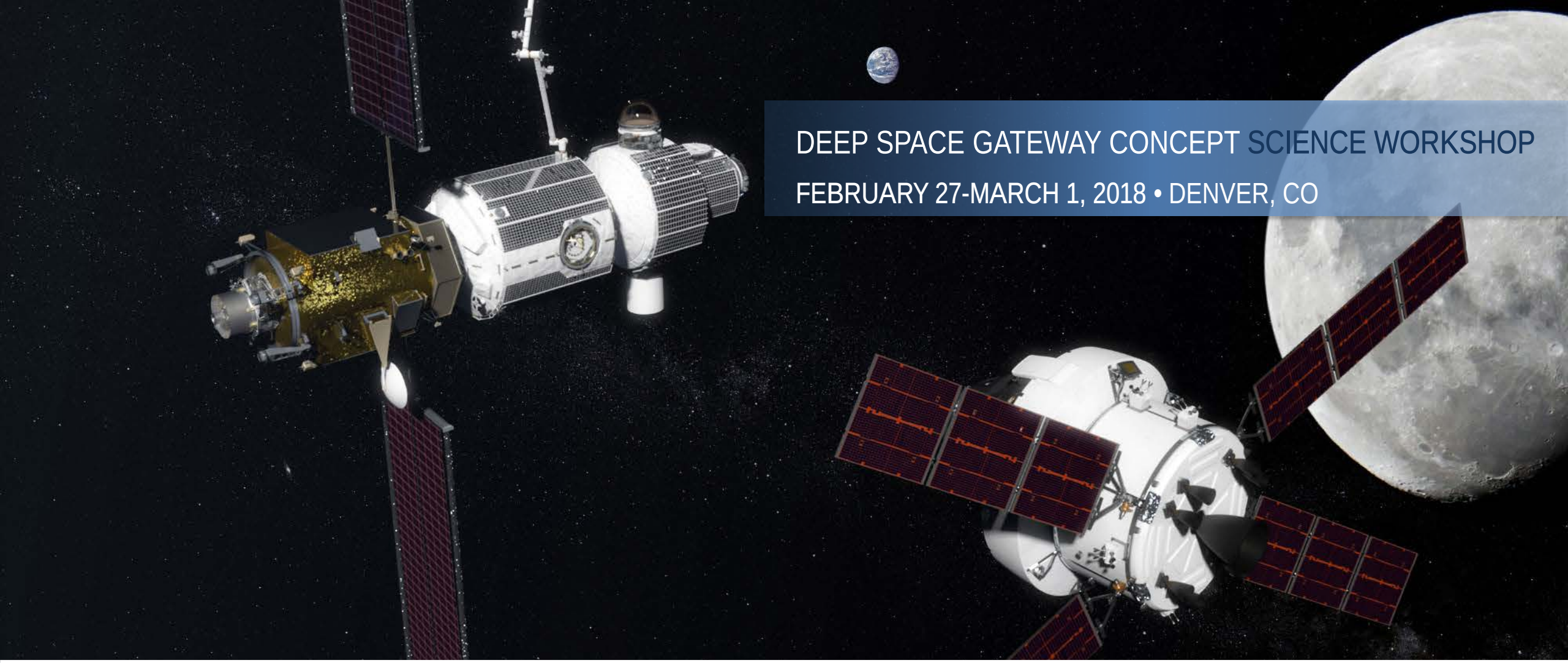

DEEP SPACE GATEWAY CONCEPT SCIENCE WORKSHOP

FEBRUARY 27-MARCH 1, 2018 • DENVER, CO

Space Biology Model Organism Research on the Deep Space Gateway to Pioneer Discovery and Advance Human Space Exploration

2/17/18

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NASA Space Life and Physical Sciences Research and Applications

Vision

- Lead the space life and physical science research community to enable space exploration and benefit life on Earth

Mission

- Enable Exploration to expand the frontiers of knowledge, capability, and opportunity in space

- Pioneer Science Discovery in and beyond low Earth orbit to drive advances in science, technology, and space exploration to enhance knowledge, innovation, economic vitality, and to inspire

Drivers for SLPSRA Science Goals:

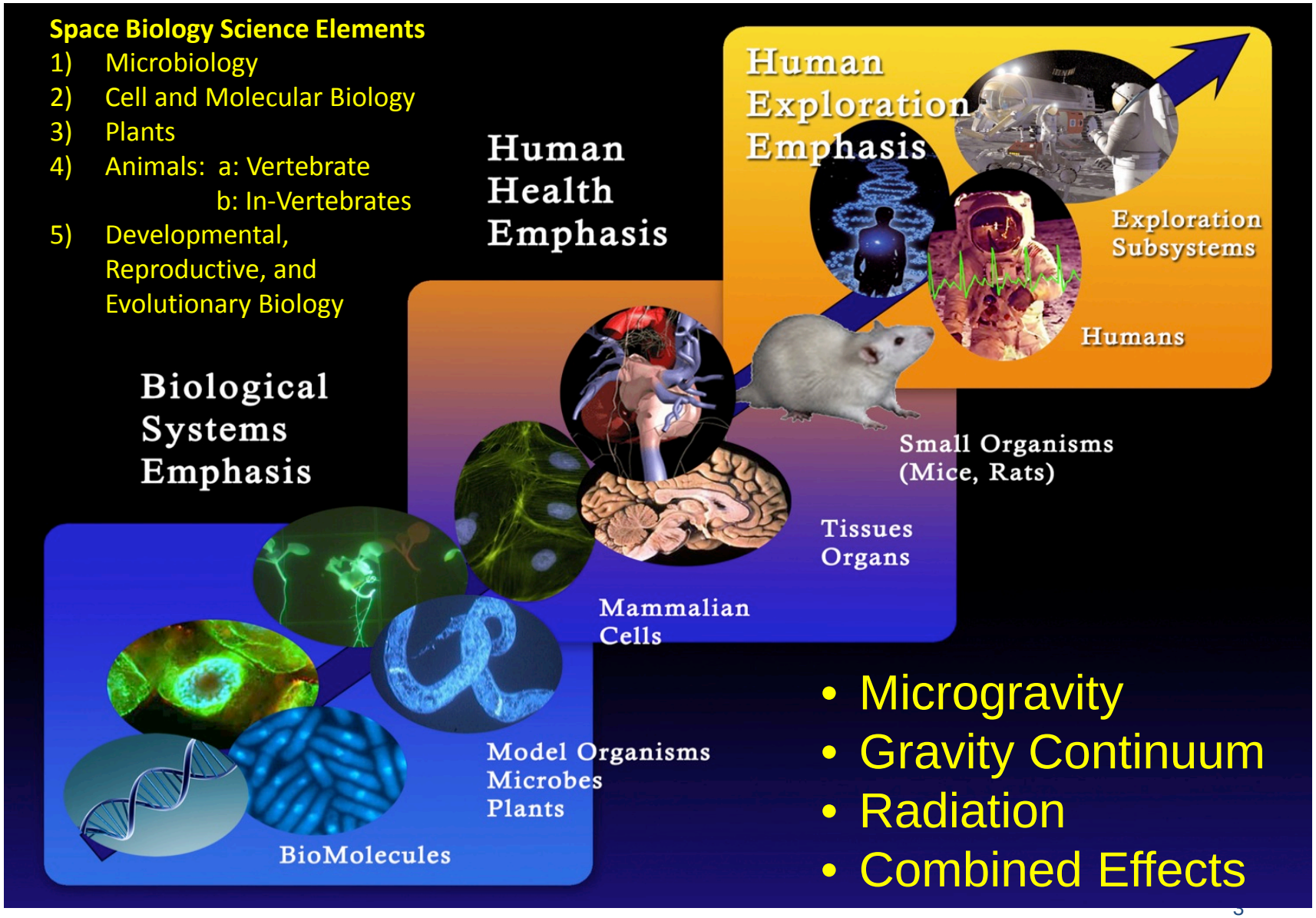
1) 2011 Decadal Survey Recommended Priorities *(Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era)*
2) NASA Agency and HEOMD Objectives for Advancement of Space Exploration
   - LEO and Beyond LEO
3) Human Research Program Pathways to Risk Reduction
4) Commercial and Earth Benefits]
5) Inspiring and training the next generation of scientists, engineers, and space exploration leadership

Space Biology Program

(Space Biology Plan - https://www.nasa.gov/content/space-biology-program)

Space Biology Vision 2016-2025:

- **NASA Space Biology research results expand the scientific knowledge base for Space Life Sciences applications and for improvement of life on Earth**
- **Space Biology and NASA's Human Research Program work cooperatively to Facilitate "Translational Research by Design"**
- **New knowledge will contribute to NASA's ability to predict human biological health and reduce engineering risks during long-term space exploration.**



Translational Research by Design: Space Life Sciences at NASA

Space Biology — Basic — Translational Research — Applied — **Human Research**

Fundamental Science

Medical Operations

Study how life responds, adapts, develops, interacts and evolves in the space environment and across the gravitational continuum:

- Cell and Molecular Biology
- Microbiology
- Animal Biology
- Plant Biology
- Developmental & Reproductive Biology

Science Exploring the Unknown

Space Biology provides knowledge and collaborates with HRP reduce risks and develop countermeasures:

- Animal Research
- Cells & Tissues
- Immunology
- Wound healing & fracture repair
- Bone & muscle
- Radiation/micro-g interactions
- Microbiome of the built environment

