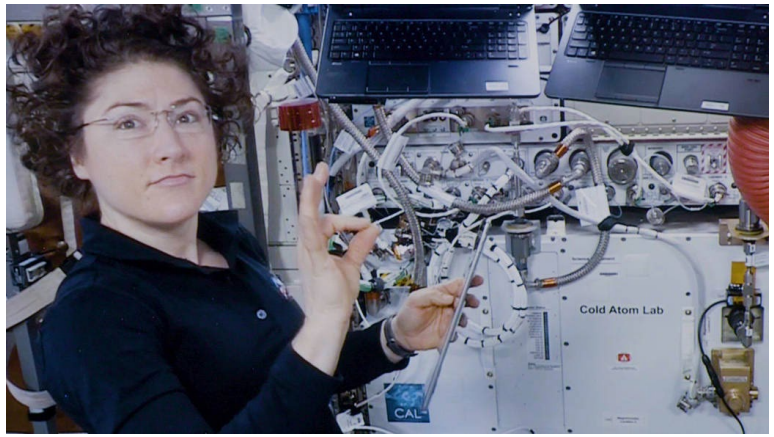
National Aeronautics and Space Administration

EXPLORE SCIENCE

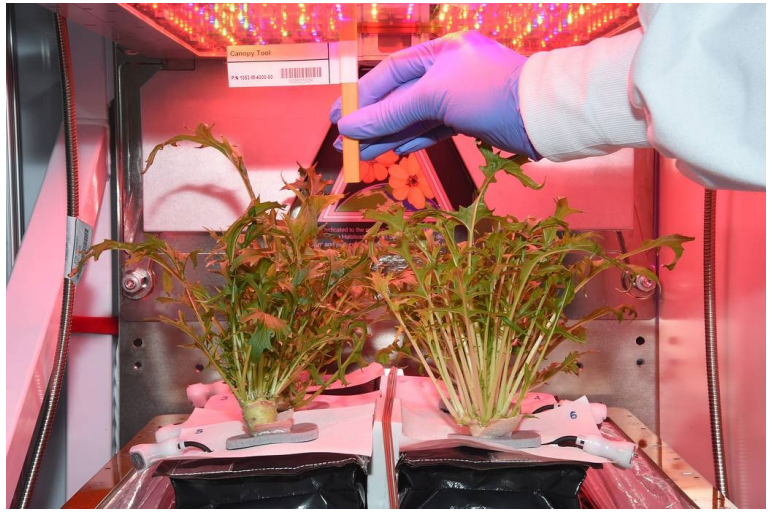
Biological and Physical Sciences (BPS)

Craig Kundrot, Director
Diane Malarik, Deputy Director

October 19, 2020



Example of Physical Sciences research: Studying quantum gasses



Example of Space Biology research: Growing plants in space

What We Do

We use spaceflight environments to **study biological and physical systems**.

Examining phenomena under extreme conditions can **help us better understand how they function**.

This can contribute to significant scientific and technological advancements that **enable space exploration and benefit life on Earth.**

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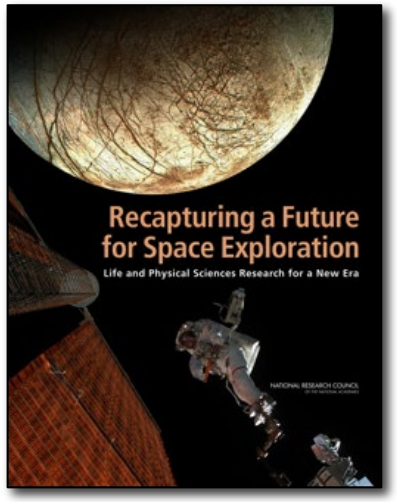
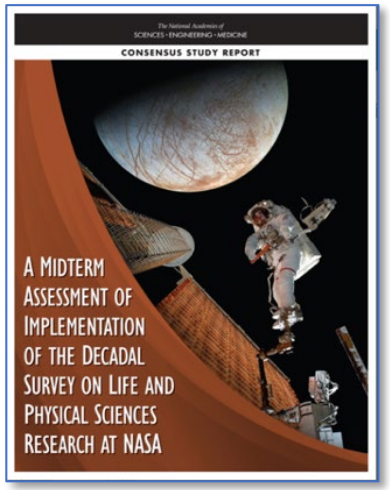
BPS Mission & Goals



