



SSEP Mission 21 to ISS: Selected Flight Experiments, Communities, Teams, and Abstracts

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A total of **441 proposals** were submitted from student teams across the 17 communities participating in Mission 21 to ISS. Of those **227 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 December 3-4, 2024, the Step 2 Review Board met via Zoom, reviewed all **58 finalist proposals**, and selected one proposed experiment to fly for each community, for a total of **17 flight experiments, which will fly on SpaceX-35**. It is noteworthy that the 441 proposals received reflected a total of **3,663 grade 5-16 students fully engaged in experiment design**.

1. Edmonton, Alberta, Canada

How Does Microgravity Affect the Oxidation of Copper in a Vinegar, Salt, Baking Soda, and Water Solution?

Grade 9, Parkview School, Edmonton Public Schools

Co-Principal Investigators: London Canterbury, Olivia Yu-Zhu

Investigators: Julian Brown, Joella Huang

Teacher Facilitator: Morgan McKinnon

Proposal Summary:

The experiment will test the effects of copper oxidation in microgravity using a mixture of vinegar, baking soda, water and salt to accelerate the process of oxidation. A piece of copper will be soaked within the solution, resulting in a form of oxidation (most likely patina). Weeks later, the piece of copper will be analyzed to determine how microgravity may have affected the growth, color, and texture of the patina. The copper wire within the mini-laboratory sent into orbit will be compared with the copper wire on Earth. This experiment is useful because many things in modern society use copper, especially in electrical conductivity and device construction. The goal for this experiment is to test the reliability of copper after a layer(s) of patina has developed, in terms of its strength and conductivity. Conducting this experiment will not only provide new insight of strength and conductivity for copper on Earth, but will also contribute to space machinery and electrical currents used in orbit, should any spacecraft in the near future consist more of copper than now. Advancements in orbit are slowly rising in demand, and knowing more strengths and weaknesses of certain materials allows for a better understanding of what should be used.

2. Mississippi Mills, Ontario, Canada

Would broccoli sprout faster in low gravity?

Grade 6, R. Tait McKenzie Public School, Upper Canada District School Board

Principal Investigator: Ellie McBride

Investigator: Ollie St.Louis
Teacher Facilitator: Laura Costello

Proposal Summary:

The purpose of the experiment is to determine if a broccoli seed (*Brassica oleracea* var. *Italica*) seed will sprout faster in low gravity. Conducting the experiment in low gravity and on Earth will help us understand if gravity plays a role in seed germination. This research is important because if scientists do not research the characteristics of seed they would have no idea how to grow it or understand the conditions for germination. It is also important because if we do not have the research, we cannot complete the experiment. Broccoli seeds will be helpful on the International Space Station because it has a short germination rate. A short germination rate is important because if a seed has a short germination rate, it will sprout faster, and produce more food and seeds. Broccoli is a good seed to grow because it is a nutrient dense vegetable.

3. Phoenix, Arizona

The Effect of Microgravity on the Growth and Structure of Covalent Organic Frameworks (COFs)

Grades 9-10, Paradise Valley High School, Paradise Valley Unified School District

Co-Principal Investigators: Vedika Kashyap, Victor Gomez

Investigators: Kyle Vo, Nikhil Karandikar, Sukrant Vaddi

Teacher Facilitator: Michelle Landreville

Proposal Summary:

This investigation will test whether microgravity improves the crystal/domain quality and functional performance of a water-grown covalent organic framework (COF), which is a porous crystalline material whose internal architecture can be tailored for separations and purification. COFs often present issues in their structure, such as irregular porosity and irregular crystalline structures, negatively impacting their functions. This experiment utilizes COF-LZU1 (a type of two-dimensional COF) by condensing an aldehyde and an amine building block in an aqueous solution with a mild acid catalyst at room temperature. The investigation will activate growth in microgravity and then stabilize the product for return. A matched Earth sample will isolate the microgravity effect. This proposal and experiment are motivated by the widespread utility of porous crystalline materials for separation and purification. If the environment of microgravity enables fewer defects and larger, more uniform domains, the same chemistry could yield COFs with improved flow and performance, directly relevant to air and water systems on both spacecraft and Earth. The investigation pre-registers these success criteria: detect characteristic COF reflections and imine linkages and evaluate how properties of the COF compare to the ground experiment within statistical confidence. The result will help define how microgravity influences aqueous imine-COF manufacturing and inform future materials development for spacecraft life support, terrestrial applications, and medical/biomedical applications.

