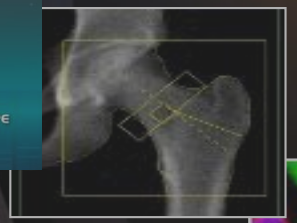
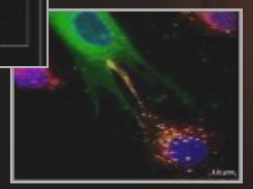
NASA Human Research Program

The Human Body in Space:

How ISS has Changed Our Perspectives and Solutions for Human Exploration





Jennifer Fogarty, PhD
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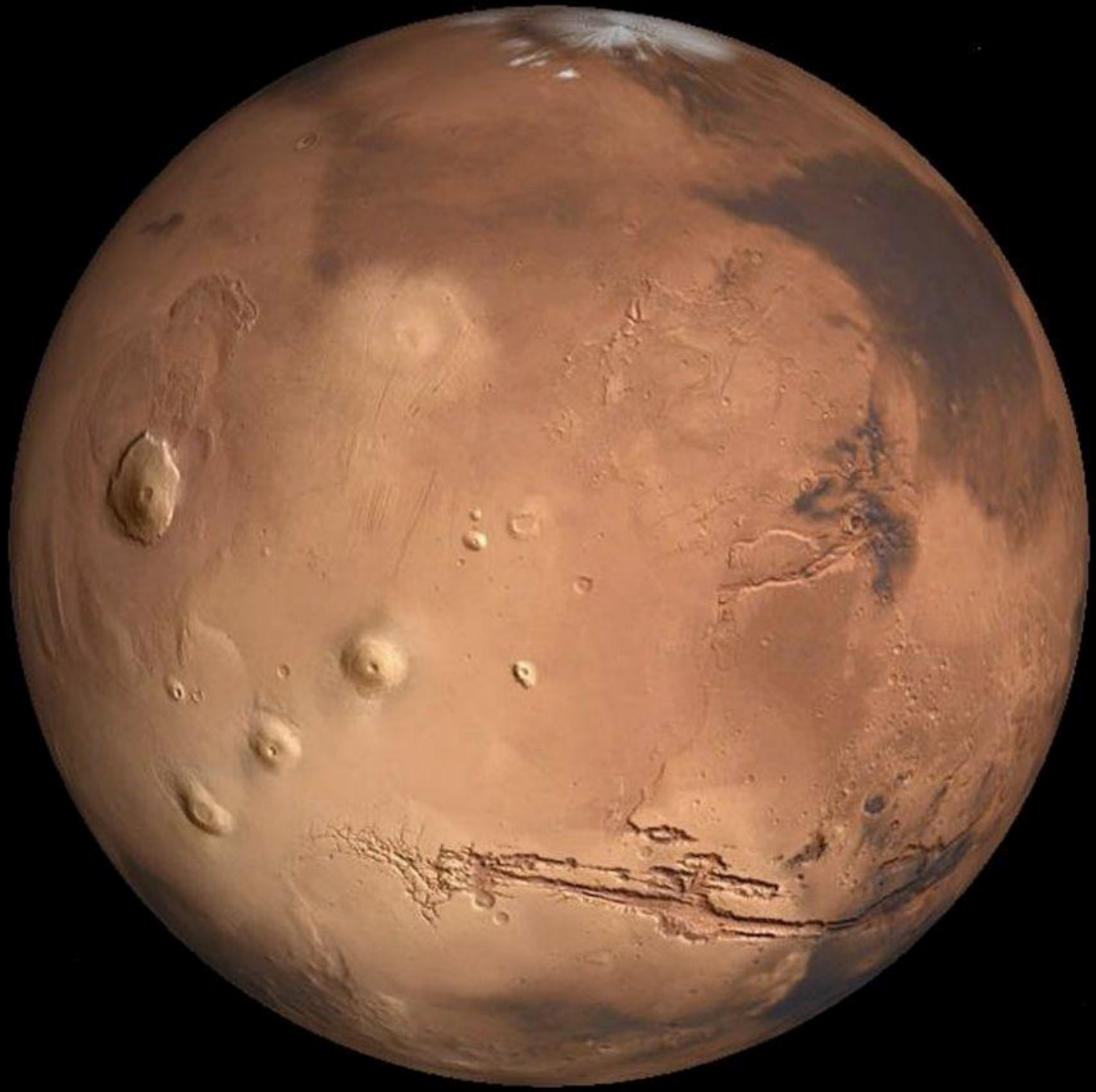
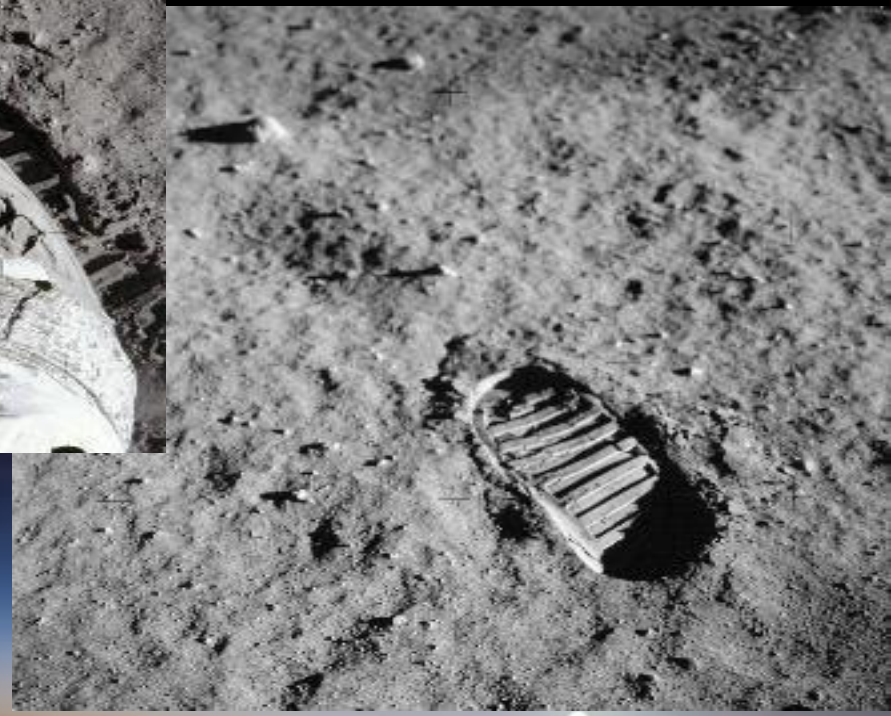
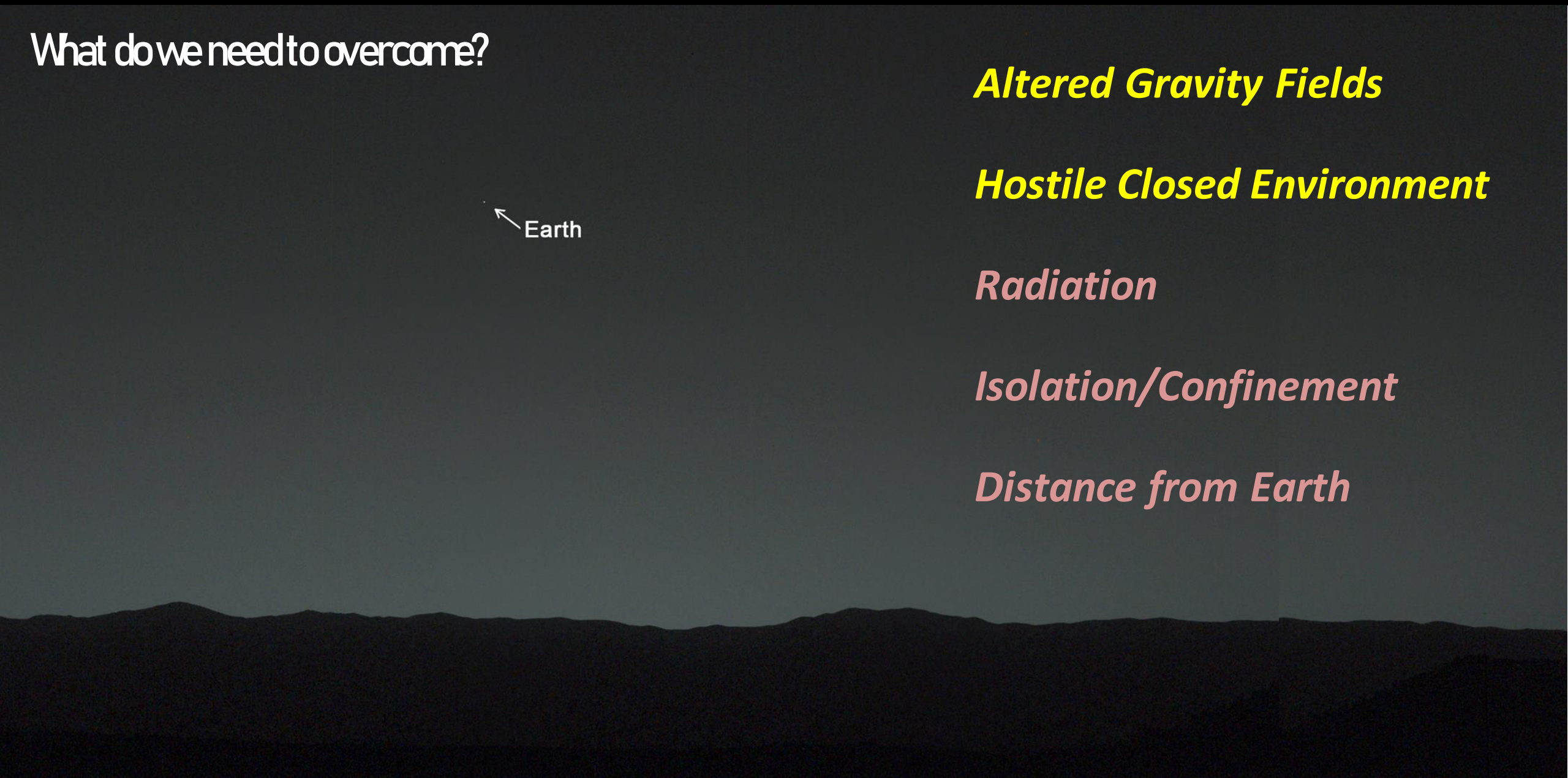


