



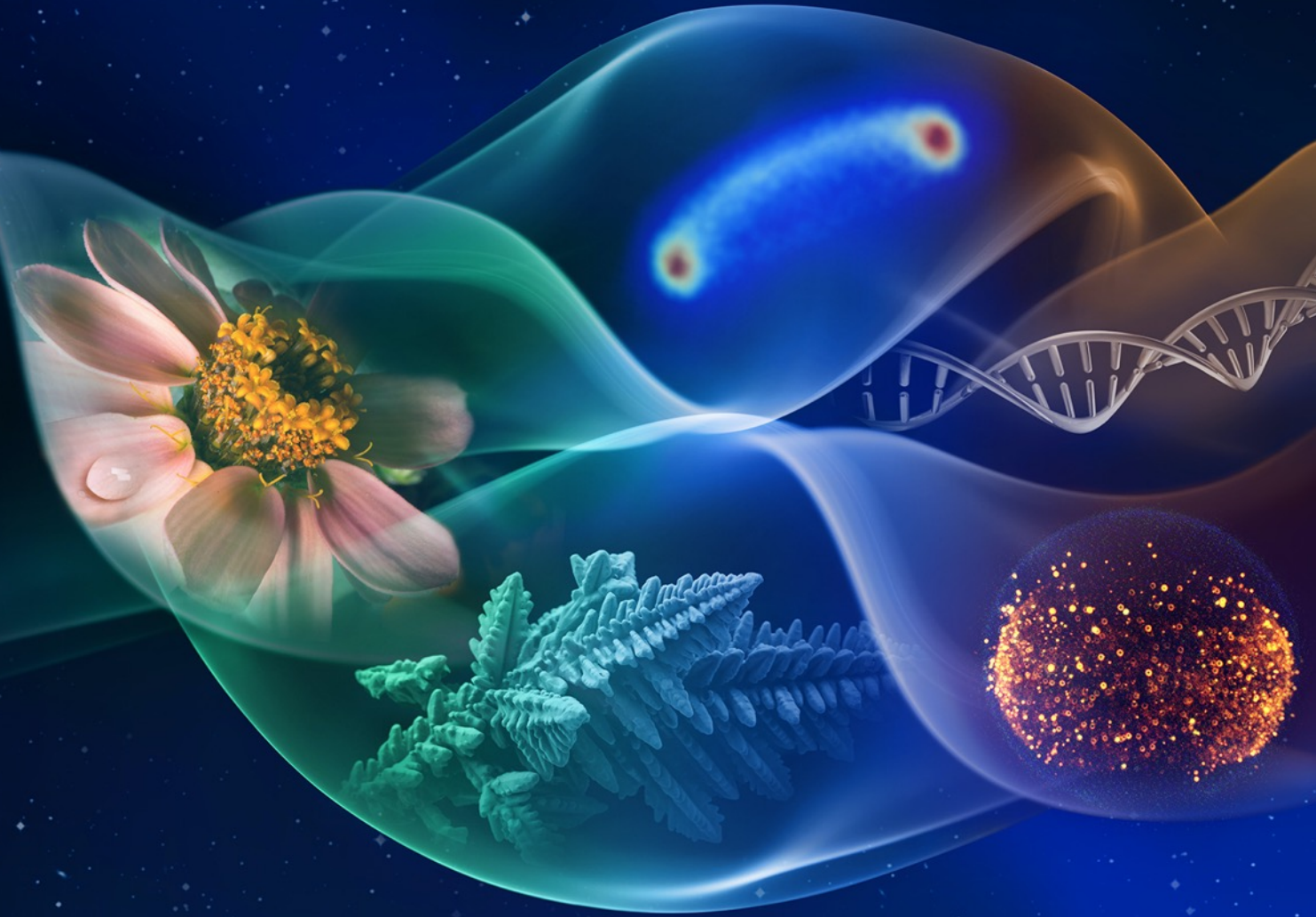
# Biological and Physical Sciences: Status and Planning

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Director

Biological and Physical Sciences Division

[science.nasa.gov/biological-physical](https://science.nasa.gov/biological-physical)



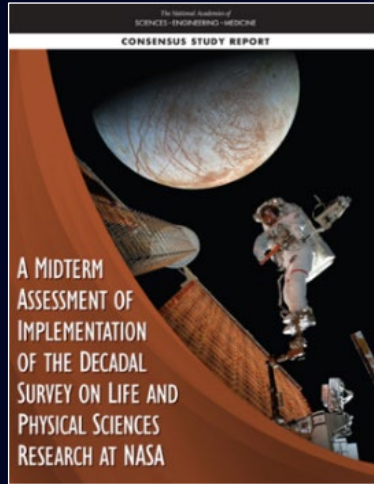
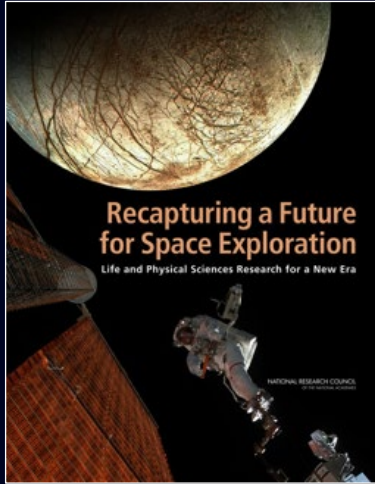
# BPS Mission

