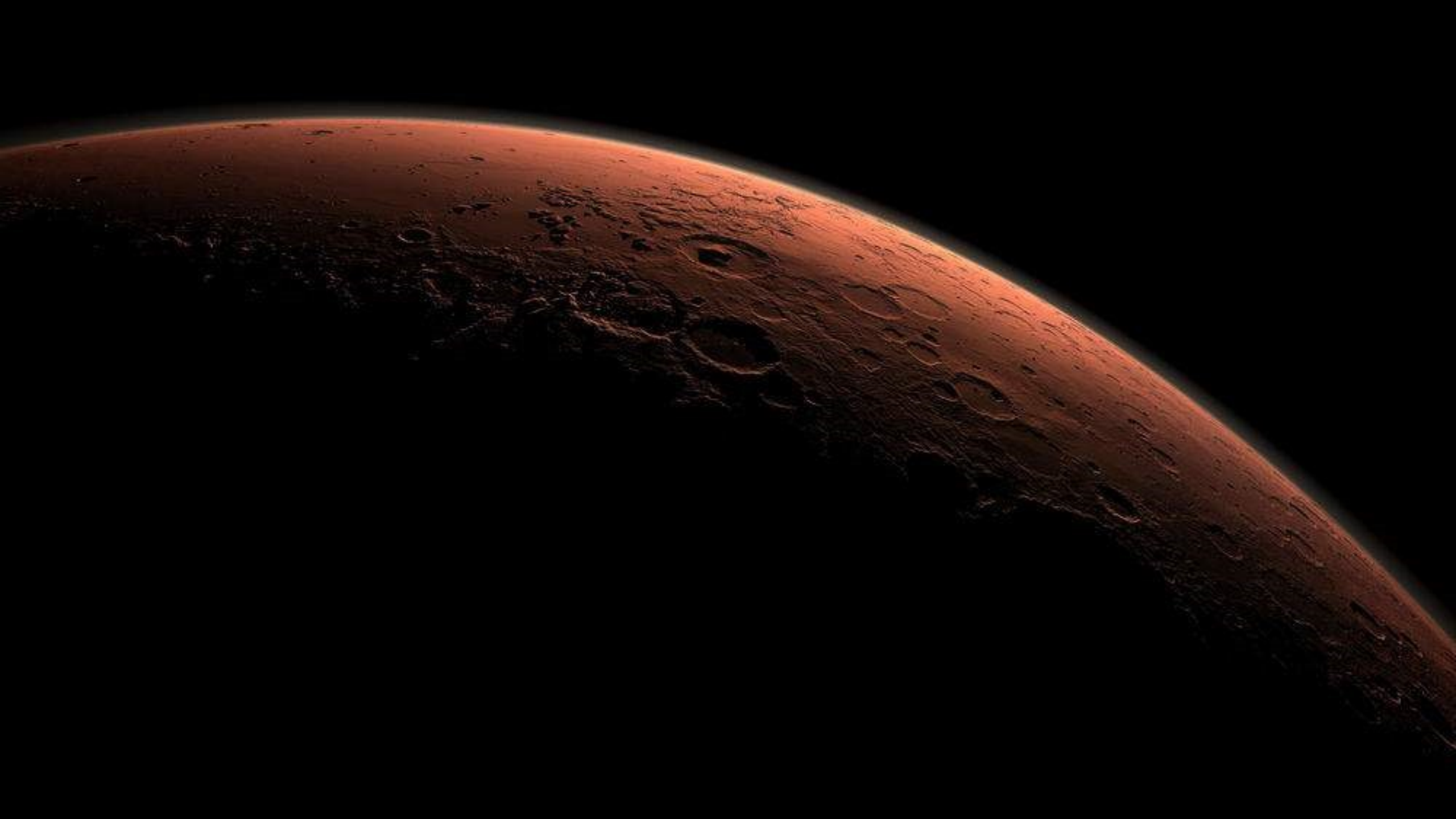
NASA Advisory Council Presentation

Dr. J.D. Polk
Chief Health and Medical Officer, NASA

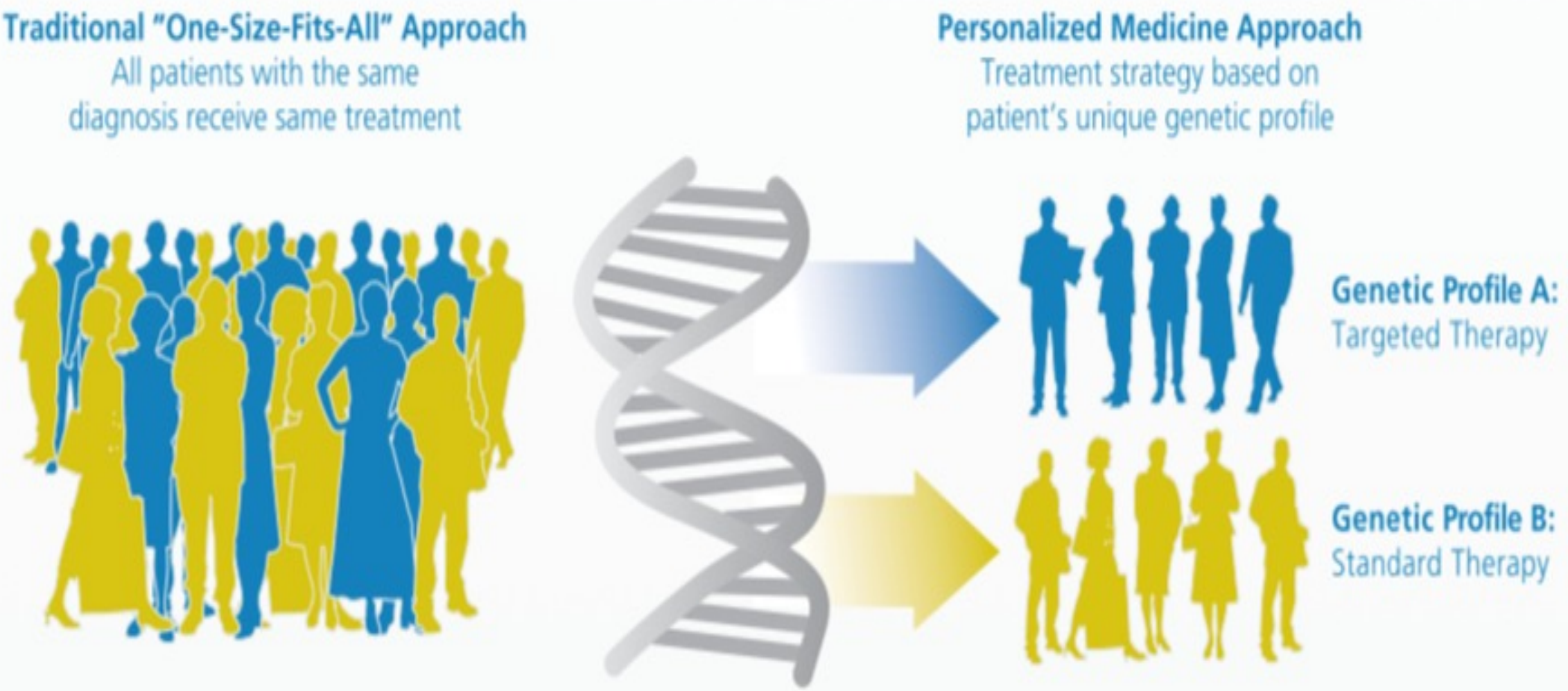
Lunar Missions



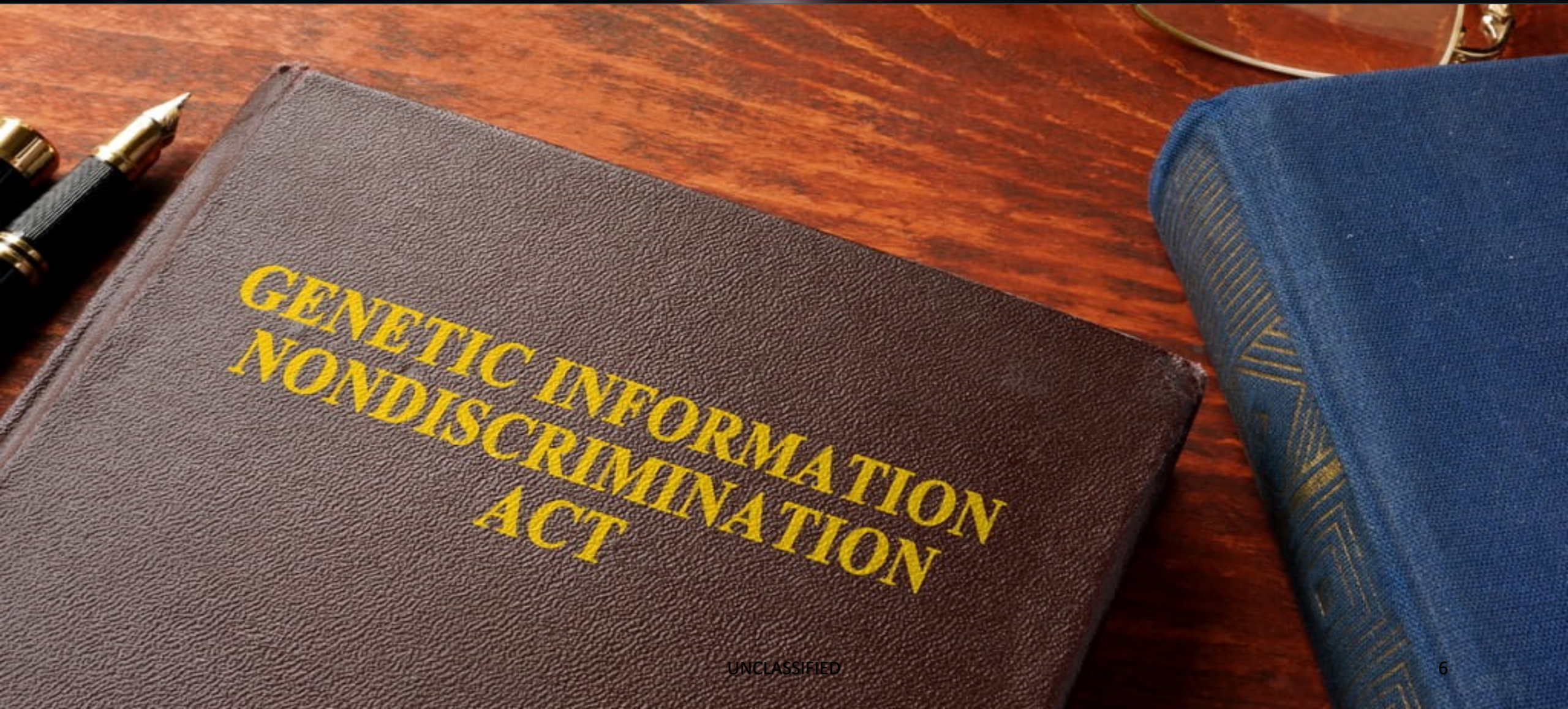
Find it, Fix it, Fly it…

- Cervical disc herniation with impingement on spinal cord
- Kidney stone x 14
- Clostridium difficile infection
- Gastroenteritis/ colitis
- Inguinal hernia x 4
- Olecranon bursitis r/o septic joint
- Hand bacterial tenosynovitis
- Pneumonia x 2
- Corneal ulcer
- Severe epistaxis
- Right ovarian cyst
- Dysmenorrhea
- Sudden hearing loss x 2
- V-tach, exercise induced
- Angina
- A-fib
- Allergic reaction - severe
- Retinal detachment x 2
- Appendicitis x 2
- Diverticulitis
- Cardiovascular Disease
- Prostate Cancer x 5
- Stroke with Patent Foramen Ovale
- Stroke from A. Fib
- Bladder Outlet Obstruction
- Ulcerative Colitis
- Flexor Digitorum Synovitis
- Bowel Resection
- Fatty Liver Disease
- Bulging Disc with Radiculopathy
- Hypercholesterolemia
- Hypertension (essential)
- Atrial Fibrillation with ablation x 6
- Brain (Pituitary) Tumor x 3
- Choledocholithiasis x 4
- Pancreatitis x 2
- Hemorrhagic cyst
- Lower GI bleeding
- Duodenal ulcer with upper GI bleeding
- Malignant Melanoma
- Total Hip Replacement x 3
- Hip Fracture with Rod and Screw
- DVT x 3
- Pulmonary Embolus
- Pilonidal Cyst
- Near Syncope
- Severe Decompression Sickness
- Elevated Intracranial Pressure

