National Aeronautics and Space Administration

NASA Initial Decadal Survey Response

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BPS

Biological & **P**hysical **S**ciences

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Next Era of Transformative Science in Space

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

A Legacy of NASA Space Science

Artemis I
2022

Apollo
1962-1972

Space Shuttle Program
1981-2011

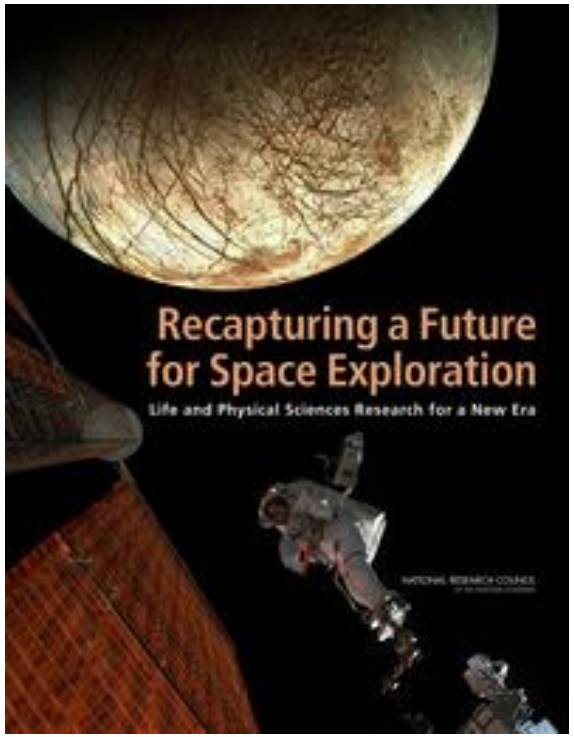
Skylab
1970s

Parabolic Flight
1958-1993

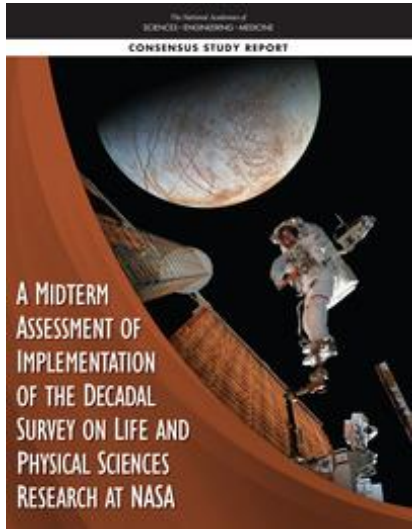
International Space Station
1998 – present (2030)