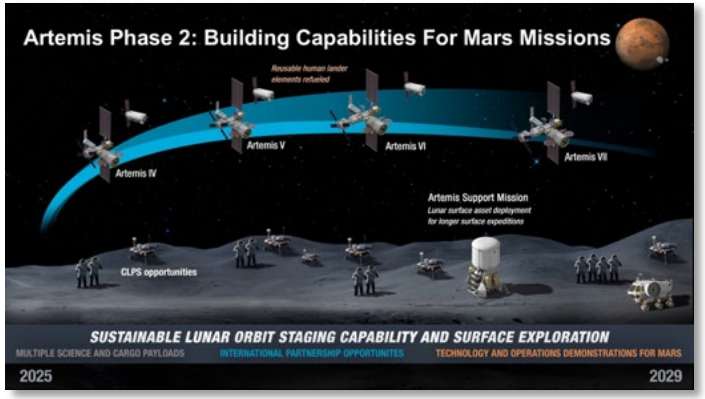
Decadal Survey



Midterm Assessment

Pioneer Scientific Discovery

- Proactively seek out new ways to expand fundamental scientific knowledge
- Provide expertise and support to others seeking to utilize space



Artemis Missions

Enable Exploration

- Anticipate and investigate critical areas for scientific knowledge and technology development
- Deliver results to STMD and HEOMD
  - *And SMD?*

