



National Aeronautics and
Space Administration

NASA Update and Initial Decadal Survey Response

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Biological and Physical Sciences Division
NASA's Science Mission Directorate

March 20, 2024

Biological & Physical Sciences



Agenda

1

BPS Updates

2

Initial Decadal Survey Response

3

Questions



BPS Updates

October 2023 - present

BPS

A close-up photograph of a man with a friendly expression, wearing a green t-shirt and a blue earpiece. He is holding a clear plastic container with both hands, examining its contents. The background shows the interior of a spacecraft or space station, with various metallic components, pipes, and a circular hatch visible. The lighting is bright and focused on the man and his work.

We use spaceflight environments to study biological and physical systems.

BPS's Mission

Pioneer Scientific
Discovery

Enable Exploration

Contribute to Life on Earth



BPS Program Areas

Space Biology

Physical Sciences

Fundamental Physics

Commercially Enabled Rapid
Space Science (CERISS)

Open Science



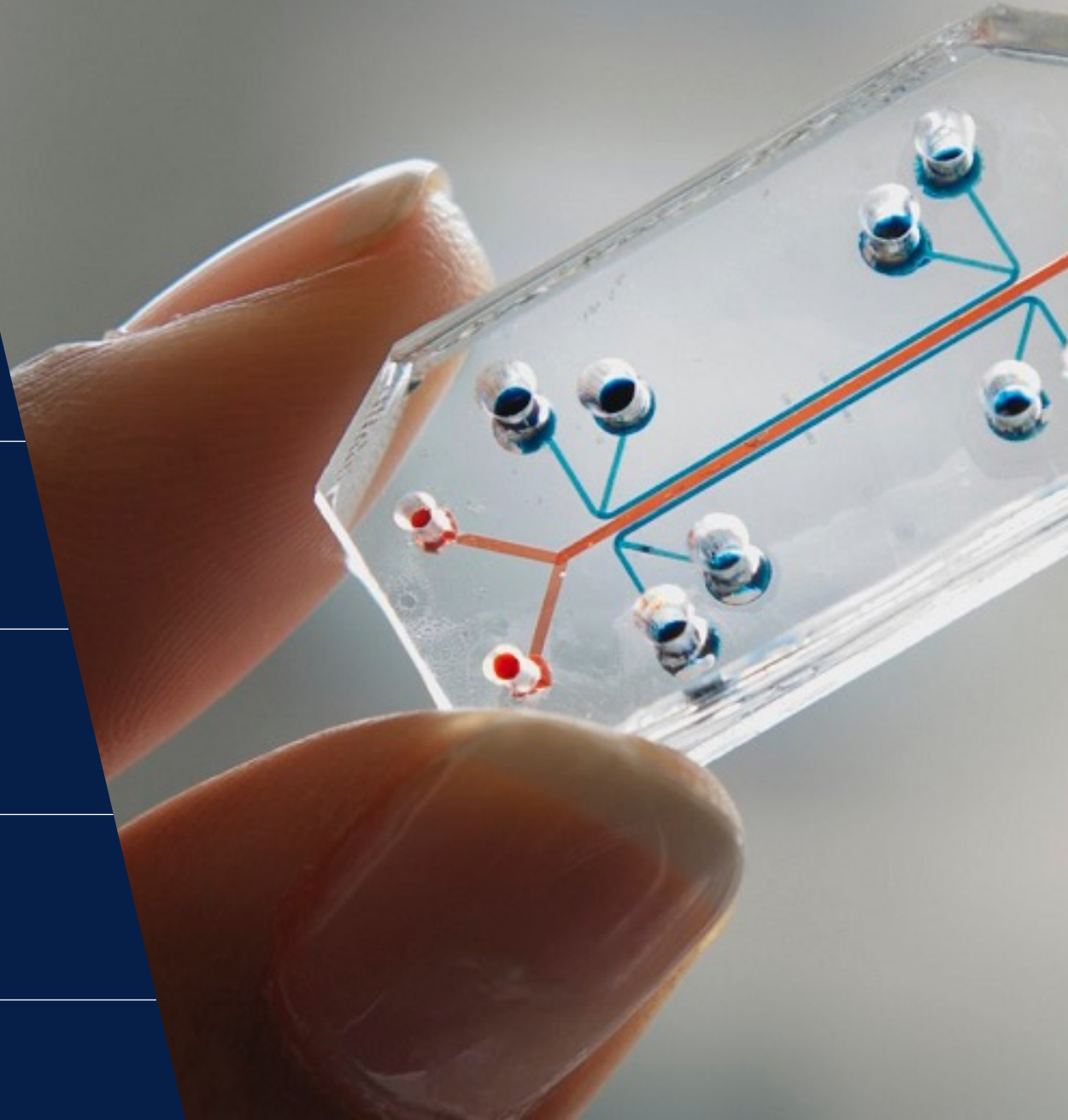
Impacts Include

Biomedical Research

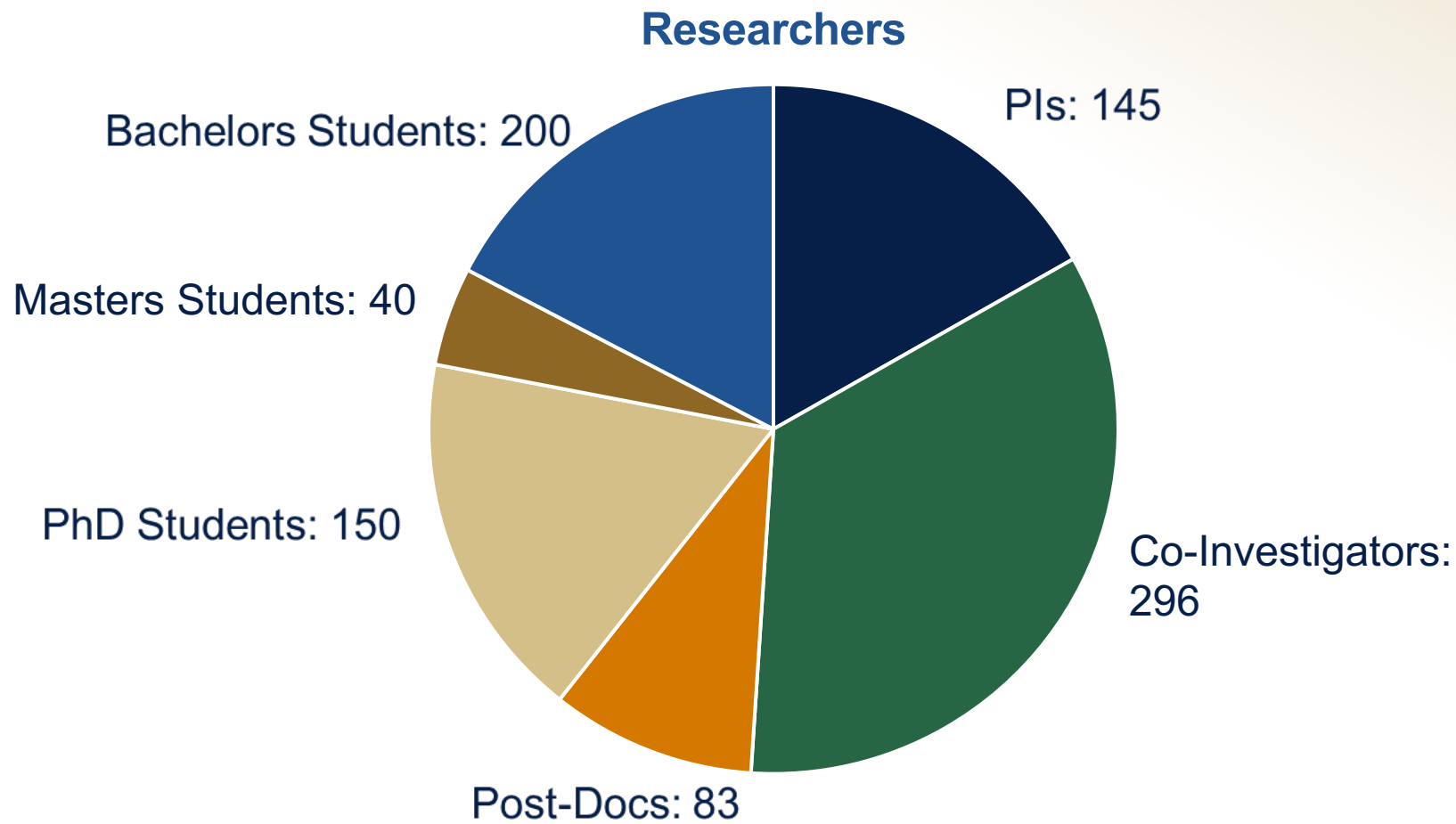
Agricultural Innovations