Moving from Population Health to Personalized Medicine



GINA

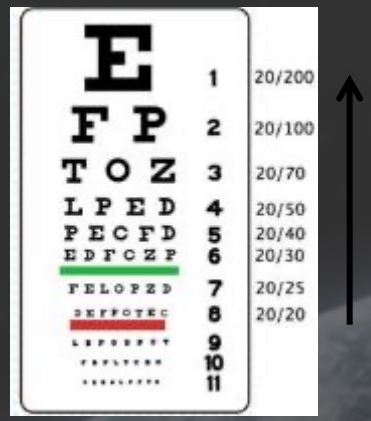


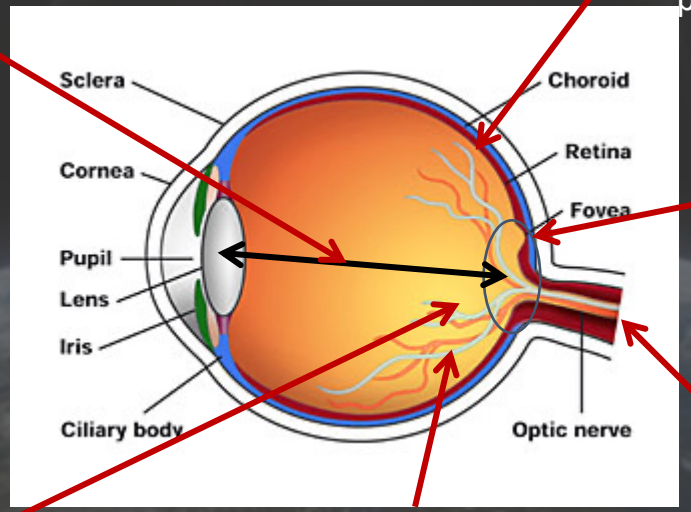
SANS/VIIP

Several known cases predominantly in long duration crew members

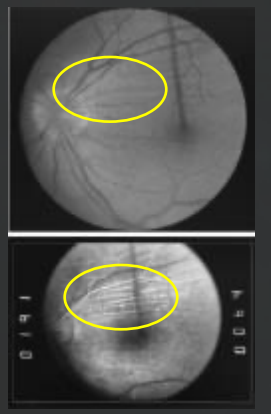
- Each with different degrees of symptoms
- Elevated measures of Intracranial Pressure (ICP) post flight
- Evaluation of shuttle fliers showed mild changes in the optic nerve diameter, even in 14 day missions.

•Hyperopic Shifts
-Up to +1.75 diopters

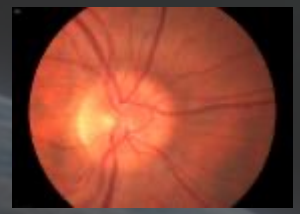




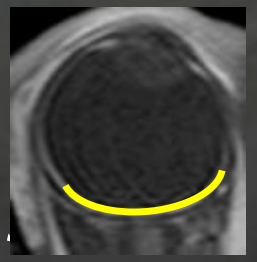
•Choroidal Folds - parallel grooves in the posterior pole



•Optic Disc Edema (swelling)



•Globe Flattening



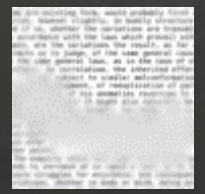
Normal Globe

Flatten Globe

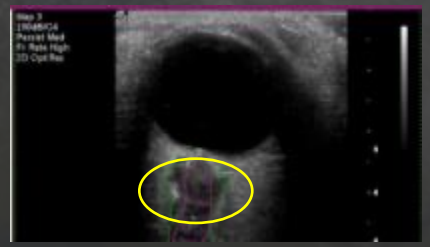
MRI Orbital Image showing globe flattening

