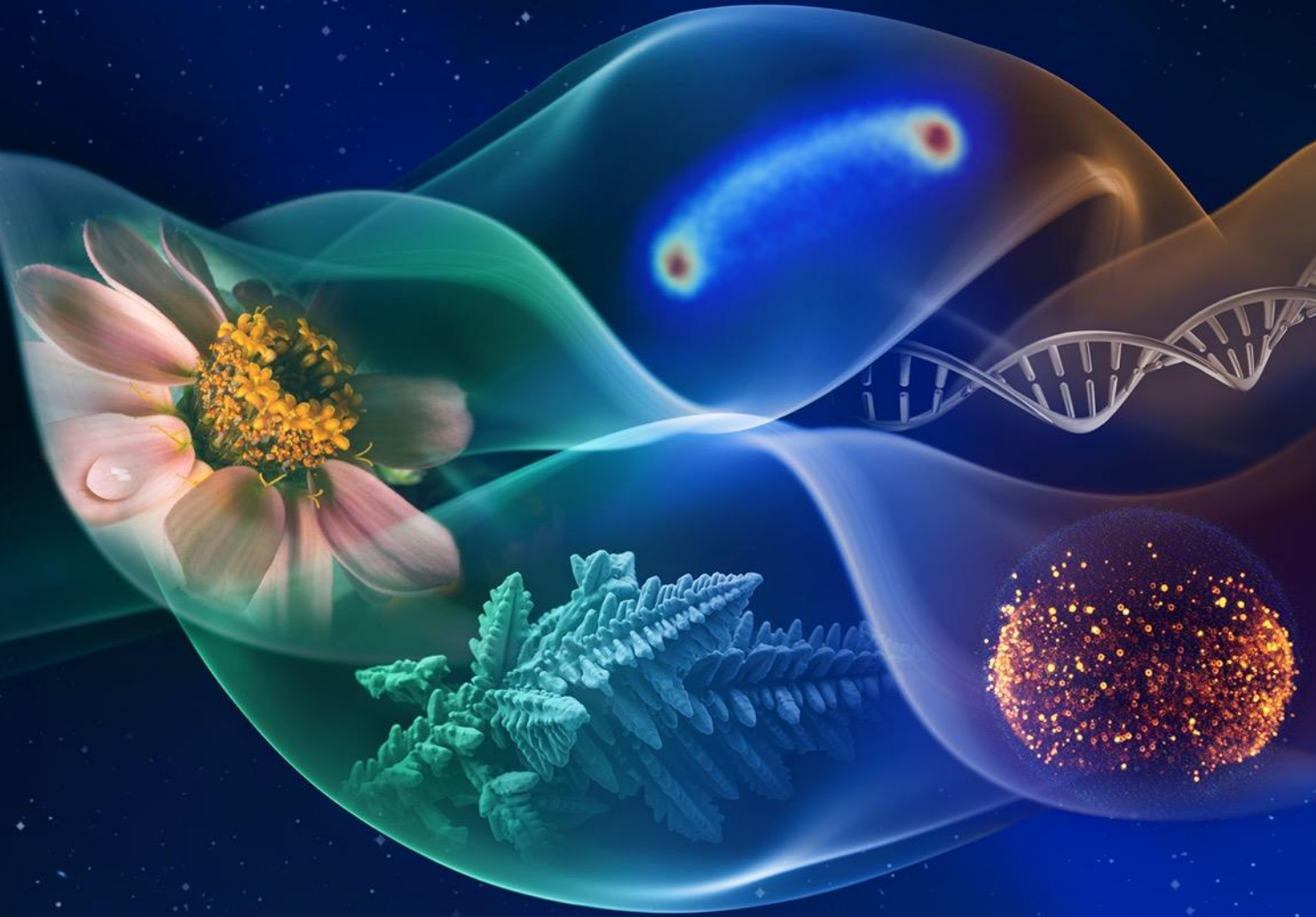
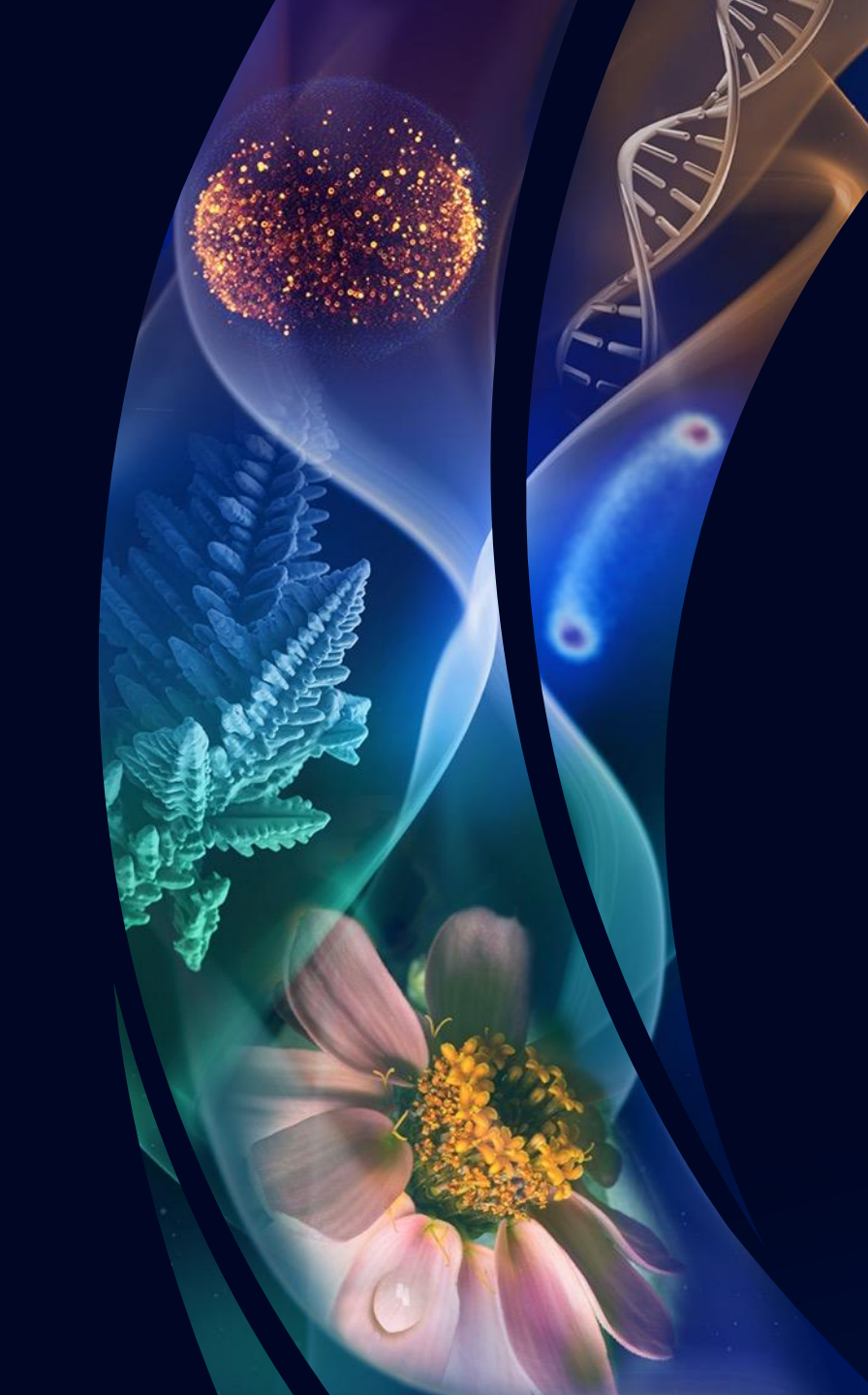