← *Critical Link!* →

Identify, characterize and mitigate the risks to human health and performance in space:

- Exercise Countermeasures
- Physiological Countermeasures
- Space Radiation Biology
- Behavioral Health and Performance
- Space Human Factors and Habitability
- Exploration Medical Capability
- Environmental Monitoring

Science Addressing The Known Risks

Instrument Function Statement and Gateway Usage

STATEMENT	INSTRUMENT/CONCEPT DETAILS
SLSPRA Space Biology will use the DSG to address questions of exploration importance that can only be answered in the deep space environment. Example questions: • How does true deep space radiation affect biology? • What are the effects on biology due to combined effects of radiation, deep space environment, microgravity, and exposure duration? • Are the impacts to biology by deep space different between LEO and beyond LEO environments (radiation and non-radiation-induced)? • Are there different biological effects between the sexes? • How are the MoBE and MoHumBio impacted in the deep space environment? • Can AG (0g-1g) mitigate or reduce deep space effects on biology? • Are the effects of the deep space environment reversible or persistent after return to Earth or exposure to a partial gravity level?	1) Investigations are conducted during crew occupation of the DSG 2) Experiments conducted during the period when crew does not occupy the DSG 3) Experiments are conducted on the outside space-exposed surface of the DSG (+/- radiation shielding) 4) Experiment conducted in the DSG habitat 5) Experiments conducted with parallel Earth and LEO experiment runs – in the future lunar or Mars surface, too 6) End-to-end experiments where the analyses are conducted on the DSG 7) Hardware that include a centrifuge for AG 8) Crew, environment, and surface sampling for characterizing the microbial diversity and ecology 9) Organisms returned alive or in a preserved state
The Deep Space Gateway enables exposure of organisms to the beyond LEO environment that cannot be accurately replicated in LEO or in Earth-based laboratories: • True deep space environment – is radiation the only difference between LEO and beyond LEO environments that is important to biology? • True deep space radiation • Combined effects (environment, exposure duration, etc.)	The types of organisms to be studied: • Invertebrates • Vertebrates (fish and eventually rodents) • Microbes • Plants All organisms have well characterized physiologies and genetics. Some organisms are models of human physiology and disease

Basic Instrument Parameters

PARAMETER	INSTRUMENT ESTIMATE & ANY COMMENTS
MASS (KG)	Dependent on hardware used
VOLUME (M)	From 1U CubeSat to double express rack locker equivalent
POWER (W)	Dependent on hardware used
THERMAL REQUIREMENTS	Dependent on hardware used
DAILY DATA VOLUME	Experiment dependent for imagery and data
CURRENT TRL	Hardware dependent – new hardware to adapting flown ISS hardware to DSG use
WAG COST & BASIS	Hardware dependent
DURATION OF EXPERIMENT	Variable duration – 30 days to 1 year or more. May include periodic sample collection for longitudinal time course studies.
OTHER PARAMETERS	Active heating and cooling; Commanding; periodic data downlink; crew access to specimens

Instrument Gateway Usage

USAGE	INSTRUMENT REQUIREMENTS & COMMENTS
ORBIT CONSIDERATIONS	None
FIELD OF VIEW REQUIREMENTS	None
REQUIRES USE OF AIRLOCK	Only for transfer of experiments to space-exposed facilities outside the DSG
CREW INTERACTION REQUIRED?	Experiment dependent - examples: experiment transfer to and from DSG, experiment initiation, sampling, analysis, and termination, surface and crew sampling,
WILL ASTRONAUT PRESENCE BE DISRUPTIVE?	No
DOES THE INSTRUMENT PRESENT A RISK TO THE CREW	Hardware dependent
OTHER CONSUMABLES REQUIRED	Normal air supply
SPECIAL SAMPLE HANDLING REQUIREMENTS	Refrigeration and freezer for specimen storage before the experiment run and for sample preservation; thermal conditioned containers for specimen return; glovebox for manual sample processing/dissections; radiation dosimeters; accelerometers; live sample return; internal and outside DSG experiment locations
NEED FOR TELEROBOTICS?	Yes – during the period of time when no crew will be at the Gateway
OTHER REQUIREMENTS OF THE GATEWAY?	Maintenance of normal power, ECLSS, temperature, and atmospheric pressure during non-crewed phase for experiments that are maintained at cabin ambient conditions; power for incubators

References and Status of Work in this Field

References:

1) https://taskbook.nasaprs.com/Publication/welcome.cfmJSC publications
2) https://taskbook.nasaprs.com/Publication/spaceline.cfm
3) https://www.nasa.gov/mission_pages/station/research/results_category

Studies in Space Biology are on-going with investigations using the wide diversity of organisms being conducted on the ground, on ISS, and free-flyers. Planning is progress for Space Biology investigations on the EM-1 Orion flight – approved allocation for Space Biology science.