Health and Medical: Considerations for Mars

Dr. J.D. Polk

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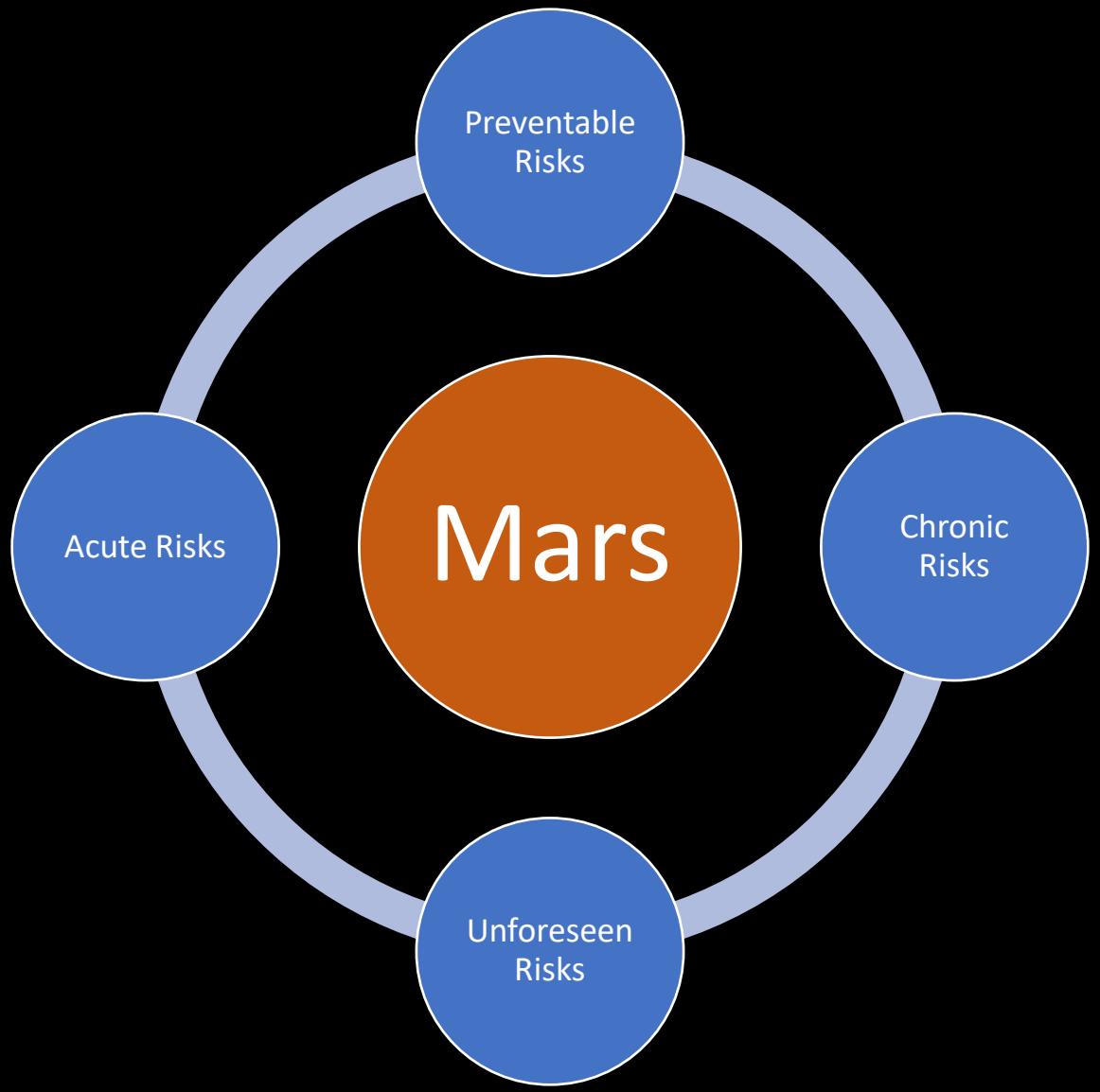

Preventable Risks
Acute Risks
Mars
Chronic Risks
Unforeseen Risks

The Six Tenets

- Mass
- Power
- Volume
- Time
- Money
- Risk

Integrated Human Performance

Space Radiation

Acute In-flight Effects
(controlled by vehicle design and operational constraints)
Long-term Cancer Risk

Isolation & Confinement

Behavioral Aspects of Isolation
Individual Well Being
Circadian Misalignment and Sleep Difficulties
Team Cohesion and Performance

Distance from Earth

Drives the Need for Effective, On-board Systems that Facilitate Crew Readiness to Respond to Demands and Annomolies – They Cannot Come Home for Treatment

Altered Gravity Fields

Spaceflight Associated Neuro-ocular Syndrome
Balance Disorders
Fluid Shifts
Cardiovascular Deconditioning
Muscle Atrophy
Bone Loss

Hostile/Closed Environments

Vehicle Design
Environmental - CO_2 Levels,
Toxic Explosures, Water,
Nutrition/Food
Decreased Immune Functions,
Microbiome Changes

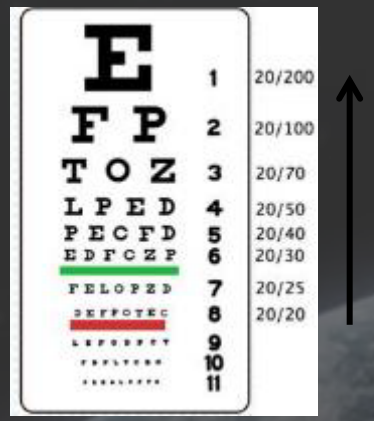
Figure 1. *Five Hazards of Human Spaceflight and Associated Human System Risks*

