National Aeronautics and Space Administration

Human Research Program

IMPACTS ON HUMANS!

NASA ISS Research Academy & Pre-application Meeting
Aug. 3, 2010

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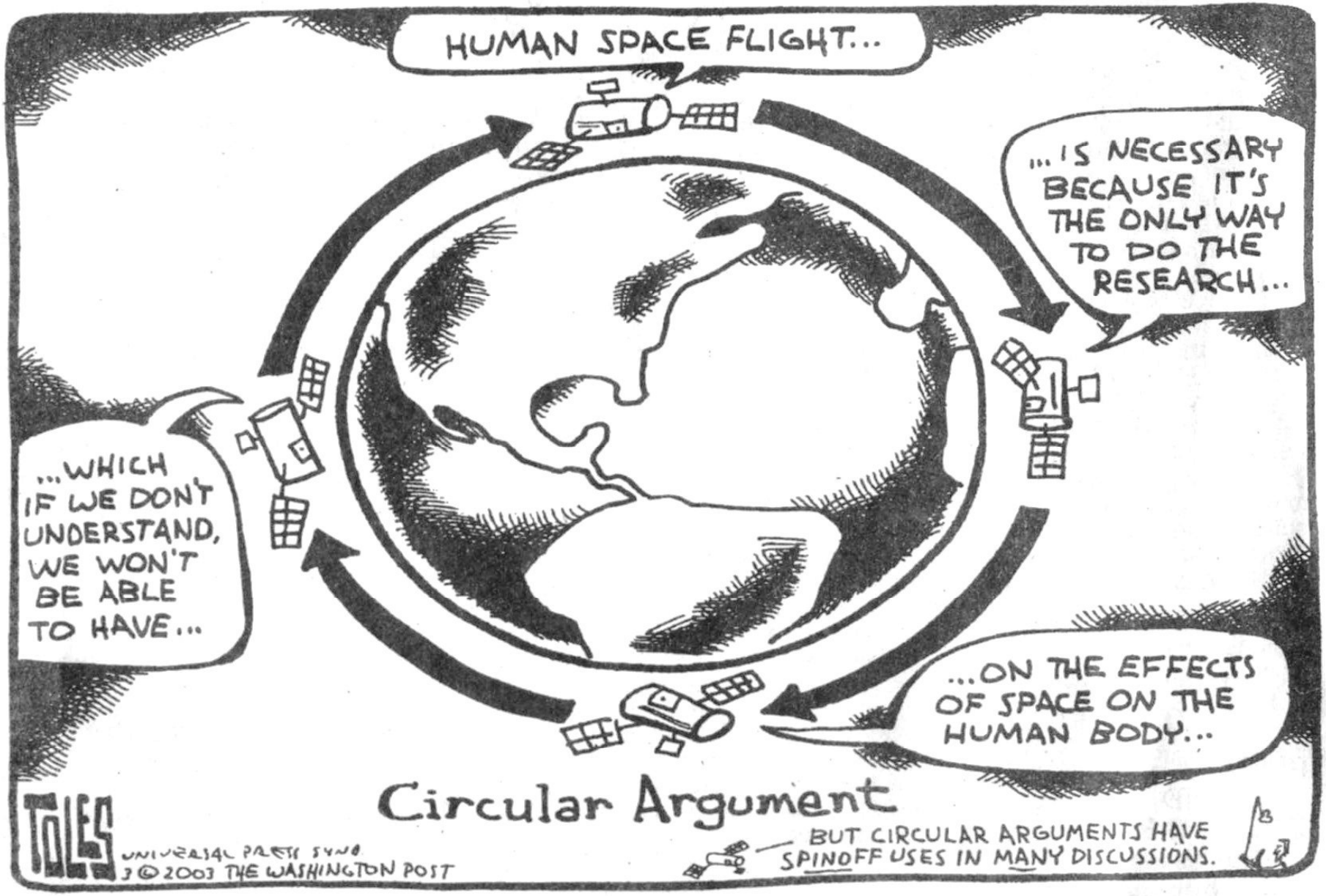
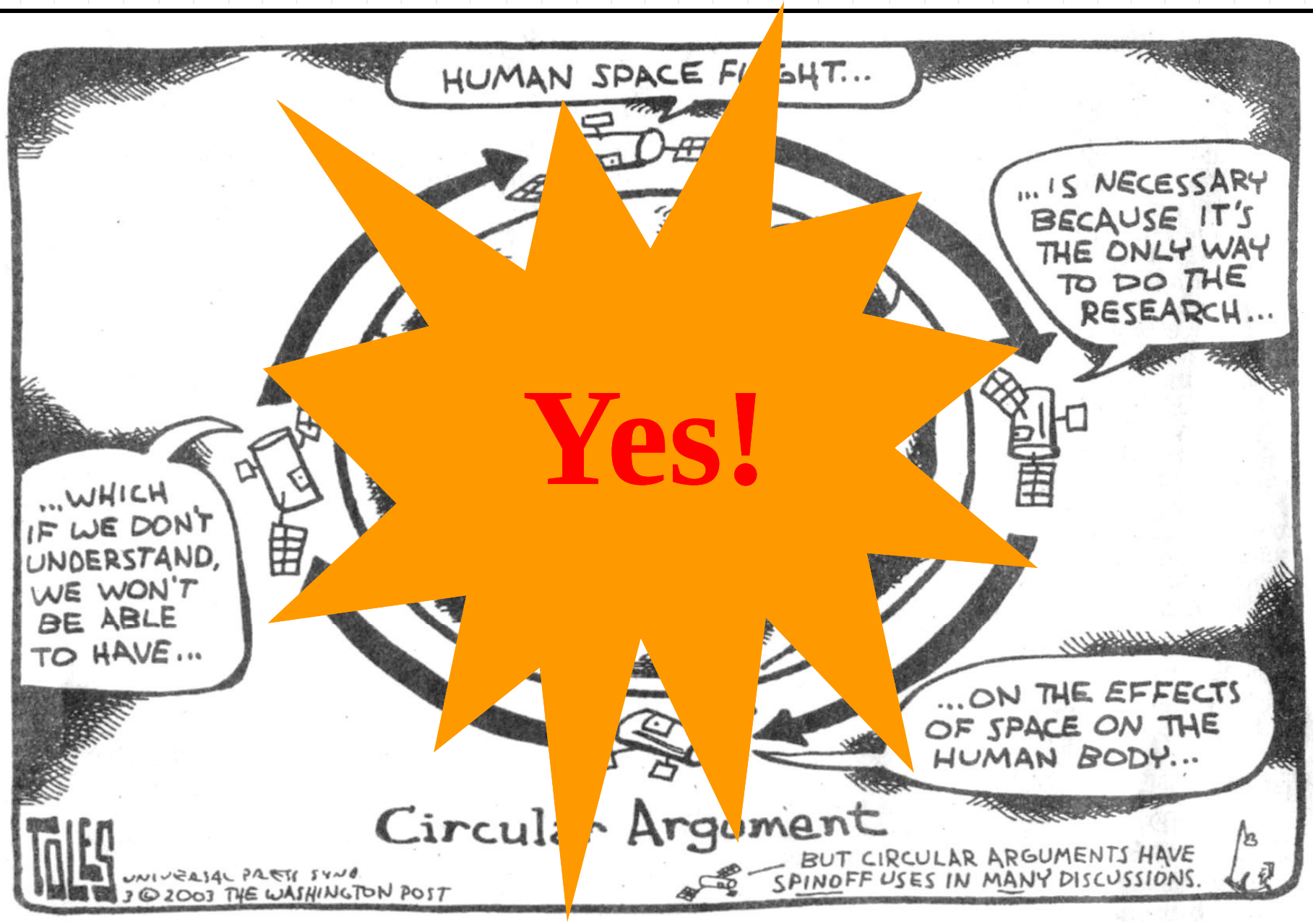
“Burning holes in the sky?”
“Going around in circles?”



Human research in space flight?