Consumer Products

Technology Advancements



167 Active Investigations, FY 2024*



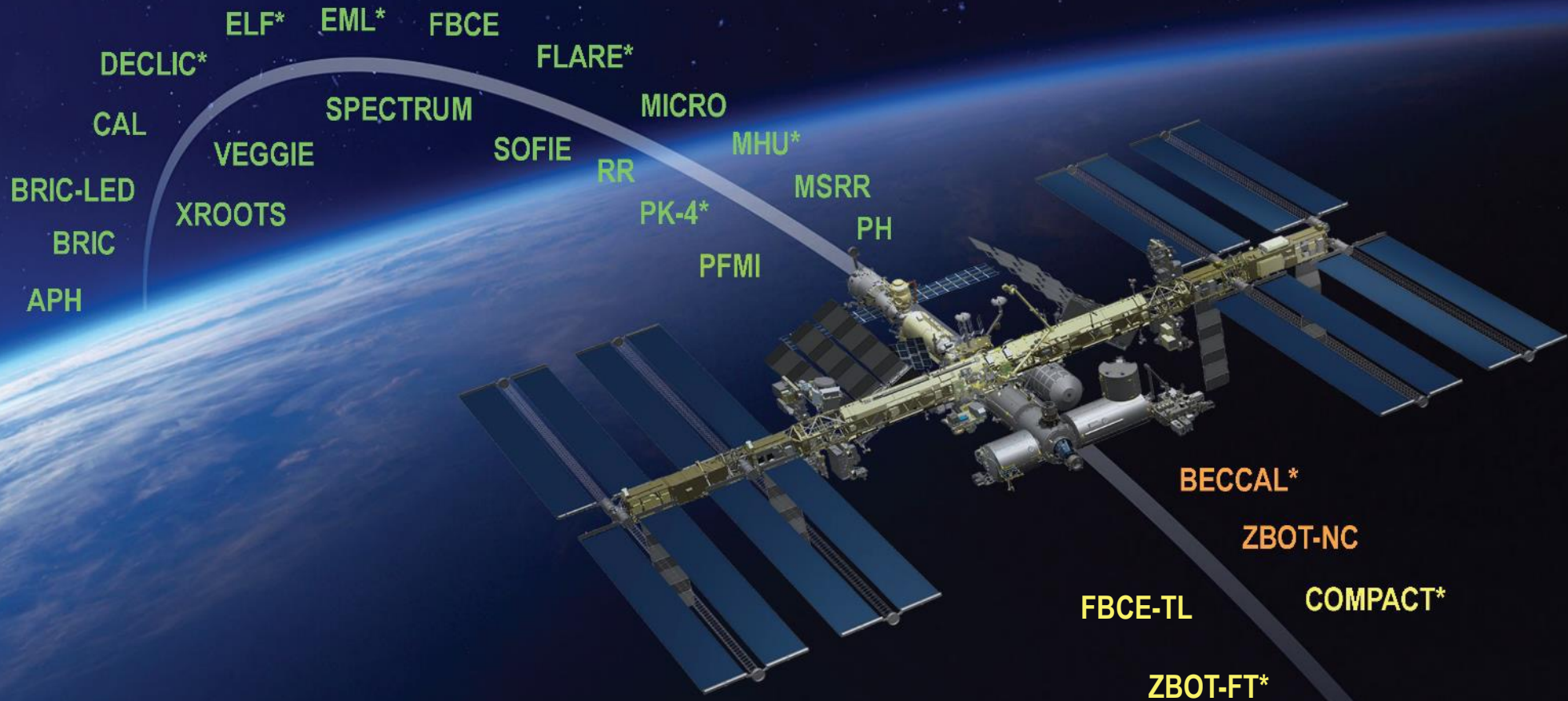
*Based on NASA Task Book entries, 10/20/2023 – 3/12/2024

BIOLOGICAL & PHYSICAL SCIENCES FLEET

- FORMULATION
- IMPLEMENTATION
- OPERATIONAL
- PARTNER-LED*



ARTEMIS II



FY25 President's Budget Request Highlights

- Developing transformative research capabilities with commercial space industry
 - Dramatically increase the pace of research through the CERISS initiative
- Optimizing BPS's budget through partnerships, including
 - Artemis campaign research, which will include science on Artemis II
 - ISS Program: Development of facility-class payloads
 - International Partnerships: rideshares, facilities, joint studies
 - Other Government Agencies, and ISS National Lab, NASA's Human Research Program (HRP) and Astromaterials Research & Exploration Science (ARES): Joint solicitations and studies
- Aligning with high-priority, high-visibility initiatives such as Cancer Moonshot
- Transformative science to address Decadal Survey recommendations
- Sustaining core capabilities, open science platforms, education and engagement, training programs, and inclusion, diversity, equity and accessibility (IDEA)