•Altered Blood flow
•"cotton wool" spots

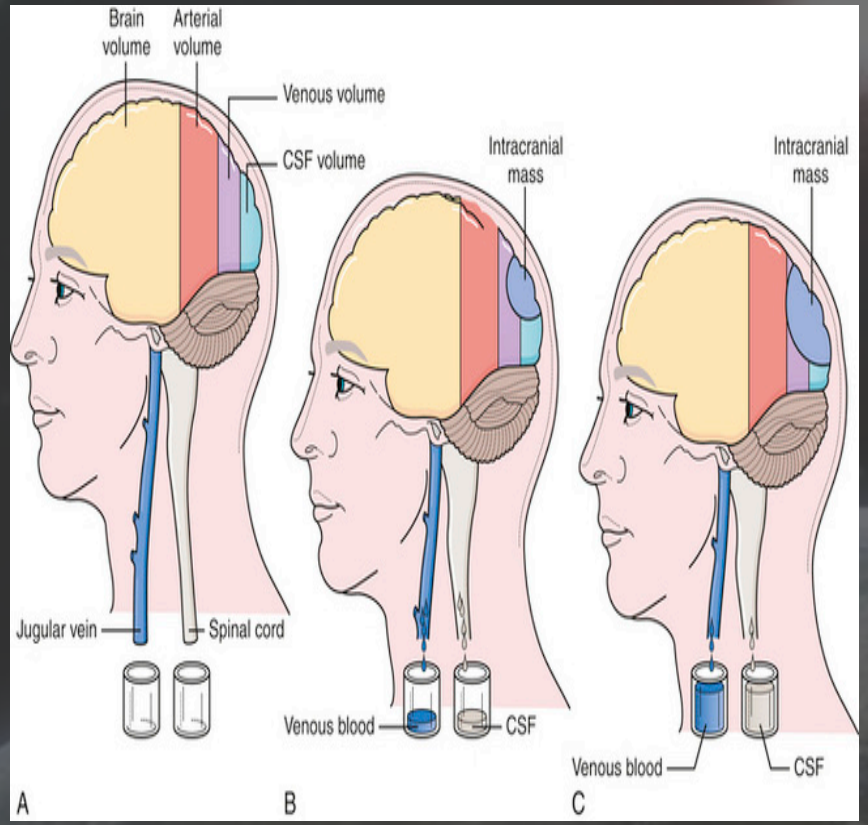
Scotoma

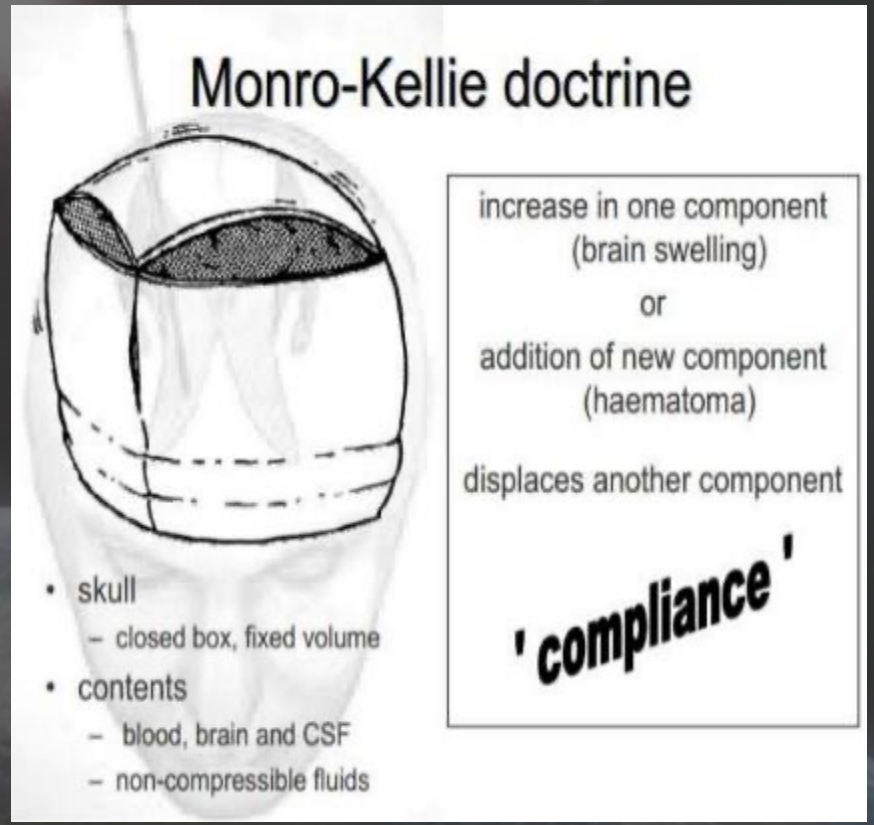


•Increased Optic Nerve Sheath Diameter



Intracranial Pressure





Skull is a rigid container. If increased fluid or pressure, something has to give.

