

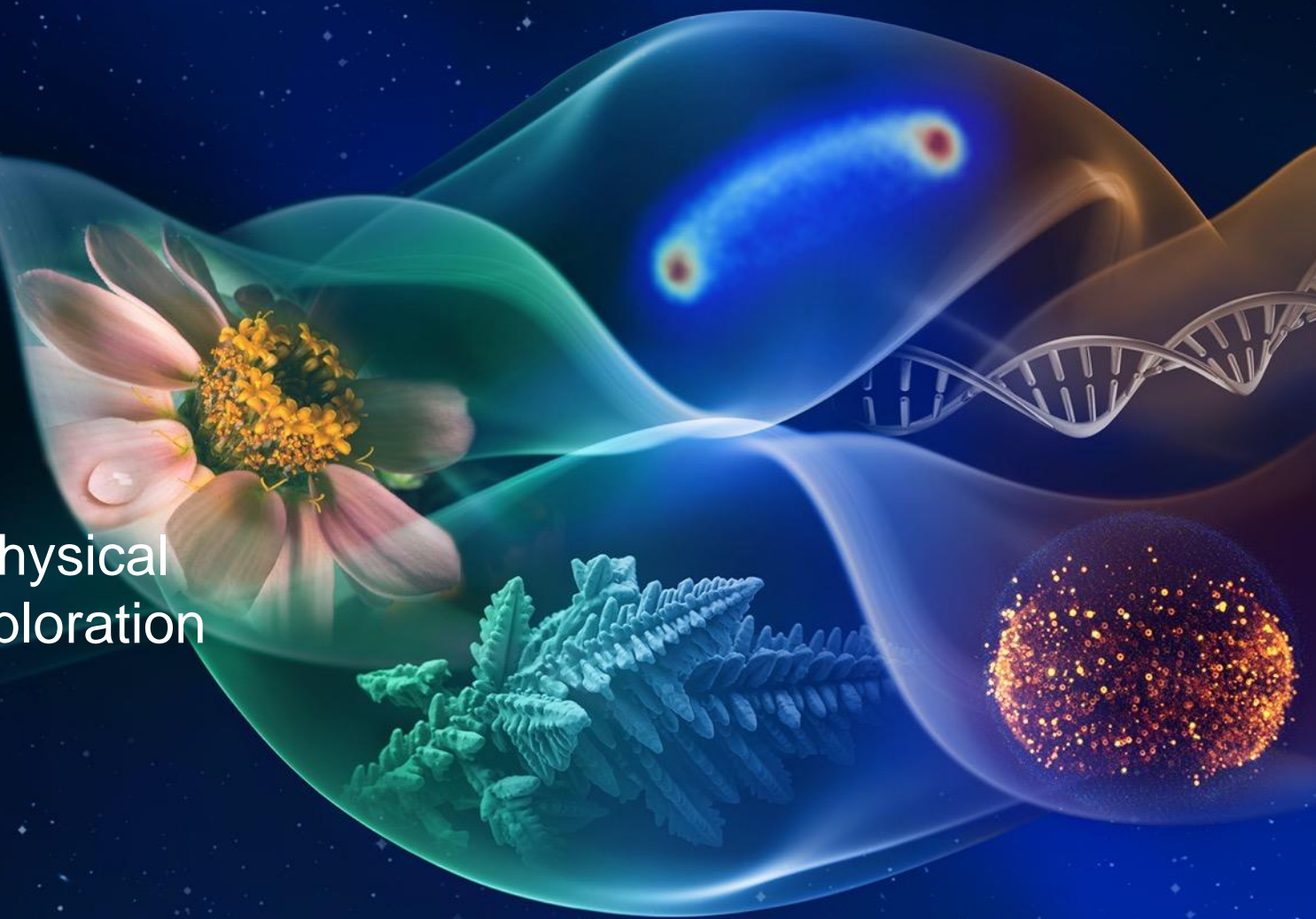


Biological and Physical Sciences Division

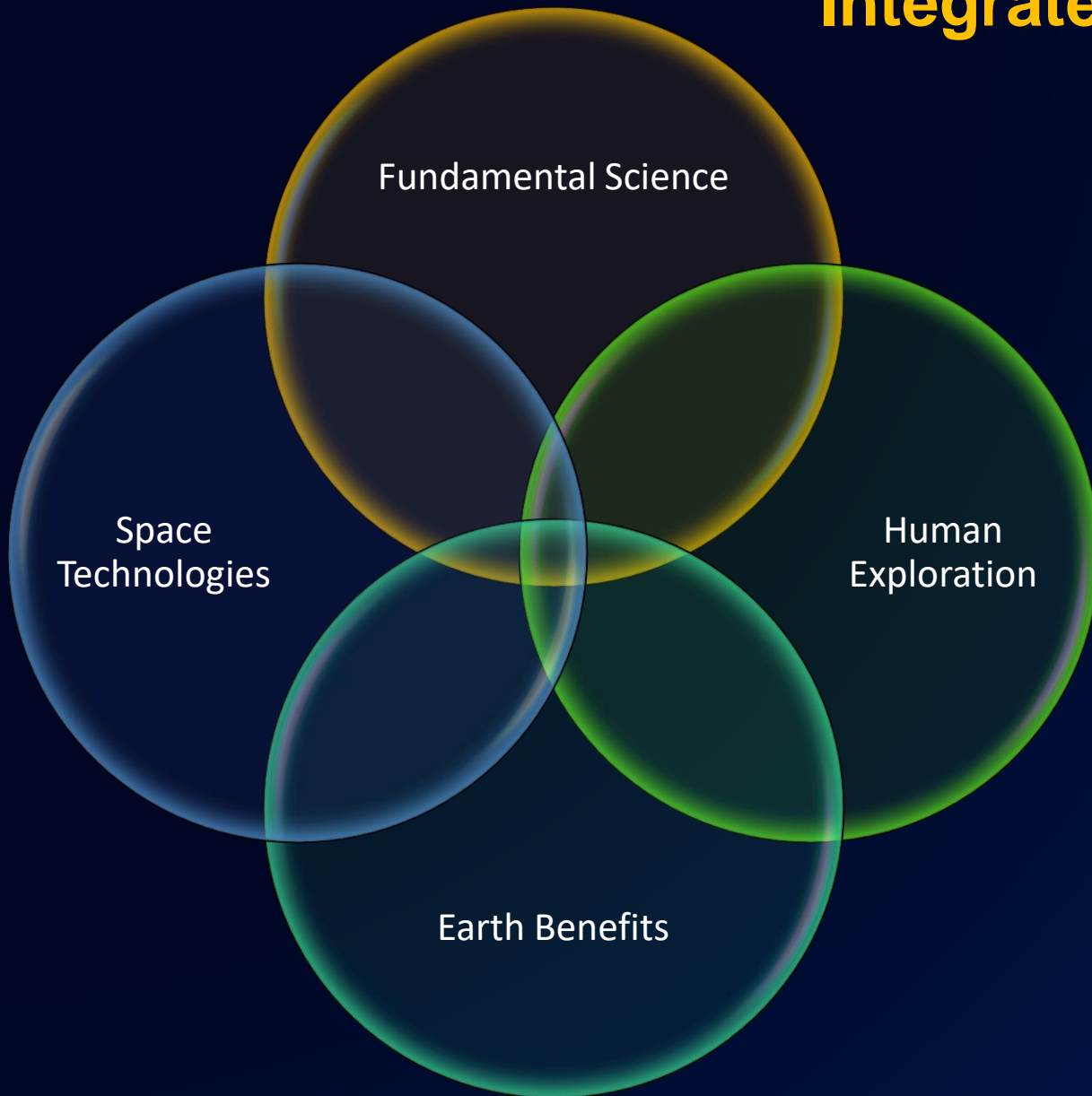
Advancing Biological and Physical
Sciences through Lunar Exploration

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Integrated Lunar Science Research



- Studies contributing to fundamental science knowledge, lunar habitation sustainability, and Mars-forward transit and surface exploration
- Provide fundamental data and knowledge contributing to research and development of applications
 - Exploration-specific needs
 - Commercial utilization needs
 - Earth benefits
- Advance our community of scientists towards new research and continue to grow this community with new beyond LEO research goals and objectives
- Inspire, educate, and train the scientists and engineers, including the next generation, who will continue to advance NASA science and technology well into the future

Multiple ways to conduct science in the lunar environment, but only one way to bring it back to Earth