## Pioneer Scientific Discovery

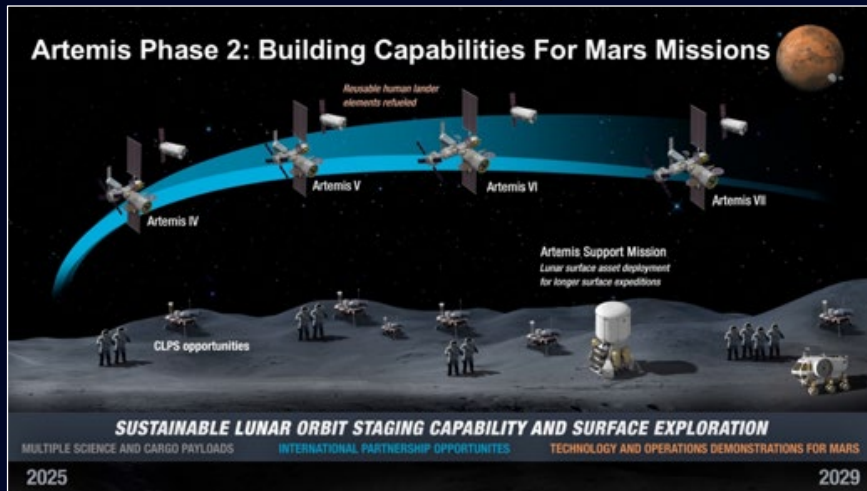
- Proactively seek out new ways to expand fundamental scientific knowledge
- Provide expertise and support to others seeking to utilize space

## Enable Sustainable Exploration

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



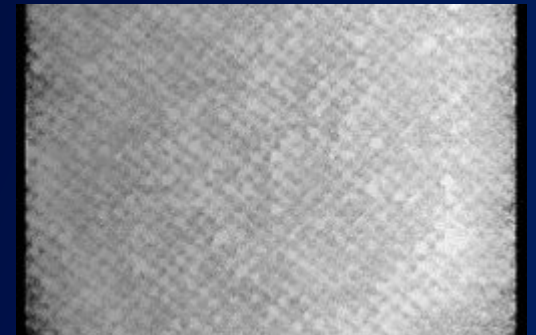
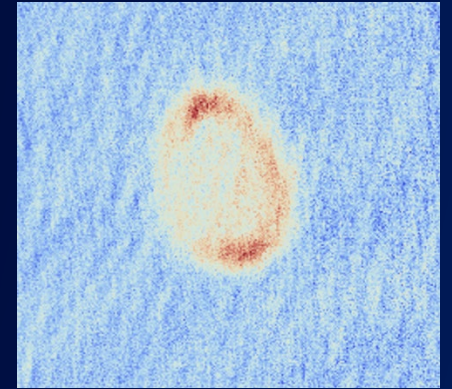
*Decadal Survey*