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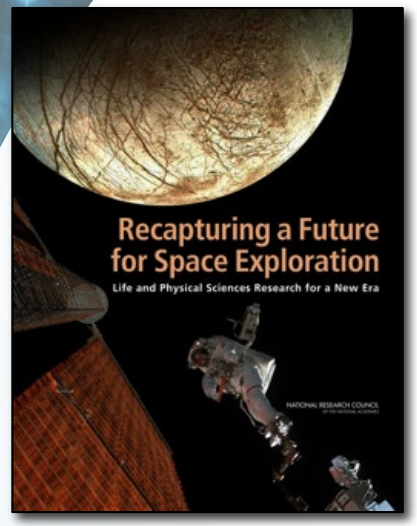
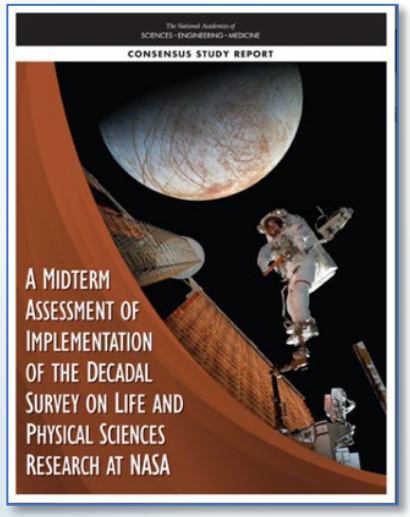
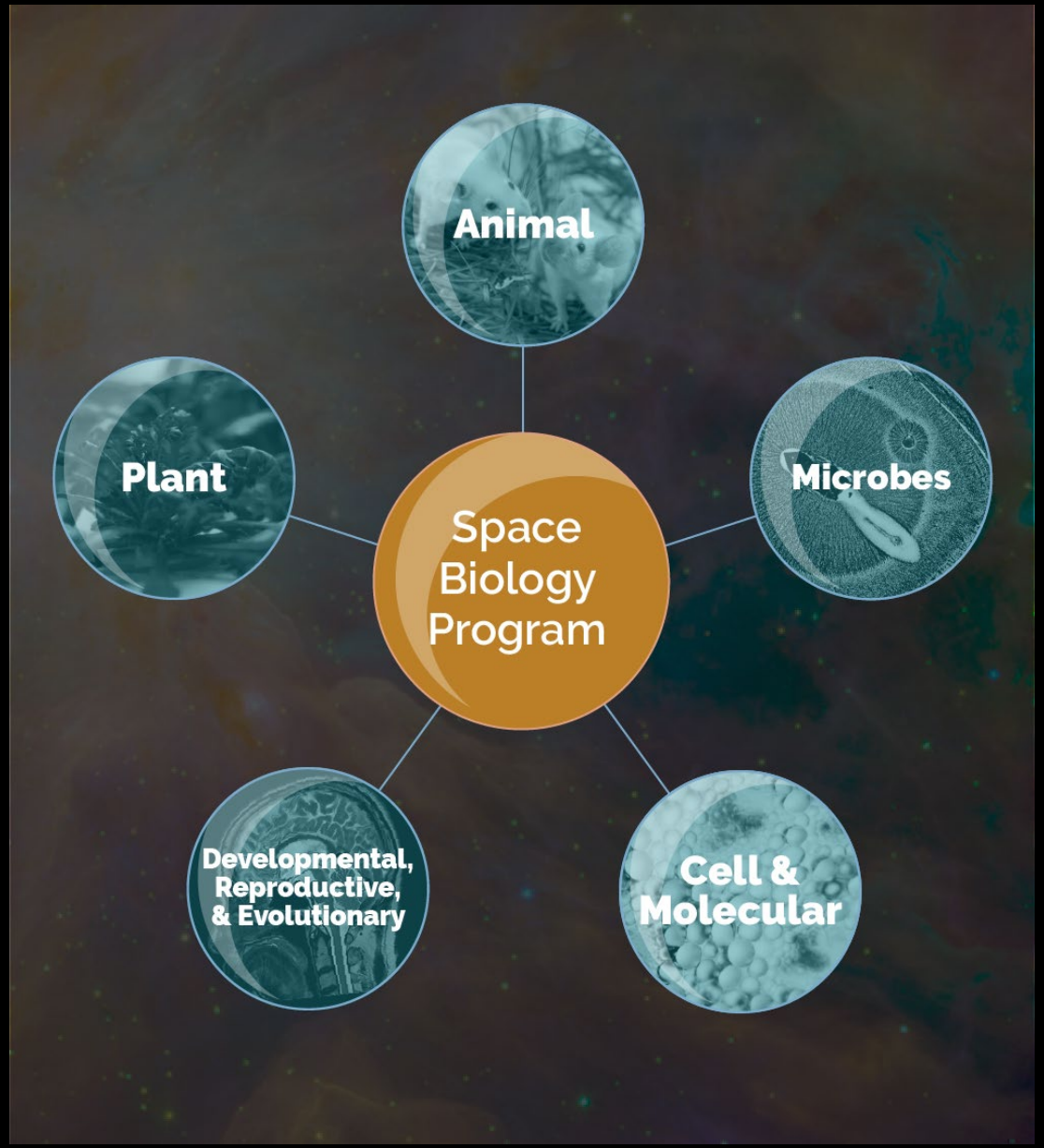




Decadal Survey

- 2011: Decadal Survey on Life and Physical Science Research at NASA
  - First decadal survey for these disciplines
  - 30+ year foundation of on-going research
    - 1970 In OMSF, OSSA and OART
    - 1992 OLMSA
    - 2000 OBPR
    - 2005 In ESMD
    - 2012: Prompted formation of HEOMD/SLPSRA
- 2017: Midterm Assessment of Implementation
- 2020: Biological and Physical Sciences moves to SMD
- Today:
  - Statement of Task for next Decadal Survey approved
  - Start late 2020 or early 2021