CEREBRAL PERFUSION PRESSURE

CPP = MAP – ICP

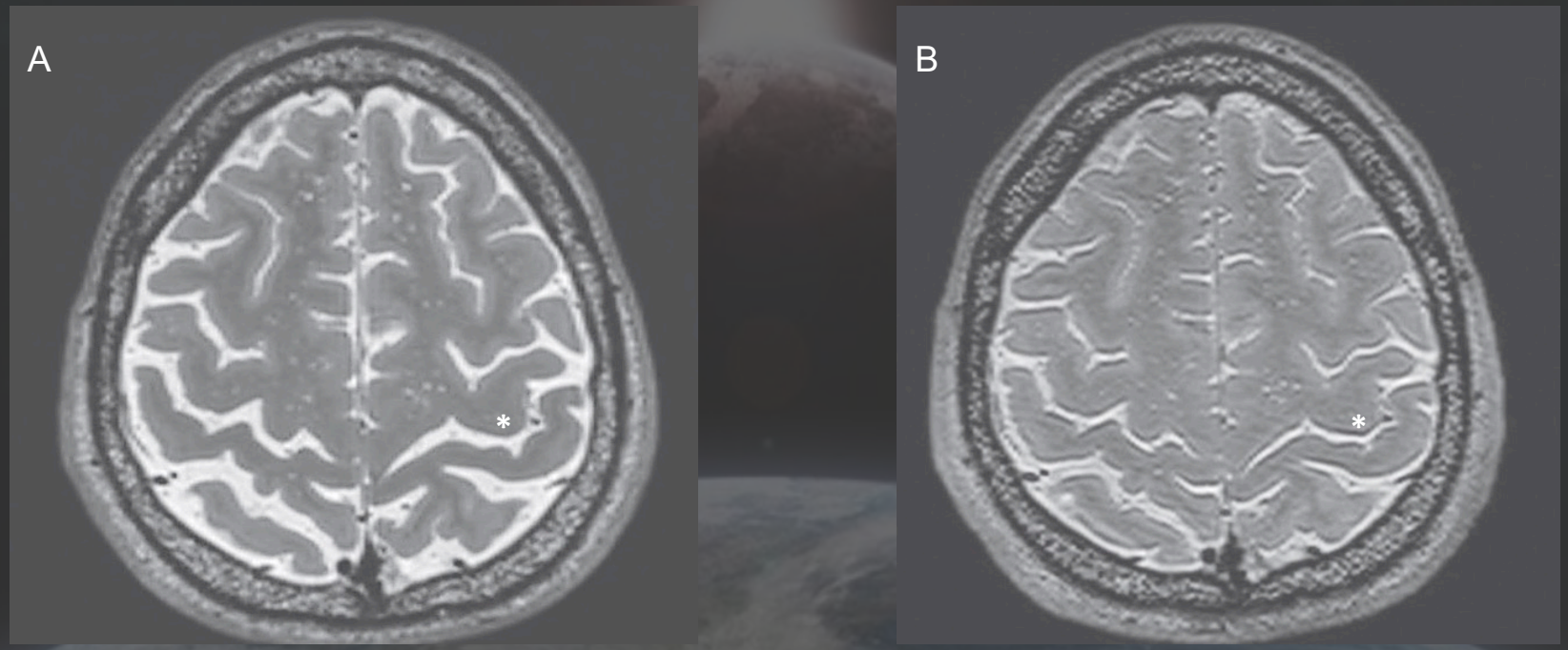
CEREBRAL PERFUSION PRESSURE = MEAN ARTERIAL PRESSURE – INTRACRANIAL PRESSURE

Why do we care?

1. Brain survival depends on cerebral blood flow meeting cerebral metabolic requirements
2. Cerebral blood flow depends on Cerebral Perfusion Pressure
3. CPP depends upon ICP