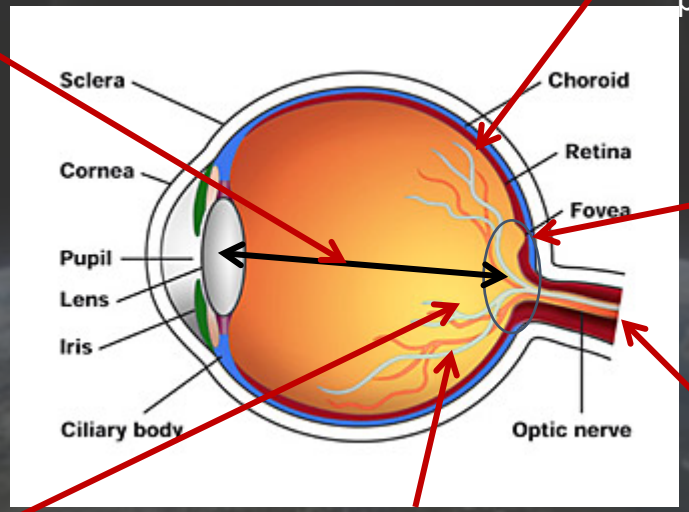
https://www.nasa.gov/wp-content/uploads/2024/01/human-health-and-performance.pdf?emrc=6e9562

SANS/VIIP

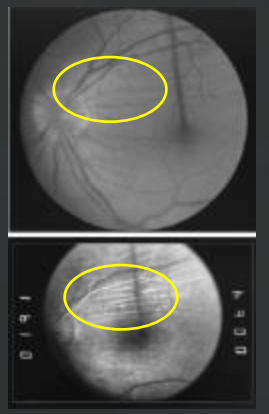
Several known cases predominantly in long duration crew members
- Each with different degrees of symptoms
- Elevated measures of Intracranial Pressure (ICP) post flight
- Evaluation of shuttle fliers showed mild changes in the optic nerve diameter, even in 14 day missions.

•Hyperopic Shifts
-Up to +1.75 diopters

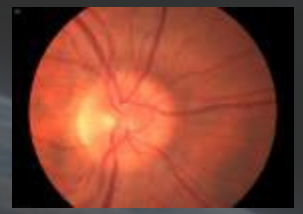




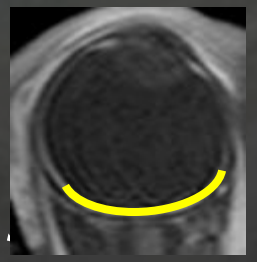
•Choroidal Folds - parallel grooves in the posterior pole



•Optic Disc Edema (swelling)



•Globe Flattening



Normal Globe

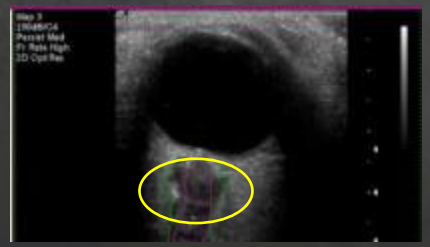
Flatten Globe

MRI Orbital Image showing globe flattening

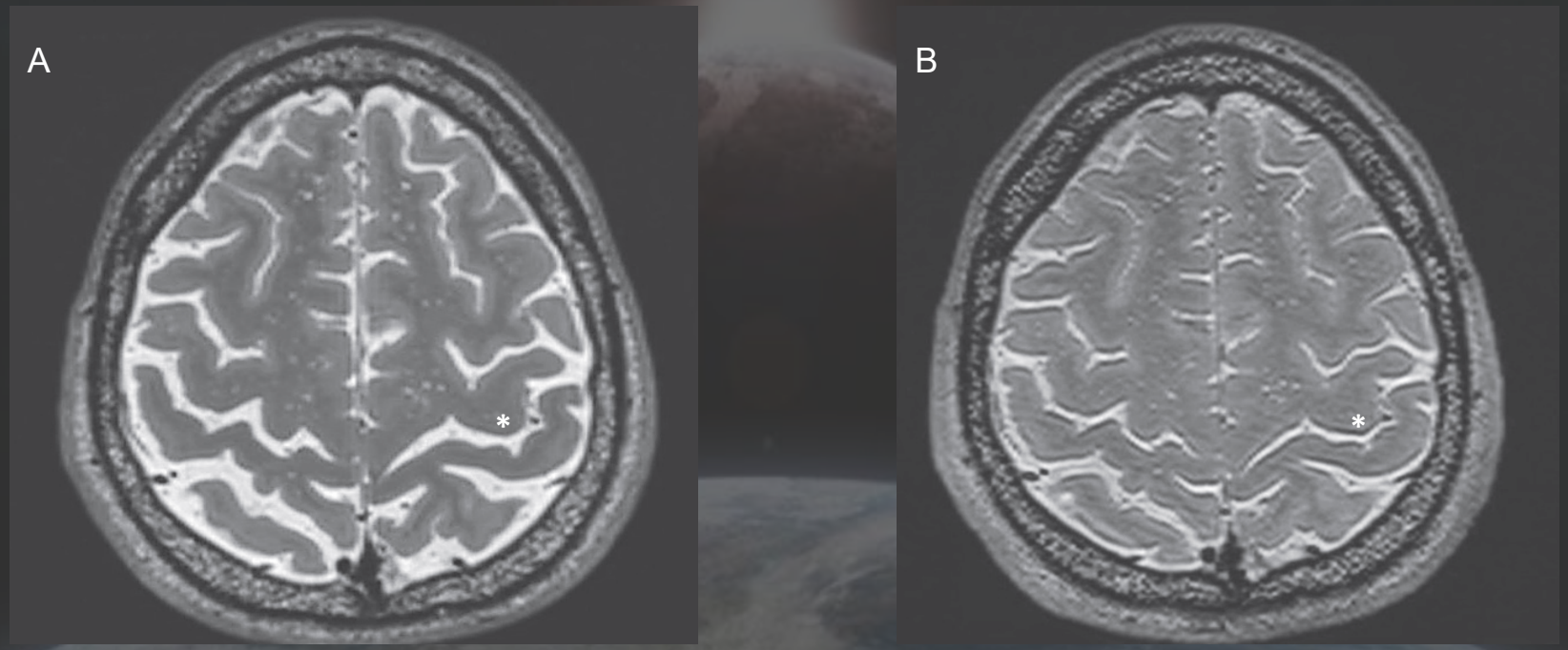
•Altered Blood flow
•"cotton wool" spots