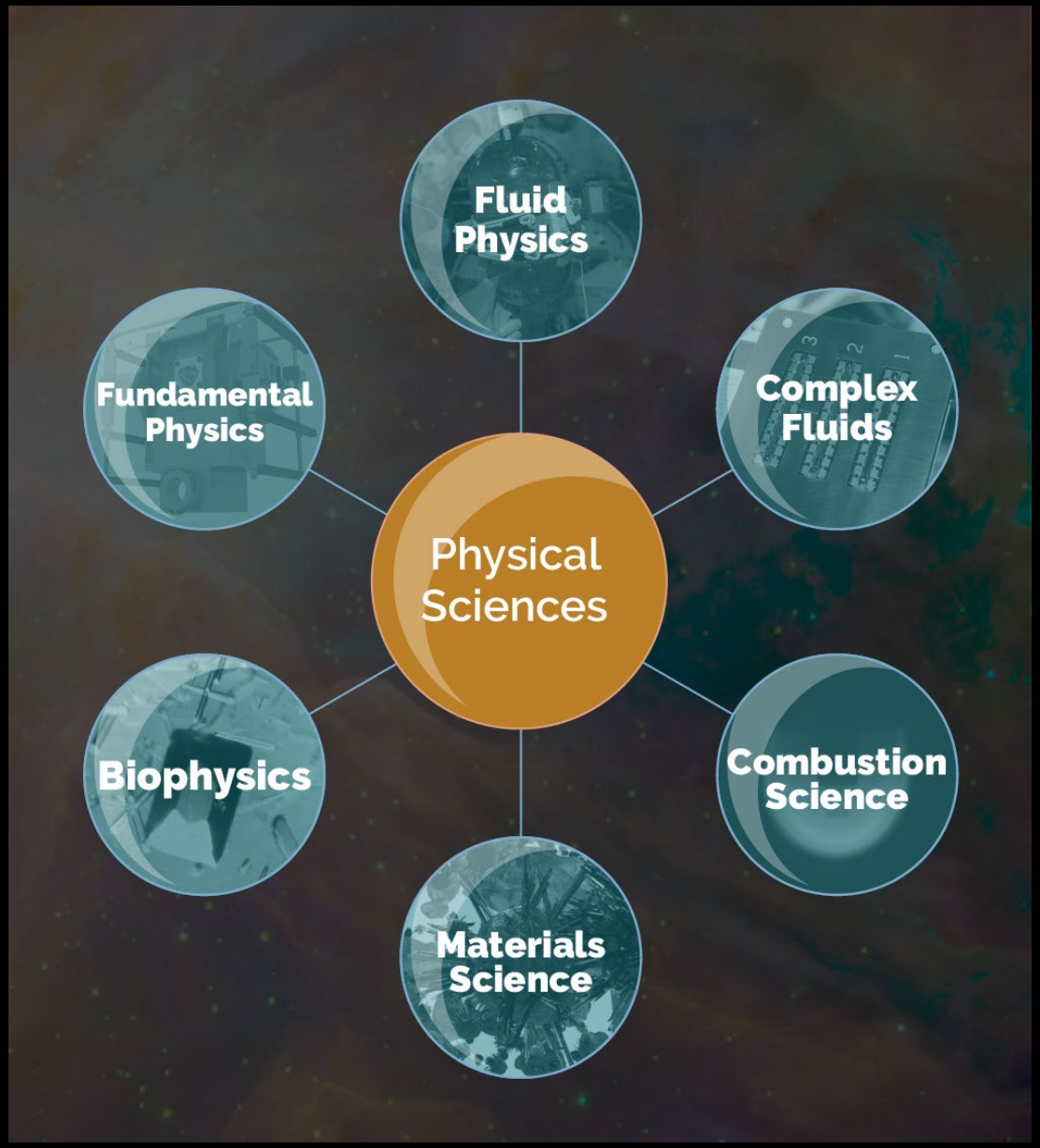


Objectives

- Discover how biological systems **respond** to the space environment
- Identify the underlying **mechanisms** and develop physiological models for biological systems in space
- Developing cutting-edge biological **technologies** to facilitate spaceflight research
- Promote **open science** through the GeneLab Data System and Life Science Data Archive
- Provide mechanistic understanding to support human **health in space**
- Support the transfer of knowledge and technology of space-based research to the understanding of life on Earth to **benefit life on Earth**

Databases and Biospecimen Sharing

- GeneLab (genelab.nasa.gov)
- Life Sciences Database Archive (lsda.nasa.gov)



Objectives

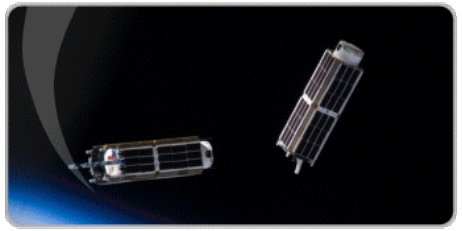
- Investigate **fundamental laws** of physics and physical processes, often using either microgravity or interplanetary distances as research tools
- Provide a **mechanistic understanding** of processes underlying space exploration technologies such as power generation and storage, space propulsion, life support systems, and environmental monitoring and control
- Develop cutting-edge **technologies** to facilitate spaceflight research
- Promote **open science** through Physical Science Informatics
- Support the transfer of knowledge and technology of space-based research to terrestrial systems to **benefit life on Earth**

