Recent US Space Biomedical Research Activities

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05 December 2016
XVI Conference on Space Biology and Medicine
Russian Academy of Sciences
Moscow, Russia
Apollo 17 (1972)
To enable space exploration beyond Low Earth Orbit by reducing the risks to human health & performance through a focused program of:

– **Basic, applied, and operational research**

leading to the development and delivery of:

– **Human health, performance, and habitability standards**
– **Countermeasures and other risk mitigation solutions**
– **Advanced habitability and medical support technologies**
Human Missions to Mars

Outbound to Mars

- DESTINATION SYSTEMS
  - SEP pre-deploy to Mars orbit
- TRANSIT HAB TO MARS
  - Aggregate in Cislunar space
- CREW
  - Launch to Cislunar space

Transit: 2-3 Years

HABITATS return to staging point for refurbishment

6-9 Months
CREW/TRANSIT HAB

6-9 Months
CREW/TRANSIT HAB

Inbound to Earth-moon system

Surface Operations:
30-500 Days

Unprecedented technological and human endurance challenges...
Crew Stressors in Deep Space Missions

- Radiation
- Altered Gravity Fields
- Hostile Closed Environment
- Isolation/Confinement
- Distance from Earth
HRP Risk Mitigation Maturation Plan

~2035–20nn
Fine-tune mitigation approaches
- Exploration vehicles
- Planetary surfaces

~2021–2030
Validate mitigation approaches
- Orion
- Deep-space hab
- Lunar surface (?)
Inform exploration system designs

Now–2024 (+/-)
Develop/test mitigation approaches
- ISS
- Spaceflight analog facilities
- Ground-based laboratories
Inform deep-space hab designs
ISS: Space Platform for HRP Studies

*HRP studies receive highest priority for NASA science payloads aboard ISS. Each USOS crewmember participates in 10-15 separate HRP experiments.*
Year in Space/Twins Study

1 YEAR BEFORE FLIGHT

FUNCTIONAL INVESTIGATIONS (Field Test, Functional Task Test): Can Scott perform tasks such as walking or operating a spacecraft after landing? It’s a lot harder after a year in microgravity!

BEHAVIORAL HEALTH (Cognition, Neuromapping, Sleep, Journals, Reaction Self Test, Biological Rhythms): Has living in space affected Scott’s psychological health? Stressful environments can impair cognitive performance.

VISION IMPAIRMENT (Fluid Shifts, Ocular Health, IPvE): Has Scott’s vision been impacted? Fluid shifts in microgravity can put pressure on the optical nerves.

METABOLIC INVESTIGATIONS (Biochemical Profile, CardioOx, Integrated Immune, Immuno, Energy, Salivary Markers): How is Scott’s immune system? Has he ever had a flu shot while he was in space?

1 YEAR IN SPACE

PHYSICAL PERFORMANCE (Sprint Study, HOP OCT, EDCS): How strong are Scott’s bones, muscles and cardiovascular system? The body deconditioning in microgravity so astronauts exercise two hours each day.

MICROBIAL INVESTIGATIONS (Microbiome, Myco): Will Scott’s microbiome change in space? Environmental changes affect Earth’s organisms and ours, too.

1 YEAR AFTER FLIGHT

HUMAN FACTORS (Fine Motor Skills, Habitability): Will Scott’s fine motor control improve? Fine motor skills are important for controlling spacecraft.

Some investigations may collect data beyond the one-year post-flight mark. Learn more about each investigation represented above at: www.nasa.gov/tyrim/research
Visual Impairment–Fluid Shifts Experiment

Challenge: Russian Segment Ops
- Obtaining Agency-level Int’l Agreements
- Coordinating activities across NASA/Roscosmos
  - Hardware certification and testing activities
  - Simulation development planning
  - Real-time crew scheduling of US and Russian crew
- Consenting and training Russian crewmembers for NASA-sponsored science activities
- Procedure/Remote Guidance translation capability an unknown commodity
Twins Study (Scott and Mark Kelly)
- ISS Sample Collection Completed
- Post Flight Sample Collection Completed

Objective
- Begin to examine next generation genomics solutions to mitigating crew health and performance risks: Personalized countermeasures

Twins Study National Research Team Examined
- Genome, telomeres, epigenome
- Transcriptome and epitranscriptome
- Proteome, Metabolome, Microbiome
- Physiology and Cognition