State of Biological and Physical Sciences in Space: NASA Perspective

Craig Kundrot
Director
Biological and Physical Sciences Division



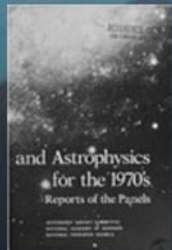


Bottom Line Up Front

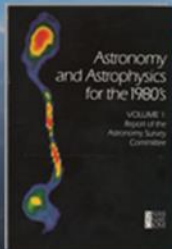
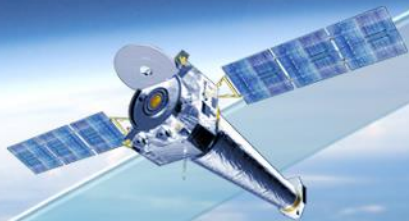
- The Decadal Survey answers key questions
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 - NASA
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 - Policy makers and appropriators
 - Commercial spaceflight industry

Astrophysics

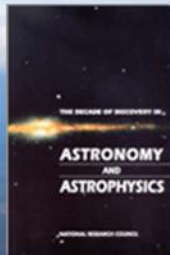
Decadal Survey Missions



1972
Decadal
Survey
Hubble



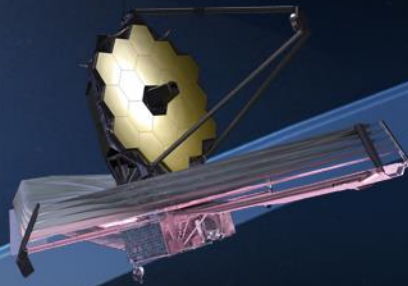
1982
Decadal
Survey
Chandra



1991
Decadal
Survey
Spitzer



2001
Decadal
Survey
Webb



2010
Decadal
Survey
Roman



2021
Decadal
Survey

?