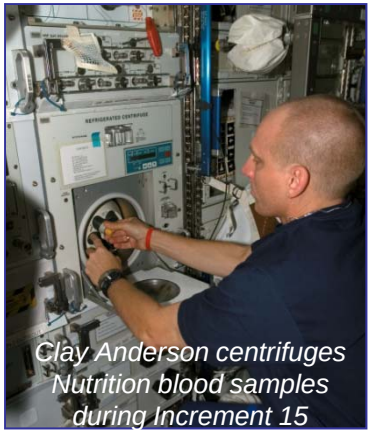


Human space flight requires human research

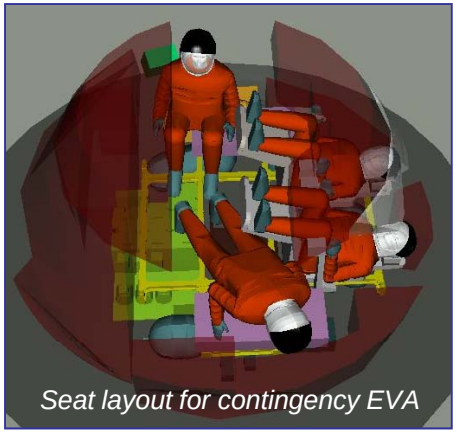
- Successful piloted space exploration beyond LEO requires an understanding of the effects of space flight—especially weightlessness—on humans
- Exposure of humans to weightlessness and other space flight factors for prolonged periods is the <u>only</u> way truly to understand the effects of prolonged exposure on human health, safety and efficiency
- The ISS provides the prolonged exposure required for the human research needed to reduce the known and expected risks to astronauts of exposure to the conditions of space flight

Human Research Program Goal

The goal of HRP is to provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration.



Clay Anderson centrifuges Nutrition blood samples during Increment 15



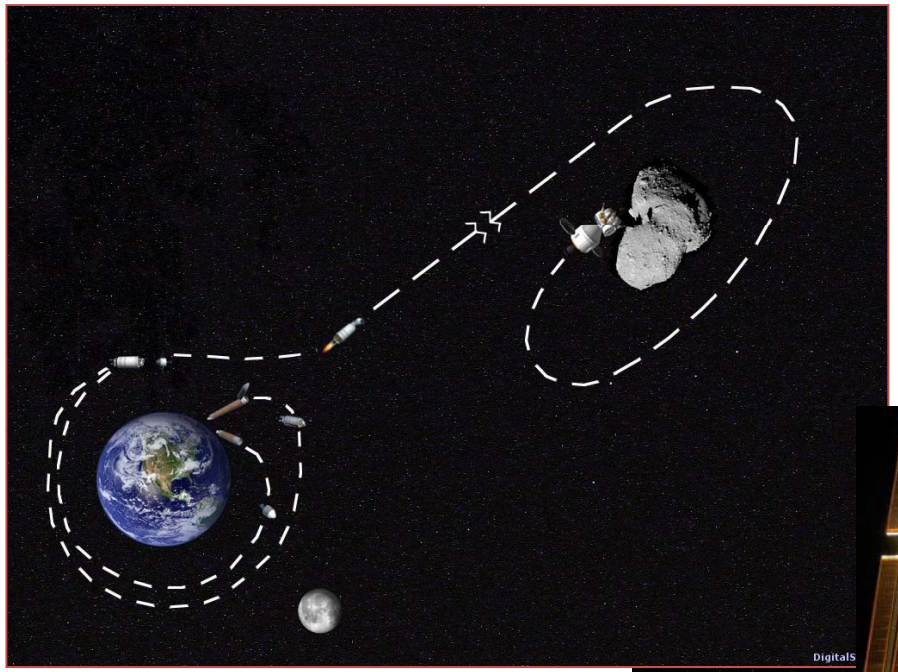
Seat layout for contingency EVA

Example of a study on the effects of center of gravity on performance

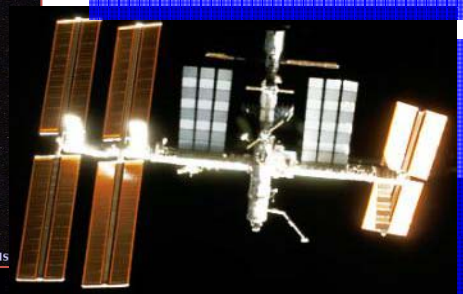
NASA's Needs: Research Supporting *in situ* Space Exploration by Humans

- International Space Station (6 months+)
  - now-2020+: 6 person crews
- Human NEO missions (6 months → 1 year?)
  - 2025ff: 2-4 person crews
- Lunar sorties (1 week → 1 month?)
  - 2020s?: 4 person crews
- Mars exploration (up to 30 months)
  - 2030s: 6 person crews

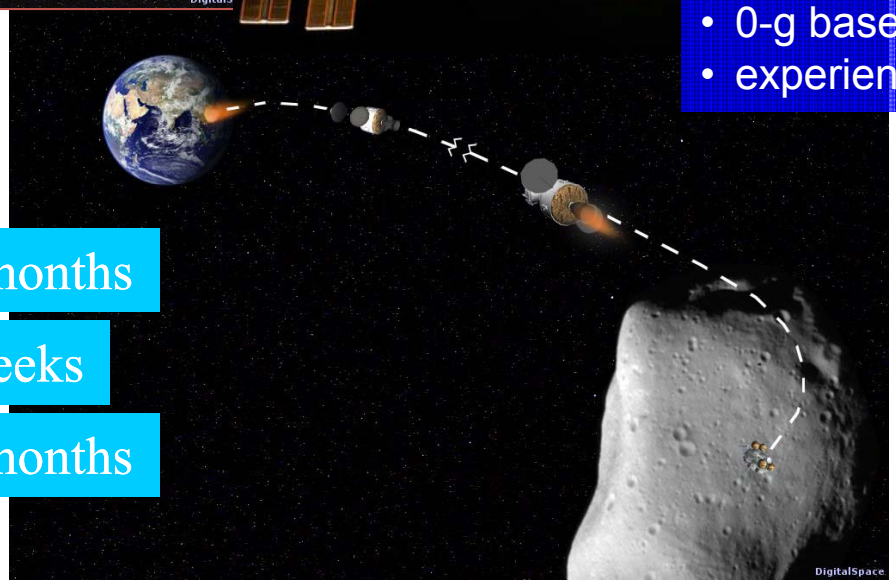
Overview of Notional NEO Expedition



NEO expeditions
- Validate Mars-forward technologies, procedures
- Acquire additional unique deep-space data
  - Dust
  - Near-NEO radiation environment
  - Behavioral health & performance



ISS expeditions of ~6 months duration simulate ~6-month+ Earth-to-NEO round trip
- 0-g baseline
- experience base