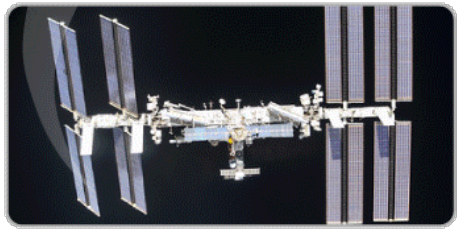
Database

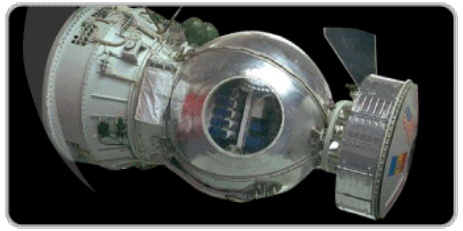
- Physical Sciences Informatics (psi.nasa.gov)

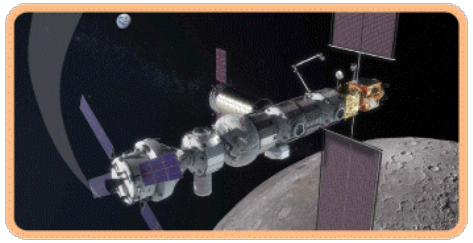
BPS Platforms for Research

*Future Platforms


CubeSat


International Space Station

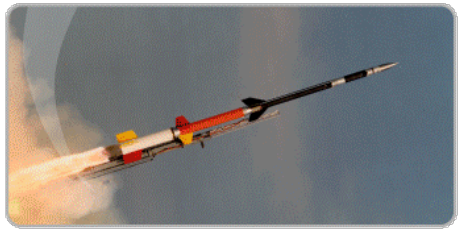

Free Flyers (BION)