BPS sciences are being integrated into all efforts for NASA activities for science beyond LEO

- Gateway
 - Phase 1 science in review
 - 15-year science strategy and objectives roadmap – including capabilities/resources
 - Space Biology DWG; Astrophysics DWG
 - Integrated work with international human health DWG and JSC Crew Health and Performance
- BPS Lunar Surface Science workshops in 2021
 - Space Biology LSSW – Jan. 20-21
- Artemis Science Definition Team – science objectives; Artemis III science
- CLPS Lunar Surface Science
 - PRISM solicitation
- ISS4Mars – ISS Analog working group meetings
- Planetary Protection Roadmap
- Integrated human health roadmap
- Beyond LEO free-flyer platforms
- Utilization Coordination and Integration Group
- Technical Assessment Team
- International Life Sciences Working Group
- International Microgravity Strategic Planning Group
- NAS Committee on Physical and Biological Sciences in Space

THE GATEWAY

Enabling Science - Deep space radiation; lack of atomic oxygen; no magnetic field; unknown environmental factors

- The Gateway studies may be part of larger integrated series of investigations that include implemented on ISS, the lunar surface, and/or Earth
- International collaborative research



Example Concepts of BPS Lunar Science

Gateway

Physical Sciences

- Material sciences investigations using external Gateway exposure facilities

Fundamental Physics

- Deep Space Quantum link studies

Space Biology

- Microbiology of the built environment
- Investigations to understand the impacts of deep space radiation impacts on biological systems
- Investigations to understand impacts of combined deep space radiation plus altered gravity on biological systems using centrifugation-capable hardware
- Internal habitation space and external exposure facility
- Multiple types of specimens, from tissue culture systems to microbiology to complex multicellular organism and plants

Artemis 1



Frederica Brandizzi, Ph.D., Michigan State University

Arabidopsis thaliana plants): *Life Beyond Earth: Effect of Space Flight on Seeds with Improved Nutritional Value*



Timothy Hammond, M.D., Ph.D., Institute for Medical Research, Inc.

Algae Chlamydomonas reinhardtii): *Fuel to Mars*



Zheng Wang, Ph.D., Naval Research Laboratory, Washington, D.C.

Fungi Aspergillus niger): *Investigating the Roles of Melanin and DNA Repair on Adaptation and Survivability of Fungi in Deep Space*



Luis Zea, Ph.D., University of Colorado, Boulder

Yeast Saccharomyces cerevisiae): *Multi-Generational Genome-Wide Yeast Fitness Profiling Beyond and Below Earth's Van Allen Belts*

Payload Developer/Project Science – NASA Kennedy Space Center

Artemis Lunar Surface Science

Human Landing Systems



Enabling Science - Deep space radiation; lunar albedo radiation; lunar $1/6xg_e$; no magnetic field; unknown environmental factors

- The lunar studies may be part of larger integrated series of investigations that include implemented on ISS, Gateway, and/or Earth