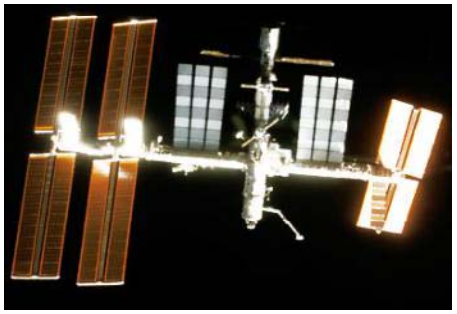


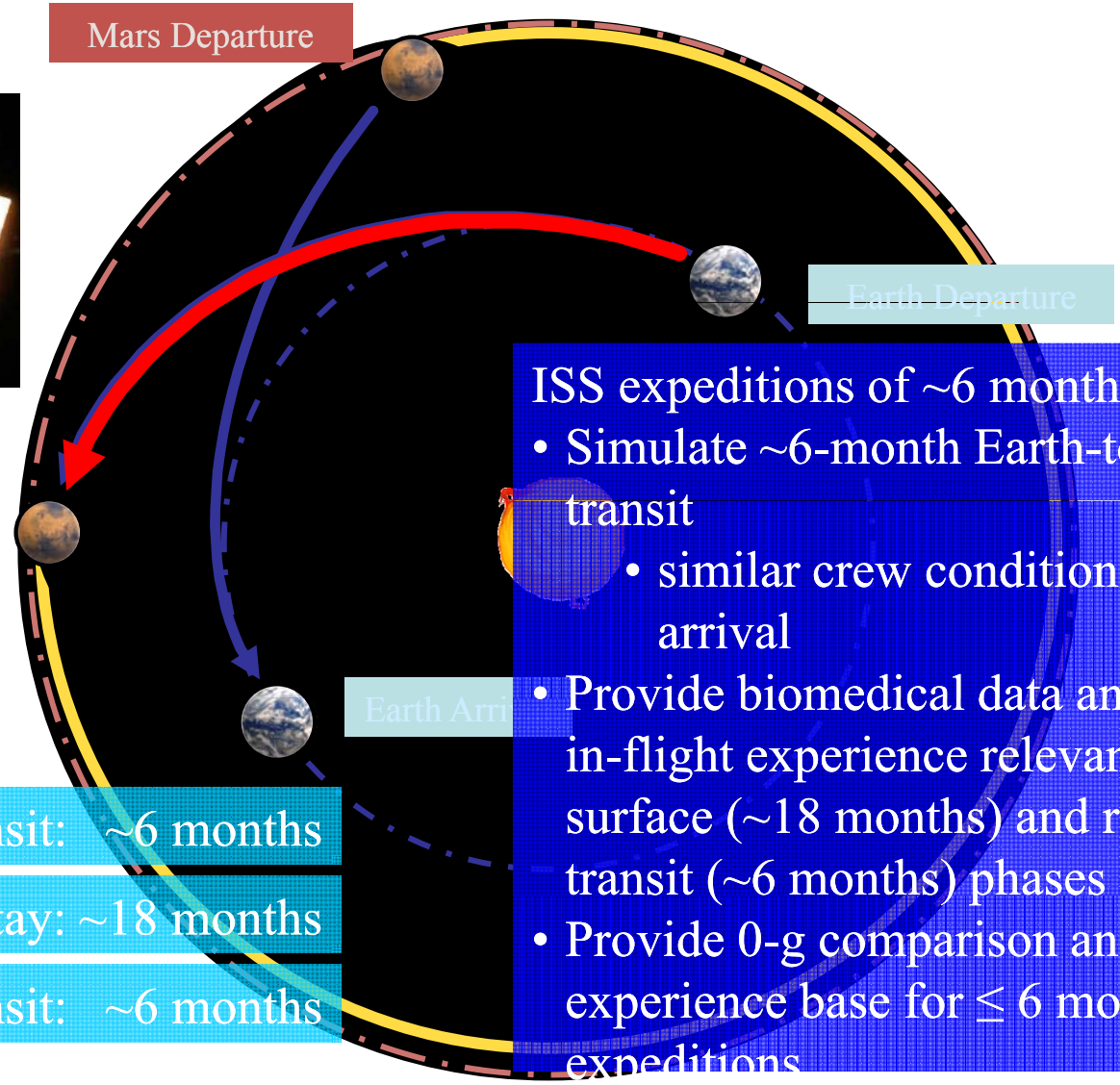
Earth-to-NEO transit: ~3 months

NEO surface ops: ~2 weeks

NEO-to-Earth transit: ~3 months

Overview of Notional Mars Expedition





ISS expeditions of ~6 months duration:

- Simulate ~6-month Earth-to-Mars transit
  - similar crew condition as at Mars arrival
- Provide biomedical data and human in-flight experience relevant to Mars surface (~18 months) and return transit (~6 months) phases
- Provide 0-g comparison and experience base for ≤ 6 month lunar expeditions