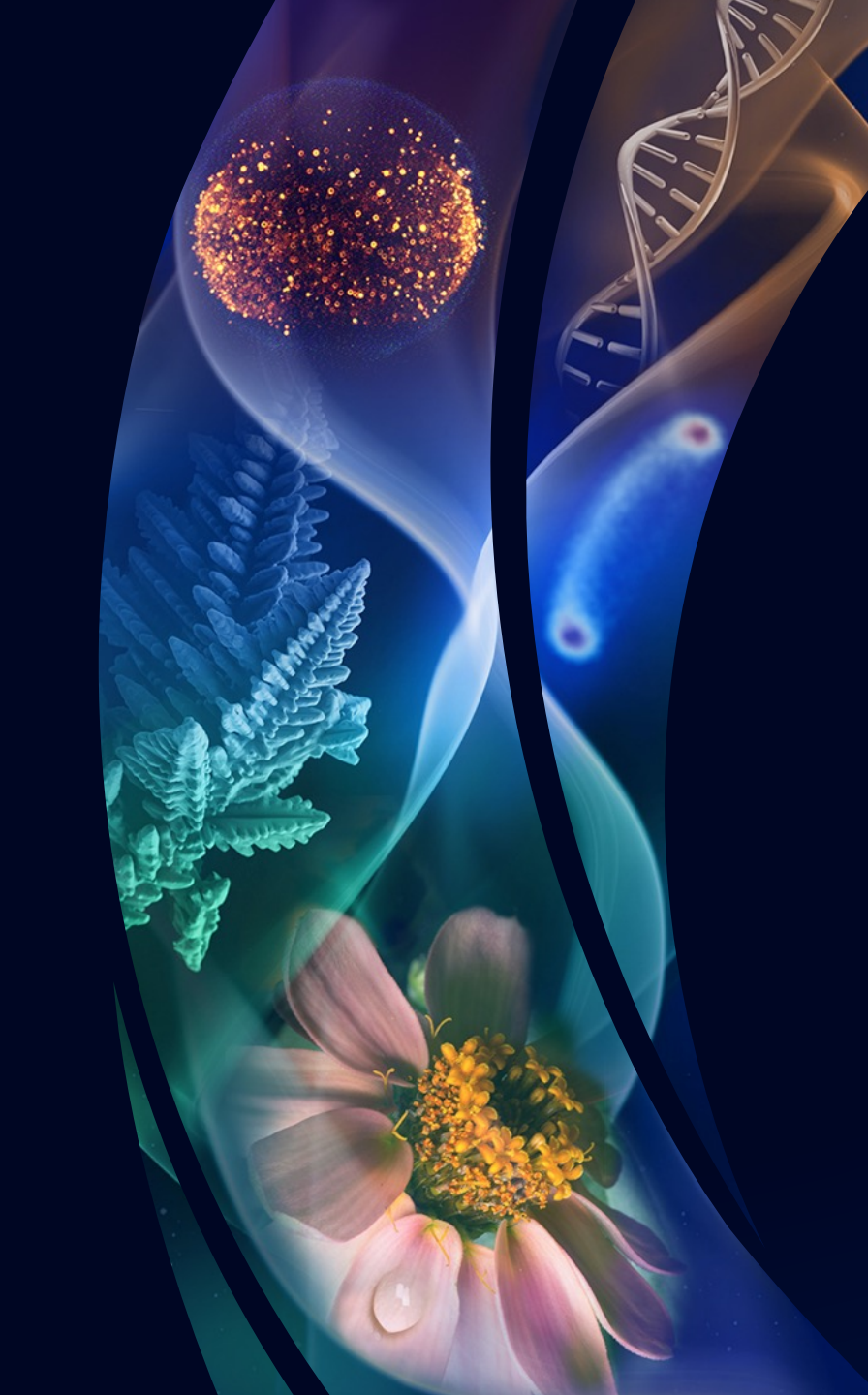


*Artemis Missions*

# Highlights from Recent Endeavors

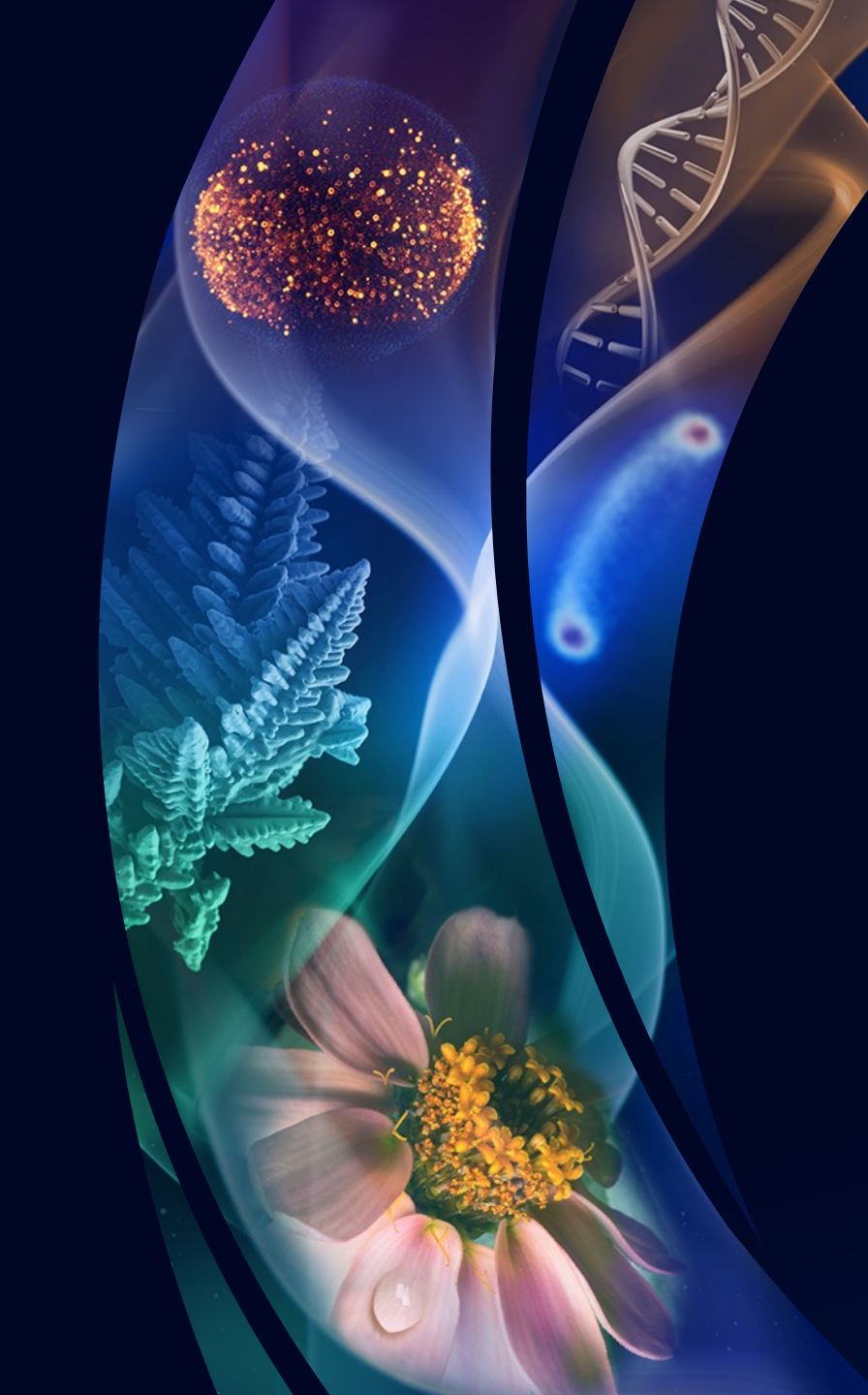
- Quantum Science
  - Bose-Einstein Condensates created in “bubble” geometry; 1 mm diameter
  - Explores phenomena when atoms meet themselves on the surface of a bubble
- Soft Matter
  - Phase diagram study produces near perfect FCC crystal of 1.3  $\mu\text{m}$  spheres (27 mm x 1.5 mm x 0.15 mm)
  - Improved modelling supports development of photonics, additive manufacturing, etc.
- Thriving in Deep Space
  - Surprising growth patterns for plants with reduced lignin, a structural molecule
  - Identifies fundamental lack of understanding, difficulty in optimizing plants for sustainable exploration





