Launching a Space Biology Research Program at JMU

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Project Budget:

$15,000

Abstract:

Understanding the effects of spaceflight in humans is essential for astronauts' health and the feasibility of long-term spaceflight missions. Astronauts in microgravity experience a wide variety of health-related challenges associated with redistribution of body fluids and the unloading of weight from bones and muscles, including bone loss. However, a better understanding of the molecular mechanisms that cause bone loss in microgravity is still needed and will be essential to develop more advanced methods to counter these effects in space. As such, my goal is to launch and establish a novel space biology research program at JMU focusing on bone biology. This will allow JMU students to perform novel and independent research projects in the field of space biology, significantly contributing to the space biology scientific community and gaining a breath of experience in the space-related field that will open new future career directions and opportunities.

Project:

Space travel has captivated and united humankind since its inception in 1957. NASA's achievements during the Apollo and space shuttle programs were unparalleled. Now, new challenges arise with the Artemis program missions to the moon and long-term space travel to Mars. Remarkably and very recently, Artemis 1 moon rocket successfully launched from NASA's Kennedy Space Center and completed its mission.

While the possibilities are endless, so are the challenges! My goal is to launch and establish a novel space biology research program at JMU, which I believe is an important step for multiple reasons:

1. Research and development is a way to offer new solutions to humanity's challenges.
2. JMU students can bring novel creative perspectives to current spaceflight challenges and contribute to the solutions by leading independent research projects with a focus in space biology.

3. JMU students at large will be exposed to a novel field of research focused on space biology by directly participating in the projects and by attending local conferences (such as the Biosymposium), workshops, and short presentations.
4. The field and knowledge related to spaceflight biology will be normalized to the JMU community (including students, faculty, staff and the Harrisonburg-area community) by participation in short presentations, open houses from the Biology Department and College of Science and Mathematics and workshops (such as madiSTEM, an annual one-day STEM conference designed for students in grades 6 to 8) where we will share the research program, results from ongoing projects, and space related-topics and experiments.

Astronauts in microgravity experience a wide-variety of health-related challenges directly associated with the lack of gravity, for example the redistribution of body fluids away from the extremities, resulting in puffiness in the face during flight and changes in the heart physiology, and the unloading of weight from bones and muscles. As a result, astronauts experience motion sickness, heart-related problems, muscle atrophy, loss of bone mass, among others. At the International Space Station (ISS), astronauts exercise approximately two hours a day to counteract these challenges. However, in longer term space missions these countermeasures will likely not be enough, and novel solutions are urgently needed.

For reference, a realistic mission to Mars will take 12-20 months round-trip, including 1 or 16 month period on Mars that allows the planets to be correctly positioned for the trip back. Of importance to my proposal, astronaut's bone loss occurs during and after spaceflight and causes a condition called *disuse osteoporosis,* which may lead to bone fracture and incapacitation during or after long-term spaceflight missions.

My laboratory at JMU currently investigates human bone formation and ectopic bone formation after injury. So we are competitively positioned to focus on space biology research questions related to bone loss under microgravity conditions. Simulated microgravity provides a unique opportunity to investigate bone differentiation in a way that it cannot be studied using standard cell culture systems. This is a unique aspect that is crucial to the launching of a space biology research program. For example, bone marrow mesenchymal stem cells that can differentiate into bone cultured in microgravity at the ISS for approximately two weeks had a 50% reduction in calcification inflight compared to ground control cells (Bradamante et al., 2018). We aim to expand on these findings by establishing and optimizing culture conditions from bone marrow mesenchymal stem cells cultured in simulated microgravity.

We currently use these cells in our laboratory in other bone-related projects led by our undergraduate and graduate students. Once our culture conditions are established, we can use the system to analyze genes and proteins of interest and observe the effects of microgravity on the cells. In addition, we aim to analyze publicly available gene expression datasets, focusing on experiments involving bone-related cells cultured in microgravity at the ISS compared to controls, such as ground-based simulated microgravity or ground control without microgravity.

Overall, my goals are to establish a space biology research program at JMU with a focus on microgravity's effects on bone health and to educate/mentor students in space biology through direct supervision of research projects, journal club paper discussions, and participation in scientific conferences. I strongly believe that exposing students to this novel area of research that blends cell, molecular and space biology will 'open the doors' for new career directions and opportunities, such as research positions at universities/government agencies/companies, and entrepreneurship by creating start-up companies that understand the challenges and opportunities of the space biology field. Finally, I hope that this research will significantly contribute to a better understanding of bone maintenance and health, the prevention and/or treatment of disuse and age-related osteoporosis and, ultimately, support long-term human space travel.

Project Budget Amount:	**$15,000**
Equipment:	$6,000
Supplies/Materials:	$9,000

Additional information to explain or expand on budgetary needs:

Equipment: The requested funds are needed to purchase a clinostat equipment to culture cells in simulated microgravity. This is a critical piece of equipment that constantly rotates the cells in culture to eliminate the effects of gravity and simulate microgravity.

Supplies and Materials: The requested funds are needed to purchase reagents to perform cell culture and molecular biology experiments. Our goal is to measure gene and protein expression changes associated with simulated microgravity. To investigate that we will culture cells in simulated microgravity and in normal culture conditions (with gravity). As such, we will need laboratory reagents that include cell culture media and supplements to culture cells, cell culture flasks, and reagents needed to extract RNA and protein as well as perform gene and protein expression analyses.