4. Pasadena, California

The Effect of Microgravity on the Crystallogensis of Hen Egg White Lysozyme

Grades 13-15, Pasadena City Community College/AT3

Co-Principal Investigators: Abel Garcia Xelhua, Andrew Fox, Bryan David, Jared Smolinski, Raia Robotham, Syeda Akther

Teacher Facilitator: Jared Ashcroft

Proposal Summary:

The proposed spaceflight experiment will investigate how microgravity will affect the crystallization of the model protein Hen Egg White Lysozyme (HEWL). High-quality protein crystals are essential for determining the three-dimensional atomic structure of proteins, a cornerstone of modern structure-based drug design. On Earth, gravity-driven phenomena such

as convection and sedimentation disrupt the formation of crystal lattices, limiting both crystal size and quality. In this experiment, a purified HEWL solution will be mixed with a buffer. After a defined growth period, a chemical fixative will be introduced to preserve the crystals for postflight analysis. The primary objective is to qualitatively evaluate whether crystals grown in the diffusion-dominated microgravity environment of the ISS show improved size, morphological perfection, and internal order (mosaicity) compared to those grown in a 1 g ground control. It is anticipated that crystals grown in microgravity will exhibit superior structural integrity and internal order. Such results would provide high-fidelity validation of the SSEP mini-laboratory platform for crystallographic investigations and further support the scientific value of microgravity to advance protein crystallization along with pharmaceutical development on Earth.

5. Colorado Springs, Colorado

Space Climate Seeds: Investigating Osmotic Stress-Primed Germination in Microgravity

Grades 13-15, University of Colorado at Colorado Springs (UCCS) and Pikes Peak State College (PPSC)

Co-Principal Investigators: Daniel Elmore, Max Pehrson

Investigators: Anthony Januskiewicz, Jake Johnson, Samantha Rithchie

Teacher Facilitator: Emily Mooney, PhD

Proposal Summary:

This investigation explores the effects of a microgravity environment on the development of brine shrimp, *Artemia Salina*, nauplii. *Artemia Salina* produces cysts that undergo cryptobiosis, remaining in a dormant state until environmental conditions are suitable for hatching, making this organism ideal for a controlled biological experiment aboard the ISS. By sending *Artemia Salina* cysts to space, this experiment aims to evaluate the extent of microgravity's impact on this organism's early-stage development, focusing on the occurrence and likelihood of potential developmental anomalies. Understanding *Artemia Salina* growth in space is crucial, as it serves as a model for studying biological challenges and differences organisms may face during spaceflight. Because mankind's ambitions for long-term space missions necessitate sustainable biological systems for agriculture and aquaculture, any increase in birth defects or developmental delays would signal risks for potential organismic maturation in similar space environments – especially for *Artemia Salina*'s fellow brachiopods and aquatic life. Comparing the rate and types of birth defects with those seen in Earth-based controls will allow the analysis of specific developmental impacts of microgravity. Findings would advance scientific understanding of aquaculture and developmental biology in the context of space travel, contributing to the design of sustainable and practical life-support systems for long-term missions.

6. Melbourne, Florida

Effects of Microgravity on Neurodegeneration using Tauopathy Model

Grades 14-15, Florida Institute of Technology

Co-Principal Investigators: Cordelia Case, Kayla Conklin, Alexis Hopper, Jessica Watkins

Teacher Facilitator: Dr. Andrew G. Palmer

Proposal Summary:

As the duration of space travel begins rapidly lengthening due to technological advances, it becomes essential for the field of space medicine to understand the physiological effects of microgravity on neurological dysfunction. While neurodegenerative diseases are widely studied and established to be influenced by genetic factors, their pathophysiologies are not fully understood. Although microgravity has been found to alter gene expression, including in genes affecting neuromuscular degeneration, its effects on tau-related neurodegeneration have not yet been investigated. This proposal researches whether microgravity accelerates or mitigates the rate of neurodegeneration in the *Caenorhabditis elegans* (*C. elegans*) tauopathy model. Tau (tubulin-associated unit) is a microtubule-associated protein implicit in neuronal degradation. It

is essential in maintaining neurological function and stabilizing microtubule networks. Abnormal tau aggregation disrupts microtubule integrity and axonal transport, leading to neuronal degradation. Tauopathy-related diseases, such as Alzheimer's, are characterized by this aggregation of tau. *C. elegans* serve as a valuable model in neurogenetic research in space due to genetic manipulability, brood size, short lifespan, and well-characterized neurological physiology. Tauopathy is researched in *C. elegans* by transgenetically inserting the human MAPT gene. By comparing wild-type and tauopathy strain *C. elegans* in microgravity to their genetically identical cohorts raised on Earth, it is possible to determine whether microgravity accelerates or mediates tau-associated neurodegeneration. Results will address the aforementioned gap in research by identifying the interaction between tau pathology and microgravity, providing essential insight for developing neuroprotective strategies in space and advancing fundamental understanding of neurodegeneration.