Biological & Physical Sciences FY25 President's Budget Request (\$M)

	Actual	CR	Request	<u>Out-Years</u>			
	2023	2024	2025	2026	2027	2028	2029
Biological and Physical Sciences	\$85.0		\$90.8	\$91.3	\$93.0	\$94.8	\$96.6
Biological and Physical Sciences	\$85.0		\$90.8	\$91.3	\$93.0	\$94.8	\$96.6
BPS Program Management	\$9.5		\$10.4	\$13.0	\$12.9	\$15.6	\$15.7
Space Biology	\$34.7		\$30.5	\$30.5	\$33.3	\$36.9	\$37.4
Physical Sciences	\$39.9		\$39.8	\$38.9	\$37.9	\$33.2	\$34.4
Commercially-Enabled Rapid Space Science	\$0.8		\$10.0	\$8.9	\$8.9	\$9.0	\$9.1

Research Partnerships

US Government Partnerships



US Academic Institutions



International Academic Institutions



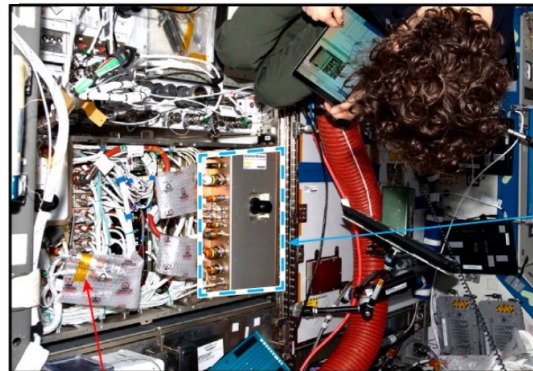
Spaceflight Partnerships

BPS leverages other NASA organizations and international space agencies to accomplish the entire portfolio of spaceflight research; equivalent of ~\$600-800M full cost value per year.

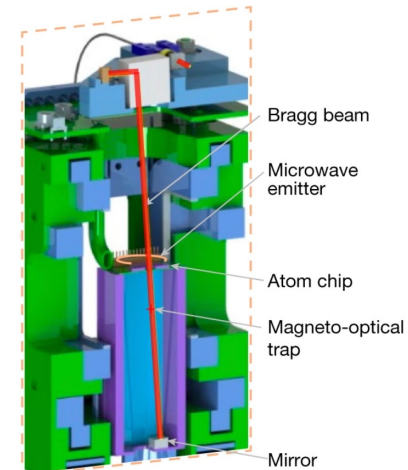
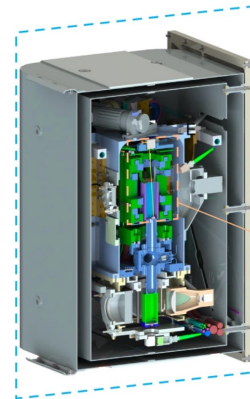


Science Spotlight: Quantum Science

- Cold Atom Lab published in Nature paper
 - Quantum gas mixtures and dual-species atom interferometry in space. Elliott, E.R., Aveline, D.C., Bigelow, N.P. et al., Nature 623, 502–508 (2023), [Abstract](#)



Science module



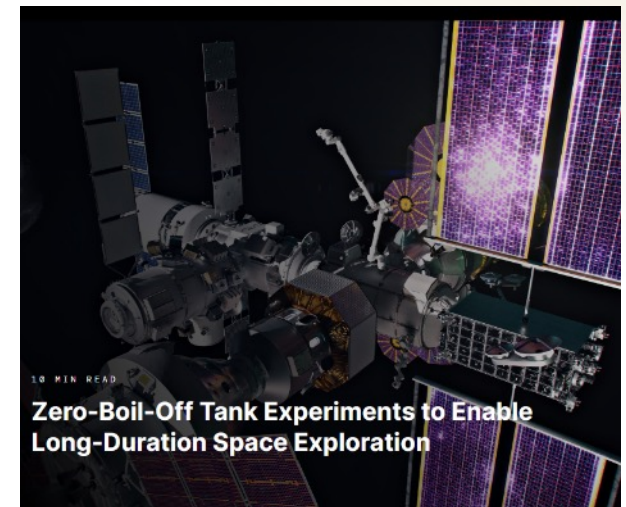
Learn more at [Nature.com](https://www.nature.com)

Science Spotlight: μ G Fluids Science

- SMD technology highlight on Zero Boil-off Tank (ZBOT) experiment series identifies challenges of propellant management in space
 - PI: Mohammed Kassemi, Case Western Reserve University



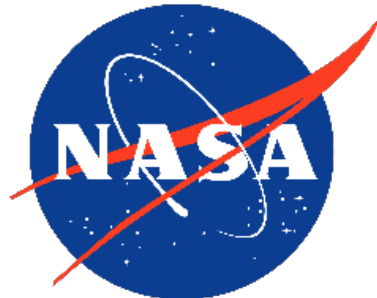
CFD Models predict fluid and thermal profile against ZBOT-1 data



Learn more at [Science.NASA.gov](https://www.nasa.gov/science)

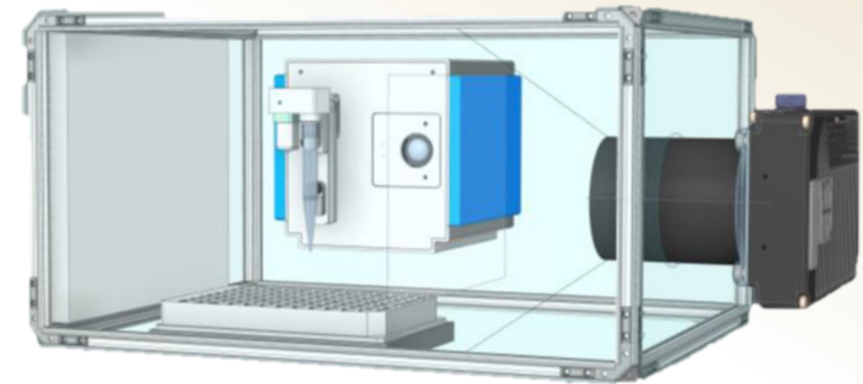
Award Spotlight: Tissue Chips

- \$18M investment: multi-agency tissue chip longevity awards
 - Multi-agency partnership investing in tissue chip models for respective agency missions
 - Research to extend viability & physiological function to a minimum of 6 months
 - Enables study of exposure to acute or chronic stressors, conditions, or compounds
 - 9 contracts supporting research through 2026-2027 timeframe at institutions across the U.S.



