior of this organism when tested on Earth after traveling in microgravity. When stressed, *B. subtilis* can form flagella, create antibiotics, or transfer DNA from one to another. When out of food, *B. subtilis* will form spores while waiting for more food to be present. We will see if these behaviors are present in the bacteria that have been active in space, a group that is dormant in space, and corresponding ground samples (one dormant and one active). This will give us insight to whether a *B. subtilis* can travel in space and remain useful on Earth. Differences in growth rate and genetic anomalies may hamper industrial use.

28. Hunter, North Dakota

Kefir Water
Grade 6, Northern Cass School, Northern Cass School District 97
Co-Principal Investigators: Trey Husar, Jacob Ose
Teacher Facilitator: Laurie Salander

Proposal Summary:
The question we are focusing on is whether kefir grains will grow in size in microgravity. We chose kefir because we learned that kefir is a healthy drink, which includes many microbes. Kefir grains are also reusable and feasible. If you are able to grow kefir on the space station then, we will be able to provide a very healthy drink for astronauts. Our experiment will include one of the mini labs. In our mini lab, we are going to include four kefir grains and sugar inside volume two of the tube and distilled water in volume one of the tube. On the interaction days, the experiment will be unclamped and shaken for 45 seconds to filter the water to interact with the kefir grains. The clamp will be re-clamped and sent back down to Earth.

29. Hershey, Pennsylvania – Milton Hershey School

Effects of Microgravity on the Growth of Algae Cysts and Lipid Production
Grades 9-10, Milton Hershey School
Co-Principal Investigators: Christian James, Logan Ford
Teacher Facilitator: Dr. Jaunine Fouché

Proposal Summary:
When in unfavorable conditions, algae forms lipids. In these conditions, the algae has the ability to turn on and off different genes. This is called epigenetics. We propose the following question: What is the effect that microgravity has on the growth of algae cysts and lipid production? Upon return to Earth, we will extract the lipids from the algae and compare it to the lipids produced by the algae in the ground truth experiments, a control experiment in the sunlight and a sister experiment done in the dark. We will then see if the algae that had been in microgravity will keep producing lipids at a higher rate. If they do keep producing lipids at a higher rate, then that may mean that the epigenetic genes that were turned on, because of the stress in microgravity, will have stayed active. This experiment could be ground breaking given that making biofuel would be simplified, because the amount of time to grow enough algae to produce lipid-based biofuel could be shortened. This would enable scientists to perfect the manufacturing of biofuel in a more effective way. We will use a Type 2 FME Mini-Lab. The lab will contain 50 microliters of algae, and seven milliliters of a 3% spring water and glucose solution. We will terminate the experiment with 2 milliliters of Fix-All fixative. We hypothesize that the algae from the microgravity environment will produce more lipids than the ground truth experiment.

The Effect of Microgravity on the Adhesion and Curing of Oil-based Artist Paint
Grade 12, Milton Hershey School
Co-Principal Investigators: Aliza Blackburn, Veronica Charyton, Hunter Shippee
Teacher Facilitator: Dr. Jaunine Fouché

Proposal Summary:
As technology continues to flourish and expand, it is no longer simply a science fiction idea that we will one day have humans living on other planets and in space. From a psychological standpoint, humans need more than just basic bodily care if we want to be both physically and mentally healthy. We need companionship, purpose, and entertainment — particularly artistic expression. Artistic expression is an often overlooked aspect of our human existence, and many see it as more of a luxury than a need. However, throughout history, expressing ourselves artistically, especially through the art of painting, has always been an essential component of a meaningful human life. This will not change when we go into space. Toward that end, we propose that it is important to research how oil-based paints are affected by the environment of microgravity. Our experiment will look at how oil-based paints are affected by microgravity and if they are still viable for use in a microgravity environment. Oil paints are created using a mixture of linseed or other plant-based oils and a pigment that will bond with the oil to create a range of

different shades and colors. Specifically, we are testing how well paint will adhere to and cure on different surfaces when in microgravity using wood, metal, and canvas as the three different materials.