# Near Term Endeavors

- **Bio-Expt-1 aboard the Artemis I mission**
  - First biological experiments to be conducted beyond the Van Allen Belts since the Apollo missions
  - Analyze the impacts of deep-space radiation and microgravity on seeds, yeast, fungus, and algae
- **Solid Fuel Ignition and Extinction (SoFIE) investigations in the Combustion Integrated Rack aboard the ISS**
  - Starting multi-year series of five investigations follows years of investigations of liquid and gaseous fuels
  - First investigation, Growth and Extinction Limit, studies flame growth, decay, and extinction
- **Flow Boiling and Condensation Experiment in the Fluids Integration Rack aboard the ISS**
  - Starting multi-year pair of investigation (BPS; NSF/ISSNL)
  - Provides data to test and validate numerical models used to design new thermal management systems



# BPS Budget Strategy

Decadal  
Survey Panels  
January 2022

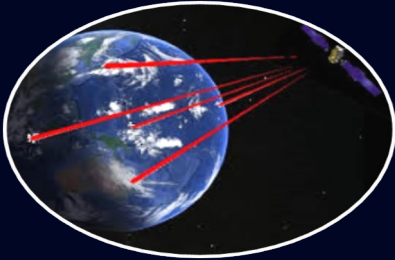
- **Near-term: Focus on transformative areas**
  - Bolster three areas likely to be recommended by the 2023 Decadal Survey
    1. Quantum Science (Cold matter)
    2. Thriving in Deep Space (TIDES) (Animal/Human, Plant)
    3. Soft Matter (Far-from-equilibrium processes; unique assemblies)
  - Prepare for large research activities to be recommended by the 2023 Decadal Survey
    - Keystone Capabilities/Missions
    - Research Campaigns
  - Pause other areas until 2023 Decadal Survey received
    - Complete funding of existing grants
    - Defer or descope future solicitations
    - Pause early-stage flight projects
- **Long-term: Implement 2023 Decadal Survey priorities**

# Quantum Science Decadal Keystone Mission Candidates

Decadal  
Survey Panels  
January 2022

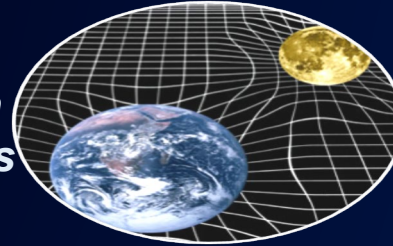
## Research on Free Flyers

Gravitation  
and Dark  
Matter



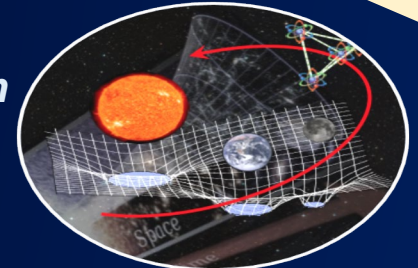
Fund Physics with Optical Clock  
Orbiting in Space (FOCOS)