Why do we dare?



Deep Space Stressors to Human Health & Performance

What do we need to overcome?



Altered Gravity Fields

Hostile Closed Environment

Radiation

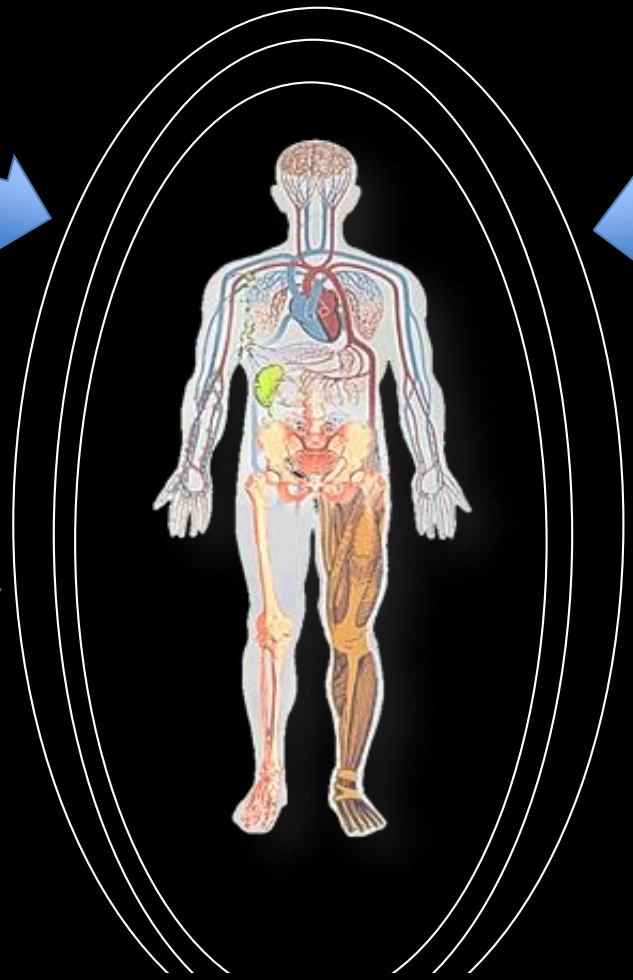
Isolation/Confinement

Distance from Earth

Integrated Human Health & Performance

Altered Gravity Fields

Hostile Closed Environment



Radiation

Isolation/Confinement

Increasing Distance from Earth

What types of solutions are needed?