BPS Vision



Example of Physical Sciences research:
Studying quantum gasses



Example of Space Biology research:
Growing plants in space

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

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

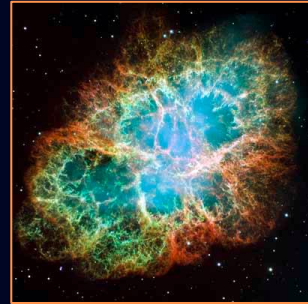
This can contribute to significant scientific and technological advancements that

**make fundamental advances in science,
enable space exploration, and
benefit life on Earth.**

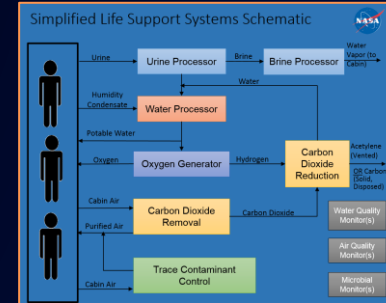
Experimental Variables in Spaceflight Environments



Microgravity



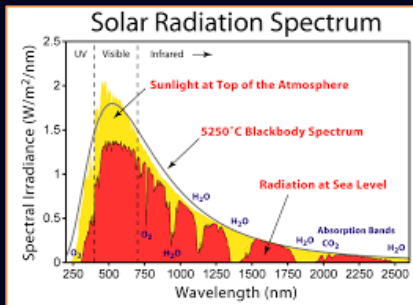
Radiation



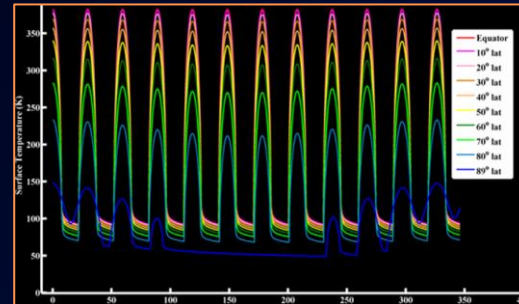
Altered Atmospheres



Regolith/Dust



Unattenuated Light

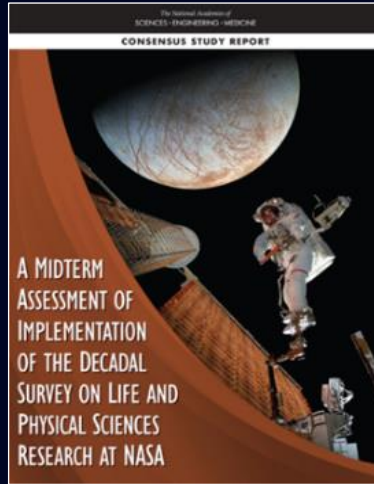
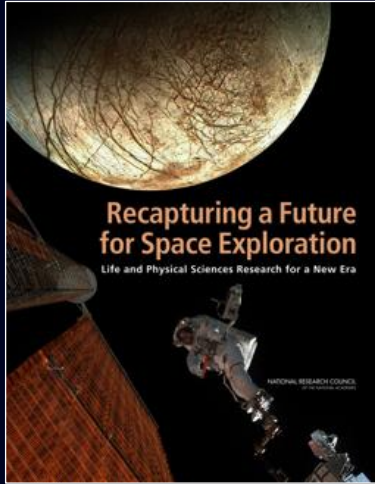