Scotoma

•Increased Optic Nerve Sheath Diameter



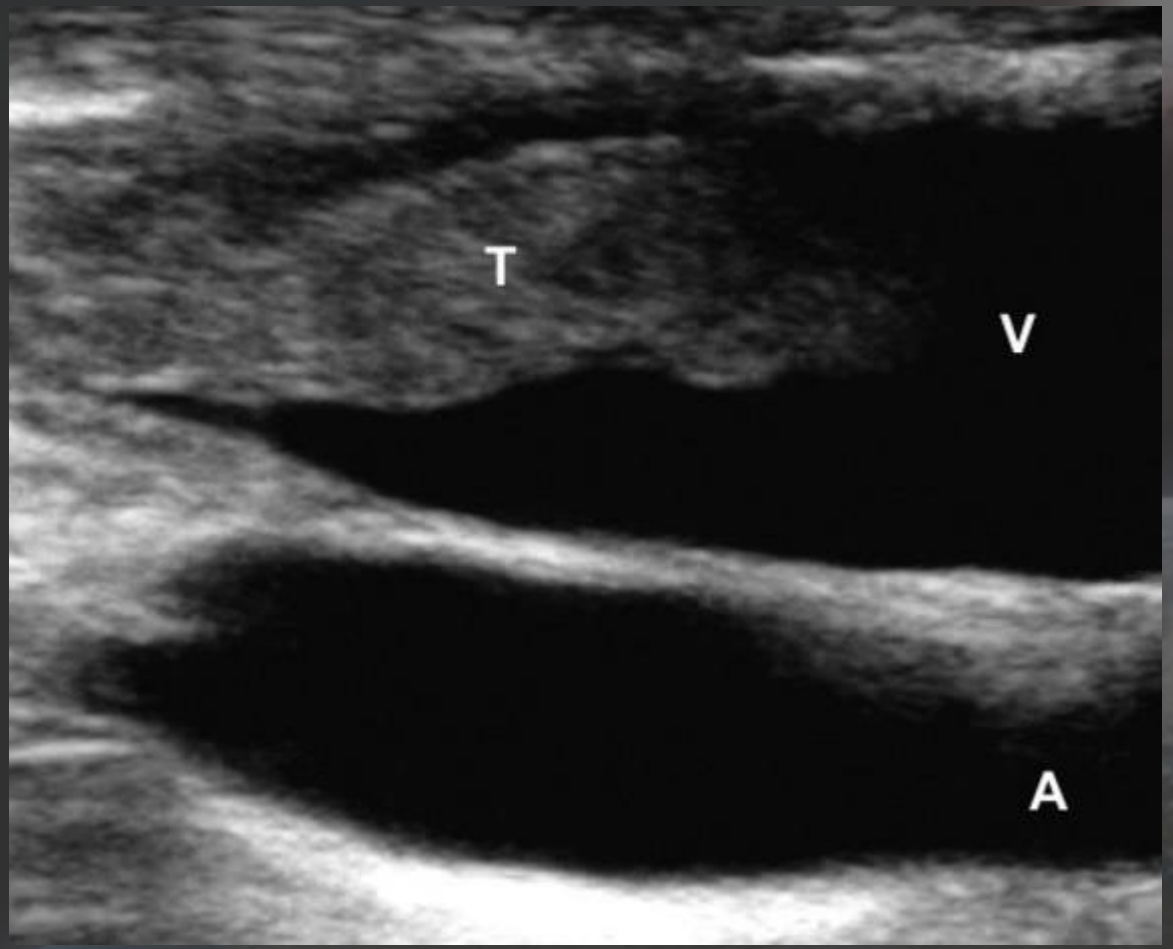
Narrowing of the CSF Spaces Within the Brain Sulci



Axial T2-weighted images of the brain obtained before (Panel A) and after (Panel B) this astronaut had long-duration spaceflight on the International Space Station. The astronaut presented with optic-disk edema syndrome after spaceflight. **Crowding of the sulci can be seen at the vertex**. The gyrus* is the precentral gyrus (primary motor cortex).