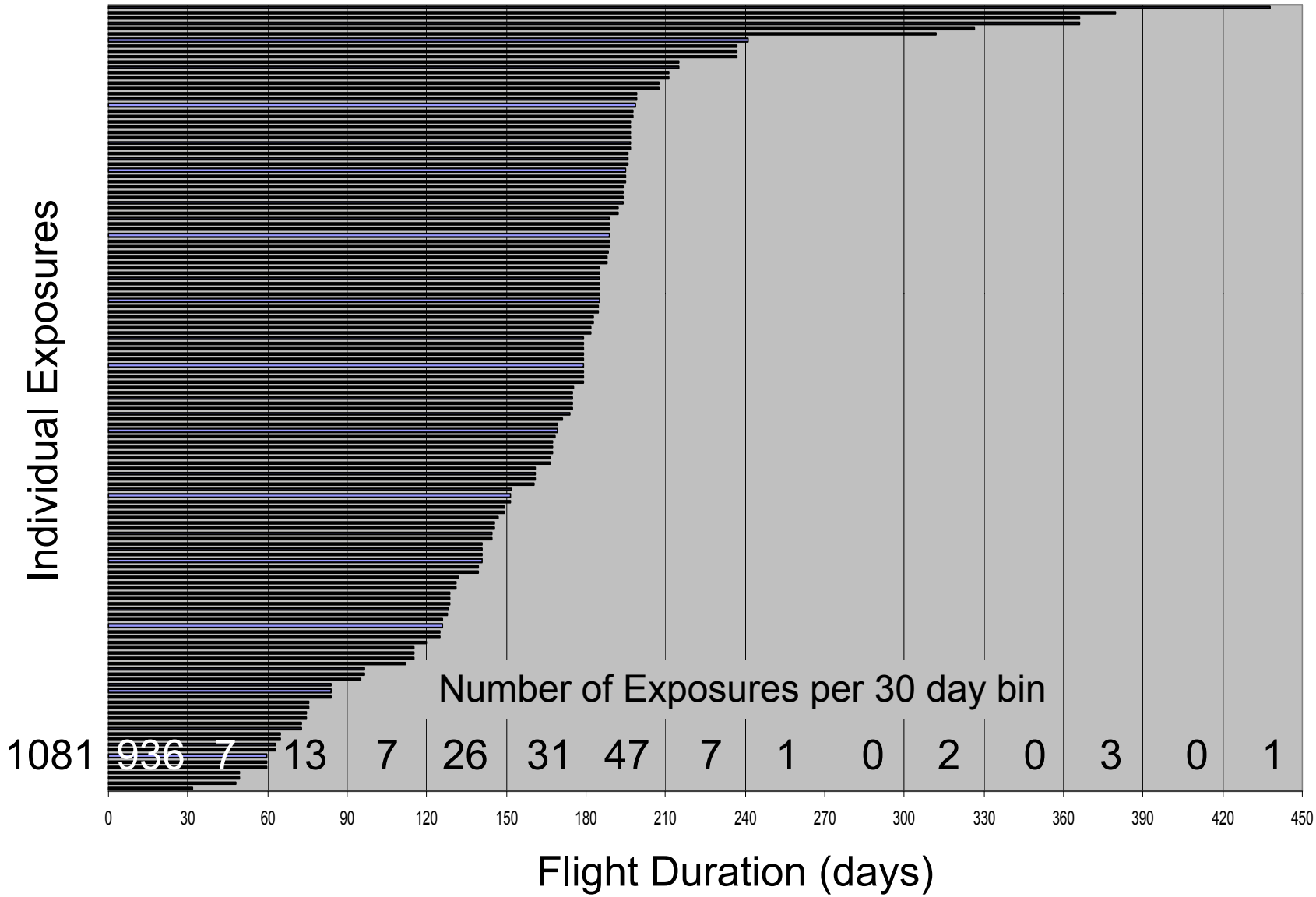
Earth-to-Mars transit: ~6 months

Mars surface stay: ~18 months

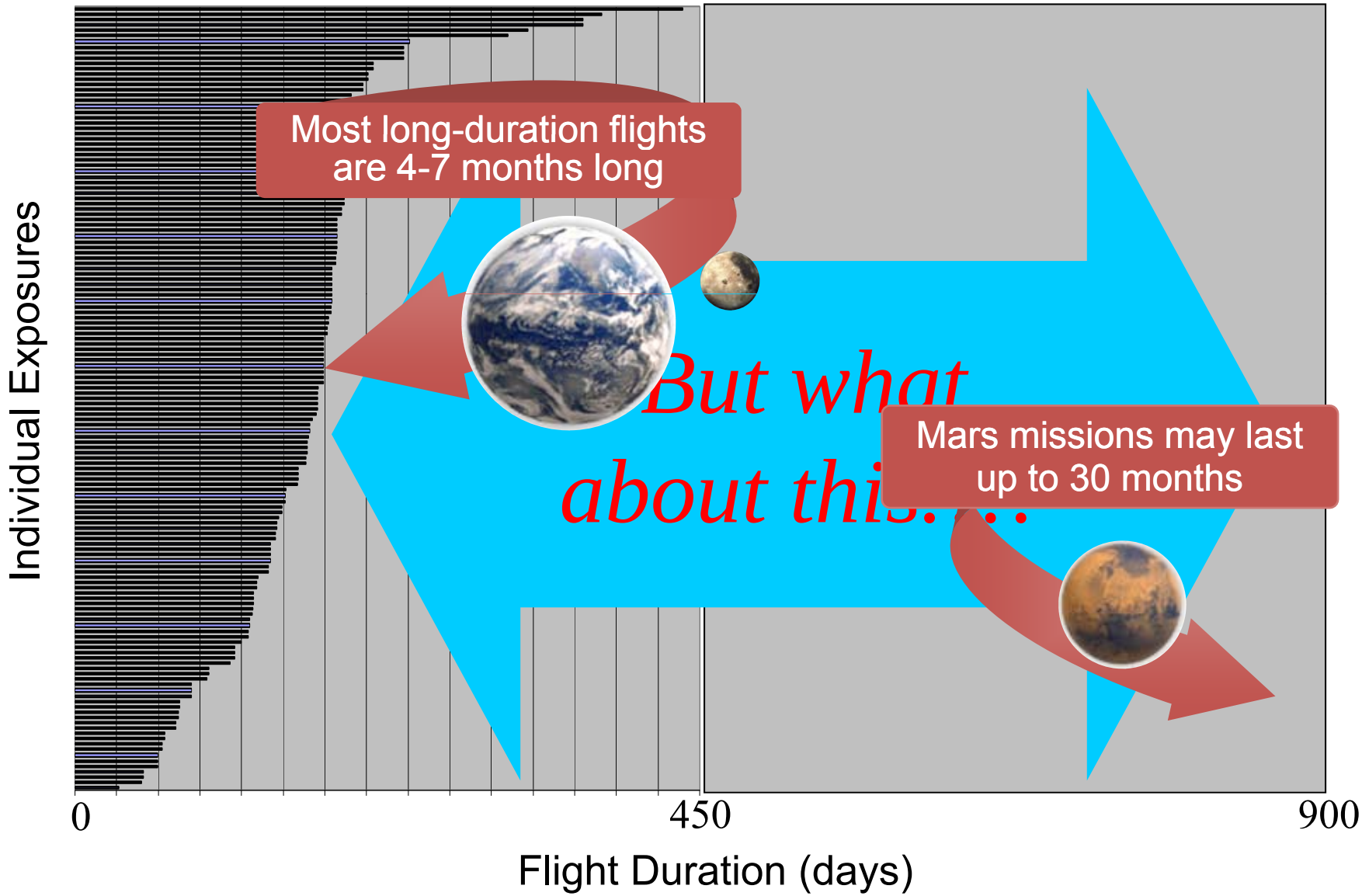
Mars-to-Earth transit: ~6 months

Continuous space flight exposure ≥ 30 days

as of June 2008

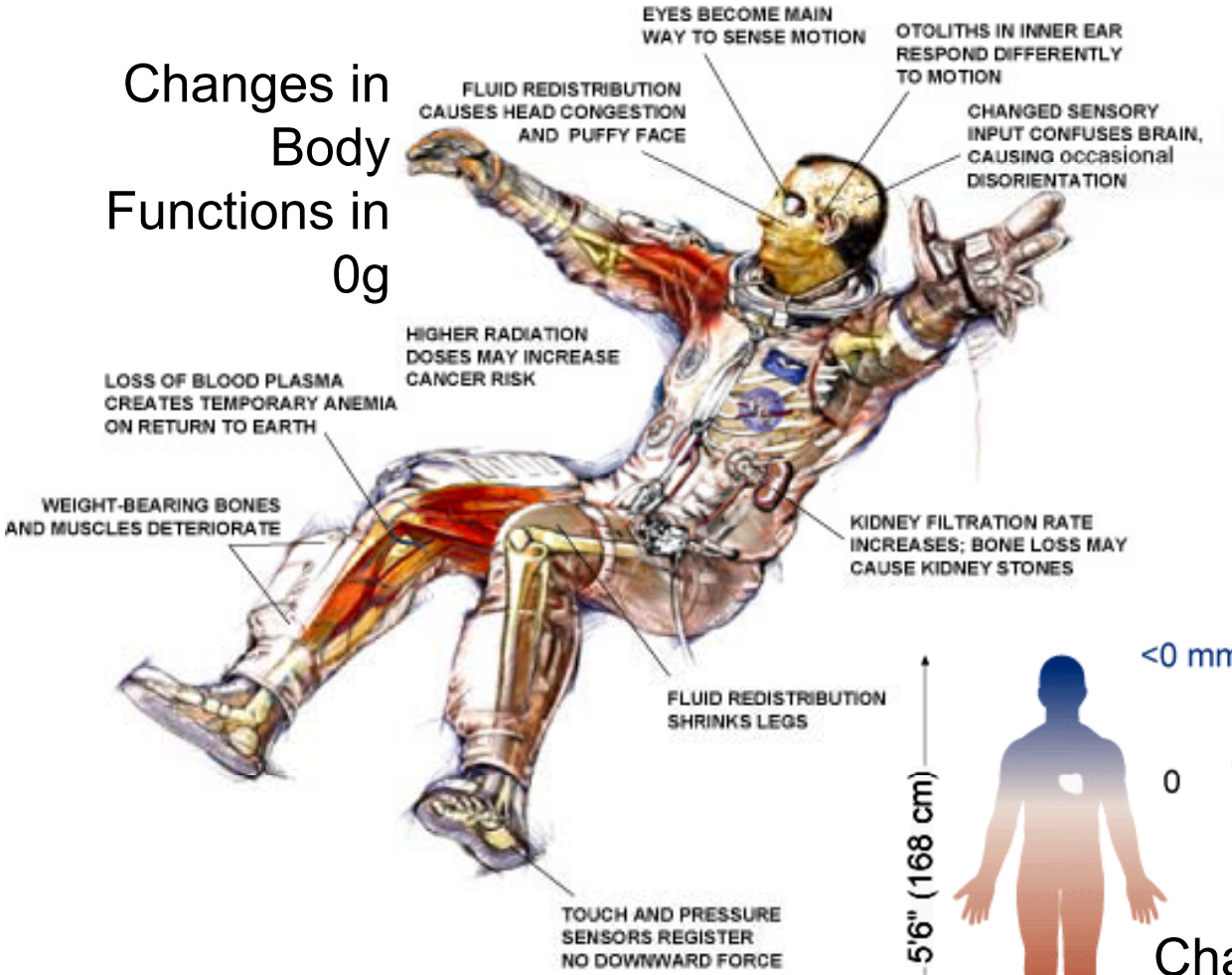


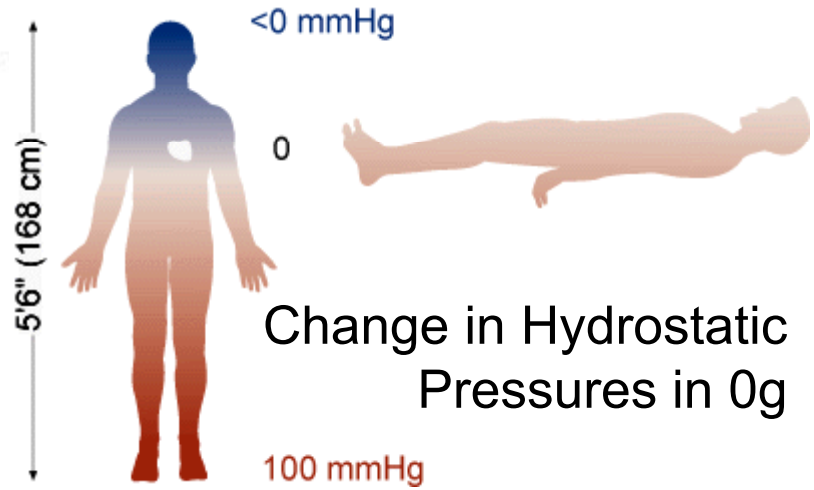
Implications for Mars missions



Human Responses to Weightlessness

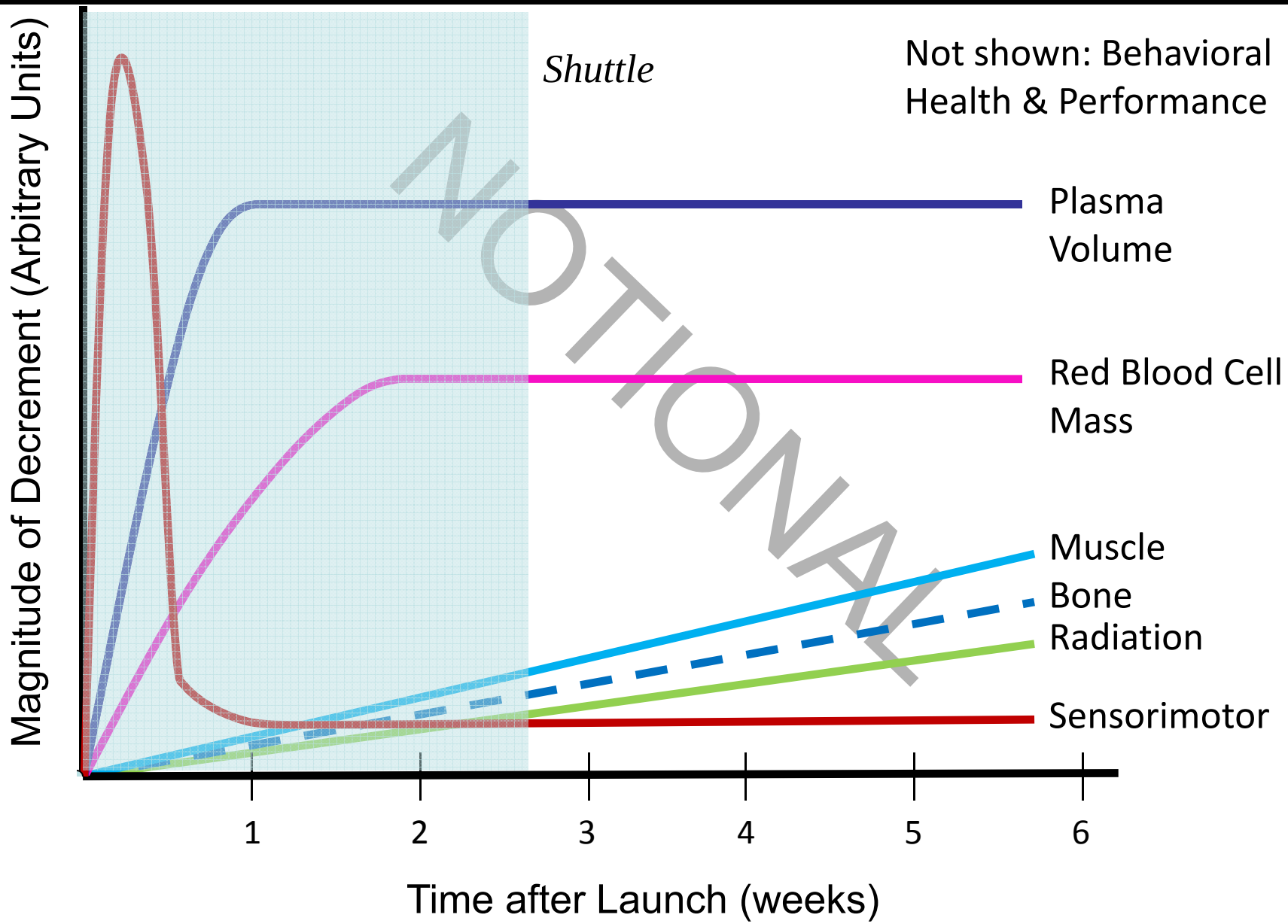
Changes in Body Functions in 0g



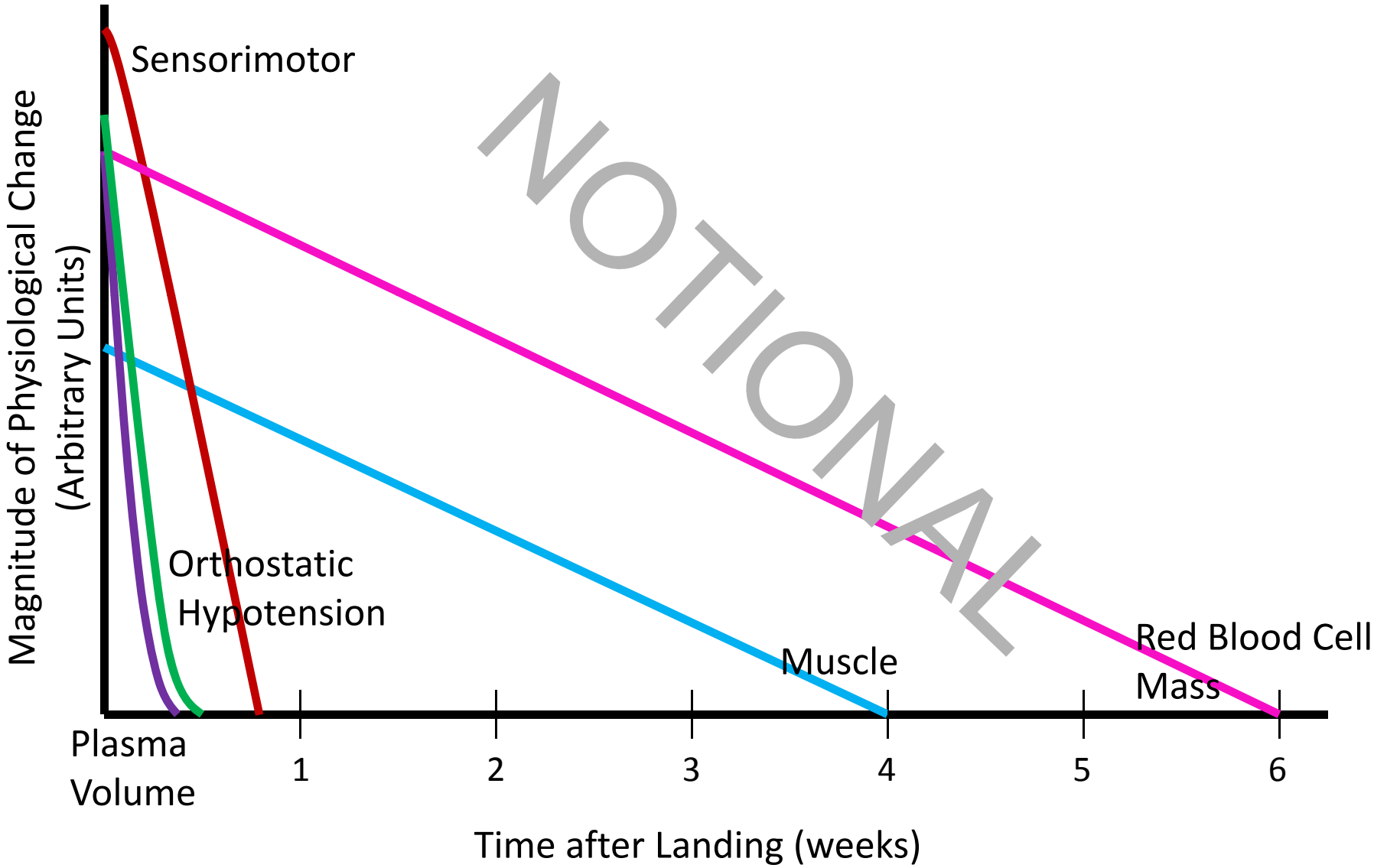