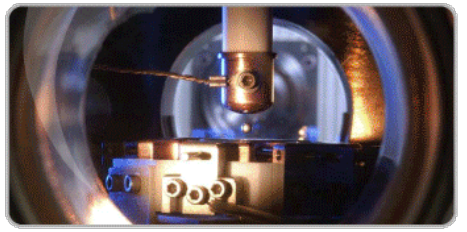

*Lunar Gateway

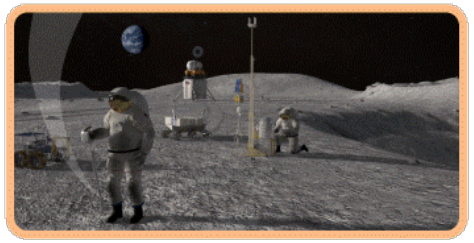

*Commercial Lunar Lander Services


Drop Tower

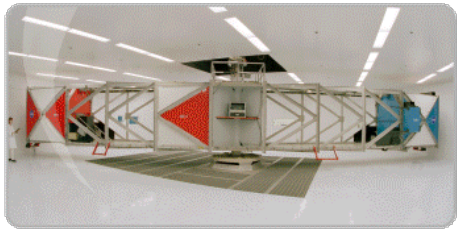

Parabolic Flight


Sounding Rocket
Sub-orbital Vehicle


Electrostatic Levitator


*Human Landing System

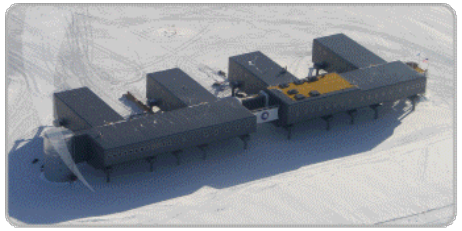

Rodent Unloading

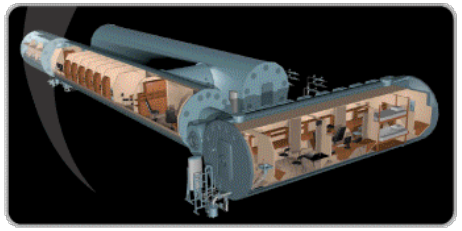

Centrifuge

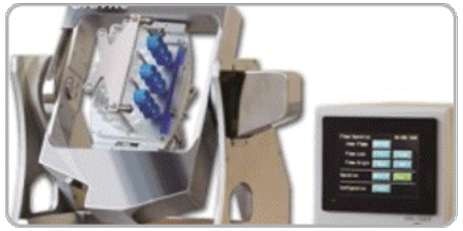

Balloon Flight

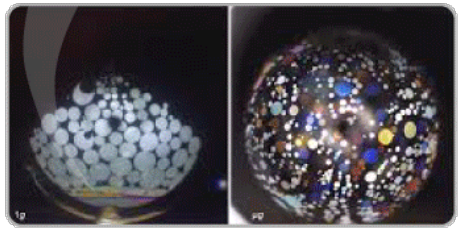

NASA Space Radiation Lab


NASA Isolation Chamber


NSF Polar Station

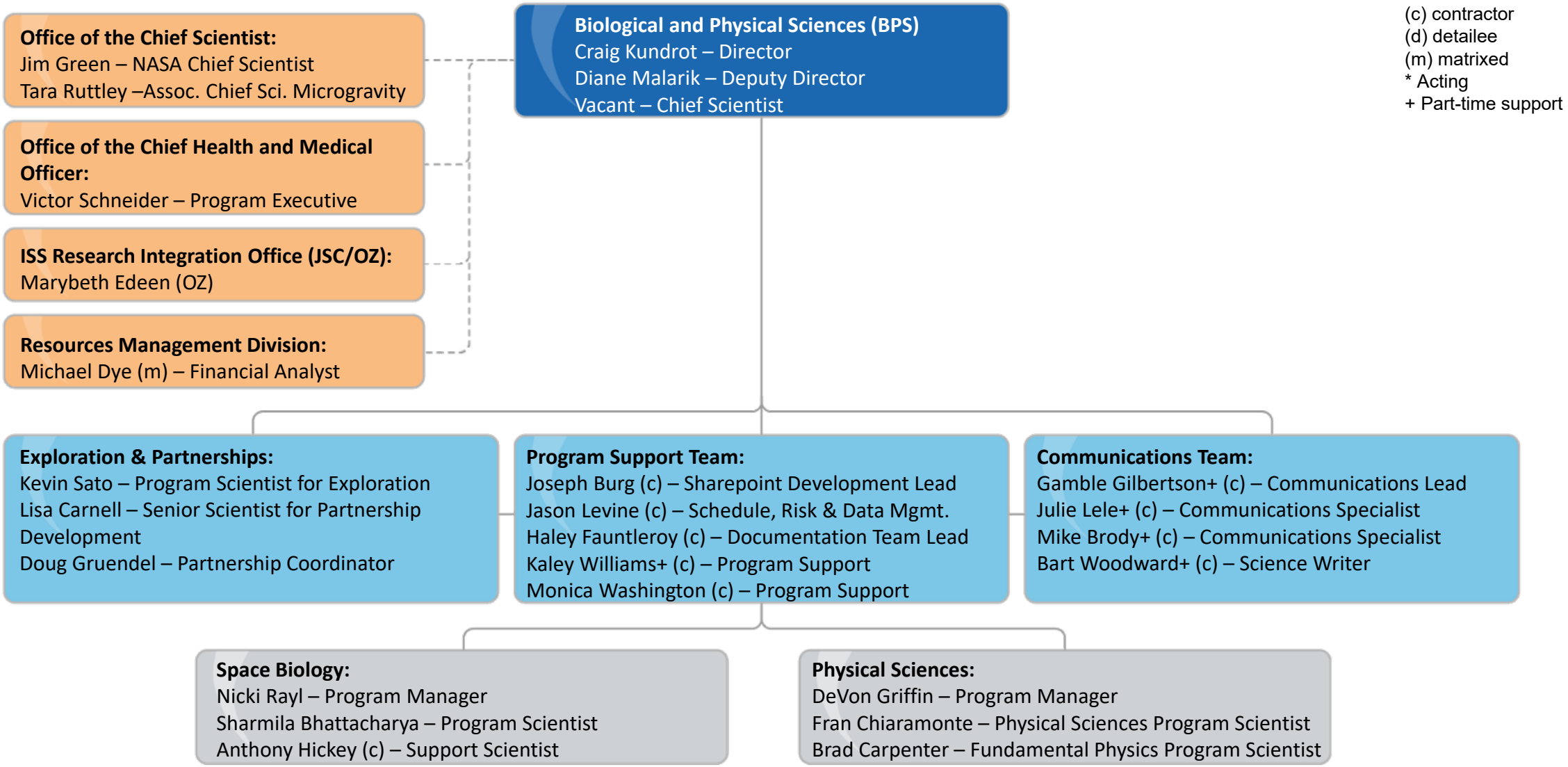

Russian Isolation Chamber


Gravity Vector Averaging


Physical Sciences
Informatics


GeneLab

Our Organization



(c) contractor
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(m) matrixed
* Acting
+ Part-time support

Leadership

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Division Director

Diane Malarik
Deputy Director

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Program Manager

Sharmila Bhattacharya
Program Scientist

Anthony Hickey
Support Scientist

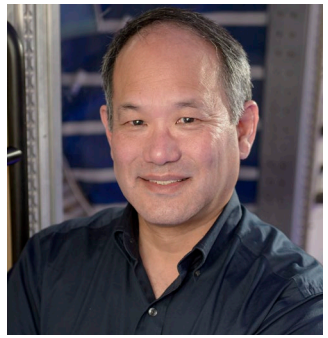
Physical Sciences

DeVon Griffin
Program Manager

Bradley Carpenter
Fundamental Physics Program Scientist

Fran Chiaramonte
Fundamental Physical Sciences Program Scientist

Exploration & Partnerships



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Communications Specialist

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Communications Specialist

Crew Sampling for Microbial Inventory

- Microbes in the built environment, including ISS, affect human health
- Examining the interplay between the ISS and crew microbiomes and changes over time
- Findings contribute to microbial control countermeasures, planetary protection, and Earth-benefits in human semi-closed and closed system habitats

E.g., Scientific Reports 8: 814 (2018)

Active experiment on ISS

Crew Sampling for Microbial Inventory

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Active experiment on ISS

Gaseous combustion to mimic solids

- Experiments on the combustion of solids require sample changeouts
- The Burning Rate Emulator experiment modulates fuel flow rate based on heat flux and temperature to mimic combustion of paper, plastic, and alcohol
- High throughput study of ignition and extinction behavior