Roberts, D. R., Albrecht, M. H., Collins, H. R., Asemani, D., Chatterjee, A. R., Spampinato, M. V., ... & Antonucci, M. U. (2017). Effects of spaceflight on astronaut brain structure as indicated on MRI. New England Journal of Medicine, 377(18), 1746-1753.

Internal Medicine- Thrombosis of the internal jugular vein



Thrombus in the left internal jugular vein.

Risk of embolization to the lungs and development of pulmonary embolus.

May increase intracranial hypertension or be result of venous stasis due to compression of veins from intracranial hypertension.

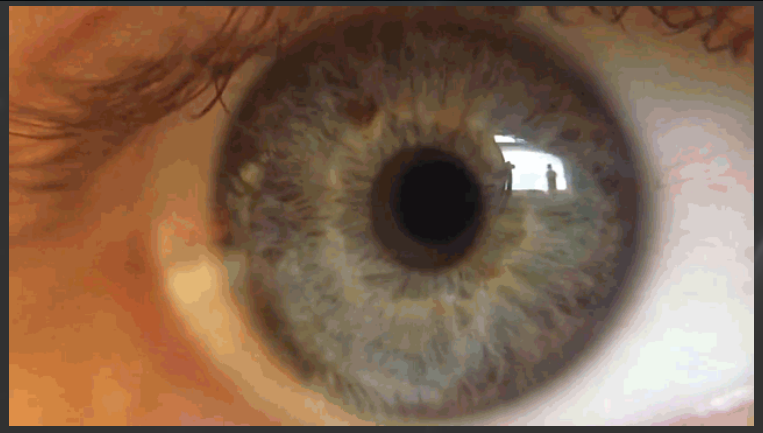
Astronauts are checked for Protein C, S and Factor V Leiden.

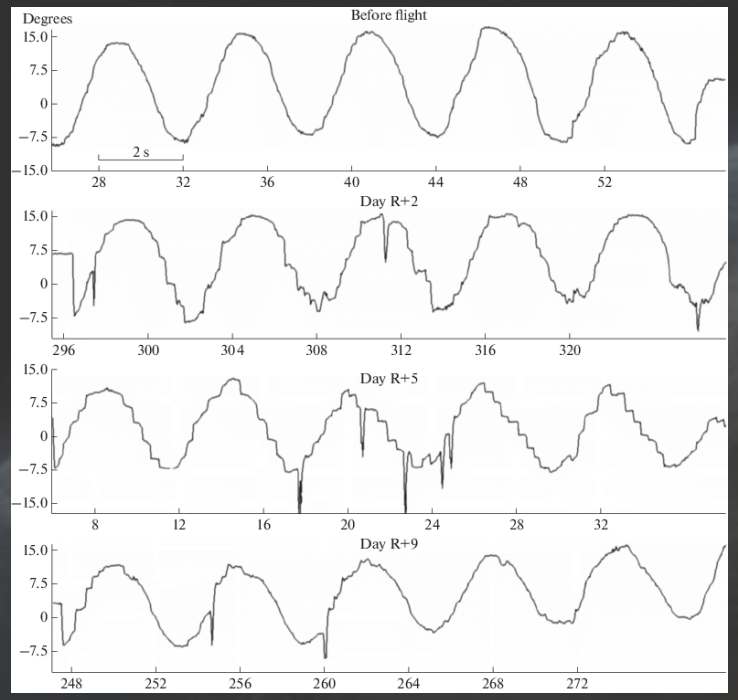
Risks: Trauma, BCP, potential changes in Tissue Factor Pathway Inhibitor