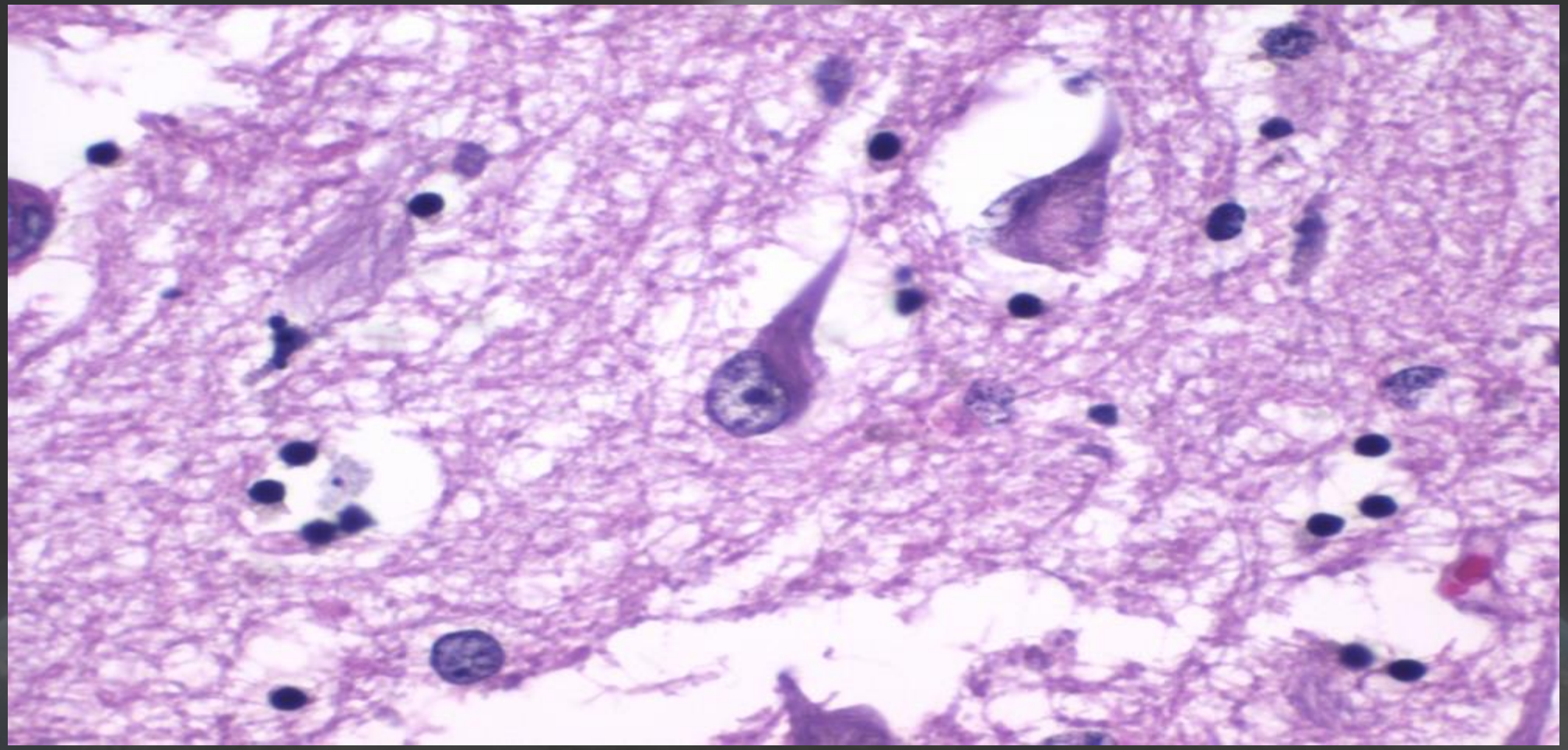
Normal CPP > 50 mmHg

Narrowing of the CSF Spaces Within the Brain Sulci

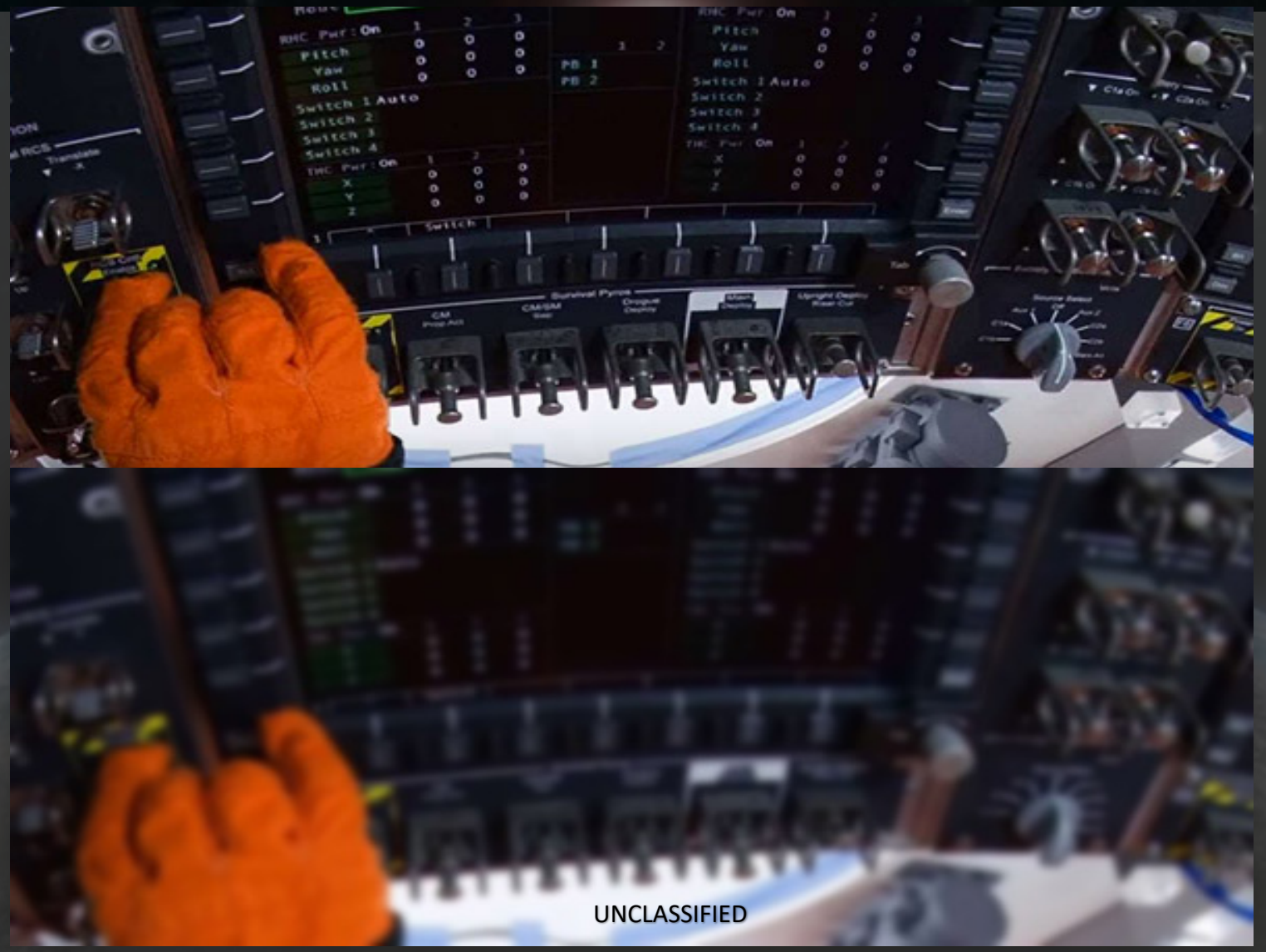


Axial T2-weighted images of the brain obtained before (Panel A) and after (Panel B) this astronaut had long-duration spaceflight on the International Space Station. The astronaut presented with optic-disk edema syndrome after spaceflight. **Crowding of