Lack of Circadian Rhythm

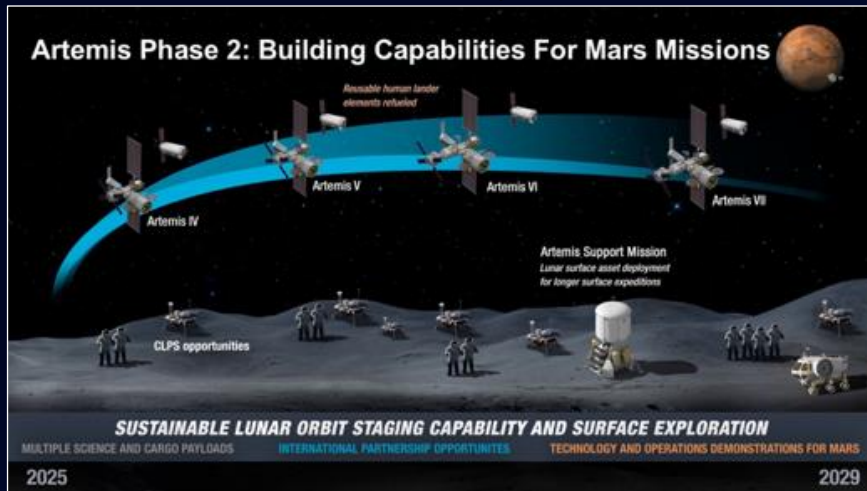


Long Distances

BPS Mission & Goals



Decadal Survey



Artemis Missions

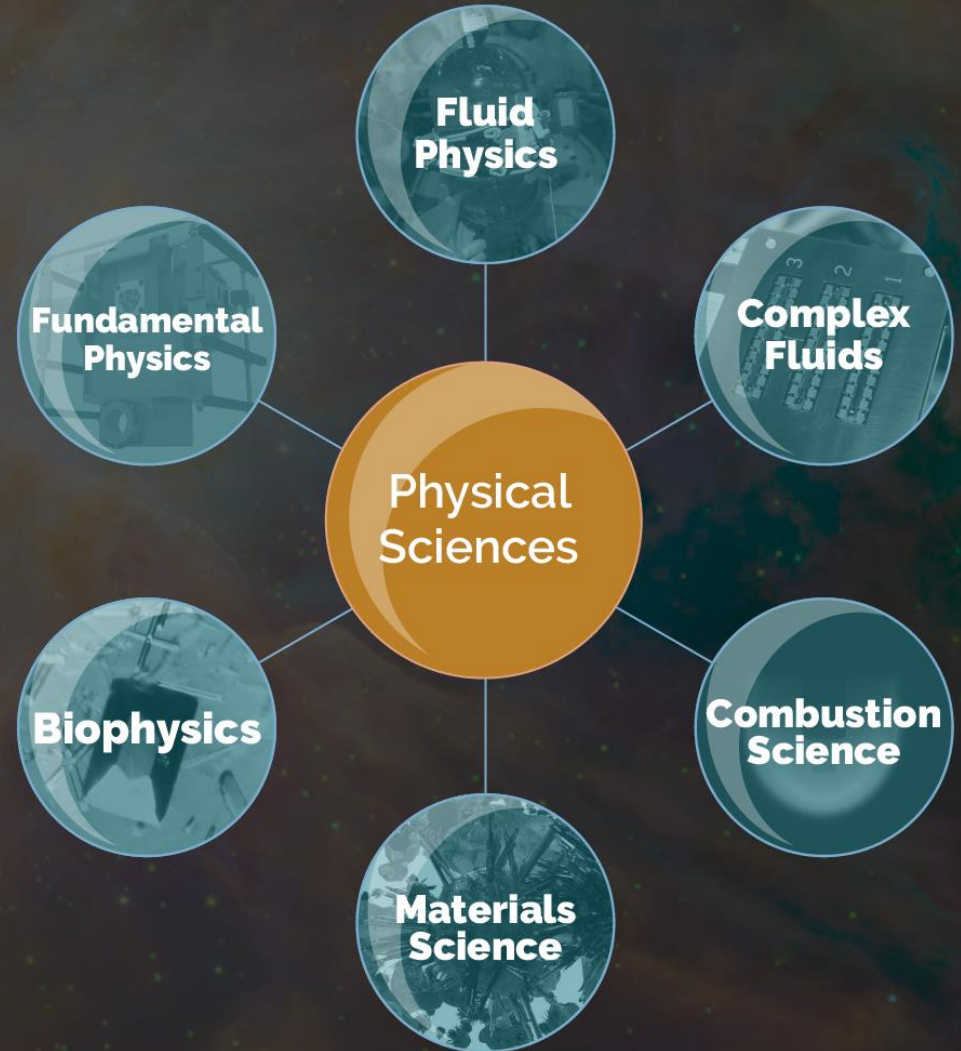
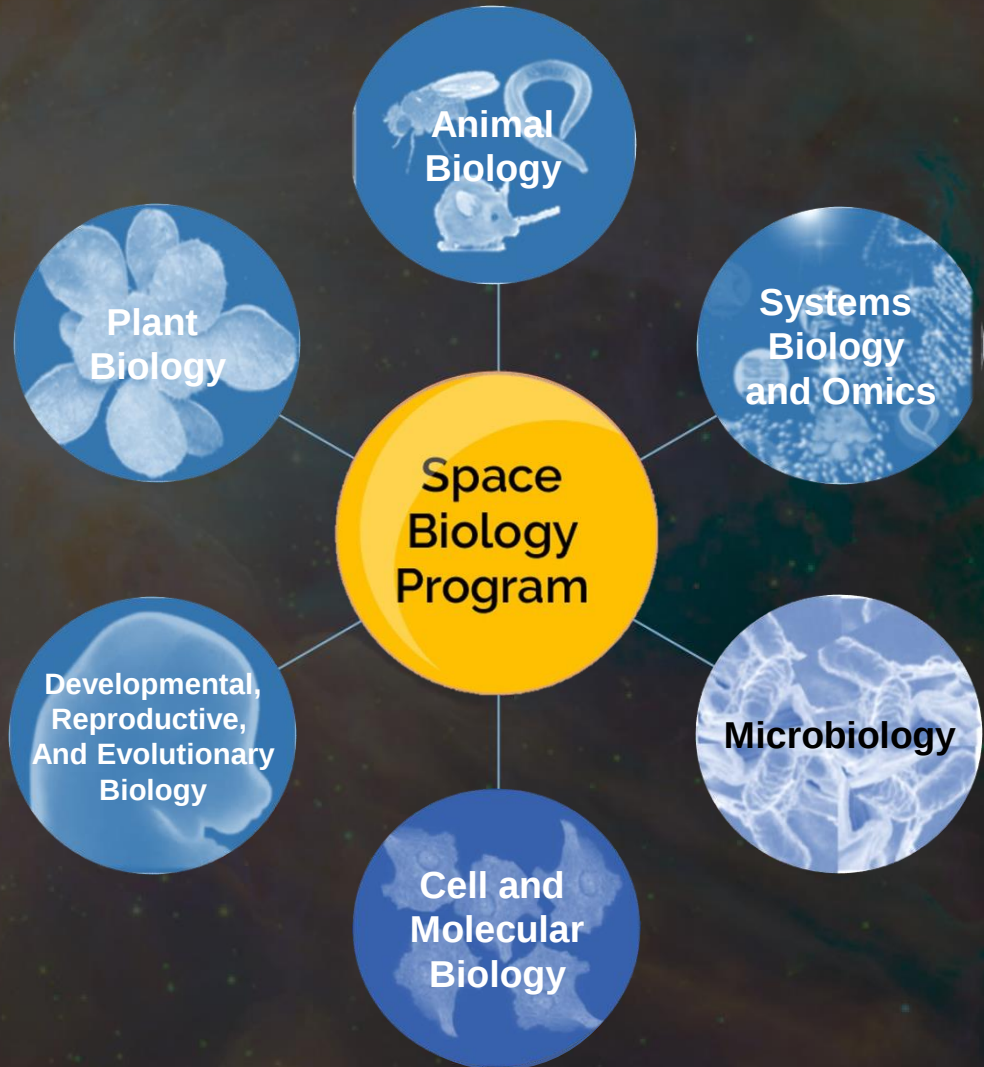
Pioneer Scientific Discovery