Award Spotlight: CERISS

- Commercially Enabled Rapid Space Science (CERISS) advances transformative in-space research capabilities to support NASA exploration
 - In partnership with NASA's Flight Opportunities Program, TechFlights 2023 selection
 - Sierra Lobo, Inc. Principal Investigator Phil Putnam awarded opportunity to demonstrate automated fluidic sample preparation capability enabling physical and biological scientific research in microgravity
 - Flight demonstration scheduled to begin in late 2024
 - Three 2023 Small Business Innovation Research Phase I awards



Award Spotlight: Space Bio & Regolith

- Space Biology Research Studies released in partnership with NASA's Astromaterials Research and Exploration Sciences (ARES) Division
- First Space Biology solicitation to look at the effects of lunar regolith
 - On plants: microbial interactions and plant growth.
 - On animal and human, cellular and tissue systems: microbial interactions and stress responses.
 - 11 proposals funded – Total of \$ 2.3M over 3 years
- Lunar regolith simulant formulated to resemble regolith from the Lunar Highlands of the Moon's south pole (to match material at the candidate landing sites for the Artemis III mission)
- Lunar regolith collected from Apollo missions granted to a subset of awardees who have demonstrated sufficient progress with simulant to conduct a final set of validation studies



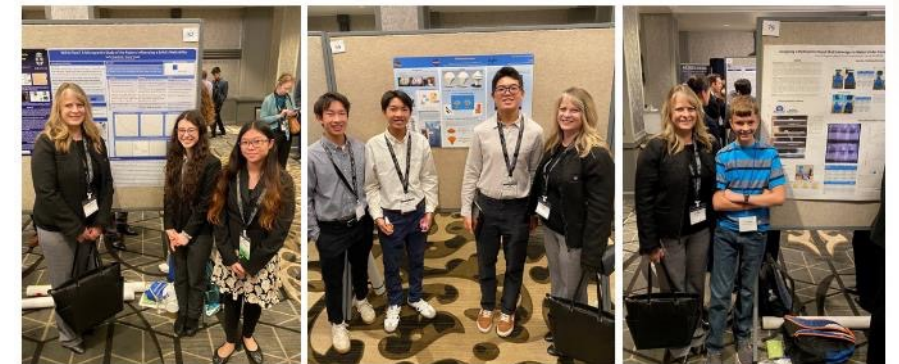
STEM Engagement and Opportunities

- Spaceflight Technology, Applications, and Research (STAR) program
- GeneLab for High Schools
- GeneLab for Universities
- Space Life Sciences Training Program
- Growing Beyond Earth
- Future Investigators in NASA Earth and Space Science and Technology (FINESST)



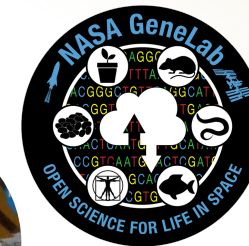
STEM Engagement and Opportunities

- BPS combustion project scientist honored by National Eagle Scout Association
 - The National Eagle Scout Association presented Dennis Stocker with its Silver Wreath Award for his Scouting-focused NASA outreach
 - Stocker has long used NASA's Eagle Scout (and Girl Scout alum) astronauts as role models to inspire youth to consider and pursue careers in STEM and at NASA
- 2023 GRC Drop Tower Challenge winners recognized at ASGSR
 - On November 18, 2023, three teams of Grade 8-12 students were recognized as winners in the nationwide Diving into Experimental Research (DIVER) Design Challenge
 - BPS Division Director Dr. Lisa Carnell met and congratulated each team



Inclusion, Diversity, Equity, Accessibility

- Growing Beyond Earth for Spanish speakers
- GeneLab 4 Universities (HBCUs/MSIs)
- Open Source Science
- SMD Bridge Program
 - Minority Serving Institutions (MSI)
 - Historically Black Colleges & Universities (HBCU)
 - Tribal Colleges & Universities (TCU)
 - Including primarily undergraduate institutions and PhD granting universities
- Dual-Anonymous Peer Review (DAPR)



Communications & Media*

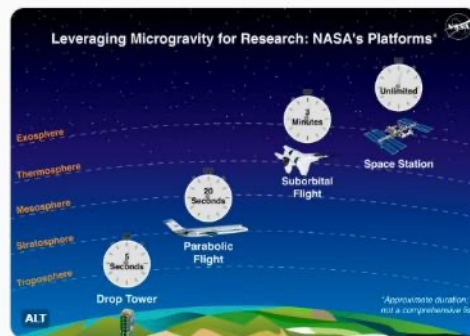
Live Conference with ISS Crew & Sen. Nelson



NG-20 ISS National Lab Webinar with Dr. Abba Zubair and Dr. Lisa Carnell



Themed Monthly Science Campaigns & Graphics



+ 4 BPS Web Features & Explainers

12 Social Videos Featuring PIs



Crystal Research with Dr. Martin Volz



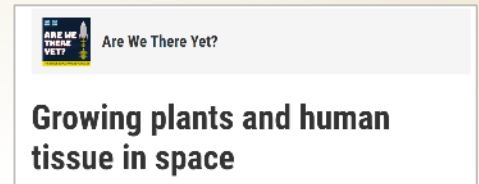
Plant Research with Dr. Simon Gilroy



Parabolic Flights with Dr. Gioia Massa



New York Times Interview



NPR Podcast



Houston, We Have a Podcast

Features in other outlets include:

- New York Times Magazine
- SpacePolicyOnline

*Not a comprehensive list

Conferences, Events & Briefings

14+ Conferences & Events | 2 Hill Staffer Briefings

- American Society for Gravitational Space Research Annual Meeting (ASGSR)
- International Space Life Sciences Working Group Meeting
- International Microgravity Strategic Planning Group Meeting
- Great Lakes Science Center Exhibit Opening
- American Geophysical Union Annual Event
- 50th Space Congress
- Architecture Workshop for International, Industry, and Academic Partners



SXSW Quantum Panel



ASGSR

- Human Research Program Investigators' Workshop (Open Science Data Repository & Plenary with Other Government Agencies)
- Congressional Staff Briefings (New York, Texas)
- ASCEND panel
- South by Southwest Quantum Panel
- Commercial Space Transportation Conference panel
- 23rd NIH Tissue Chip Consortium Meeting
- Engineering Biology Research Consortium Space Health Roadmap Workshops
- AwesomeCon (Attended)