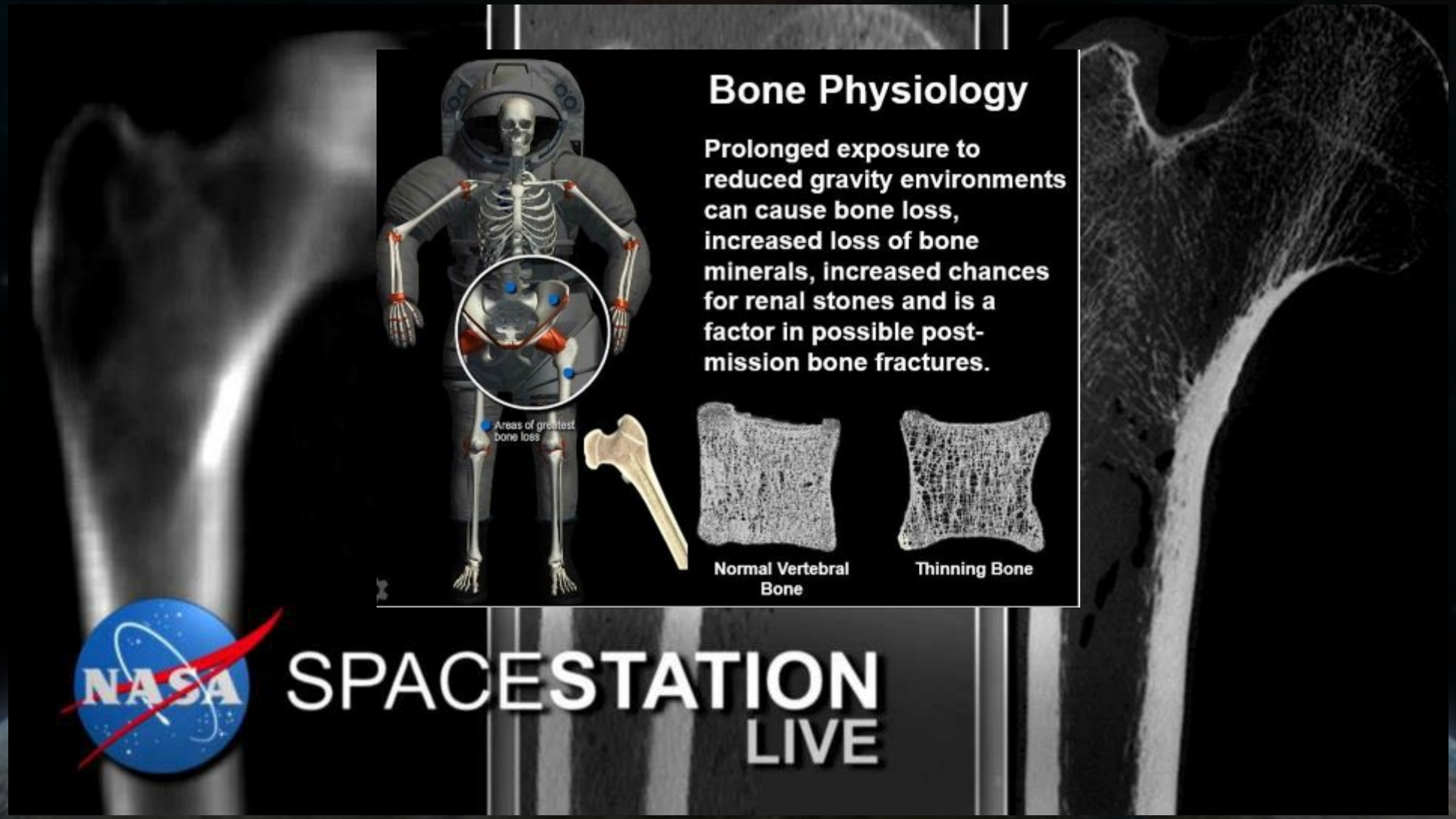
Treatment: LMWH, Lovenox (inj), Xarelto/Eliquis (oral)

Auñón-Chancellor, S. M., Pattarini, J. M., Moll, S., & Sargsyan, A. (2020). Venous thrombosis during spaceflight. New England Journal of Medicine, 382(1), 89-90.

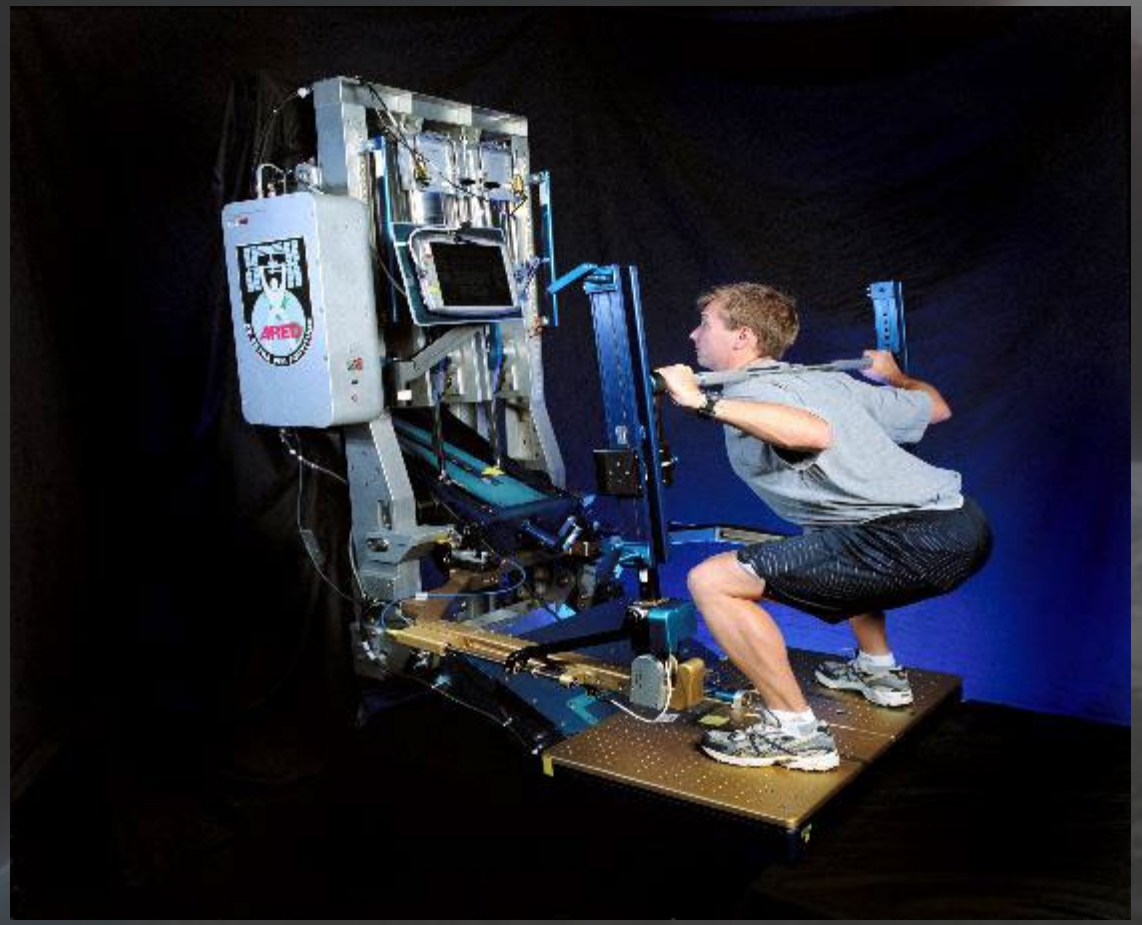
Optimizing Function






Bone Physiology
Prolonged exposure to reduced gravity environments can cause bone loss, increased loss of bone minerals, increased chances for renal stones and is a factor in possible post-mission bone fractures.
Areas of greatest bone loss
Normal Vertebral Bone
Thinning Bone
SPACESTATION
LIVE