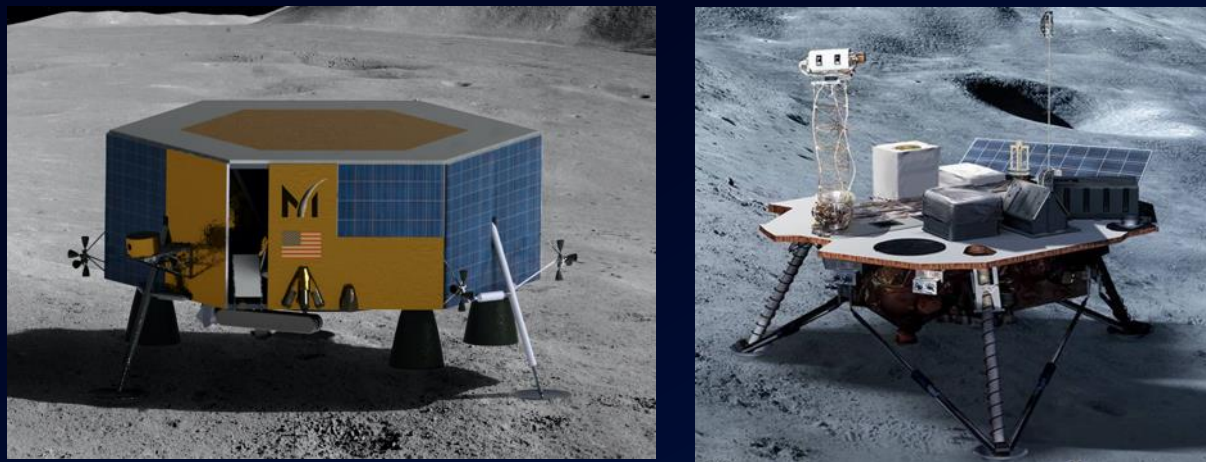
Lunar Surface Science Delivery

- Deliver science instruments/experiment payloads
 - Autonomous execution of the experiments
- Deliver instruments/experiment for pre-positioning on the lunar surface for moonwalker access

Research Solicitations

- Payloads and Research Investigations for the Moon (PRISM) Calls
- BPS Science Program Calls

Commercial Lunar Payload Services Landers



Example Concepts of BPS Lunar Science

Lunar Surface

Physical Sciences

- Creation of lunar regolith concrete samples in the lunar environment
- Material flammability testing at lunar and Martian g-levels for spacecraft materials
- Conversion of water-ice to gaseous hydrogen and oxygen, and liquefaction of gasses for propellant storage
- Pool and Flow Boiling
- Lunar resource recovery of Oxygen, Al, Fe or Mg using ionic liquids

Fundamental Physics

- Lunar dust studies to understand the dynamics of dust charging and lofting under space plasma conditions and in the presence of humans and specific dust properties, such as the forces of adhesion and repulsion at work between the dust particles and between particles and relevant surfaces

Space Biology

- Investigations to understand impacts of combined deep space radiation plus altered gravity on biological systems Microbiology of the built environment
- Multiple types of specimens, from tissue culture systems to microbiology to complex multicellular organism and plants

Lunar Explorer Instrument for Space Biology Applications (LEIA)

Objective:

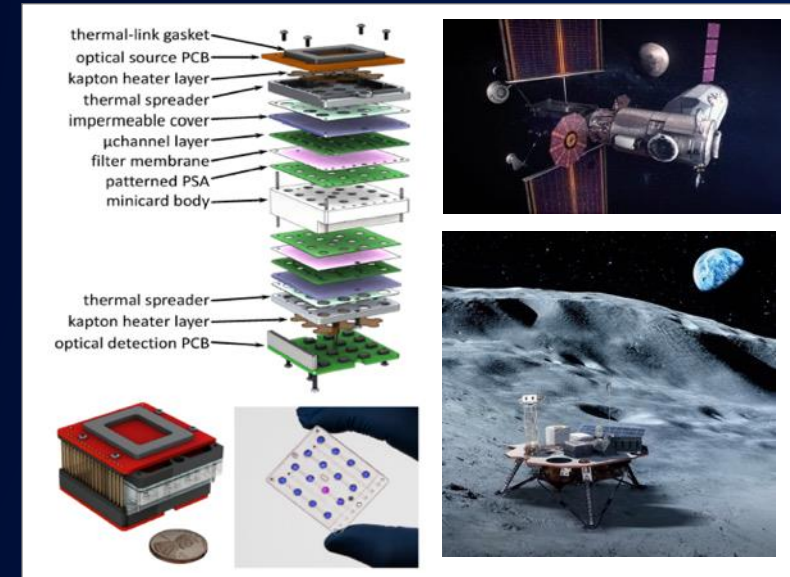
Biological research beyond LEO using autonomous, radiation-tolerant research hardware, compatible with a wide range of flight opportunities.

Relevance / Impact:

- Transportation flexibility to take advantage of all opportunities for conducting science in flight in deep space and planetary environments.
- Increased understanding of the biological effects of the unique environment(s) beyond LEO.
- Contribution to advancing technologies on Earth and technology transfer to the commercial space sector.

Project Development Approach and current status:

- Research solicitation and awards will take place through NRA process
- Will support launch opportunities in FY23 and FY25



LEIA is based on the Biosentinel Small Sat (NASA AES) BioSentinel Engineering and Science – NASA Ames Research Center Piggyback payload that will be deployed into a heliocentric orbit from the second stage of the Artemis 1 launch vehicle



Thank You