Launches (1 of 2)

3 Launches | 11 Investigations/Resupplies

- SpX-29 (Nov. 2023)
 - **Bacterial Adhesion and Corrosion (BAC)**: Studying biofilm growth aboard station – *Dr. Robert McLean, Texas State University*
 - **Plant Water Management (PWM-05, -06)**: Understanding of the physical aspects of fluid flow and inform designs of fluid delivery systems for reduced gravity environments – *Dr. Mark Weislogel, Portland State University*
 - **Rodent Research (RR-20)**: Studying reproductive capabilities – *Dr. Lane K. Christenson, University of Kansas Medical Center*
 - **Plant Habitat (PH-06)**: Investigating the physiological and genetic responses to defense activation and immune system function in tomatoes during spaceflight – *Dr. Anjali Iyer-Pascuzzi, Purdue University*
- NG-20 (Jan. 2024)
 - **Advanced Plant Experiment (APEX-10)**: Plant-microbe interactions in space – *Dr. Simon Gilroy, University of Wisconsin*
 - **MABL-A**: Role of Mesenchymal stem cells in microgravity-induced bone loss, part A – *Dr. Abba Zubair, Mayo Clinic*
 - **Biological Research in Cannisters (BRIC-25)**: Studying the Accessory Gene Regulator quorum-sensing system of *Staphylococcus aureus* – *Dr. Kelly Rice, University of Florida*



Launches (2 of 2)

3 Launches | 11 Investigations/Resupplies

- SpX-30 (Mar. 2024)
 - **Genomic Enumeration of Antibiotic Resistance in Space (GEARS):** Studying how bacteria adapt to space by surveying the space station for antibiotic resistant-organisms – *Christopher Carr, Georgia Institute of Technology*
 - **Electrostatic Levitator Furnace Experiment (ELF-1):** Investigating thermophysical properties affecting impurities during the steel-making process – *JAXA partner-lead investigation, co-principal investigator Dr. Robert Hyers, Worcester Polytechnic Institute*
 - **Cold Atom Lab Science Module-1 (CAL-SM-1):** A temporary replacement module that will enable NASA to continue quantum experiments aboard the International Space Station while researchers troubleshoot upgraded equipment – *Kamal Oudrhiri, CAL Project Manager and Jason Williams, CAL Project Scientist, Jet Propulsion Laboratory*
 - **Flow Boiling Condensation Module Power Filter Module (FBCE-CMHT PFM):** Replacing equipment and resuming research – *Dr. Issam Mudawar, Purdue University*





Initial Decadal Survey Response

BPS

Committee on Biological and Physical Sciences Research in Space, 2023–2032

ROBERT J. FERL, University of Florida, Co-Chair

KRYSTYN J. VAN VLIET, Cornell University, Co-Chair

ADAM P. ARKIN, University of California, Berkeley

SUSAN M. BAILEY, Colorado State University

DEBJYOTI BANERJEE, Texas A&M University

PAUL M. CHAIKIN (NAS), New York University

KATHLEEN E. CULLEN, Johns Hopkins University

DANIEL H. GESCHWIND (NAM), University of California, Los Angeles

ROBERT W. HYERS, Worcester Polytechnic Institute

YIGUANG JU, Princeton University

CHRISTOPHER E. MASON, Weill Cornell Medicine

MICHAEL J. PECAUT, Loma Linda University

WILLIE S. ROCKWARD, Morgan State University

ELBA E. SERRANO, New Mexico State University

PETER VOROBIEFF, University of New Mexico

RONALD L. WALSWORTH, University of Maryland

SARAH WYATT, Ohio University

LUIS ZEA, University of Colorado, Anschutz Medical Center

ZHUOMIN ZHANG, Georgia Institute of Technology

A Legacy of NASA Space Science

Artemis I
2022



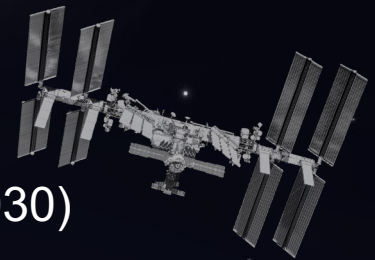
Apollo
1962-1972



Space Shuttle
Program
1981-2011



International
Space Station
1998 – present (2030)



Skylab
1970s



Parabolic Flight
1958-1993



Project Mercury
1958-1963



Continuing the Legacy, Starting the Next Era



Moon to Mars
2023 - Beyond



Artemis III
2026



Artemis II
2025



**Commercial Lunar
Payload Services
(CLPS)**
2023 - Beyond

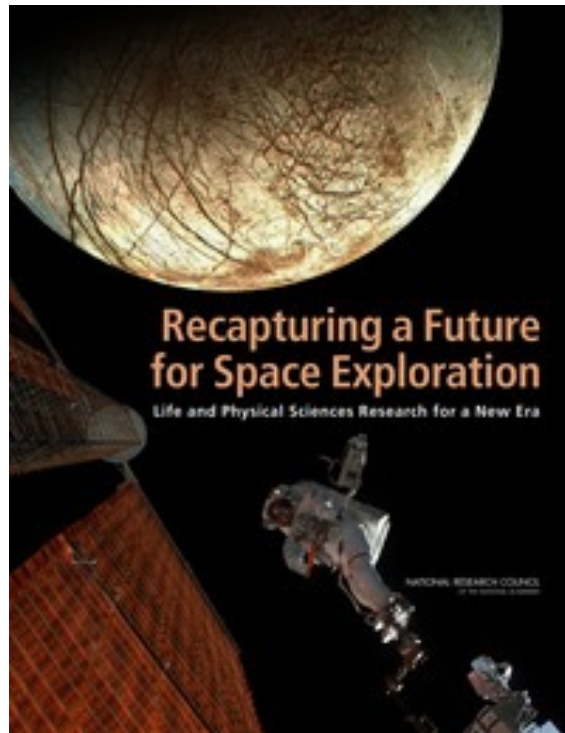
**Commercial Low Earth Orbit
Destinations (CLDs)**
2025 - Beyond



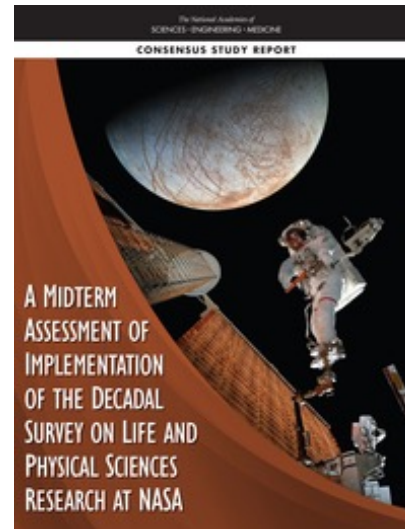
**Commercial Parabolic
and Suborbital**
Present