Active experiment on ISS

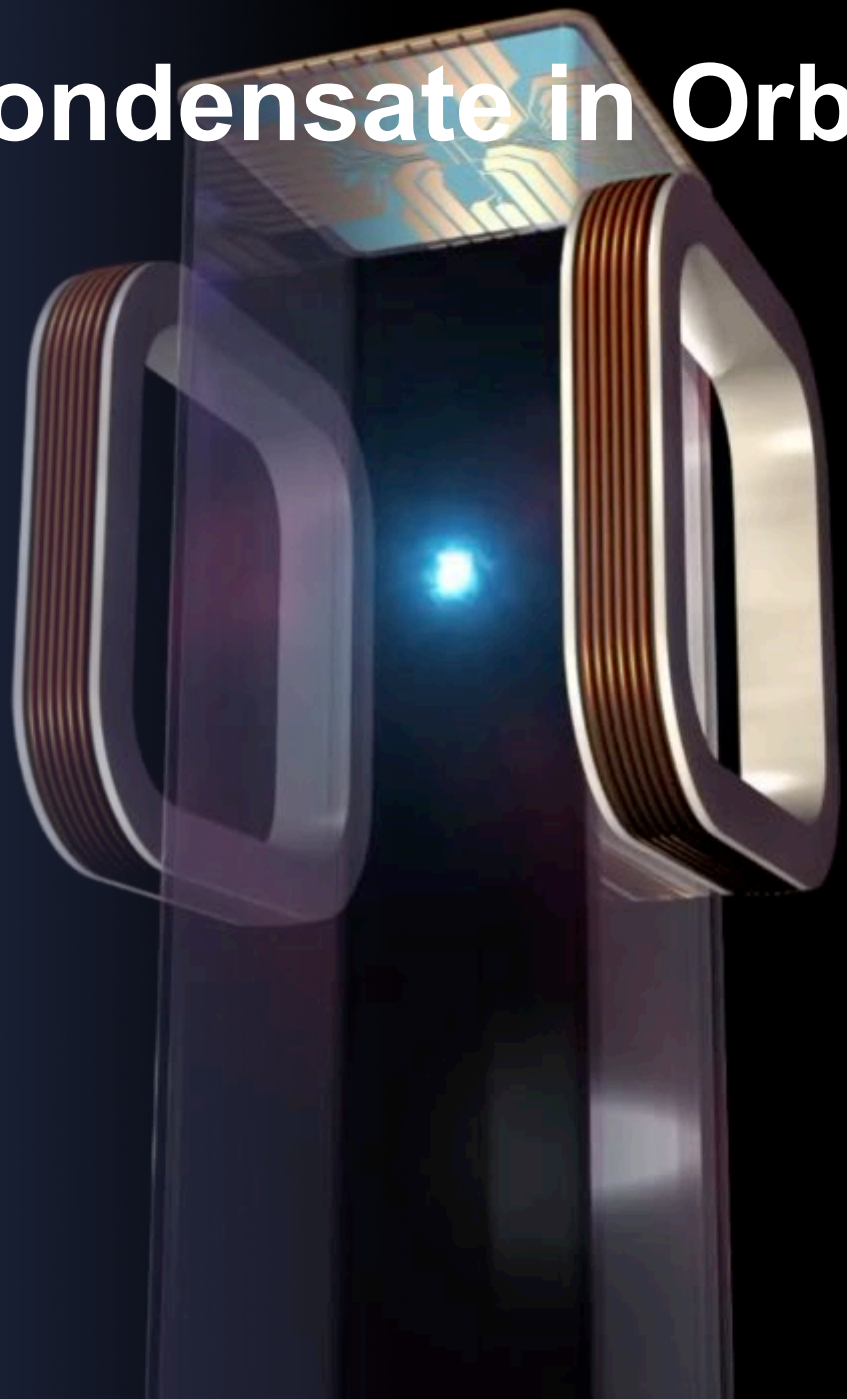
Long Distance Plant Defense Signaling

- Preparation for a flight experiment leads to discovery published in *Science*
- Lack of laboratory capability on ISS drives need for remote monitoring of biological systems
- PI developed fluorescent method for monitoring Ca^{++} signaling
- Discovered glutamate triggered Ca^{++} wound signaling

Science, 361:1112-1115 (2018)

Bose-Einstein Condensate in Orbit

- World's first multi-user facility for the study of ultra-cold atoms in space
- Provides suite of tools to cool, tune, and probe clouds of ultra-cold atoms including Bose-Einstein condensates
- Over 100,000 PI experiments performed on cooling to sub-nanoKelvin temperatures, atom lasers, and the first ever bubble geometry traps.



Nature, 582:193–197 (2020)

Conclusion

- **BPS uses the spaceflight environment (e.g., reduced gravity, radiation) to study biological and physical systems**
  - Two-fold mission
    - Pioneer scientific discovery
    - Enable exploration
  - Space Biology: microbes, cells, tissues, plants, animals
  - Physical Sciences: fluids, combustion, materials, fundamental physics
  - Moved from HEOMD to SMD July 2020
- **Decadal Survey**
  - Statement of Task finalized
  - Start late 2020 or early 2021
- **Looking forward to exploring opportunities to coordinate and to collaborate with the Astrophysics Division and other SMD Divisions**
- science.nasa.gov/biological-physical

Acronyms

BPS- Biological and Physical Sciences

ESMD- Exploration Systems Mission Directorate

HEOMD- Human Exploration and Operations Mission Directorate

OART- Office of Advanced Research and Technology

OBPR- Office of Biological and Physical Research

OLMSA- Office of Life and Microgravity Science and Applications

OMSF- Office of Manned Space Flight

OSSA- Office of Space Science and Applications

SMD- Science Mission Directorate

SLPSRA- Space Life and Physical Sciences Research and Applications

STMD- Space Technology Mission Directorate