Change in Hydrostatic Pressures in 0g

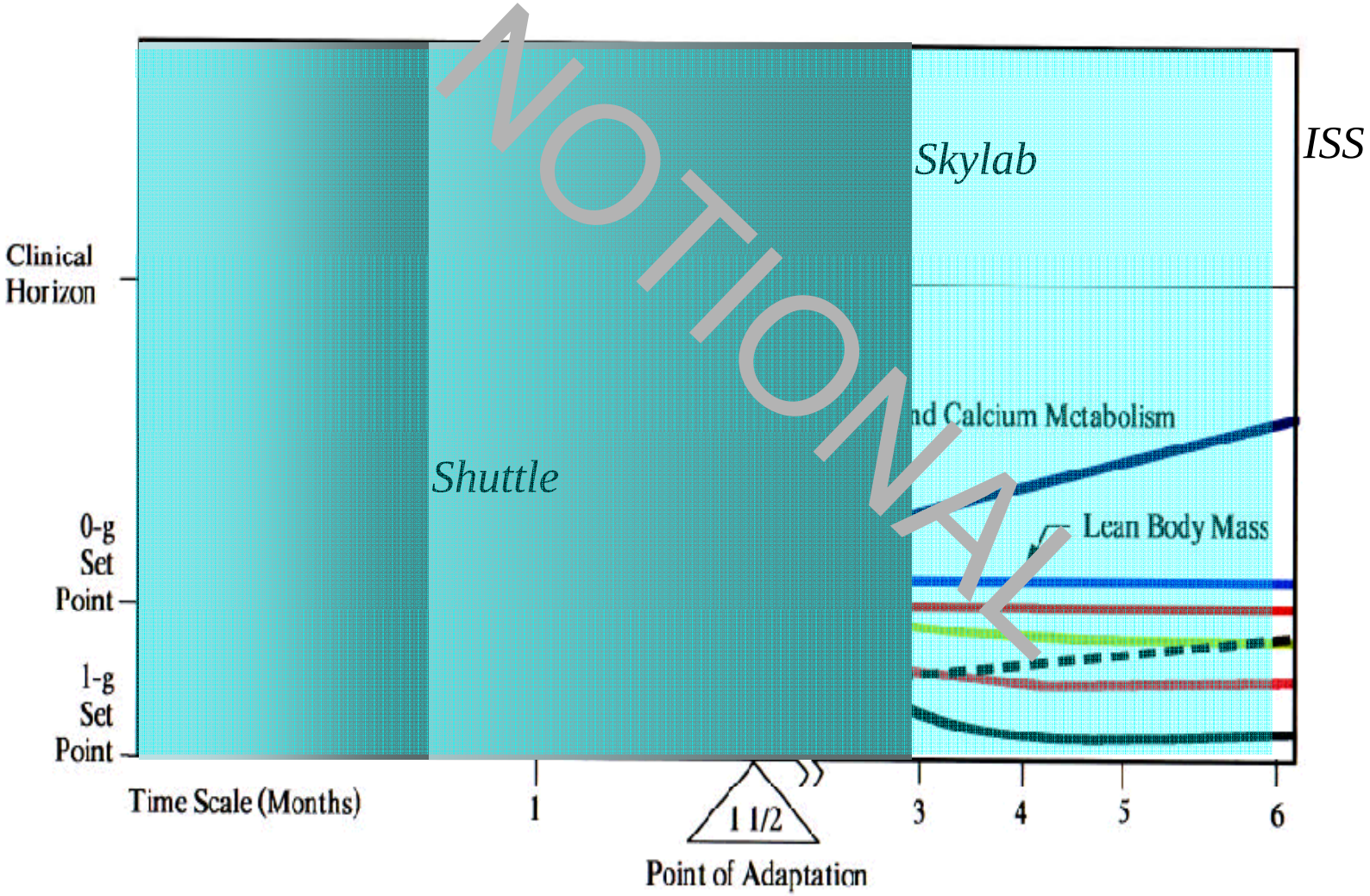
Changes during short-duration space flight



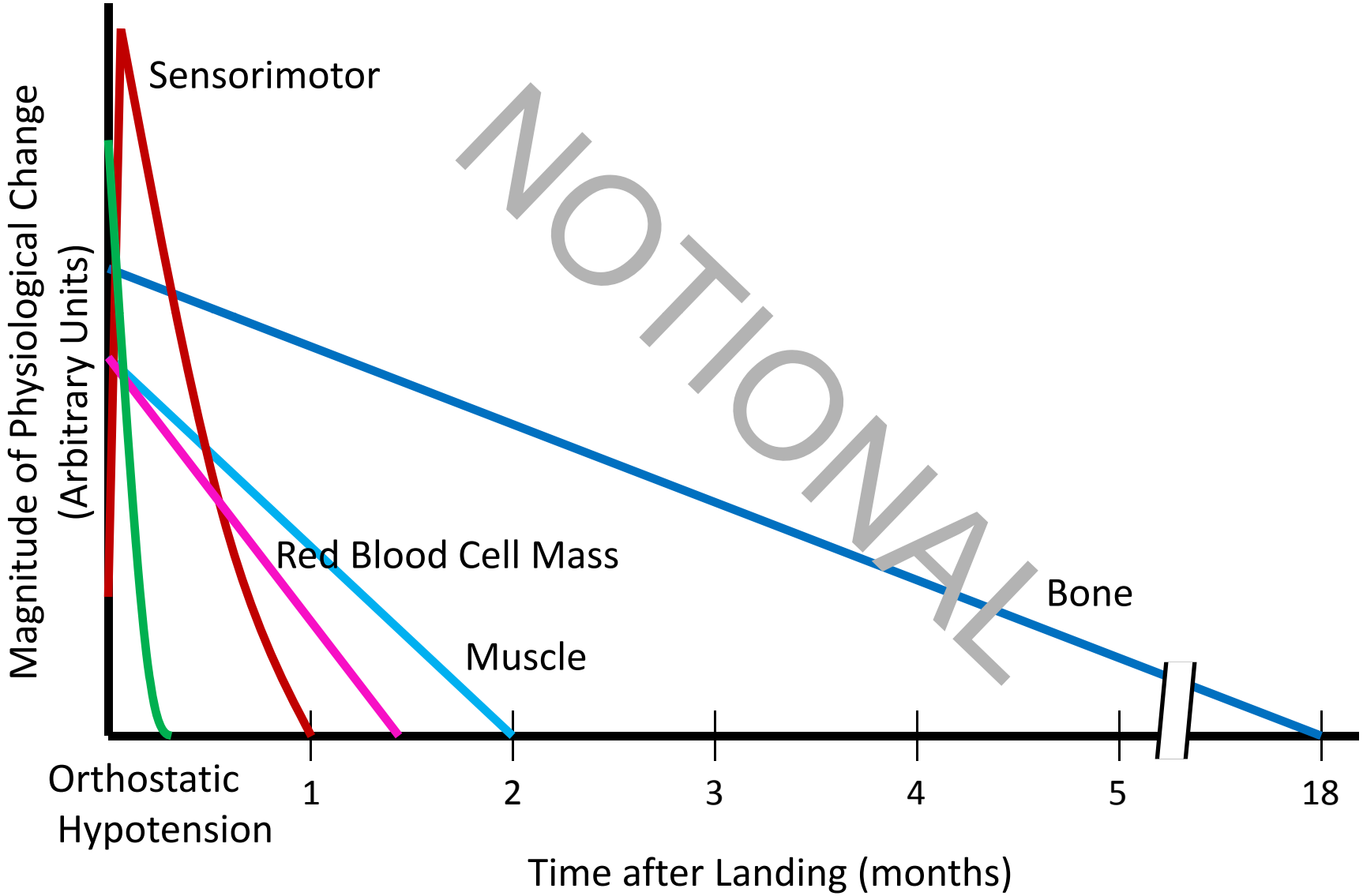
Recovery after Short-duration Spaceflight



Changes during long-duration space flight



Recovery after long-duration space flight



Impacts of space flight on humans

Accumulated evidence to date

- Too voluminous for 30-minute presentation!
- Current literature reviews is publicly available in NASA HRP Evidence Book, http://humanresearch.jsc.nasa.gov/elements/smo/hrp_evidence_book.asp
- Most significant real and suspected effects of prolonged space flight are captured in HRP risks and risk factors

HRP risks, risk factors

Space Radiation	
Substantially supported	*Suspected*
• Radiation Carcinogenesis	• Acute or Late Central Nervous System Effects from Radiation Exposure
• Acute Radiation Syndromes Due to Solar Particle Events	• Risk of Degenerative Tissue or Other Health Effects from Radiation Exposure