Project Mercury
1958-1963

BPS's Second Decadal Survey



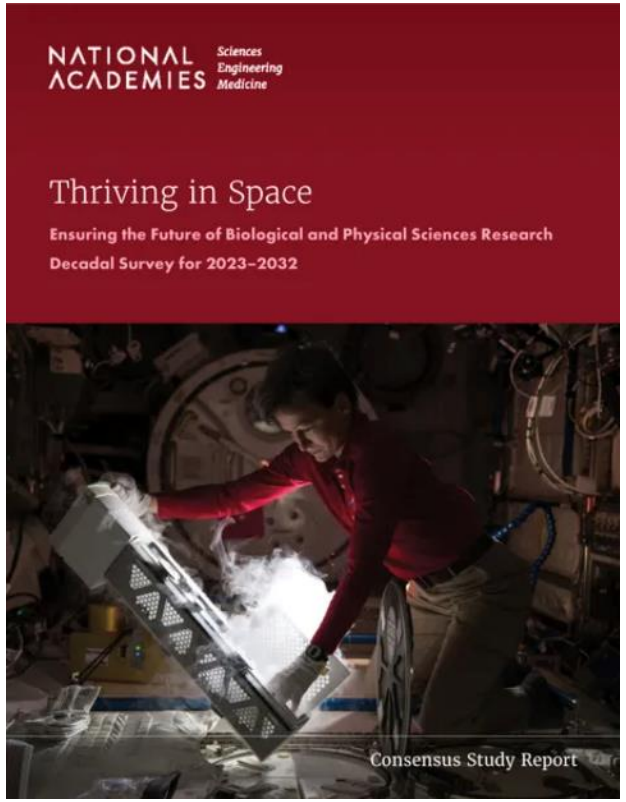
2011
First Decadal



2018
Midterm Assessment

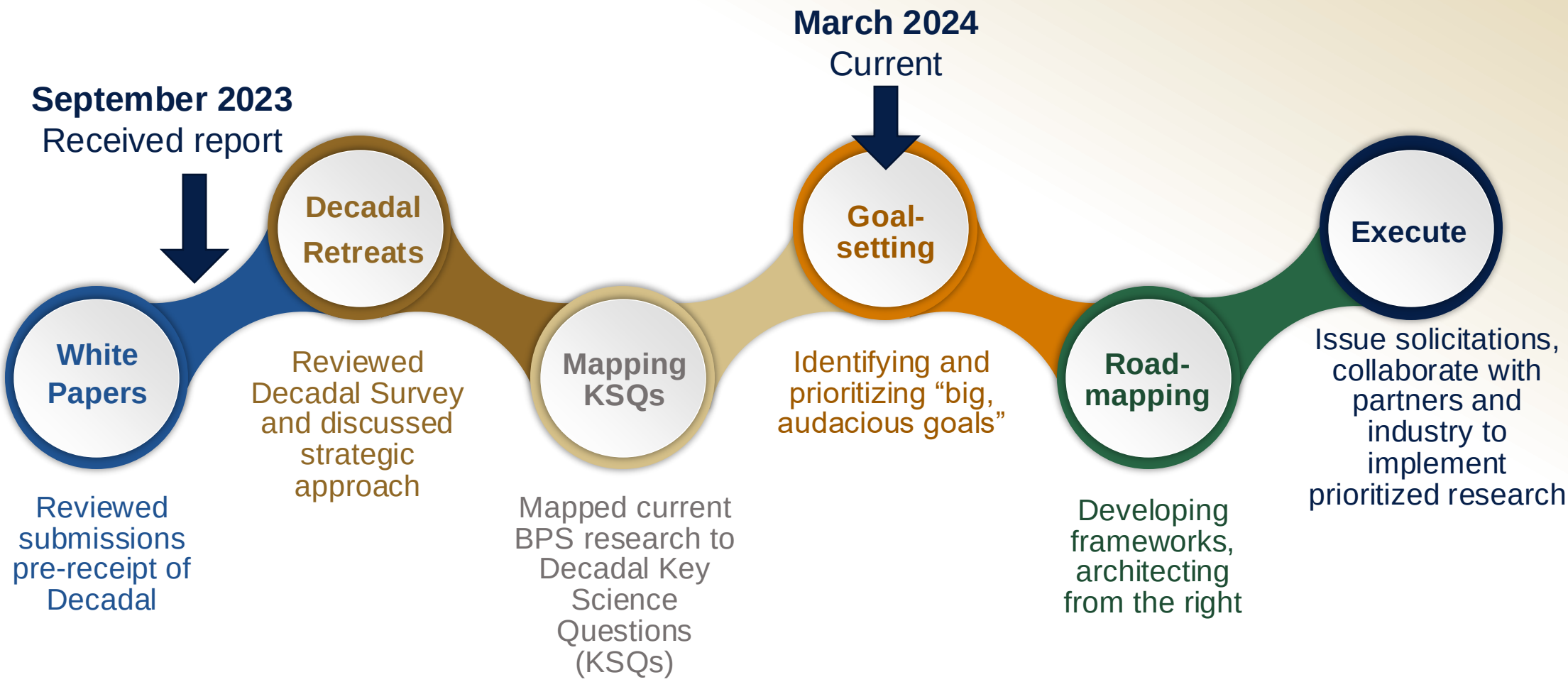
2023
Second Decadal

“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

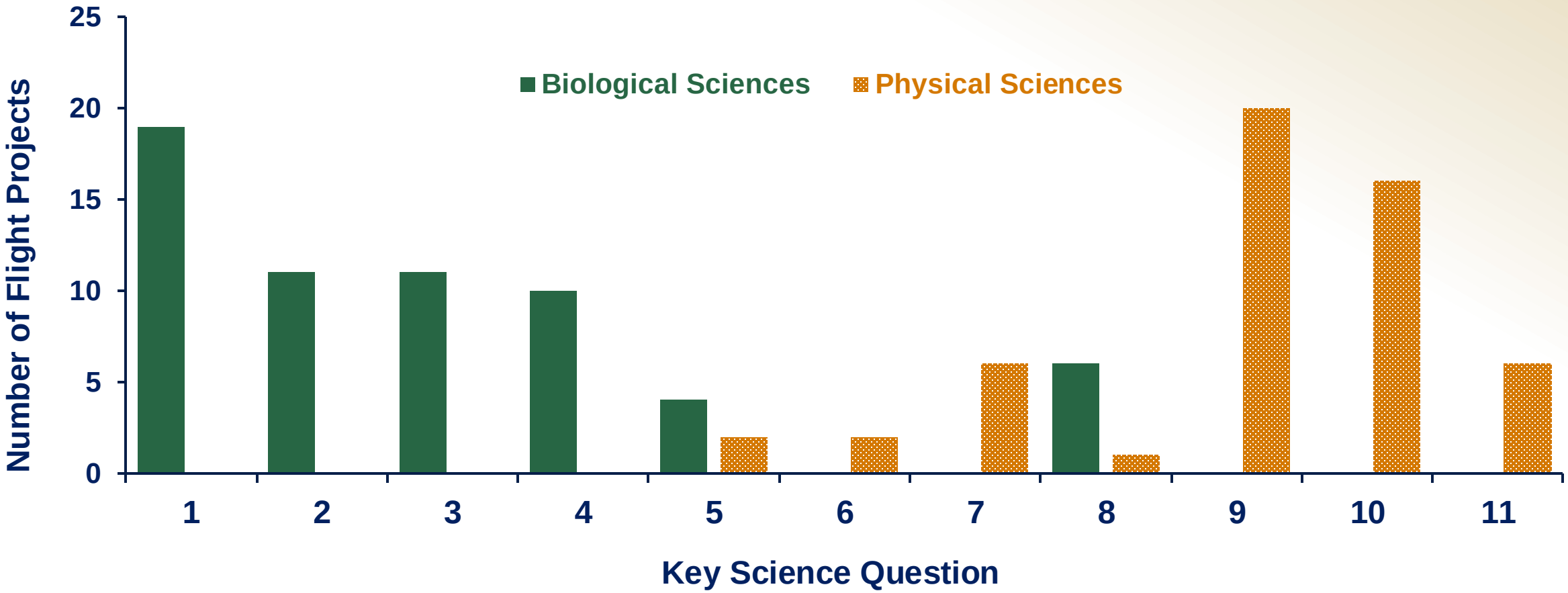
Recommendation:

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)



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

Collaboration

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

Rec. 7-1, 7-8, 7-9, 7-10, 7-13, 7-14

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:

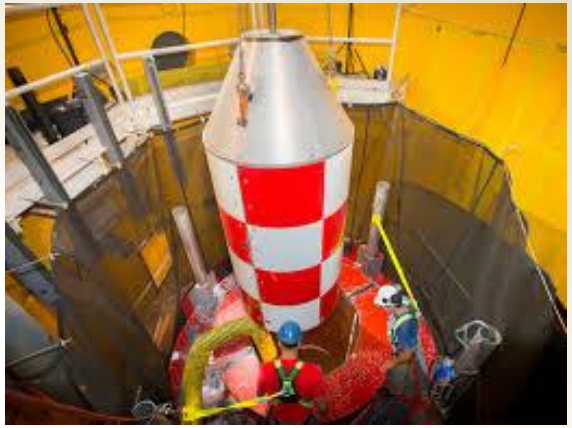
Develop and maintain sufficient ground-based infrastructure.

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

**Ground Capabilities*

Rec. 7-7

New Office

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 end of the decade.

NASA Initial Response:

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

Decadal Survey-Recommend Budgetary Decision Rules

- 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!

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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?