7. St. Petersburg, Florida

The Effect of Microgravity on the Formation and Properties of Calcium Alginate Hydrogels

Grades 13-14, St. Petersburg College

Co-Principal Investigators: Eilya Yazdani, Nicholas Tsongranis, Vinicio Castillo

Teacher Facilitator: Dr. Grace Moore

Proposal Summary:

This experiment investigates how microgravity affects the formation and properties of Calcium Alginate Hydrogels formed from aqueous solutions of Sodium Alginate and Calcium Chloride. Under the influence of Earth's gravity, Calcium Alginate Hydrogels form due to ion diffusion and convection forces. However, under microgravity, convection forces are greatly reduced, leading to a distinct crosslinking structure and uniformity that potentially yields different material properties. This experiment compares hydrogel's properties such as density, electrical conductivity, UV radiation shielding, transparency, swelling ratio, water retention, and degradation rate of hydrogel samples formed in microgravity against Earth-based control samples, with gravity being the only variable. Understanding how gravity affects hydrogel's three-dimensional water-absorbing network and mechanical behavior provides valuable insight into biomedical and engineering applications of hydrogel in both terrestrial and space settings.

8. Tampa, Florida

Microgravity Effects on Chitosan Hydrogel Structure for Potential Wound-Care Applications

Grades 13, 15 and 16, University of South Florida

Principal Investigator: Krystal Walford

Investigators: Jaiden Brick, Olivia Bruhn, Jade Fei, Hannah Kirschenmann

Teacher Facilitator: Sylvia Thomas

Proposal Summary:

Wound healing presents a critical challenge in spaceflight, where access to conventional medical treatments is limited. Hydrogels are promising wound-care materials because they maintain moisture, protect damaged tissue, and can deliver therapeutic agents directly to the site of injury. Chitosan, a natural biopolymer derived from shellfish and insect exoskeletons, is biodegradable, biocompatible, and exhibits strong antibacterial activity. When cross-linked into a hydrogel network, chitosan forms a soft, adhesive matrix capable of accelerating tissue repair and preventing infection. On Earth, gravity influences how hydrogels settle and cross-link. In microgravity, these same processes may behave differently, potentially changing the gel's structure, strength, and water-retention ability. The proposed investigation will determine whether the absence of gravity results in a more uniform and stable chitosan hydrogel, which could enhance its performance for medical use. By forming and comparing chitosan hydrogels in microgravity and on Earth, this study aims to identify structural differences that reveal how

gravity affects polymer network formation. The results could improve the design of advanced wound-treatment materials for astronauts on long-duration missions and for patients on Earth. Understanding how microgravity alters chitosan hydrogel behavior will also contribute to the broader development of sustainable biomaterials for use in future space medicine and biomedical engineering applications.

9. New Orleans, Louisiana

Coacervate Protocells in Microgravity: Stability, Function, and Implications for the Origins of Life Beyond Earth

Grades 14-16, Tulane University

Co-Principal Investigators: Noa Aval, Brenden Findlay, Nam Joshua Nguyen

Teacher Facilitator: Noshir Pesika, PhD

Proposal Summary:

Previous studies suggest that life on Earth may have originated from simple protocells capable of compartmentalizing and supporting primitive biochemical reactions. Coacervates – liquid droplets formed by the phase separation of oppositely charged polymers – are the leading model as they concentrate nucleic acids and proteins, enhance reaction rates, and exhibit growth-like behavior. While extensively studied under Earth's gravity, the behavior of coacervates in microgravity has never directly been examined. This project will investigate the influence of microgravity on the formation, stability, and function of the coacervate model for protocells. We hypothesize that in microgravity coacervate formation will exhibit reduced coalescence, molecular cargo partitioning will be enhanced, and enzymatic activity within the droplets will be greater when compared to ground controls. By isolating the role of gravity on protocell formation and persistence, the study will provide insight into the plausibility of life beyond Earth and expand current earthly models of early prebiotic evolution. These results not only have implications in astrobiology but also inform the design of self-assembling biomaterials and future space biomanufacturing technologies.