Comprehensive

Data and predictive analytics driven

Autonomous, robust, light, lean

Agile and responsive to changing environment

Integrated into vehicle systems, processes, and procedures

ISS: Space Platform for HRP Studies

Exploration Health & Performance Risks – Mars DRM

Altered Gravity Field

1. Spaceflight-Associated Neuro-ocular Syndrome (SANS)
2. Renal Stone Formation
3. Impaired Control of Spacecraft/Associated Systems and Decreased Mobility Due to Vestibular/Sensorimotor Alterations Associated with Space Flight
4. Bone Fracture due to spaceflight Induced changes to bone
5. Impaired Performance Due to Reduced Muscle Mass, Strength & Endurance
6. Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity
7. Adverse Health Effects Due to Host-Microorganism Interactions
8. Urinary Retention
9. Orthostatic Intolerance During Re-Exposure to Gravity

Concerns

1. Concern of Clinically Relevant Unpredicted Effects of Medication
2. Concern of Intervertebral Disc Damage upon and immediately after re-exposure to Gravity

Radiation

1. Risk of Space Radiation Exposure on Human Health:
   - Acute solar events
   - Cancer
   - CNS impairment
   - Tissue degeneration (cardio)

Distance from Earth

1. Adverse Health Outcomes & Decrements in Performance due to inflight Medical Conditions
2. Ineffective or Toxic Medications due to Long Term Storage

Isolation/Confinement

1. Adverse Cognitive or Behavioral Conditions & Psychiatric Disorders
2. Performance & Behavioral health Decrements Due to Inadequate Cooperation, Coordination, Communication, & Psychosocial Adaptation within a Team