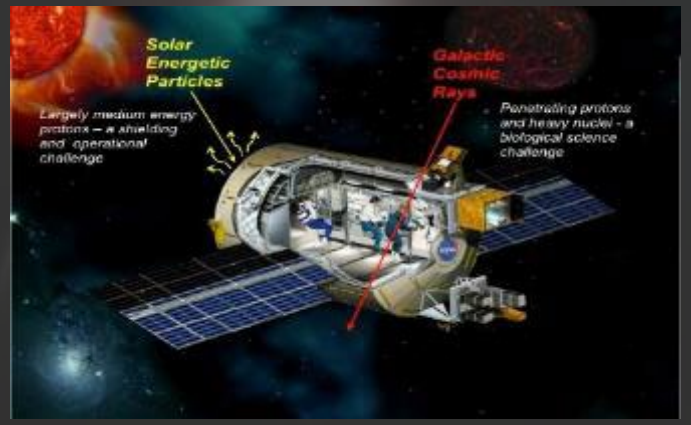
Countermeasures



Mars Primary Space Radiation Mitigations

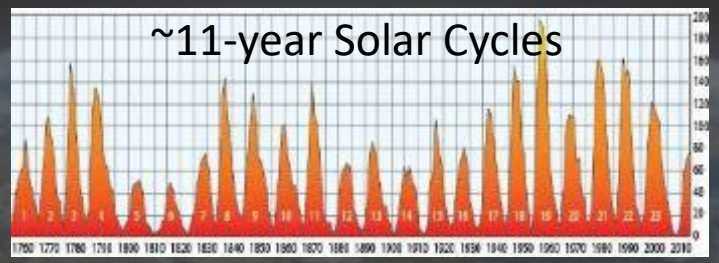
Optimized Spacecraft Shielding/Storm Shelters Can Protect Crew Against Solar Particle Events (SPEs)

- Shielding is only marginally effective against galactic cosmic rays (GCRs)
- Increasing shielding thickness adds substantial mass with minimal additional GCR exposure reduction



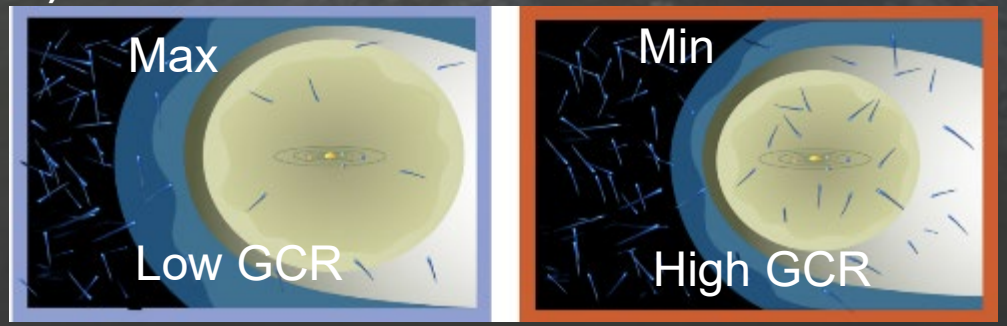
Timing A Mars Mission Around Solar Cycle's Maximum Can Help Protect Crew Against GCRs

- At solar maximum, the interplanetary magnetic field & solar wind increase to expand the heliosphere, shielding the solar system from incoming GCRs
- GCR exposure can be reduced at solar max by up to a factor of two



Decreasing Transit Time (propulsion) helps decrease exposure.

Shielding built into habitats.