Significant Privacy and Ethics Issues
NASA is developing new genomics policy (modeled after NIH policy) that addresses informed consent, data privacy approaches, and genetic counseling on consequences of discovery (individual, family)

Preliminary Results Expected at HRP IWS (January 2017)
Circadian Regulation via Lighting

“Real Work Underway To Keep Mars Travelers Alive”

The clock is running on ISS testing for Mars missions

Oct 19, 2016 Frank Morring, Jr. | Aviation Week & Space Technology

Astronaut Kate Rubins recently installed new lighting in the International Space Station (ISS) crew quarters that could help her successors in space survive a mission to Mars. Known as a solid-state lighting assembly (SSLA), the device emits light in wavelengths that can be tuned to help space travelers get a better night’s sleep. The SSLA is a simple example of the complex testing underway on the ISS as NASA and its international partners prepare for eventual human travel to Mars.

Solid State Lighting Assembly (SSLA)

- Energy efficient, longer life span, no toxic mercury vapor.
- Excellent, bright light for visual performance and color discrimination.
- Suppresses melatonin to better manage circadian rhythms.
- Provides spectral adjustments to aid sleep and circadian disruption.
  - Blue shifts for the morning
  - Red shifts for the evening

Delivery and Testing Aboard ISS

- 7/8/16: 1st 4 SSLAs launched on SpX-9
- 10/5/16: Kate Rubins installed 3 SSLAs in Crew Quarters
- 11/15/16 Lighting Effects Flight Study begins on 49S
- 12/?/16: Next 11 SSLAs launch on HTV6

Risk of renal stone formation/development is elevated during and early after flight
- Fluid redistribution, bone loss, muscle atrophy, diet

**Current Risk Mitigation Strategy:**
- Preflight ultrasound screening
- In-flight prevention: resistive exercise, increased fluid intake, appropriate diet
- Oral Calcium citrate

**Future Risk Mitigation Research Goals:**
- Flexible Ultrasound System (FUS) to provide clinical grade imaging of asymptomatic stones.
- FUS to provide therapeutic modalities:
  - Moving a kidney stone away from the ureters
  - Moving a kidney stone lodged in the ureter
  - Non-invasively breaking-up a kidney stone.
Spaceflight Analog Facilities

- NSRL Beam Line
- Parabolic Flight
- 6° HDT Bedrest
- DLR :enviHab Facility
- JSC HERA Facility
- NSF/ South Pole Station
- IBMP NEK Chamber
- Simulator of the Martian surface
External and Internal Fields

The external field is modified as it passes through shielding and tissue
- Slowing down due to atomic processes
- Attenuation and breakup of heavy ions due to nuclear collisions
- Secondary particle production (especially neutrons)

Selected particle spectra in free space (left) and behind 5 g/cm$^2$ of aluminum and 30 g/cm$^2$ of water (right) during solar minimum.
Preparing for cis-Lunar Space

THE JOURNEY CONTINUES
Advanced Exercise Countermeasures

MPCV Exercise Device (ROCKY)
Servo-motor controlled, single cable exercise system
• Provides resistive loads up to 400 lbf at velocities up to 2 m/s
• Software-modifiable exercise loading profiles
  - Inertial characteristics of free weights for resistive training
  - Oar/boat loading dynamics for aerobic (rowing) training
  - Custom profiles for eccentric overloading, weight racks, etc.
• Capacitor bank allows unpowered operation in rowing mode

ROCKY = Resistive Overload Combined with Kinetic Yo-yo

Deep Space Exercise Device (ATLAS)
Servo-motor controlled, double cable exercise system
• Leverage the MPCV/ROCKY, MMED2, and SBIR efforts
• Demonstrate/validate on ISS asap (NET 2019)
• TTO to augment/replace ARED after initial valid

Design Goal: ATLAS will exceed ARED capabilities at 1/10 of its mass and volume.

ATLAS = Advanced Twin Lifting and Aerobic System
Human travelers to Mars will experience unprecedented physiological, environmental, and psychosocial challenges that could lead to significant health & performance decrements in the absence of effective mitigation strategies.

Success of any human mission to Mars will hinge on the mission designers’ ability to develop and implement such strategies.

NASA’s Human Research Program is responsible for identifying those strategies.