- 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 and industry

BPS Disciplines



BIOLOGICAL & PHYSICAL SCIENCES FLEET

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

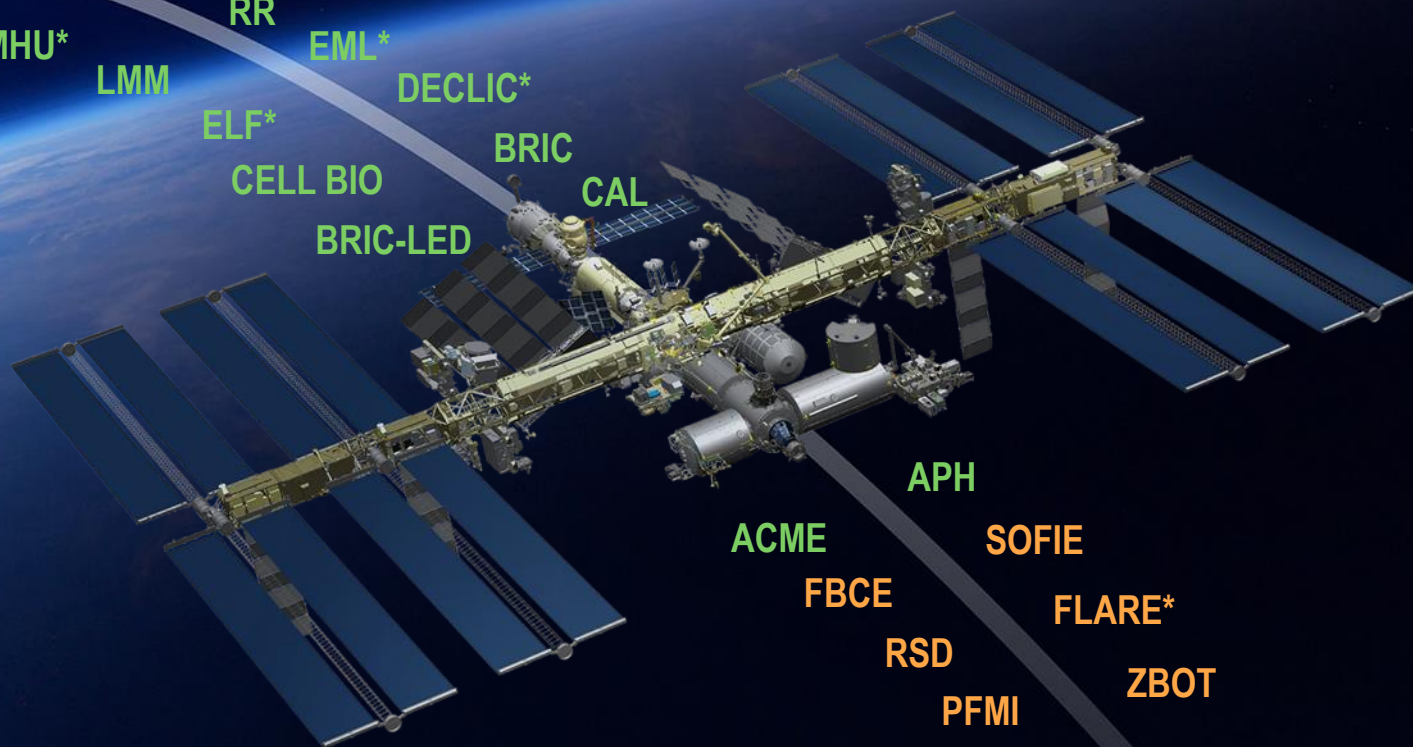


LEIA

BIOEXPT-1

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

RAD-SEED
BION*



APH
ACME
FBCE
RSD
PFMI
SOFIE
FLARE*
ZBOT
BECCAL*

BPS Platforms for Research

**Future Platforms*



CubeSat



International Space Station



Free Flyers (BION)