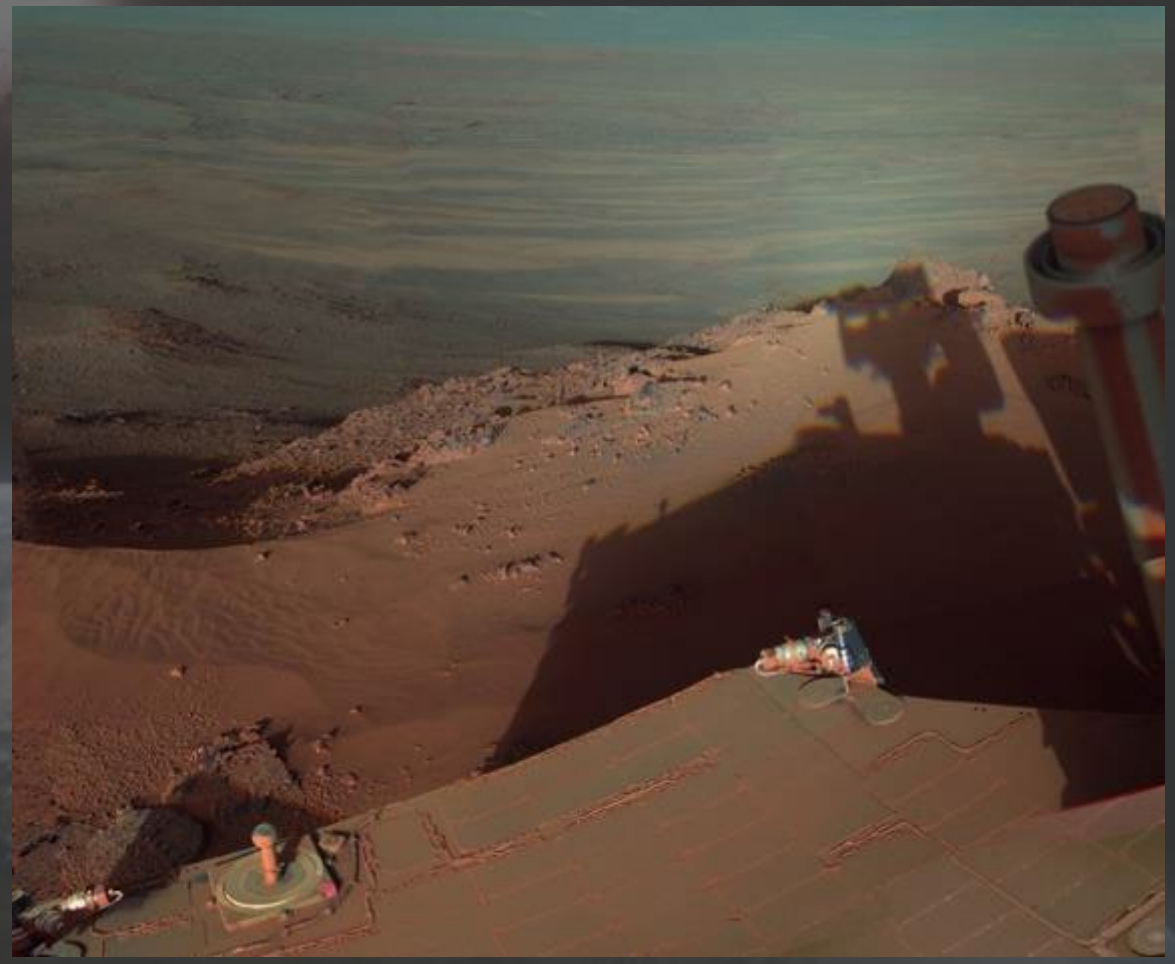


Behavioral/Psychological

Locard’s Exchange Principle:
It can be summarized as ‘whenever two objects come into contact, a transfer of material will occur’.

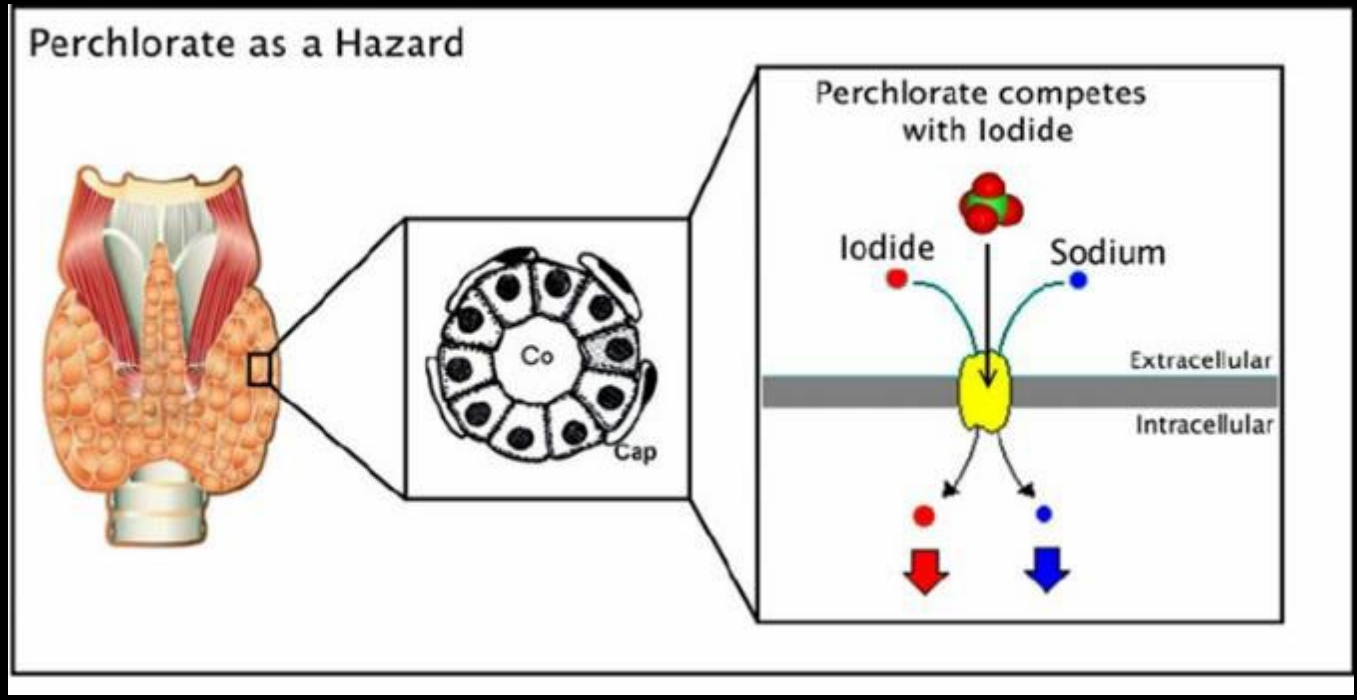
Mars Dust

- <1 to 5µm, average 3.2µm for suspended dust.
- Dust has magnetic properties due to high ferric content.
- While the thin atmosphere holds particles to a lesser degree than on earth, the lack of moisture leads to long atmospheric residence-time for suspended particles.
- Chromium, Manganese, Perchlorates