30. Pittsburgh, Pennsylvania – University of Pittsburgh

Transcriptomic Analysis of *Escherichia coli* Response to Ciprofloxacin in Microgravity
Grade 16, University of Pittsburgh School of Pharmacy
Co-Principal Investigators: Mohamed Kashkoush, David Katz, Anu Patel
Teacher Facilitator: Christian Gauthier

Proposal Summary:
Antimicrobial resistance is a growing public health issue that has a global and even a universal effect. With the concurrently increasing frequency, duration and overall ambition of space exploration, it is important to approach the treatment of infections during spaceflight with confidence and precision. A closed, high-touch environment aboard the ISS and other space vessels, combined with increased bacterial virulence and human immunosuppression during spaceflight further highlight the importance of research into antimicrobial therapies under microgravity conditions. A troubling example of this infectious risk is highlighted from a 96-day spaceflight where a Russian cosmonaut became ill with a methicillin-resistant *Staphylococcus* infection after another cosmonaut was treated with ampicillin. Prior experiments have shown that bacteria undergo transcriptomic changes that result in accelerated growth and increased resistance when challenged with antibiotics in space. Building upon these principles, this proposal aims to determine the transcriptomic changes that occur in *Escherichia coli* with exposure to ciprofloxacin in microgravity. By analyzing the bacterial transcriptome, this project aims to further understand the mechanisms of microgravity-associated antimicrobial resistance. Specifically, this experiment will explore whether or not survival responses previously shown during spaceflight are antibiotic-specific or broadly attributable to other antibiotics. This will provide data towards constructing evidence-based guidelines for the treatment of infectious disease during spaceflight, as well as provide insight into mechanisms of antimicrobial resistance for drug development on Earth. In doing so, we can make space and Earth safer for all.

31. Knox County, Tennessee

How to Produce a Synthetic Soil from Waste Generated on Board ISS
Grades 10-11, Career Magnet Academy, Knox County Schools
Co-Principal Investigators: Scott Foster, Diamond Thomas
Co-Investigators: Isabella Beal, Elizabeth Randolph
Collaborators: Katelynn Horner, Hannah Shinzato
Teacher Facilitator: Cindy Brown

Proposal Summary:
We have selected the Blue Oyster mushroom as our decomposer organism due to its various properties. We intend to test this mushroom's ability to decompose a solid waste sample composed of "simulated" human waste, typical astronaut food scraps, and office–type wastes (Strayer, R., et. al. 2011). In the microgravity environment of ISS, we are interested in which waste components and how much sample mass can be affected by the mushroom's enzymes. By comparing the experimental waste sample with the Earth-based control, we will analyze the impact of microgravity on decomposition rate, hyphae growth, and quantity of decomposition residue. This information will provide valuable insights to optimize conversion of waste in a microgravity environment. The second stage of our experiment is designed to assess the agricultural potential of the experimental and control media (which we will refer to as soils) to

support crop production. To evaluate this potential, Microgreens have been selected for the germination and growth trials. The productivity of each soil will be determined by its crop production, expressed in terms of yield (grams biomass/grams soil). We expect to learn a great deal from the agricultural trials of our SSEP experiment. Data from these trials will provide possible future directions into extraterrestrial food production. We realize that that this initial microgravity experiment is a first step that is unlikely to produce for most Earth plants. It is our belief that with optimized decomposition systems and use of genetically engineered crop plants, sustainable food sources can be cultivated beyond Earth.

32. Burleson, Texas
The Effects of Microgravity on the Growth of Red Wiggler Earthworms
Grade 6, STEAM Middle School, Burleson Independent School District
Co-Principal Investigators: Ashlyn Johns, Sohan Islam, Carolyne Harvey, John Irons, Sara Gutierrez Cortazar
Teacher Facilitator: Alyssa Sanchez

Proposal Summary:
The question we propose to answer: Can a decomposer grow in microgravity? We are going to test to see if a decomposer can live outside of Earth's gravity. We are going to be using earthworms as our decomposer. This will determine if gravity affects the growth of the earthworm. Earthworms are crucial to the colonization of a planet due to being a decomposer. They improve nutrients of the soil and they remove the dead roots, grass, and biotic factors and break them down. The process of breaking down organic matter to improve the nutrients of the soil. Also, earthworms are able to "worm" their way in the ground to create air pockets. These air pockets are another benefit to the soil because it allows airflow for the fertility of the soil. We are proposing a study that compares the effect of microgravity on earthworms due to the exploration of other planets that will need decomposers due to the benefits they bring to the soil. The growth of earthworms on other planets and on the ISS, in microgravity, will be beneficial for humans that will be growing vegetation outside of Earth's gravitational influence. We are going to compare the size of the earthworms grown in microgravity to the earthworm grown in Earth's gravity. The growth size is a determining factor if earthworms are able to further space exploration and assist with the colonization of planets as decomposers are a critical part of an ecosystem.