10. Lowell, Massachusetts

Aging and Coarsening of Milk-Protein Micelles

Grade 14, University of Massachusetts Lowell

Co-Principal Investigators: Need permission to post names

Teacher Facilitator: Supriya Chakrabarti

Proposal Summary:

This experiment investigates how microgravity affects the stability and aggregation behavior of milk-protein colloids, focusing on casein micelles that determine the texture and structure of dairy products. On Earth, these micelles gradually separate through creaming and sedimentation due to gravity, which accelerates aggregation and leads to nonuniform textures. In microgravity, those processes are suppressed, allowing the study of how micelles age and coarsen when particle motion is governed only by diffusion and intermolecular forces. A Type 3 Fluids Mixing Enclosure (FME) will be used, with compartments containing a casein suspension, a phosphate buffer to stabilize pH, and an ethanol fixative to halt aggregation. The astronaut will sequentially mix these components to initiate and preserve micelle evolution. Upon return, particle size, turbidity, and texture will be analyzed and compared to ground-based controls. The results will reveal how the absence of gravity alters colloidal aging, providing insights relevant to both soft-matter science and the development of stable dairy-based foods for future space missions.

11. Omaha, Nebraska

Neutron Radiation Detection via Bubble Neutron Dosimeter Near Solar Maximum

Grade 14, Metropolitan Community College

Co-Principal Investigators: Eric Tomjack, Nikoli Vanosdall

Collaborator: Alvaro Gonzalez-Cruz
Teacher Facilitator: Kendra Sibbersen

Proposal Summary:

The investigation aims to discover how much neutron radiation is present aboard the International Space Station (ISS) payload area during high solar activity near solar maximum. Higher solar activity could potentially lead to greater exposure of neutron radiation, thus affecting future SSEP missions, astronauts, and equipment aboard. Through the usage of bubble neutron dosimeters, the investigation will collect retainable data during the flight experiment. This data is pertinent to the understanding of the amount of neutron radiation future SSEP missions, astronauts, and equipment are exposed to during an active solar cycle period.

12. Albany, New York

The effects of microgravity on red maple tree seed germination

Grade 8, William S Hackett Middle School, Albany City School District

Co-Principal Investigators: Need permission to post names

Teacher Facilitator: Craig Ascher

Proposal Summary:

This experiment aims to determine whether germinating red maple trees in a microgravity environment is more effective than on Earth. This experiment aims to demonstrate how seeds adapt to new environments. In the long term, this experiment could help with deforestation issues with new and more effective ways to grow trees. The hypothesis for the experiment is that if there is a red maple tree in microgravity and on the ISS, then it will germinate at a faster rate than it would on Earth. On both Earth and on the ISS, there will be 4 red maple tree seeds in one section that will be divided by one clip. In the second section, there will be 3 milliliters of water that will slowly be added whenever the astronauts can interact with it in space. In the third compartment, there will be formalin to stop the growth and preserve it. So once it arrives back, both can be compared and analyzed. This will help future long-term space missions when astronauts will need to grow their own food and produce oxygen.

13. Asheville, North Carolina

How are lubricating oils affected by microgravity?

Grade Undergraduate, Asheville Buncombe Technical Community College

Principal Investigator: Curtis Epley

Investigators: Need permission to post names

Teacher Facilitator: Shannon T. Bonomi

Proposal Summary:

The experiment will involve sending various lubricating oils into a microgravity environment to observe how their properties are affected. A control sample will remain on Earth to serve as a baseline for comparison. The knowledge gained will help determine what lubricating greases are most suitable for flight and sustained operation in microgravity.

14. Athens, Ohio

Examining the Effect of Microgravity on the Metabolism of the Antihistamine Promethazine HCl, using *Caenorhabditis elegans* as a Model

Grades 13-14, Ohio University

Co-Principal Investigators: Elliana Naso, Ja'Laura Morris, Tiffany Carter, Makenna Brown

Teacher Facilitator: Emma Canaday

Proposal Summary:

Microgravity causes many health concerns for astronauts, including space motion sickness (SMS), which causes nausea and dizziness. As space aeronautics advances, and with growing

interest in expanding space exploration, it becomes increasingly important to ensure astronaut health. Promethazine hydrochloride (HCl), an antihistamine, is currently used to treat SMS, but its pharmacokinetics in microgravity are not fully understood. This experiment is examining how promethazine HCl is metabolized in microgravity through the model organism *Caenorhabditis elegans* (*C. elegans*). As a result of their previous uses in both drug testing and space related experiments, *C. elegans* are the ideal subject for the proposed experiment. The specimens will be transported as dauers, which will permit them to survive longer under the SSEP's experimental constraints. The initiation of the experiment will involve the specimens' release into a larger compartment containing *C. elegans* maintenance medium (CeMM) and promethazine HCl. To end the experiment, formalin will be released into the other compartments, killing the *C. elegans* whilst maintaining their metabolic reaction to the medication. Using metabolomics via high pressure liquid chromatography (HPLC), metabolites of promethazine HCl from the media and the *C. elegans* will be analyzed in comparison with the control samples. The hypothesis of this experiment posits that the quantity of metabolites from the media and the *C. elegans* will decrease in spaceflight as compared to on Earth. The results of this study aim to deepen the understanding of promethazine HCl's potential effects on future deep-space missions, and the overall efficacy of drugs in spaceflight.