Quantum/  
Gravitation  
Correlations



Space Experiments Exploring Quantum  
Entanglement and Relativity(SEEQER)

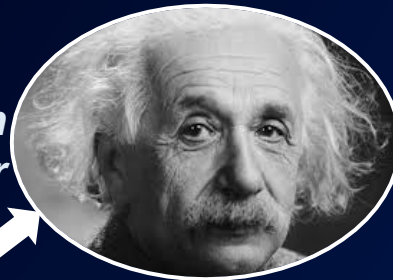
Gravitation  
and Dark  
Energy



Gravity Observation and Dark Energy Detection  
Explorer in the Solar System (GODDESS)

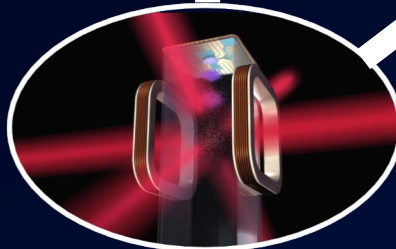
## Research on crewed platforms (ISS, Gateway, etc.)

Gravitation with  
Quantum Matter



Quantum Test of  
Equivalence and  
Space Time (QTEST)

Quantum  
Matter



CAL SM4



BECCAL (DLR)



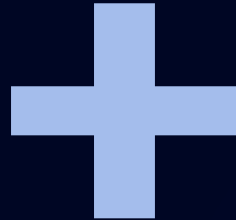
Quantum Explorer (QUEX)

# Thriving in Deep Space (TIDES)

Decadal  
Survey Panels  
January 2022

## Understand Fundamental Mechanisms

Use model organisms to determine how animals/humans respond to deep space environments



## Build the Blocks to Support Human Life

Understand how model plants, crops, & seeds respond to and can thrive in deep space environments



## Build a Foundation for Sustained Life on Mars

Engineer habitats and ecosystems to enable astronauts' independence from Earth

- Stabilize human/animal-plant-microbial ecosystems in the context of multiple deep space stressors

### DEEP SPACE STRESSORS

Gravity

Radiation

Temperature/Atmosphere

Day/Night/Circadian Cycle

Isolation

### PLATFORM PROGRESSION

Ground

Sub-Orbital

LEO/ISS

Gateway

Lunar Surface

Mars Transit

Martian Surface

### MODEL ORGANISM PROGRESSION

Unicellular (e.g., yeast, fungi)

Invertebrates (e.g., flies, worms, tardigrades)

Vertebrates (e.g., mice, fish; tissue chips)

Humans

Simple model plants (e.g., *Arabidopsis*)

Edible & others (for micronutrients, etc.)

# Elements of the Soft Matter Initiative

Decadal  
Survey Panels  
January 2022

## Ground-Based Research

- ✓ Ground-based microgravity facilities
- ✓ Modelling
- ✓ Annual Funding Opportunities

## Space-Flight Research

- ✓ Physical Science microscope on ISS
- ✓ Use IP and commercial hardware available on ISS
- ✓ Proposal call every 3 years

Soft Matter Dynamics aims to improve the understanding of nonequilibrium phenomena to enable the *control and use* of soft matter dynamical systems