33. Ector County, Texas
A Novel Way to Treat a Cancer with *C. sporogenes* in Microgravity
Grade 6, Nimitz Middle School, Ector County Independent School District
Co-Principal Investigators: Maryam Akram, Sydney Richardson
Co-Investigators: Eva Brower, Aidan Gomez, Maison Leet, Jean Machado Torres
Teacher Facilitators: Courtney Smith and Priscilla Torres

Proposal Summary:
Radiation in space causes cancer, especially colon cancer. We are sending an anaerobic, rod-shaped bacterium that produces oval subterminal endospores named *Clostridium sporogenes*. We chose *Clostridium sporogenes*because it has been used in colon cancer treatments. It is also not pathogenic, so it is safe to fly to the ISS. The aim of this study is to treat colon cancer in astronauts with a novel method when they get exposure of radiation in space. The way our experiment will work is first we will have 2 clamps on the tube. We are going to place both 20% formalin and *C. sporogenes*separately into a Type 3 FME Mini-Lab tube. Section 1 will carry *Clostridium sporogenes*, Section 2 will carry formalin, and Section 3 will carry another batch of *C. sporogenes*for control study. While in space, Clamp One will be removed after 48

hours, causing Sections 1 and 2 to mix and leaving Section 3 alone. This will cause the *C. sporogenes* that were in section 1 to fix and stop growing. Our end goal is to see how much the *C. sporogenes* changes in 48 hours versus the ones that will stay during entire trip. This experiment has a lot of potential because if this works we can use this information to treat people with other cancers while taking long voyages through space.

34. Klein, Texas
The Effect of Self-Assembled Monolayers on Microgravity Protein Crystallization
Grades 11-12, Klein High School, Klein Independent School District
Co-Principal Investigators: Yannie Guo, Max Hall-Brown, Michael Ji
Teacher Facilitator: Vicki Hermsdorf

Proposal Summary:
The proposal is an extension of previous research into protein crystallization, which has shown that microgravity and the presence of a self-assembled monolayer (SAM) can each independently improve the efficiency of protein crystallization. However, as no research has yet been done to demonstrate the combined effects of microgravity and SAMs, our research attempts to determine whether a treatment of both in conjunction will improve crystallization, as measured by crystal purity and size, even more than either factor would individually. If the experiment does result in improvement, this could have far-reaching impacts, ranging from medical treatment to biochemical research into the structure of biological compounds. For example, if the process can produce higher-quality lysozyme crystals, then it will also be able produce higher-quality insulin crystals, allowing a greater variety of diabetes research.

35. Marfa, Texas
Eradicating Bacteria Growth in Microgravity
Grades 4-6, Marfa Elementary School, Marfa Independent School District
Co-Principal Investigators: Charlotte Browning, Ashley Certain
Co-Investigators: Madison Cash, Daniela Fernandez, Colette Fowlkes, Mabel Melgaard
Teacher Facilitator: Cheri Aguero

Proposal Summary:
In the experiment, “Eradicating Bacteria Growth in Microgravity,” we would like to explore if bacteria commonly found in the ISS (*Bacillus subtilis*), are tougher in microgravity or on Earth. Our question is: “Will using isopropanol to eradicate bacteria work more completely in microgravity than in gravity?” We hypothesize that the isopropanol will work more completely in gravity. In order to find out what will happen in this situation we will add isopropanol to a known concentration of bacteria. We will sterilize, then prepare the FME with freeze dried bacteria on one end with a clamp. The center section will contain a media broth (tryptic soy broth). The last section will contain isopropanol. Once the FME is in space, the astronauts will open clamp A to rehydrate the freeze dried bacteria, shake for 15 seconds, then open Clamp B to release isopropanol onto the bacteria. When the FME returns to Earth, we will calculate the number of bacterial colonies by plating the bacteria from the tube. We will incubate the plates for 48 hours and carefully count the number of bacterial colonies and compare that number to the one gathered here on Earth.