BPS's Second Decadal Survey



2011
First Decadal

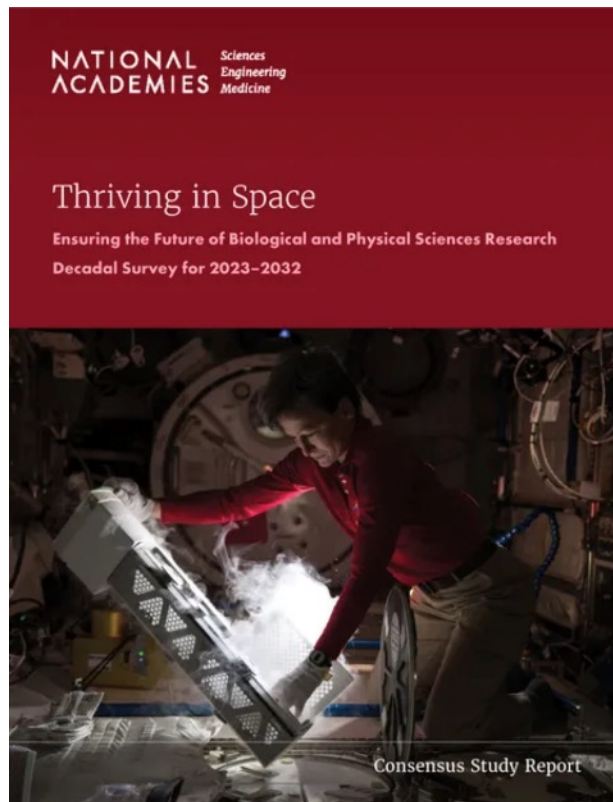


2018
Midterm Assessment



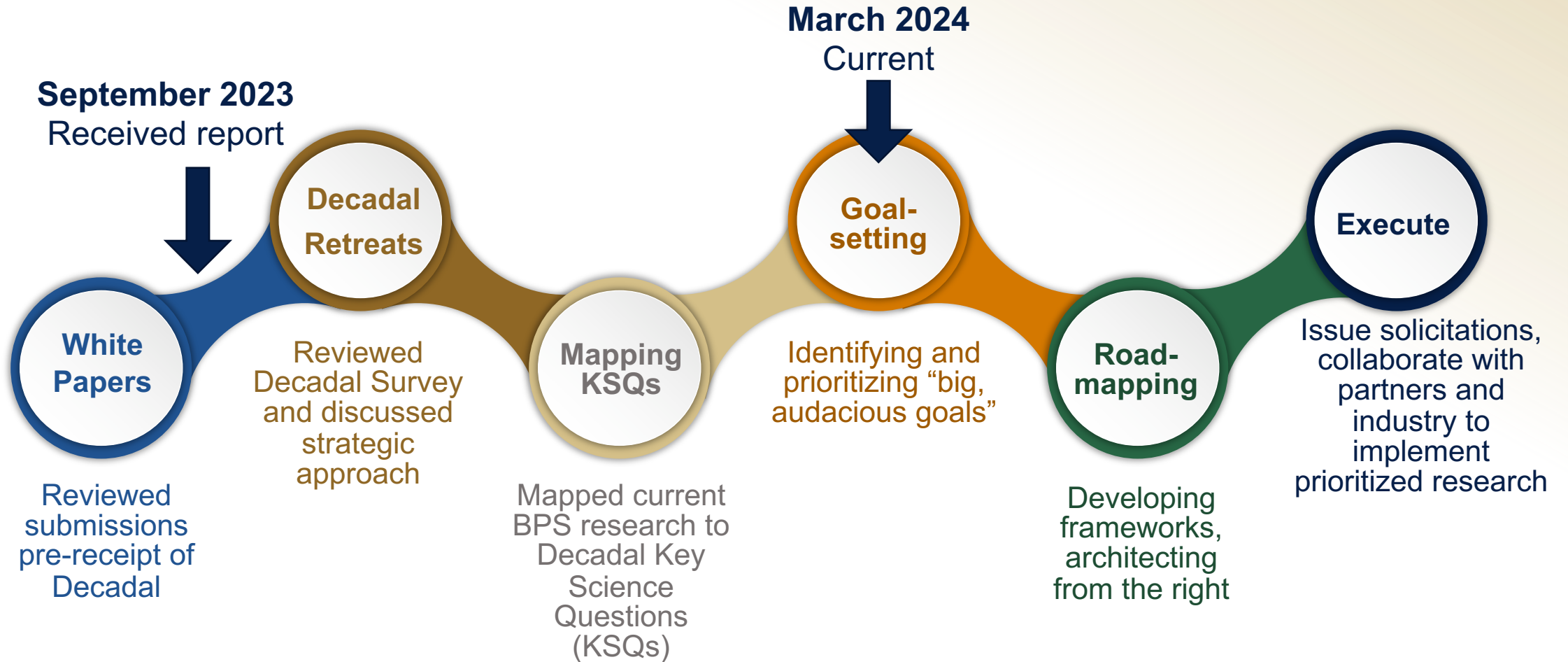
2023
Second Decadal

“Thriving in Space”



- **3** science themes:
 - Adapting to Space
 - Living and Traveling in Space
 - Probing Phenomena Hidden by Earth
- **11** Key Scientific Questions (KSQs)
- **2** research campaigns
- **25** recommendations

BPS Decadal Response Approach



Key Science Questions (KSQs)

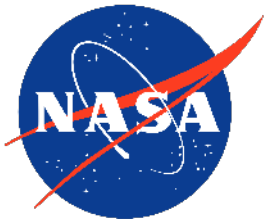


Rec. 3-1,
3-2, 3-3,
4-2, 5-1



Recommendation:

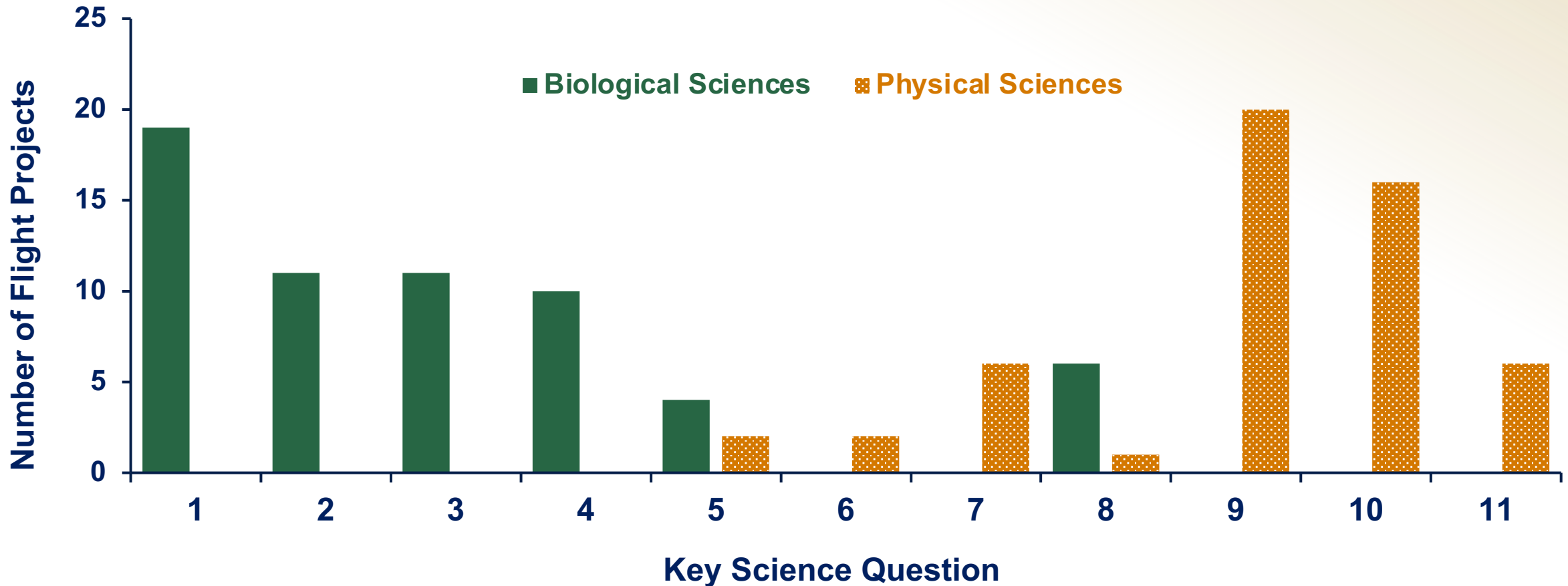
Direct resources toward the key scientific questions.



NASA Initial Response:

BPS has numerous funded activities that align with each of the KSQs.

Mapping Current BPS Flight-Relevant Research to Key Science Questions (KSQs)



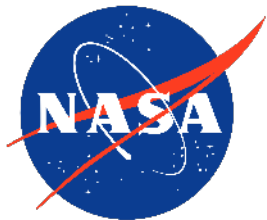
Collaboration



Rec. 3-2,
4-1, 5-1,
5-2, 7-3,
7-7, 7-8



Recommendation:
Collaborate broadly.



NASA Initial Response:
BPS will continue to partner across NASA, with other government agencies, academic institutions, and international partners.

Commercial Engagement



Rec. 7-1



Recommendation:

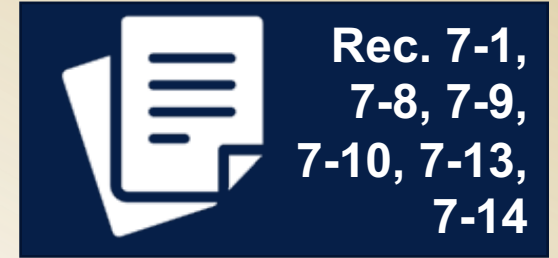
Actively engage commercial spaceflight firms to ensure that BPS needs are met.



NASA Initial Response:

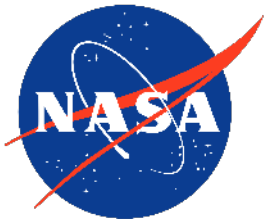
The current budget supports the CERISS program. BPS is working with commercial space industry, NASA's Flight Opportunities Program, and Commercial LEO Destination Program to take advantage of commercially available platforms.

Inclusion, Diversity, Training



Recommendation:

Addressing inclusion, diversity, and training within the BPS science community.



NASA Initial Response:

BPS participates in the Science Mission Directorate's programs to proactively address inclusion, diversity, equity, and accessibility.

Open Science



Rec. 7-6



Recommendation:

Continue open science and open data.



NASA Initial Response:

The current budget supports open science. BPS continues to maintain its open science archival databases in Space Biology and Physical Sciences.

Ground Infrastructure



Rec. 7-3,
7-5



Recommendation:

Develop and maintain sufficient ground-based infrastructure.



NASA Initial Response:

BPS plans to maintain existing ground-based facilities.

Current BPS Ground Facilities

- Zero Gravity Drop Tower (Glenn Research Center)
- Microgravity Simulation Support Facility (Kennedy Space Center)
- Plant Processing Area (Kennedy Space Center)
 - Veggie*
 - Advanced Plant Habitat*
 - Controlled Environmental Chambers*
- Electrostatic Levitation (ESL) Facility (Marshall Space Flight Center)
- Rodent Gravity Unloading (Ames Research Center)
- Centrifuge / Gravity Loading (Ames Research Center)
- NASA Space Radiation Lab (Brookhaven National Laboratory)



Drop Tower



PONDS Watering System in Veggie

New Office



Rec. 7-7



Recommendation:

Work with U.S. government agencies to establish an office/mechanism for commercial sponsorship and collaboration with non-profit organizations.



NASA Initial Response:

BPS will continue to work closely with other government agencies through NASA's Partnership Office to foster relationships with commercial industry and non-profit organizations.

Research Campaigns

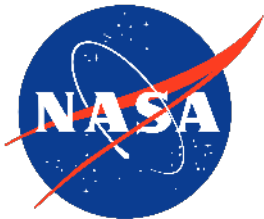


Rec. 6-1,
6-2



Recommendation:

Pursue dedicated research campaigns.



NASA Initial Response:

BPS is developing plans that will address the KSQs and work towards recommended research campaign objectives within the budget allotted.

Big, Audacious Goals

- Developing a select number of high-impact goals
 - Integrated, multidisciplinary approach
 - Each goal will contain projects addressing multiple KSQs
 - Creating notional roadmaps which could extend beyond the decadal horizon
 - May serve as steppingstones towards achieving research campaign objectives
- Leveraging NASA Moon-to-Mars missions and delivering Earth benefits
 - Science enabling exploration and exploration enabling science

Funding



Pg. 4,
Rec. 7-1,
7-9



Recommendation:

Increase funding by a factor of 10 before the decade.



NASA Initial Response:

BPS will seek to maximize science returns within the budgets we are given.