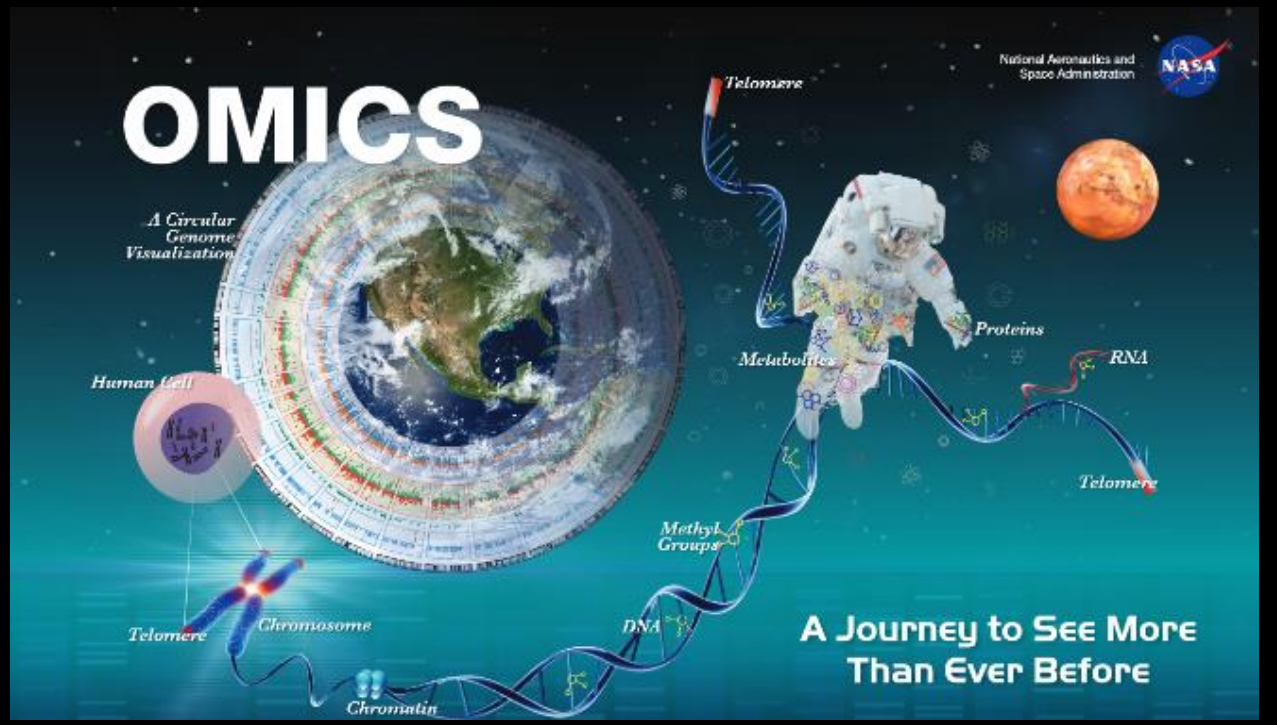
Hostile Closed Environment

1. Acute and Chronic Carbon Dioxide Exposure
2. Performance decrement and crew illness due to inadequate food and nutrition
3. Injury from Dynamic Loads
4. Injury and Compromised Performance due to EVA Operations
5. Adverse Health & Performance Effects of Celestial Dust Exposure
6. Adverse Health Event Due to Altered Immune Response
7. Reduced Crew Performance Due to Hypobaric Hypoxia
8. Performance Decrements & Adverse Health Outcomes Resulting from Sleep Loss, Circadian Desynchronization, & Work Overload
9. Reduced Crew Performance Due to Inadequate Human-System Interaction Design
10. Decompression Sickness
11. Toxic Exposure
12. Hearing Loss Related to Spaceflight

Key: High LxC Medium LxC Low LxC TBD LxC

Managed/configuration-controlled by NASA Human Systems Risk Board

ISS: Year in Space/Twins Study



i1YM Selected Studies

Human Health and Performance Integration

Norcross - Validation of Fitness for Duty Standards Using Pre- and Post-Flight Capsule Egress and Suited Functional Performance Tasks in Simulated Reduced Gravity

Downs - Temporal changes in astronauts muscle and cardiorespiratory physiology pre, during, and post spaceflight (CM efficiency and subsystem interrogation)

Shelhamer - Assessment of Otolith Function and Asymmetry as a Corollary to Critical Sensorimotor Performance in Missions of Various Durations

Reschke - Neuro-Vestibular Examination During and After Spaceflight (Vestibular Health)

Bouxsein - Time Course of Spaceflight-Induced Adaptations in Bone Morphology, Bone Strength and Muscle Quality

Boyd - The effect of long-duration space flight on bone microarchitecture and strength using three-dimensional high-resolution imaging (CSA)

Romaniello - Evaluating Resistive Exercise as a Long-term Countermeasure for Spaceflight-induced Bone Loss Using Calcium Isotopes

Liphardt - Joint health during a 1 year mission to the ISS - an assessment of exploration relevance (DLR)

Hughson - Manifestations of spaceflight-induced sub-clinical cardiovascular disease as a long-term health risk (CSA Vascular)

Arbeille - Preventive Medical Ultrasound Investigation of Organs Potentially Affected by Prolongated Exposure to Microgravity (CNES)

Bailey - Telomeres

Levine - Coronary Anatomy and Physiology During 1 Year in Space

Cranial Optical Axis

Macias - Investigating Structure and Function of the Eye (SANS)

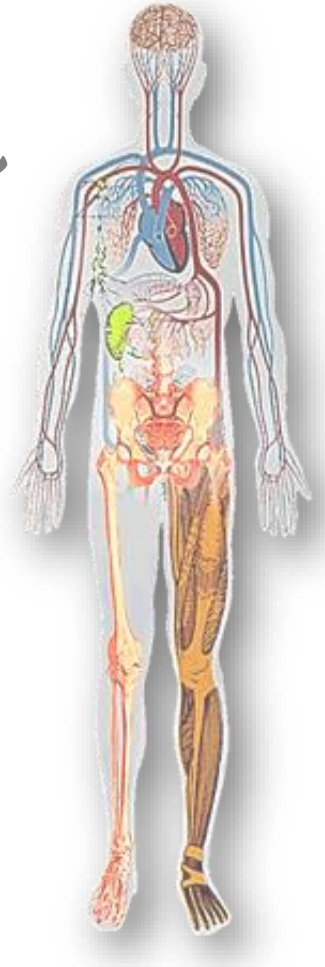
Basner - Temporal Nature of Cognitive and Visuospatial Brain Domain Changes during Long-Duration Low-Earth Orbit Missions