## Soft Matter facility (post-decadal)

- ✓ Low earth orbit
- ✓ Beyond low earth orbit

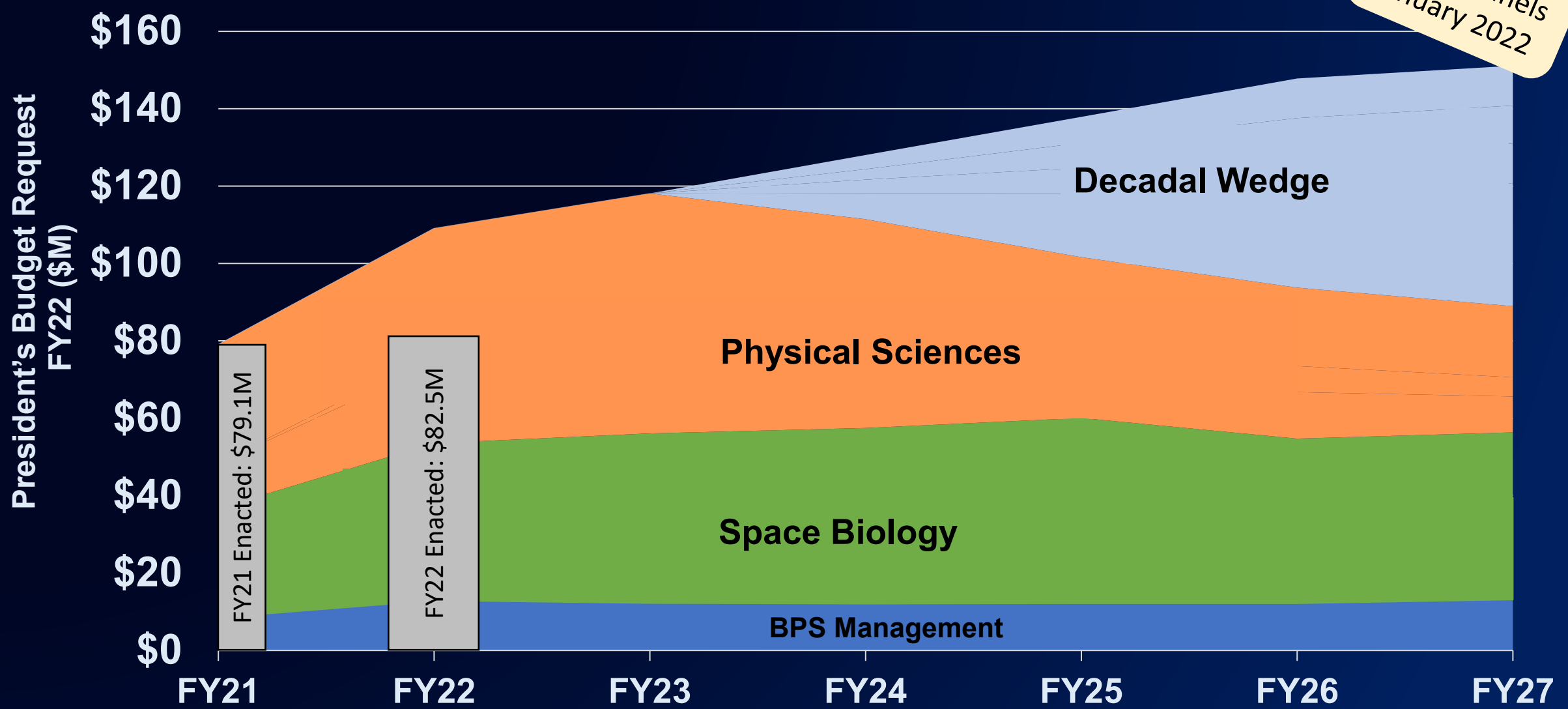
## AI/ML/Big data platform

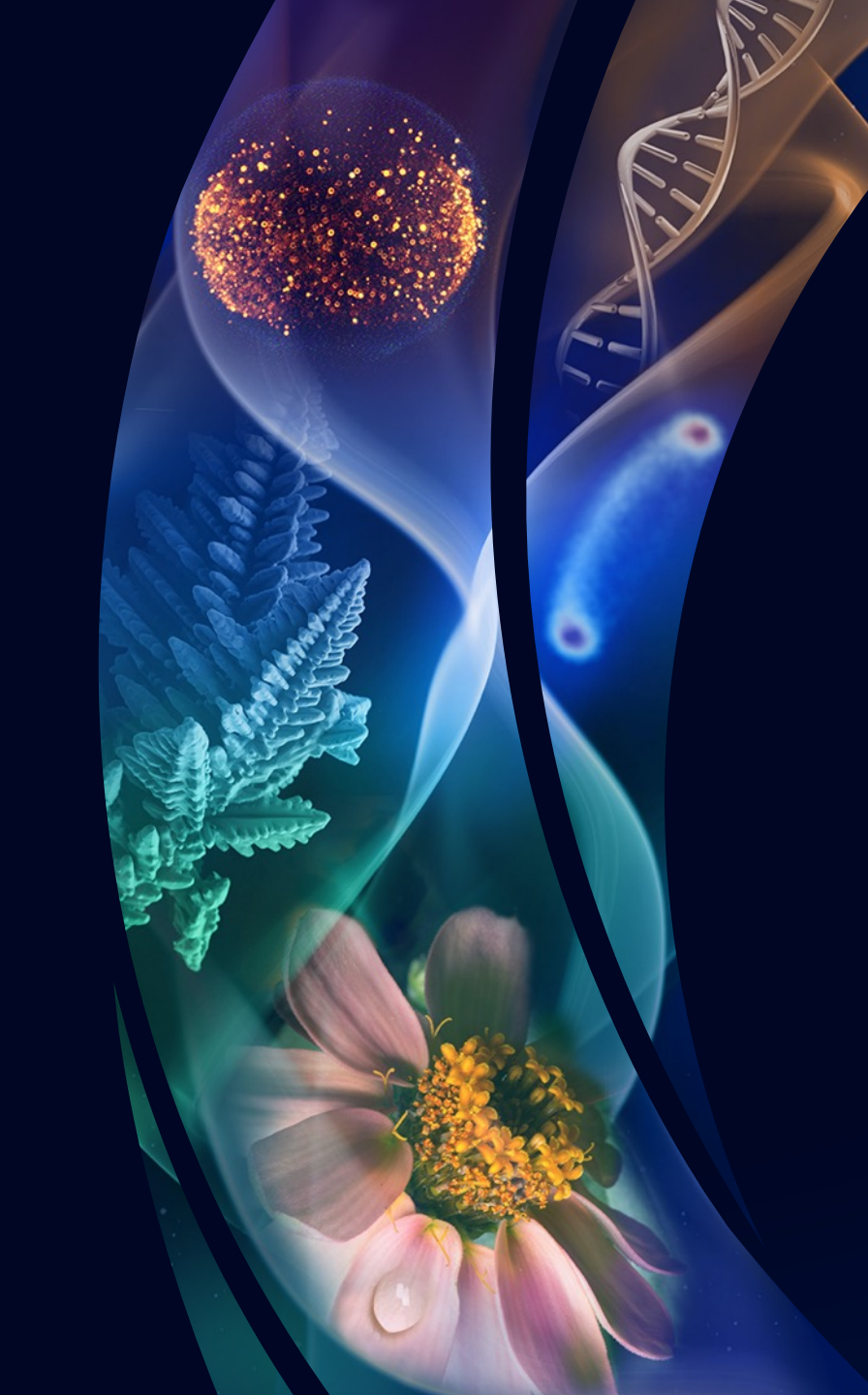
- ✓ Improved computation
- ✓ Better experimentation, imaging, and data analysis