**Lunar Gateway*



**Commercial Lunar Lander Services*



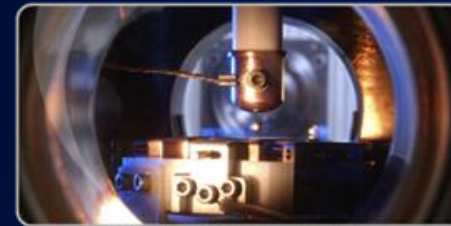
Drop Tower



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



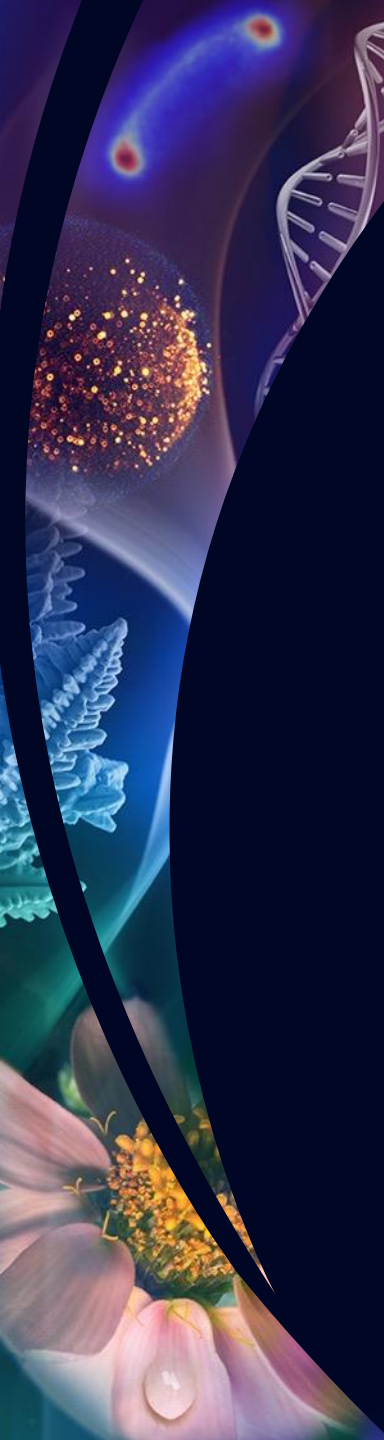
Gravity Vector Averaging



Physical Sciences
Informatics

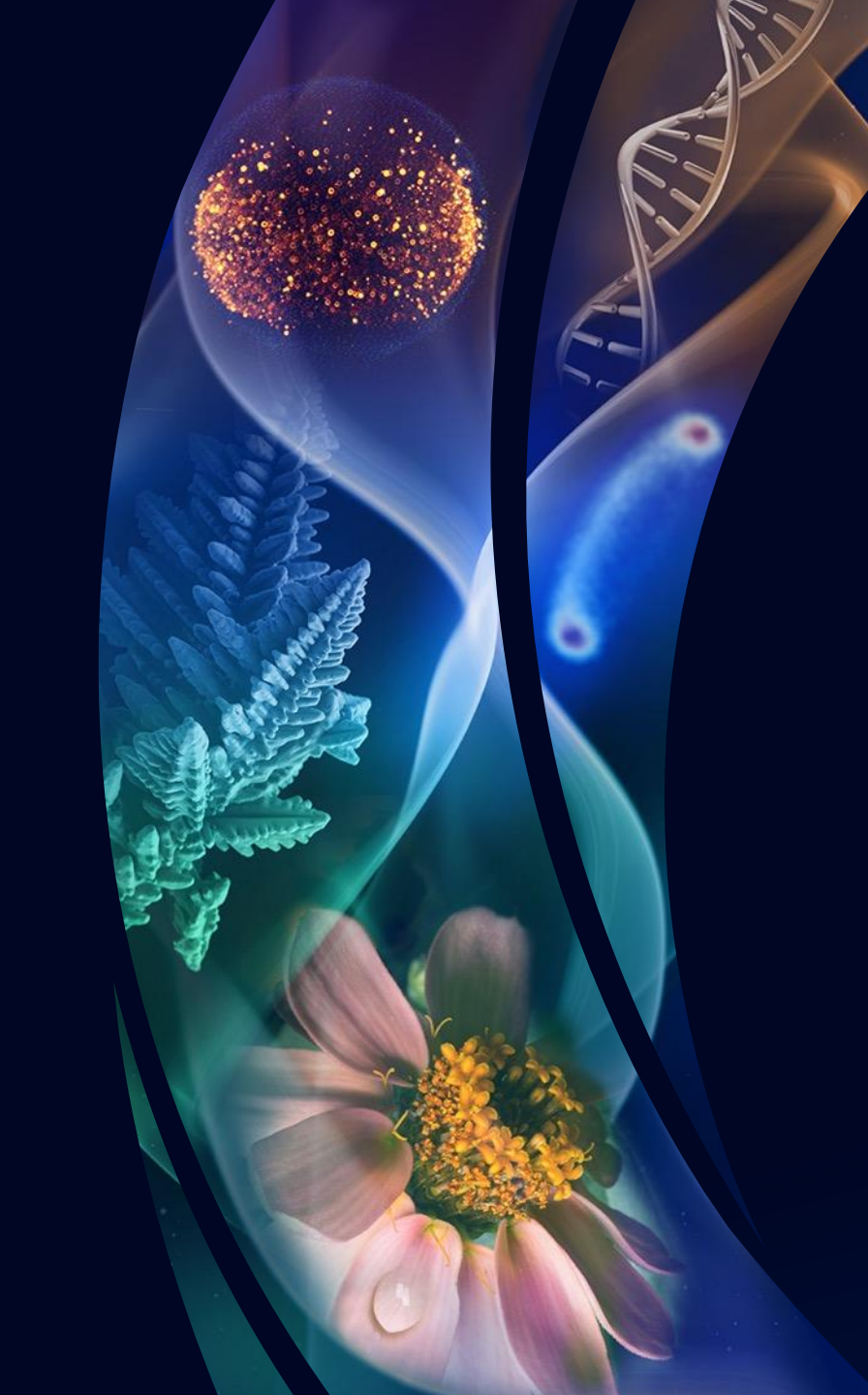


GeneLab



Decadal Survey Statement of Task: Key Points

- Transformative science
 - The most compelling science challenges
 - At the frontiers of biological and physical sciences research in space
- Three areas of benefit
 - Advance scientific knowledge
 - Meet the needs of human and robotic exploration missions
 - Provide terrestrial benefits
- Recommendations for
 - Research activities including facilities and platforms (e.g., “Keystone Capabilities”)
 - Including those not currently available but which could be developed in the future
 - Research Campaigns
- Provide broad cost categories for facility and platform capabilities, and research campaigns