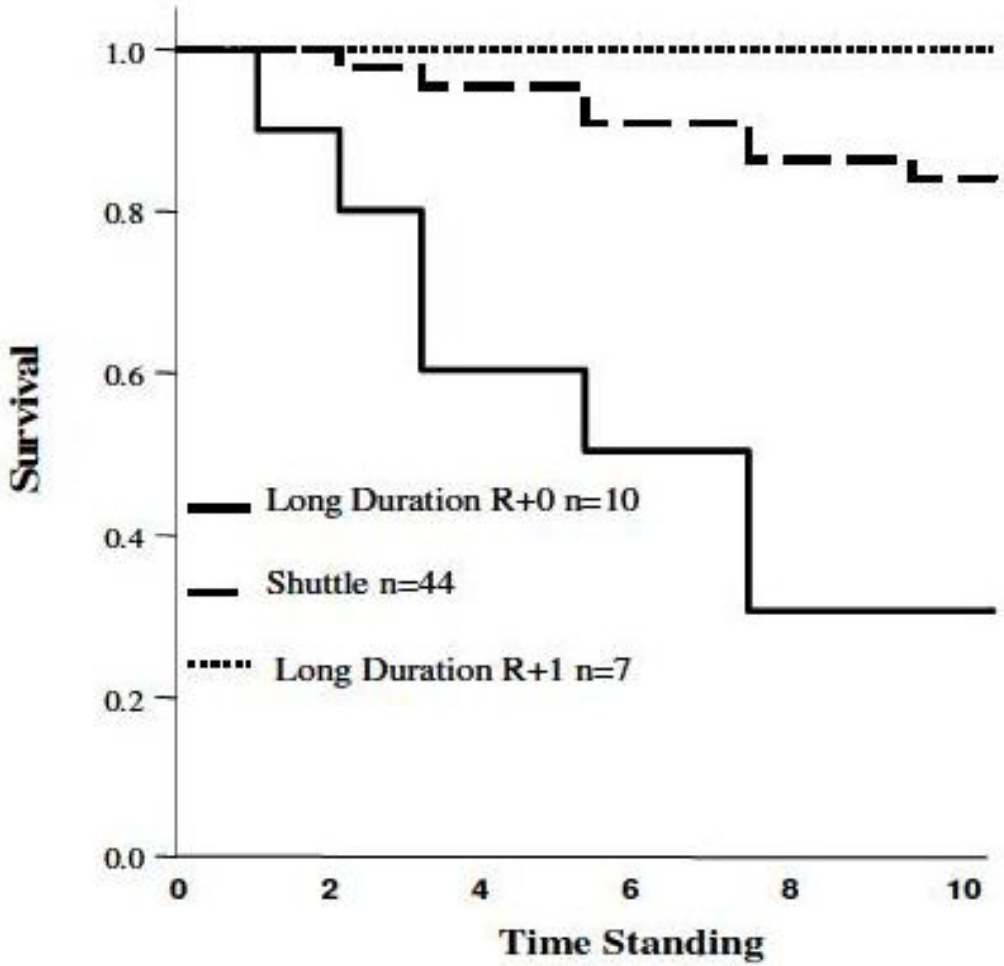
Source: PRD Rev. B HRP-47052

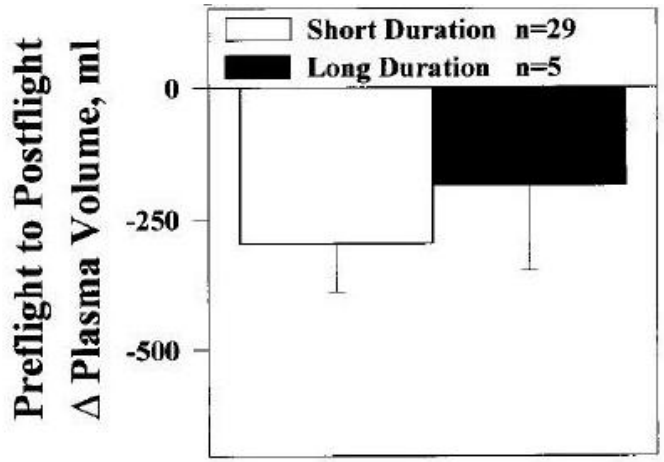
HRP risks, risk factors

Cardiovascular, cardiopulmonary	
Substantially supported	*Suspected*
• Orthostatic Intolerance During Re-Exposure to Gravity	• Risk of Cardiac Rhythm Problems
• Unnecessary Operational Limitations Due to Inaccurate Assessment of Cardiovascular Performance	• Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity

Source: PRD Rev. B HRP-47052

Orthostatic intolerance after long duration space flight





Platts et al., Risk of Orthostatic Tolerance During Re-Exposure to Gravity, NASA HRP-47060, Mar. 2008

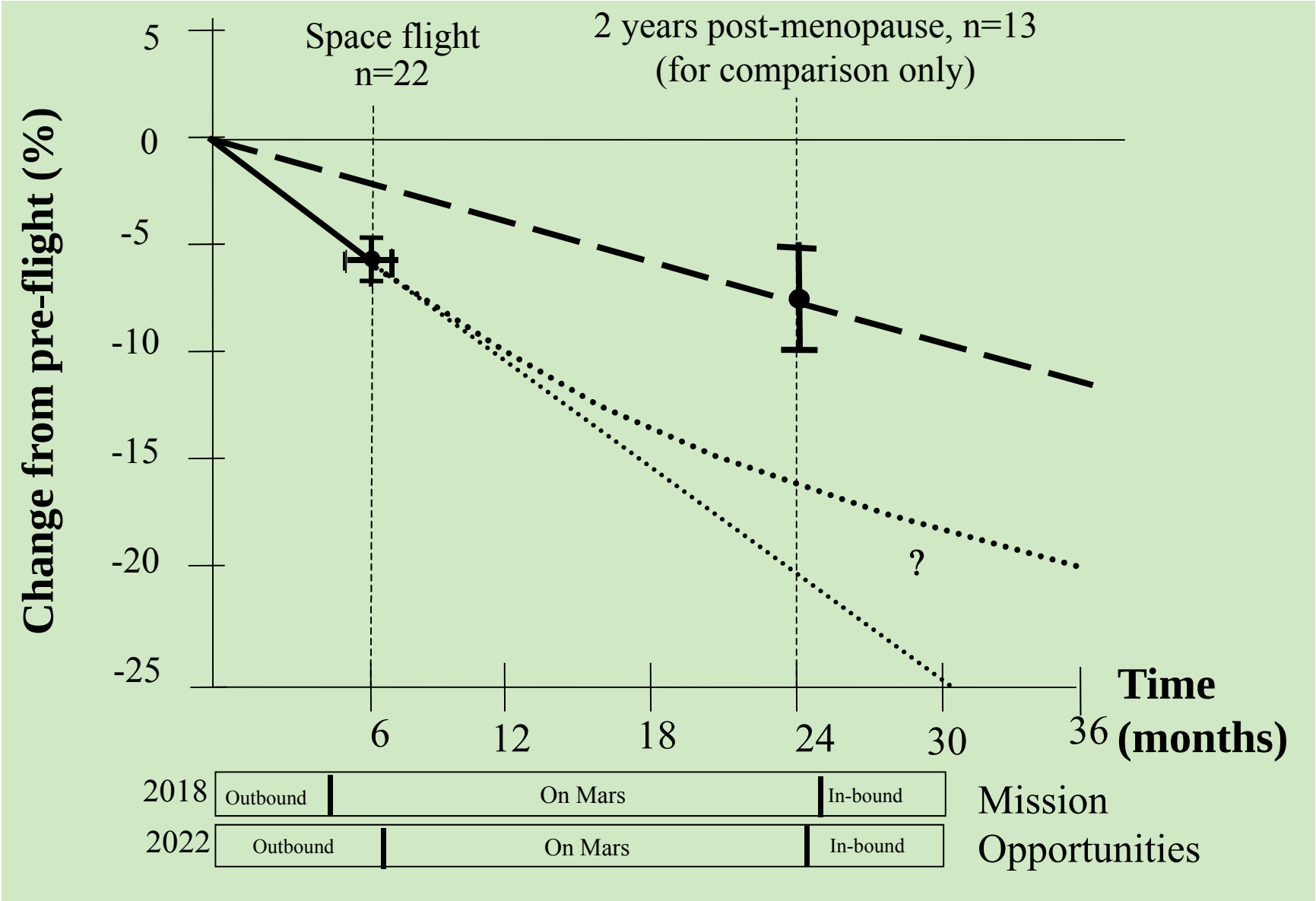
HRP risks, risk factors

Bone	
Substantially supported	*Suspected*
• Accelerated Osteoporosis	• Risk of Bone Fracture • Risk of Invertebral Disc Damage • Risk of Renal Stone Formation