Zhang - Characterizing the Baselines of Sleep Quality, Cognitive / Operational Performance, Immune Function, and Intracranial Fluids for Deep Space Expeditions (SANS/Immune)

Functional
Translational
Comprehensive
Mechanistic
Descriptive
Multi System
Performance Focus

Systems Evaluated for Adaptation

CNS and Ocular



Cognition

Sensorimotor

Cardiovascular/Hematological

Microbiome

Immune

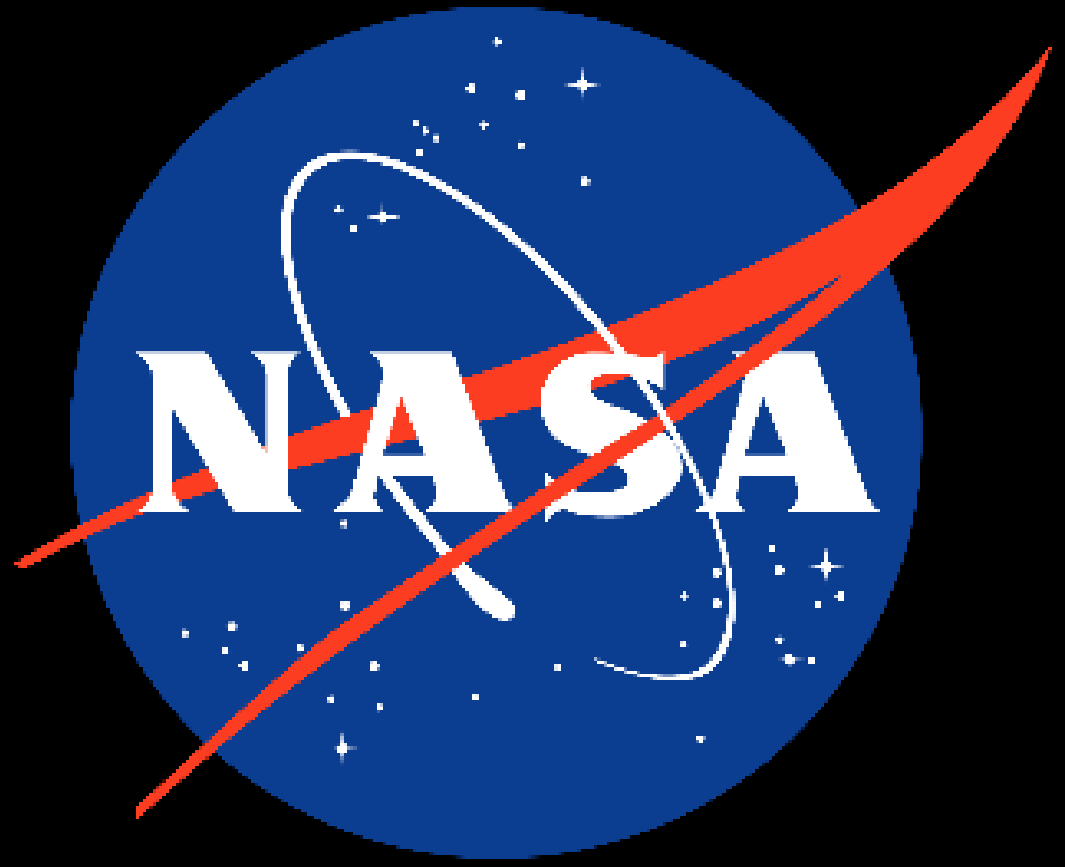
Musculoskelatal

Physical Performance

Foundation Provided by Standard Measures

Planning Exploration-Simulation Missions Aboard ISS

- **Extend Increments to 1 Year**
  - Validate effectiveness of microgravity countermeasures for longer missions
- **Enable More Crew Autonomy**
  - Limit interactions with ground control
  - Delay communications
  - Reduce re-supply
  - Use hardware and procedures that do not rely on ground control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