15. Pittsburgh, Pennsylvania - CCAC

Evaluating the Effect of Microgravity on Insulin Activity and Glucose Regulation Post-Flight

Grades 13-14, Community College of Allegheny County

Principal Investigator: Need permission to post names

Investigator: Need permission to post names

Teacher Facilitator: Francis Cartieri

Proposal Summary:

This experiment examines whether exposure to microgravity alters the structure or activity of the protein hormone insulin. Insulin is essential for controlling blood-glucose levels in the body, and astronauts must rely on stored medications during missions. The microgravity environment, along with radiation and vibration, could change how insulin molecules fold or function over time. We will use a Type 3 Rhodium Fluid Experiment Tube (RhFET-01) that separates insulin, glucose solution, and a fixative. At A+2, the astronaut will mix the first two chambers to simulate insulin interacting with glucose under space conditions. At U-5, the second valve will be opened to introduce the fixative and stop the reaction. The same procedure will be carried out on Earth at 1 g for comparison. By studying changes in glucose concentration and protein structure after flight, we hope to learn whether microgravity affects insulin's ability to regulate sugar levels. This research can help prepare for future human missions that require long-term medication storage.

16. San Antonio, Texas

The Effects of Microgravity On the Growth of Stems and Roots in Length and Direction of Rye Plants

Grade 7, Space and Engineering Technologies Academy (SETA) at Krueger Middle School, North East ISD

Principal Investigator: Miah Stepanenko-Riccio

Investigators: Anjail Penaflor, Andrew De Marigny

Teacher Facilitator: Kameron Sakaguchi

Proposal Summary:

The experiment will study the growth in length and direction of stems and roots of Rye Plants (*Secale Cereale*) in microgravity. In summary, the experiment will test if microgravity changes the way rye seed's stems and roots grow. The reason for this experiment is to learn more about how plants grow in space and, if possible, to see if future astronauts could potentially grow produce in space. If the experiment determines that growth in space is possible, it could make

way for future research and help us understand more about plant life in space.

17. iForward-Grantsburg, Wisconsin

The germination and growth of lentil sprouts in microgravity

Grade 7, iForward Public Online Charter School, Grantsburg School District

Co-Principal Investigators: Allan Jackson, D'Symer Jackson, Leana Lamphere, Moses Packard, Kegan Wilmar

Collaborators: Alivia Basler, Alivia Radke

Teacher Facilitator: Joie Berg, B.S. Ed.

Proposal Summary:

This proposal discusses the analysis of growing lentil sprouts in microgravity. Lentil sprouts would provide many beneficial minerals and vitamins, positively impacting the astronaut's health. It has been proven that plants can acclimate to space and develop a different growth pattern, making them more nutritious for astronauts. This knowledge helps to demonstrate that plants can grow quite well in space. The research team aims to compare the size and root length of lentil sprouts grown in microgravity with those grown on Earth. The research team is using a Rhodium Fluid Experiment Tube (RhFET-01) Mini-Laboratory Configuration. In volume 1, there will be 3mL of water. In volume 2, there will be 2 mL of soil with 4 lentil seeds. Then, finally, in volume three, 3 ml of formalin. To start this experiment, the astronauts will open Valve A and gently shake the tube for 20 seconds. Next, they would have to wait. The experiment would have a better chance if left alone until the end of the experiment. To finally stop the experiment, they would open valve B, introducing the formalin into the mixture, and gently shake it to mix, then stop the experiment. The research team hypothesizes that due to the lack of sunlight, the lentil sprouts grown in microgravity will be smaller compared to those grown on Earth.

The Student Spaceflight Experiments Program [or SSEP] is a program of the National Center for Earth and Space Science Education (NCSSE) in the U.S. and the Arthur C. Clarke Institute for Space Education internationally. It is enabled through a strategic collaboration with Rhodium Scientific, America's first commercial space biotech and mission Spaceflight Implementation Partner, ISS Commercial Service Provider, working with NASA through a CASIS Agreement to utilize its facilities aboard the International Space Station for this mission. SSEP is the first pre-college STEM education program that is both a U.S. national initiative and implemented as an on-orbit commercial space endeavor.