Acknowledgement and Disclaimer

This presentation represents the views of the author and not necessarily NASA or USAF
NASA Centers

[Map of NASA Centers across the United States]
Why Should Physicians Care About Space?
Why Should Air Force Flight Surgeons Care About Space?
Why Should Air Force Flight Surgeons Care About Space?
What is new and different in Space Medicine?
Write This Down

Homeostasis

The human body will *always* try to reach homeostasis with its environment, including microgravity

[Diagram showing compensation, inflection point, and pathology]
What do NASA Flight Surgeons do?
Hazards of Spaceflight

Spacecraft

Space Environment

Mission
Hazards of Spacecraft

- Structure
- Environmental
- Personal Space
Spacecraft

Structure

• Training
Spacecraft

Structure
• Launch
Spacecraft

Structure and Personal Space
Spacecraft

Environmental
• Exposures
• Habitability

Figure 3. Bacterial Colonies (smooth)
Figure 4. Fungal Colonies (fuzzy)
Hazards of Environment

- Space Radiation
- Distance
- Microgravity
Space Environment

Space Radiation

• Three main sources
  • Galactic cosmic radiation (GCR)
    **biggest threat to deep space missions**
  • Trapped Radiation
  • Solar particle events (SPE)
Space Environment

Space Radiation Mechanisms of Damage

[Diagram showing the interaction of radiation with water molecules and DNA, resulting in free radicals and damage to the DNA helix.]
Space Environment

Magnetosphere
Space Environment

Van Allen Belts

- Inner Belt: 1,000 – 8,000 miles
- Outer Van Allen Belt
- Magnetic field lines
- Inner Van Allen Belt
- Low-Earth Orbit (LEO)
- International Space Station: 230 miles
- Van Allen Probe-A
- Van Allen Probe-B
<table>
<thead>
<tr>
<th><strong>Typical Dose (rem)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Round-trip NY to London / Chest x-ray (1 film)</td>
<td>0.01</td>
</tr>
<tr>
<td>Natural background radiation per year</td>
<td>0.3</td>
</tr>
<tr>
<td>CT scan</td>
<td>3-10</td>
</tr>
<tr>
<td><strong>Typical mission dose on ISS</strong></td>
<td>10-15</td>
</tr>
<tr>
<td>Estimated dose for 3-yr Mars mission</td>
<td>100-150</td>
</tr>
<tr>
<td>Atomic bomb survivors</td>
<td>Up to 400</td>
</tr>
<tr>
<td>Human LD$_{50}$, no medical intervention</td>
<td>350-550</td>
</tr>
<tr>
<td>Human LD$_{50}$, with medical intervention</td>
<td>500-1000</td>
</tr>
</tbody>
</table>
Space Environment

Protection from Radiation

- Time, Distance, Shielding
Distance

• Distance to the Moon ~ 238,854 miles
• Average distance to Mars ~ 142 million miles
  (range 56 - 401 million miles)
Space Environment

Microgravity
Space Environment

Microgravity - Normal physiology, abnormal environment

- Neurovestibular
- Cardiovascular
- Musculoskeletal
- SANS
- CO₂
Space Environment

Microgravity

• Neurovestibular

- EYES
  Vision

- INNER EARS
  Linear acceleration
  Angular acceleration

- SPINAL / PERIPHERAL NERVOUS SYSTEM
  Proprioception (body position and movement)

BRAIN

GRAVITY DEPENDENT

UNCLASSIFIED
Space Environment

Space Motion Sickness

Treatments?

79%
Space Environment

Microgravity

• Neurovestibular
Space Environment

Microgravity
• Cardiovascular

Earth
In Space
Adaptation
Return

Lujan and White (1995)
Space Environment

Microgravity

• Cardiovascular
Space Environment

Microgravity
• Musculoskeletal

Bone Remodeling

OSTEOCLASTS (resorb bone)
OSTEOBLASTS (build bone)

Gravity Dependent
Space Environment

Microgravity
- Musculoskeletal
- Post-flight changes in bone density compared to preflight
In-flight Countermeasures

<table>
<thead>
<tr>
<th>System</th>
<th>T2 (Treadmill 2)</th>
<th>CEVIS (Cycle Ergometer with Vibration Isolation &amp; Stabilization)</th>
<th>ARED (Advanced Resistive Exercise Device)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurovestibular</td>
<td>✔</td>
<td></td>
<td></td>
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<tr>
<td>Cardiovascular</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Musculoskeletal</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
Space Environment

Future In-flight Countermeasures

- Size of craft will affect space available for exercise equipment
- Optimal design would allow for multifunctional equipment
- Does this provide sufficient medical benefit?
Space Environment

Microgravity

- Spaceflight Associated Neuro-ocular Syndrome (SANS)

Fluid pressure causes optic nerve compression, flattening of the back of the eyeball, and optic disc swelling.
Space Environment

Microgravity

- SANS

Decreased near visual acuity, distant vision intact

Design and Mission Impacts
Microgravity

- $\text{CO}_2$
  - Terrestrial partial pressure of $\text{CO}_2$: 0.39 mmHg
  - Hardware design based on original ISS Flight Rule limit for $\text{CO}_2$ of 7.6 mmHg
  - Flight Rule limit revised to 5.3 mmHg in 2008
  - Recently limit for 24-hr average was decreased to 3.0 mmHg
  - Current evidence would suggest that an operational limit between 0.5 and 2.0 mmHg
Hazards of Mission

Limited Resources

Mental

Physical
Mission

Limited Resources

• Medical Training and Assets
Mission

Crew Health Stabilization
Mission

Physical Challenges

• EVA
Mission

Physical Challenges

• DCS

NORMAL LUNG TISSUE

EBULLISM
Mission

Physical Challenges

• Suits

US EMU – 4.3 psi

Russian Orlan – 5.8 psi
Mission

Physical Challenges

• Suits

Figure 3. Largest crater found on the PMIA handrail was 1.85 mm diameter with 0.33-mm-high crater lips.

Figure 6. Mastracchio’s left glove after STS-118 EVA #3.
Mission

Physical Challenges

• Light
Mission

Physical Challenges

• Return
Mission

Physical Challenges

• Postflight
Mission

Mental Challenges

• Significant physical and psychosocial stressors
Data Extrapolation

Value relative to Preflight (%)

Time in Space (months)

100

1 year

shuttle

MIR

ISS
Space is Hard
Summary

- Space is hard…but super cool
- Aerospace Medicine Specialists are uniquely positioned to understand the physiologic and operational challenges of extreme environments
Questions?