Perchlorates

- Perchlorate decreases the active transport of iodine into the thyroid potentially decreasing the production of thyroid hormone.
- Our review of the data to date on Mars dust risk suggests that perchlorates and other chemical constituents pose manageable crew health risks. There is a strong body of scientific evidence in regard to risk assessment for perchlorates, which in turn helps us strategize for mitigations and controls.



Toxicology for Mars

- Can you keep the environment perfectly clean?
- Would the ALARA principle used in radiation be a good strategy to follow?
- Plan on Black Swan events (fault tolerance).
- Environmental Monitoring.
- Prevent Iatrogenic Events.
- What risk mitigations can you add?
  - Filtration system (cartridge- air and water)
  - Magnets (air ventilation system/floor)
  - Shower system/Drain
  - Double Airlock/Suit Ports with Rear Entry
  - Negative Pressure/Positive Pressure
  - UVC (forward protection)

Engineering Design Solutions

Questions

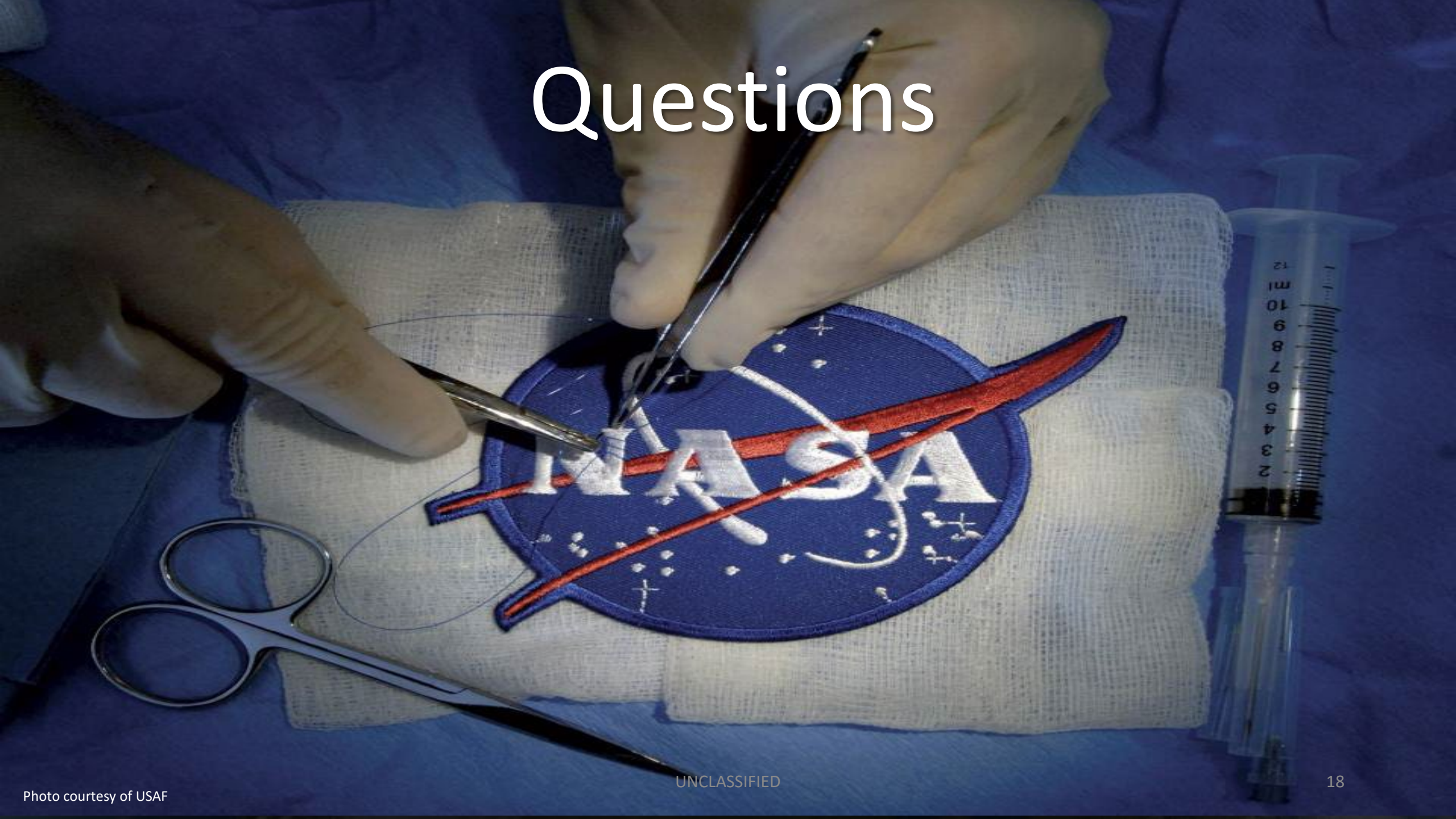


Photo courtesy of USAF