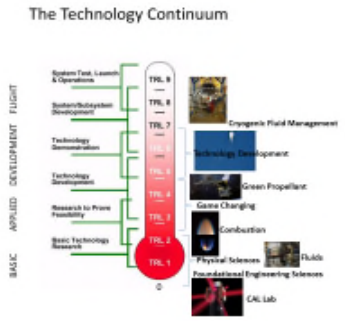
American Society for Gravitational and Space Research
Biological and Physical Sciences Bridging Earth and Space
www.asgsr.org

Spring 2020 - U.S. Research in Microgravity and Gravitational Research: Ground, Low Earth Orbit and Beyond

The next step in human spaceflight is return to the moon and on to Mars. Humans have not ventured beyond the Van Allen belts in decades. In order to prepare for extended human missions beyond Low Earth Orbit (LEO) much still needs to be done. New technology affords opportunities for research and scientific discovery enabling humans to move deeper into space safely. Using microgravity platforms in low Earth orbit, such as the International Space Station the lunar gateway leverage our national ability to surmount a wide range of complex and difficult biomedical, physical science, and engineering-related challenges***. Strategic, productive and uninterrupted commitment to research by the U.S. government are critical to exploiting the space environment for advancing U.S. science and innovation agendas.***

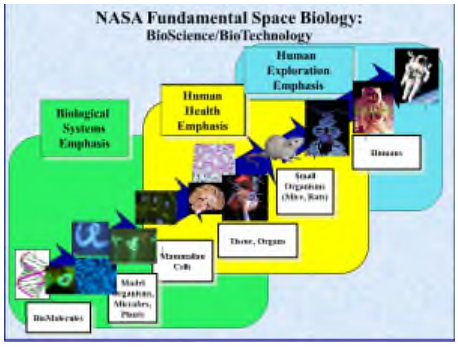
Importance of Microgravity Research in Biology and Physical Sciences

This basic microgravity research in biology and physical sciences is the pipeline into innovative biology and technology breakthroughs.



Fluids - There are four factors that influence the behavior of liquids and gas in a microgravity environment: 1）"Absence of buoyancy and sedimentation", 2）"Absence of convection", 3）"Absence of hydrostatic pressure" and 4）"containerless float". These phenomena nullify what generally are considered as natural phenomena on Earth. In addition, phenomena, which are hidden by the gravitational effects, would show themselves quite clearly in the microgravity environment. If these gravitational forces that pulls everything downwards on Earth are negated in microgravity, then these phenomena can be observed more clearly in space.

Example – The Zero Boil Off Tank (ZBoT) measures fluid behavior in microgravity. Cryogenic fluid stowage and transfer are a challenge both in space and on Earth. Rocket fuel, spacecraft heating and cooling systems, and sensitive scientific instruments rely on very cold cryogenic fluids. ... Zero Boil-Off Tank (**ZBOT**) uses an experimental fluid to test active heat removal and forced jet mixing as alternative means for controlling tank pressure for volatile fluids. Comprehensive ground based and microgravity tests are conducted to study the effects of heat flux, fill level, and mixing on thermal stratification, pressurization and pressure control. Data from these experiments are used to refine computational fluid dynamics (CFD) models which are used by NASA (refueling Artemis), SpaceX, Boeing, Lockheed Martin as well as other aerospace industry.



Plants - Normally, **plant** roots **grow** downward, where it's easy for them to soak up water and nutrients that make their way into the soil. In **space**, roots **grow** in every direction, and water and other essential **plant** foods float. Research with plants in space is dedicated to systematic studies that explore the role gravity plays at all stages in the life of higher plants. Research focuses on the interaction of gravity and other environmental factors with plant systems, and uses hypergravity, simulated hypogravity, and microgravity as tools to advance fundamental knowledge of plant biology. Results of the research contribute efforts to further human exploration of space and to improve the quality of life on Earth through applications in medicine, agriculture, biotechnology and environmental management.

Example – Studies are taking place researching how plants can be enhanced for use in space exploration. As humans explore space plants will be critical for keeping astronauts healthy on long-duration missions. A lack of vitamin C was all it took to give sailors scurvy, and vitamin deficiencies can cause a number of other health problems. Simply packing some multi-vitamins will not be enough to keep astronauts healthy as they explore deep space. They will need fresh produce. Astronauts receive regular shipments of a wide variety of freeze-dried and prepackaged meals to cover their dietary needs. When crews venture further into space, traveling for months or years without resupply shipments, the vitamins in prepackaged form break down over time, which presents a problem for

astronaut health. Plant research is looking at ways to provide astronauts with nutrients in a long-lasting, easily absorbed form—freshly grown fresh fruits and vegetables. The challenge is how to do that in a closed environment without sunlight or Earth's gravity. This research also has applications in vitamin enrichment of plants on Earth potentially.

Who Conducts the Research? Research Grants throughout the U.S.

Partnerships – Intra- and inter-agency partnerships in work or in discussions – a few examples

- 3-d tissue modeling (NIH/NASA)
- Fluids physics –(NSF/NASA)
- Dusty plasma – (NSF/NASA)
- Cold Atom Lab – talks with Army Research Office
- Joint solicitation on plant research in controlled environments with NIFA (NASA/USDA) in discussion
- Tissue chips (NASA (Human Research Program, Space Biology, Translational Research Institute)/NIH (potential))

2004 NASA OBPR Budget (Biology & Physical Sciences)	**2012-2020 NASA Biology & Physical Sciences**
$512 (2004 $) $678 (2020 $)	~ 81M/year

WHAT IS NEEDED?

- An integrated national strategy on space life and physical sciences microgravity research
- Whitepaper on benefits of inter-agency collaboration
- Slight increase in funding; NASA and other federal agencies in this research. funding has been flat for at least the last eight years; physical sciences has not announced a research solicitation in several years due to using budget for hardware build

Summary:

Microgravity research is a continuum of efforts that extend from laboratories and analog environments on the ground, through other low-gravity platforms like parabolic aircraft and suborbital rockets, and into extended-duration spaceflight. Research on the ISS is a component of this continuum, and the capabilities it provides are essential to addressing many of the most important research questions identified by the National Academies. However, similar to other sciences such as astrophysics, gravitational research is platform agnostic, and should be aligned to address fundamental and applied research themes that benefit from this type of research research.

About the Organization

The American Society for Gravitational and Space Research (ASGSR), founded in 1984, provides a forum to foster research, education and professional development in the multidisciplinary fields of gravitational research. ASGSR brings together a diverse group of scientists, engineers and students from academia, government and industry to promote research, education, training and development in the areas of Space Life and Physical Sciences research. The knowledge gained leads to a better understanding of the effects of gravity on living and physical systems on Earth and enables human space exploration. The society's mission is "to inspire, educate, and advocate" for this research. www.asgsr.org

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