Nutrition	
Substantially supported	*Suspected*
• Risk Factor of Inadequate Nutrition	

Source: PRD Rev. B HRP-47052

Bone Integrity in Weightlessness



HRP risks, risk factors

Behavioral Health and Performance	
Substantially supported	*Suspected*
• Behavioral and Psychiatric Conditions	• Risk of Performance Errors Due to Poor Team Cohesion and Performance, Inadequate Selection/Team Composition, Inadequate Training, and Poor Psychosocial Adaptation
• Performance Errors Due to Sleep Loss, Circadian Desynchronization, Fatigue, and Work Overload	

Sensorimotor	
Substantially supported	*Suspected*
	• Impaired Ability to Maintain Control of Vehicles and Other Complex Systems

Source: PRD Rev. B HRP-47052

HRP risks, risk factors

Muscle	
Substantially supported	*Suspected*
• Compromised EVA Performance and Crew Health Due to Inadequate EVA Suit Systems	
• Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance	
• Operational Impact of Prolonged Daily Required Exercise	

Source: PRD Rev. B HRP-47052

HRP risks, risk factors

Exploration medical capabilities	
Substantially supported	*Suspected*
	• Inability to Adequately Treat an Ill or Injured Crew Member

Pharmacology	
Substantially supported	*Suspected*
	• Therapeutic Failure Due to Ineffectiveness of Medication

Immunology	
Substantially supported	*Suspected*
	• Crew Adverse Health Event Due to Altered Immune Response

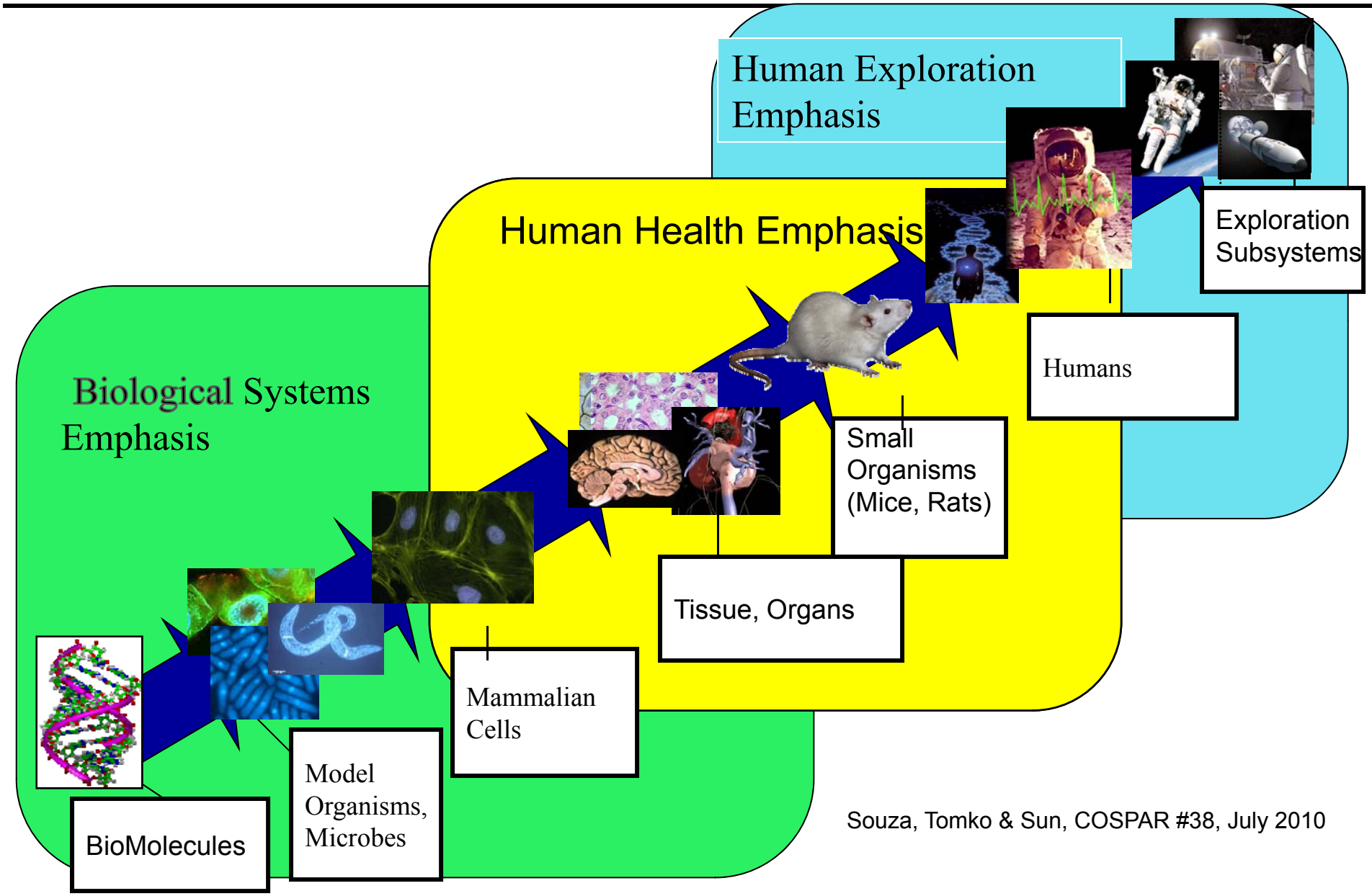
Source: PRD Rev. B HRP-47052

HRP risks, risk factors

Space human factors and habitability	
Substantially supported	*Suspected*
• Error Due to Inadequate Information • Risk Associated with Poor Task Design	• Reduced Safety and Efficiency Due to Poor Human Factors Design
• Risk Factor of Inadequate Food System	• Adverse Health Effects from Lunar Dust Exposure

Source: PRD Rev. B HRP-47052

Life Sciences Research in Space



Souza, Tomko & Sun, COSPAR #38, July 2010

"Operational" (e.g., applied) and "Fundamental" (e.g., basic) SLS research for NASA's purposes

OPERATIONAL RESEARCH

FUNDAMENTAL RESEARCH

Enables Human Exploration of Space

- Radiation Health
- Behavior and Performance
- Environmental Monitoring and Control
- Advanced Life Support
- Clinical / Operational Medicine

Transitional Research

- Cell and Molecular Biology
- Tissue Engineering
- Organismal and Comparative Biology
- Behavior and Performance

Intrinsic Scientific Importance or Impact

- Cell and Molecular Biology
- Developmental Biology
- Organismal and Comparative Biology

Strategic translation of basic results into applied products

Adapted from the ReMaP (2002-2004) Research Review; from Tomko, COSPAR #38, July 2010

NEW Solicitation for human research

NASA HRP and NSBRI NRA "Research and Technology Development to Support Crew Health and Performance in Space Exploration Missions" (NRA NNJ10ZSA003N, http://nspires.nasaprs.com/) released July 23, 2010

- Ground-based, bed rest definition and flight definition proposals
- Step-1 proposals are due on September 2, 2010
- Invited Step-2 proposals are due on December 1, 2010

NASA	NSBRI
Host-Microbe Interactions	Cardiovascular Alterations
Crew Microbiome	Human Factors and Performance
Workload Measures	Musculoskeletal Alterations
Habitability Concept Tools	Neurobehavioral and Psychosocial Factors
Psychosocial Aspects of Food Acceptability	Sensorimotor Adaptation
Neurocognitive Performance	Smart Medical Systems and Technology
Team Autonomy	Bone: Fracture Healing
Behavioral Health and Performance ISS Utilization	
Muscle: Gender and Hydration	Muscle: In-flight Changes
Nutrition and Exercise	Immunology
Pharmacology: Space Motion Sickness	
EVA Physiology: Suit Injury Countermeasures	

Final Thoughts

- Humans will continue to explore space *in situ*, as well as with remote and robotic surrogates.
- Space flight has been shown to have significant effects on some organ systems of the human body
  - Those not yet showing such effects may not yet have studied adequately
- Exploration-oriented program has specific data needs to meet programmatic requirements
- Increasing possibility of basic research providing new, unexpected insights
- ISS provides unmatched, unprecendented venue for in-depth research