Decadal Survey-Recommend Budgetary Decision Rules



Pg. 218

- Funding levels
- Access to the International Space Station
- Access to Commercial LEO Destinations (CLDs)
- Interagency cooperation and co-funding
- International cooperation

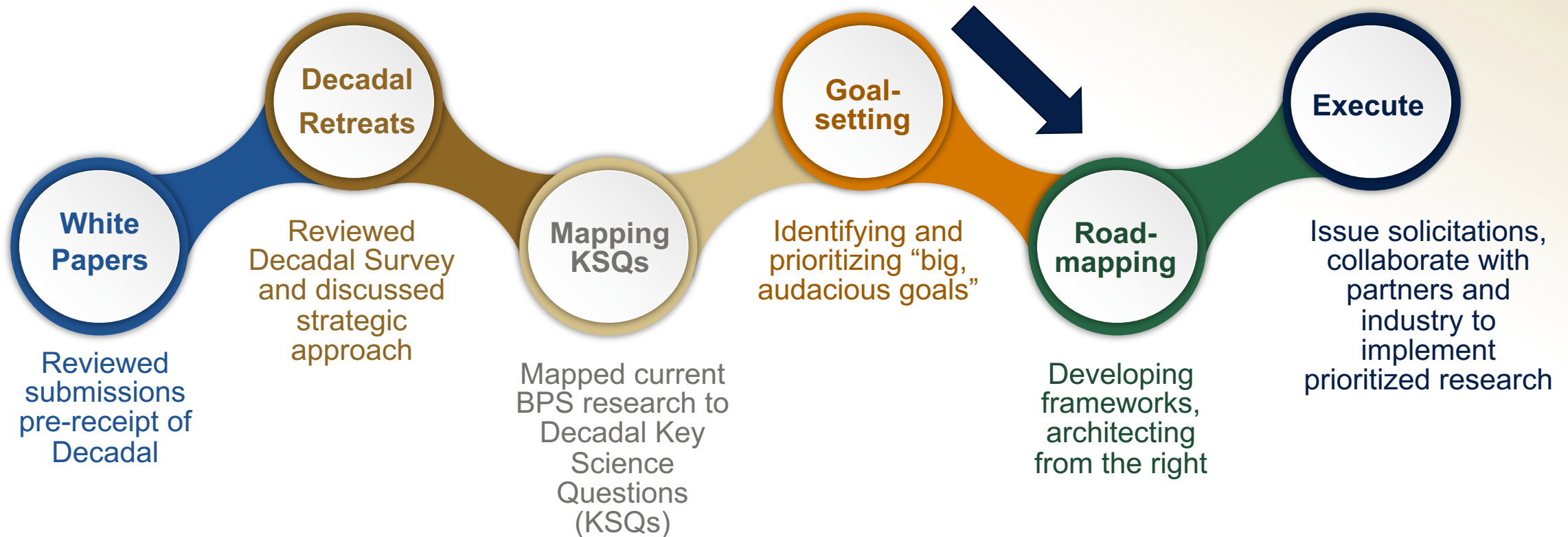
BOX 7-1

Decision Rules to Guide the NASA Biological and Physical Sciences Division (BPS Division) Response to Favorable and Unfavorable Changes in External Circumstances Affecting Progress on Key Science Questions (KSQs) or Research Campaigns, Relative to Prior Year

1. **NASA is appropriated *more* or *less* federal funding for the BPS Division:** If the NASA BPS Division receives *more* federal funding than anticipated, it is allocated to research programs and teams that documented at least one published milestone that was demonstrated to the general public, and that documented maintenance or increase in diversity of research project participants per NASA's definition and strategic plan. If the NASA BPS Division receives *less* federal funding than anticipated, maintaining funding levels on KSQs that hit research milestones in the prior budget year is prioritized.
2. **NASA-sponsored researchers are granted *more* or *less* access to the International Space Station (ISS):** If researchers are granted *more* crew time or upmass on the ISS, experiments that serve as development or validation of commercial low Earth orbit (LEO) destination-planned experiments are prioritized. If researchers are granted *less* crew time or upmass on ISS, technical/biological replicate experiments are prioritized.
3. **BPS researchers have *more* or *less* access to commercial LEO destinations (CLDs) or payload service providers:** If researchers have *more* access to CLDs, projects focused on KSQs representing all three themes and research campaign elements are prioritized. If researchers have *less* access to CLDs, projects focused on KSQs representing at least the adapting to space theme and probing hidden phenomena theme are prioritized until answered.
4. **NASA gains *more* or *less* U.S. interagency cooperation and co-funding of BPS research:** If NASA gains *more* cooperation and co-funding from other U.S. agencies, KSQs and research campaigns with synergy with those agencies are increased in scope, participation, or duration. If NASA anticipates *less* cooperation and co-funding, KSQs that enable space exploration are prioritized.
5. **The United States enjoys *more* or *less* international cooperation with launch, crew time for research, or infrastructure and mission co-development:** If international collaboration *increases*, research campaigns are expanded in scope and participation. If international collaboration *contracts*, KSQs and research campaigns that include industry cooperation are prioritized to enable continued progress on these research programs.

Next Steps

- Publish initial written response and presentation to BPS's website
- Refine “big, audacious goals” and continue road-mapping
- Establish a cadence of regular solicitations





Thank you!

Follow us on X: @NASASpaceSci

Website: science.nasa.gov/biological-physical



Backup

Key Science Questions (KSQs) from Decadal Survey

KSQ 1	How does the space environment influence biological mechanisms required for organisms to survive the transitions to and from space, and thrive while off Earth?
KSQ 2	How do genetic diversity and life history influence physiological adaptation to the space environment?
KSQ 3	How does the space environment alter interactions between organisms?
KSQ 4	What are the important multi-generational effects of the space environment on growth, development, and reproduction?
KSQ 5	What principles guide the integration of biological and abiotic systems to create sustainable and functional extraterrestrial habitats?
KSQ 6	What principles enable identification, extraction, processing, and use of materials found in extraterrestrial environments to enable long-term, sustained human and robotic space exploration?
KSQ 7	What are the relevant chemical and physical properties and phenomena that govern the behavior of fluids in space environments?
KSQ 8	What are the mechanisms by which organisms sense and respond to physical properties of surroundings and to applied mechanical forces, including gravitational force?
KSQ 9	What are the fundamental principles that organize the structure and functionality of materials, including but not limited to soft and active matter?
KSQ 10	What are the fundamental laws that govern the behavior of systems that are far from equilibrium?
KSQ 11	What new physics, including particle physics, general relativity, and quantum mechanics, can be discovered with experiments that can only be carried out in space?