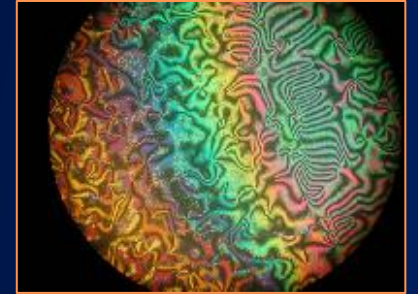
Transformative Research

- 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

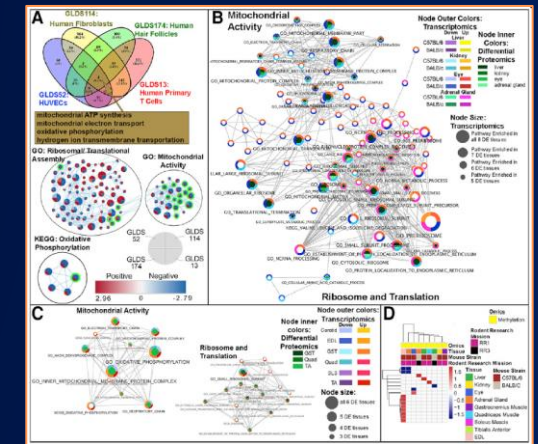
Candidate Transformative Areas- Physical Sciences

- Soft Matter: Active, non-equilibrium systems responsive to external forces controlled in space and time.
- General Relativity (GR) – precision metrology exploring the limits of GR
- Quantum Matter – the physics of few- to many-body quantum systems
- Dark Matter (DM) and Dark Energy (DE) – quantum mechanics applied to search for signatures of DM and DE
- Quantum Mechanics – entanglement in relativistic systems and over solar system-scale distances
- Combustion: High pressure transcritical combustion; low temperature chemical kinetics
- Fluid Physics: Cryogenic fuel management; thermal management systems
- Materials Science: Additive manufacturing; lunar surface construction using regolith