36. Pharr, Texas

What are the Effects of Microgravity on the Cellular Growth of *Spinacia oleracea*?

Grade 11, PSJA Thomas Jefferson Early College High School T-STEM, Pharr-San Juan – Alamo ISD
Principal Investigator: Joahna Evasco
Co-Investigators: Nolberto Cortez, Rachel Martinez
Collaborator: Diego Tijerina
Teacher Facilitator: Roxanne Ruelas

Proposal Summary:
The proposal for this experiment is to determine how microgravity affects the growth of *Spinacia oleracea* seeds. Under normal growth, *Spinacia oleracea* responds to the external stimuli of gravity by resisting and growing in the opposing direction. *Spinacia oleracea*, in natural conditions has roots that grow towards the center of the Earth in the direction that gravity is pulling. What will happen to its cells if it is exposed to microgravity? Cellular chemical reactions are affected by gravity, this plays a key role on molecules that control cellular processes like growth and division (Tay, 2017). How will the cells respond towards a microgravity environment, what will the end result be on the anatomy of *Spinacia oleracea* cells, and what will the end result be for the whole experiment? The plan for this experiment is to use distilled water, felt, *Spinacia oleracea* seeds and Formalin. The experiment will require a Type 3 FME Mini-lab. Volume 1 will contain seven *Spinacia oleracea* seeds encased within cotton balls for the germination process. Volume 2 will contain 1.5 mL of distilled water. Volume 3 will contain Formalin to preserve and to stunt the growth of the *Spinacia oleracea*. When the experiment is completed, its cells will be observed to see any anatomical changes and root cells will be viewed under a microscope to see any changes of the cells compared to a regular *Spinacia oleracea*.

37. Raleigh County, West Virginia

Effects of Microgravity on the Growth of *Caulobacter Crescentus*

Grades 11-12, Shady Spring High School, Raleigh County School District
Teacher Facilitator: Elizabeth Hegele

Proposal Summary:
Caulobacter crescentus is a unique oligotrophic bacterium that produces an incredibly strong adhesive. This natural “super-glue” is being researched by material scientists in order to develop new technologies for medical and engineering purposes. An easily manufacturable adhesive could prove to be valuable in long-term space travel and colonization. The adhesive has biodegradable qualities, making it a candidate for the replacement of sutures and staples in surgery, and its strength could make it very useful in construction and engineering. The goal of our team’s experiment is to study the effects of microgravity on the growth of a colony of *Caulobacter crescentus* by activating the freeze-dried bacteria in orbit so the colony can grow, then using a preservative solution to stop the growth until its return to the community, where the results will be compared to a control experiment conducted on Earth. We believe that when the mass production of this bacterium-based glue becomes viable, our experiment will help provide a better understanding of how the bacteria growth changes within a microgravity environment, so that future technologies can be implemented into and produced within such an environment.

38. iFoward-Grantsburg, Wisconsin

What Happens to the Germination of *Solanum lycopersicum* 'Red Velvet' Seeds in Microgravity?

Grades 9-11, iForward Public Online Charter School, Grantsburg School District
Co-Principal Investigators: Sella Benzing, Jessica R. Ojeda-Barojas, Lily Olson, Holly Orth
Teacher Facilitator: Laura Kavajecz

Proposal Summary:
Our experiment will test the germination of *Solanum lycopersicum* 'Red Velvet' in microgravity. This variation of tomato is the popular food source, known as the cherry tomato, appreciated for its sweet taste and small size. The purpose of our experiment is to determine whether the *Solanum lycopersicum*'Red Velvet' seeds can germinate correctly in a microgravity environment. Our experiment will use a three chamber fluid mixture enclosure (FME) set up. Volume one will be filled with 2.0 milliliters of distilled water, the second volume will contain 2.8 milliliters of vermiculite and six *Solanum lycopersicum* 'Red Velvet' seeds, and the third chamber will contain 2.8 milliliters of 10% neutral buffered formalin. If *Solanum lycopersicum* can germinate in microgravity, this could result in a new plant for astronauts to grow in space and this could be especially helpful in missions that are a longer duration, which require more food, because this plant could potentially be grown successfully, during flight.