National Aeronautics and Space Administration



Update on Biological and Physical Sciences

Committee on Biological and Physical Sciences in Space March 25, 2021

Craig Kundrot Director, Biological & Physical Sciences Division



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.**

BPS Mission & Goals



Decadal Survey



Midterm Assessment



rtemis Missions

Pioneer Scientific Discovery

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

Enable Exploration

- Anticipate and investigate critical areas for scientific knowledge and technology development
- Deliver results to other NASA organizations



Objectives

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

Databases and Biospecimen Sharing

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



Objectives

- Investigate <u>fundamental laws</u> of physics and physical processes, often using either microgravity or interplanetary distances as research tools
- Provide a <u>mechanistic understanding</u> 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 <u>technologies</u> to facilitate spaceflight research
- Promote <u>open science</u> through Physical Science Informatics
- Support the transfer of knowledge and technology of space-based research to terrestrial systems to <u>benefit life on Earth</u>

Database

Physical Sciences Informatics (psi.nasa.gov)

SLPSRA strategy in HEOMD

- Execute broad range of Decadal Survey (2011) highest priority recommendations
 - Decadal Survey has 65 high priority recommendations
 - BPS funding is spread among 56



Investigations may be mapped to more than one topic



Space Biology Content



Total SB FY20 Grants	124
Flight	67
Ground	57

Number Directed vs Competed				
Directed	3			
Competed	121			





Total PS FY20

Flight

Ground

Grants	104	Number Directed vs Competed		
	64	Directed	10	
	40	Competed	94	

The Next Decadal Survey (2023)

- Recommendations for a decade of transformative science at the frontiers of biological and physical sciences research in space
 - Uniquely advance scientific knowledge
 - Meet the needs of human and robotic exploration missions
 - Provide terrestrial benefits
- Recommendations for
 - Research activities
 - Associated facilities and platforms ("Keystone Capabilities")
 - Proof-of-concept Research Campaigns
- Recommendations organized into broad cost categories
 - E.g., New Worlds, New Horizons in Astronomy and Astrophysics (2010)
 - Table ES.4 "\$100M to \$200M", "\$60M to \$200M"
- BPS anticipates recommendations for a small number (3-5) each of
 - Keystone Capabilities
 - Research Campaigns
- The Keystone Capabilities and Research Campaigns will be the building blocks of BPS's scientific program for the next decade

Candidate Disciplines for Research Campaigns or Keystone Capabilities

• <u>Thriving In Deep Space (TIDES)</u>

- Transformative biological science and exploration applications
 - Animal biology (human analogous systems)
 - Plant biology
 - Microbiology
- Transformative engineering and/or physical sciences
 - Combustion
 - Fluid Physics
 - Advanced Materials

Transformative science

- Precision measurements (Clocks, Thermophysical)
- Novel configurations of matter (Quantum Matter, Soft Matter, Materials Science)

BPS Strategy in SMD

- Focus on transformative research
 - Recommended by the Decadal Survey (2011)
 - Likely to be recommended by the Decadal Survey (2023)
- Include large research activities
 - Keystone Capabilities
 - Research Campaigns
- Balance flight-based research program with strong ground-based research program
- Pivot toward focused, transformative areas in FY22
 - Jump start areas likely to be recommended by the Decadal Survey (2023)
 - Pause other areas until Decadal Survey (2023) released
 - Complete funding of existing grants
 - Descope future solicitations (e.g., ground-based only) or defer
 - Pause early-stage flight projects at logical milestone
- Implement Decadal Survey (2023) recommendations
 - Keystone Capabilities and Research Campaigns
 - May be contingent on additional funding
 - May be phased to level funding across years

Space Biology Pivot: Leading Ideas

- <u>Thriving In Deep Space (TIDES)</u>
 - Transformative scientific knowledge and enabling exploration
 - Fill knowledge gaps in HEOMD Human Research Program and other HEOMD orgs
- Determine how animals and plants respond to the multiple stressors of spaceflight environments to
 - Understand how humans can thrive as they go to, from, and stay on the Moon and Mars
 - Determine how the rapid, reversible effects of spaceflight relate to mechanisms of aging and disease on Earth
- Use model organisms to understand the biological mechanisms underlying the human and plant responses to spaceflight
 - Increase collection and analysis of curated spaceflight biospecimens, data deposition into GeneLab, and analysis by GeneLab Analysis Working Groups and solicited investigations
- Develop a first-generation capability for unicellar organisms for lunar research
 - Lunar Explorer Instrument for space biology Applications (LEIA)
 - Set stage to expand capability to multi-cellular animals and plants
 - Likely through open competition
- Research Campaign and Keystone Capability in miniature

Physical Sciences Pivot: Leading Ideas

- Support of exploration awaits clearer definition of exploration architecture and needs
- Pioneering Scientific Discovery: Novel configurations of matter
- Transformative scientific knowledge
 - "What are the fundamental rules that govern our Universe?"
 - "How does complexity in the Universe arise from simple underlying physics?"
- Quantum Science
 - Upgrade Cold Atom Lab to enable new studies of
 - Quantum droplets
 - Spontaneous symmetry breaking in spinor condensates
 - Tests of Einstein's Equivalence Principle (EEP) with atom interferometry
 - Establish a BPS Quantum Science Community to utilize the CAL upgrades
- Soft Matter Physics
 - Upgrade ISS capability to enable new studies of
 - Colloids, granular media, foams, polymers, etc.
 - Application of external forces
 - Establish a Soft Matter Science Community to utilize the ISS upgrades
- Keystone Capabilities in miniature



Decadal Survey (2023)

- Statement of Task finalized
 - <u>https://www.nationalacademies.org/our-work/decadal-survey-on-life-and-physical-sciences-research-in-space-2023-2032</u>
- Nominations for Committee and Panel members closes March 31
- Look for the call for whitepapers
 - Whitepapers are key input
 - A large number of whitepapers across a broad range of research areas will greatly assist the Decadal Survey process
 - BPS funding ASGSR facilitation of development of whitepapers
 - <u>https://asgsr.org/decadal-survey/</u>

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Thank you



Transformative Research

- Transformative research challenges current understanding or provides pathways to new frontiers
- Transformative research involves
 - ideas, discoveries, or tools that
 - radically change
 - our understanding of an important existing scientific or engineering concept or
 - educational practice or
 - leads to the creation of a
 - new paradigm or
 - field of science, engineering, or education.

https://www.nsf.gov/about/transformative_research/definition.jsp