Decadal guidance will shape the future of this initiative

# BPS Budget Plan Based on President's Budget Request

Decadal  
Survey Panels  
January 2022

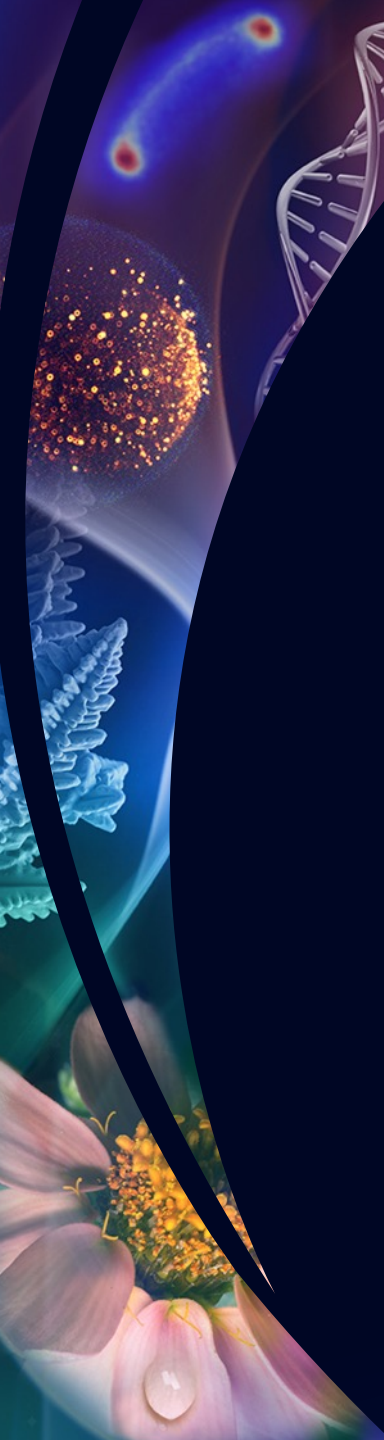




# BPS Budget Strategy

Decadal  
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January 2022

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- **Long-term: Implement 2023 Decadal Survey priorities**



# The Next Decadal Survey for BPS (2023-2032)

- 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, and/or
  - Provide terrestrial benefits
- Recommendations for implementing the transformative science goals and objectives
  - Research activities
  - Associated facilities and platforms (“Keystone Capabilities/Missions”)
  - Research Campaigns
- Recommendations organized into broad cost categories
  - Example: New Worlds, New Horizons in Astronomy and Astrophysics (2010)
    - Table ES.4 “\$100M to \$200M”, “\$60M to \$200M”
- **Release scheduled summer 2023**