Candidate Transformative Areas- Space Biology

- Systems Biology of Microbes, Plants, Animals
- Quantitative Genetics of Microbes, Plants, Animals
- Genetic Engineering of Plants
- 3D Tissues & Organ-on-Chip Models
- Automation, Miniaturization & Data Telemetry
- Artificial Intelligence/Machine Learning (AI/ML)



Summing Up



- The next decade will offer many exciting opportunities for BPS research
 - Wide range of experimental science
 - NASA in LEO, on/around the Moon, preparing for Mars
 - Industry providing launches/landings, platforms, experiment hardware
 - Sub-orbital, LEO, lunar

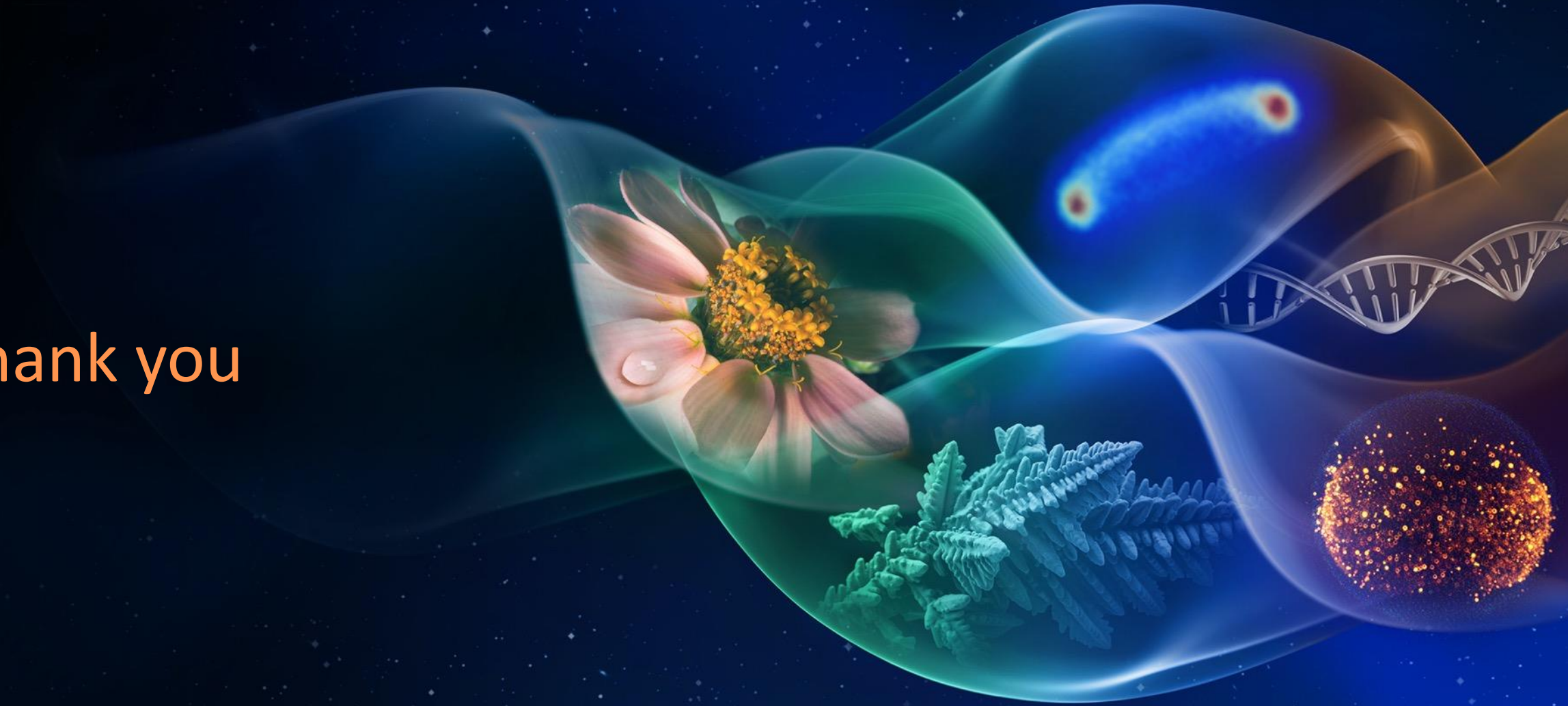


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 - NASA
 - Other government agencies and international partners
 - Policy makers and appropriators
 - Commercial spaceflight industry

Thank you



BPS Partnerships



National Institut
of Health



National Center
for Advancing
Translational Sciences



National Institute of
Allergy and
Infectious Diseases



National Institute of
Standards and Technology



esa



University of
Zurich^{UZH}