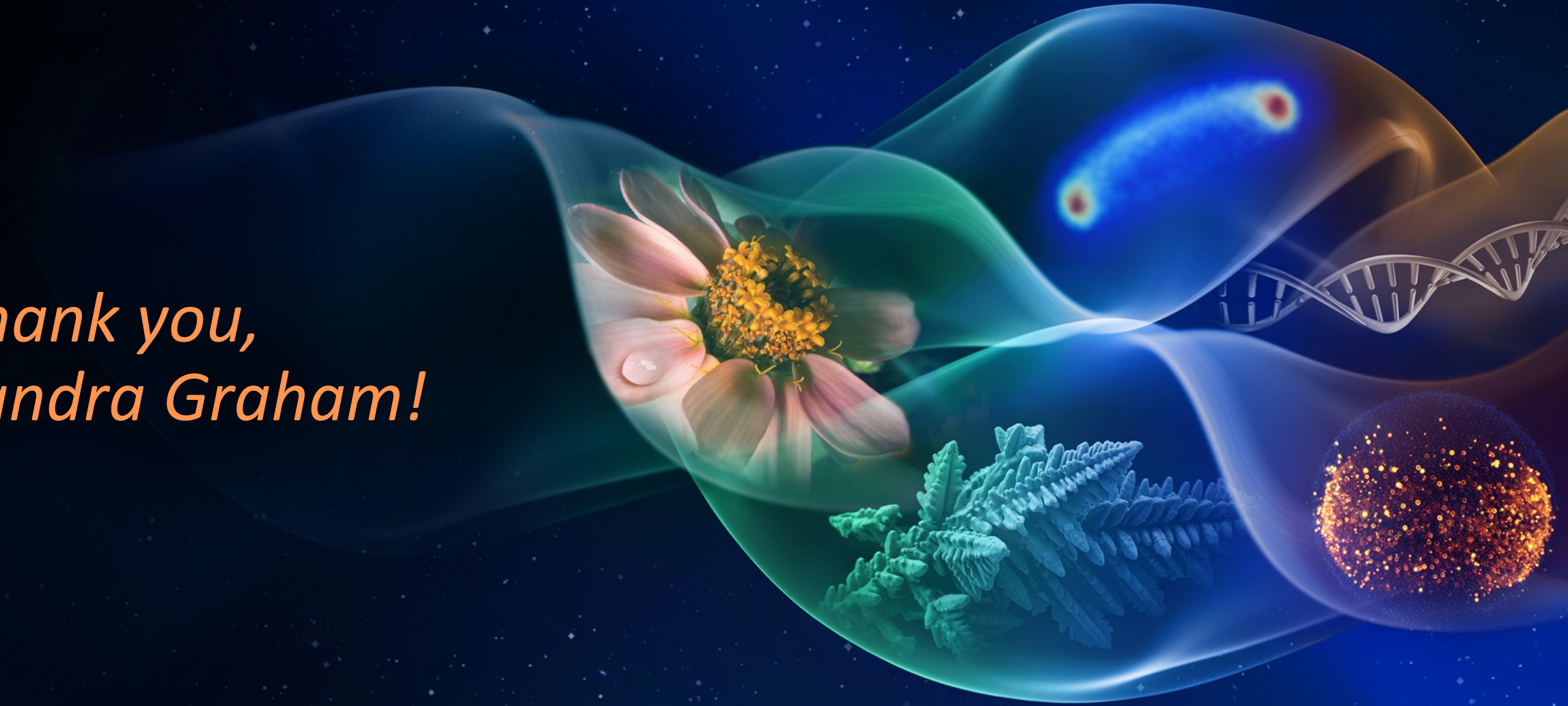
The transformative science conducted through Keystone Capabilities and Research Campaigns will be the building blocks of BPS’s scientific program for the next decade

# BPS over the Next 10 Years



- Pioneer transformative science at the frontiers of biology and physical sciences in space
  - Frontiers: Conceptual and Physical
    - Areas where BPS can uniquely
      - Advance scientific knowledge
      - Meet the needs of exploration missions
      - Provide terrestrial benefits
    - Locations include
      - Commercial and governmental ground-based; commercial sub-orbital
      - ISS; Commercial Low Earth Orbit Destinations
      - Lunar orbit (Gateway)
      - Lunar surface (Commercial Lunar Payload Services, Human Landing System)
      - Mars transit vehicle prototype
  - Pioneer
    - BPS first or among first at a frontier
      - Other organizations (government, commercial, academic, international) may join or follow
    - BPS collaborates in all phases
      - First tests of feasibility
      - Refining research
      - Sustained research

*Thank you,  
Sandra Graham!*



# BIOLOGICAL & PHYSICAL SCIENCES FLEET

- FORMULATION
- IMPLEMENTATION
- OPERATIONAL
- AVAILABLE
- PARTNER-LED\*



LEIA

BIOEXPT-1

VEGGIE  
FFL  
PK-4\*  
SMD\*  
SUBSA  
WETLAB-2  
MSRR  
PBRE  
MT  
MHU\*  
LMM  
MICRO  
RR  
ELF\*  
CELL BIO  
BRIC-LED  
EML\*  
DECLIC\*  
BRIC  
CAL

RAD-SEED  
BION\*

ACME  
FBCE  
RSD  
PFMI  
BECCAL\*  
APH  
SOFIE  
FLARE\*  
ZBOT  
COMPACT\*

*Thank you*

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