the sulci can be seen at the vertex**. The gyrus*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

Edematous cells are Inefficient at Protein Removal



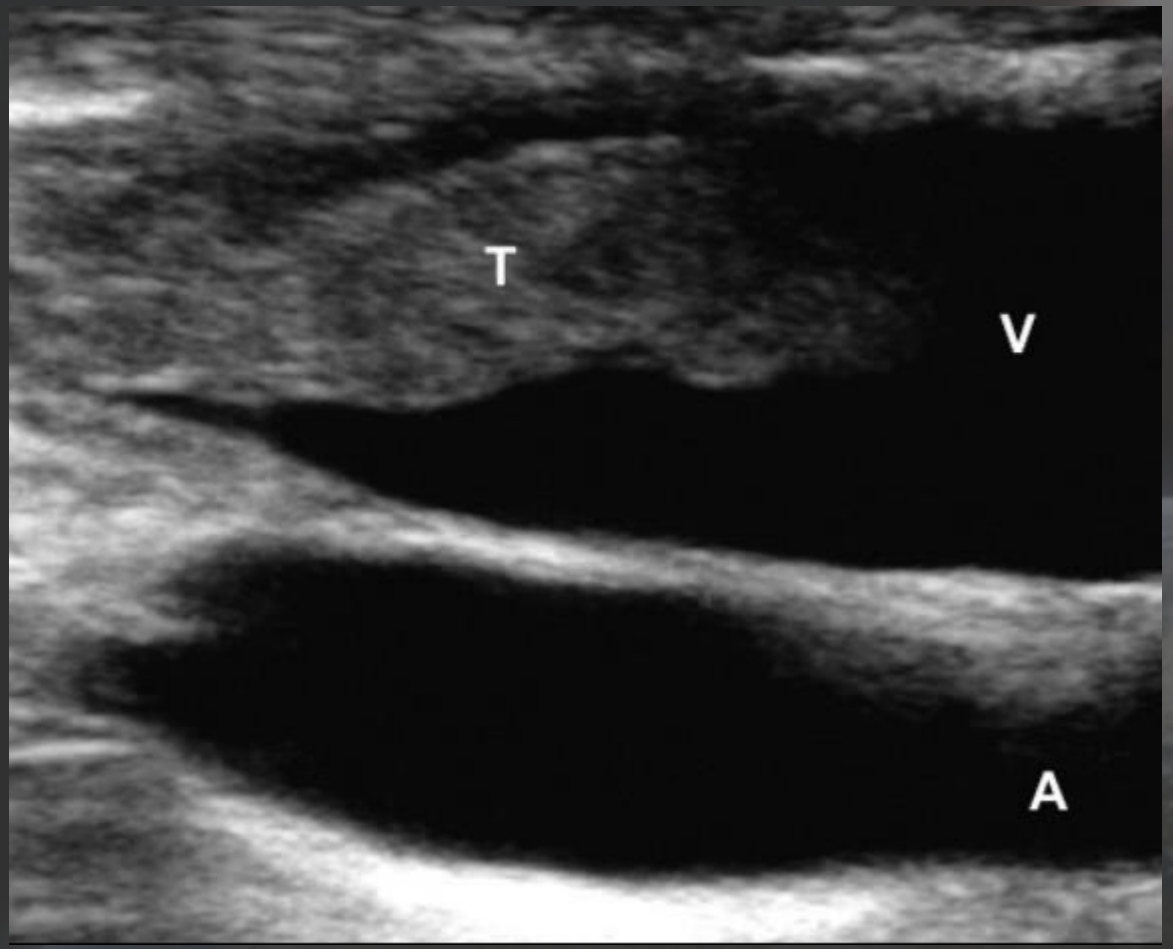
Impacts to Design



Running out of Runway

- SANS does not typically manifest vision change until 2-3 months into flight.
- We may not even see a vision change or this entity for Gateway.
- The risk is that we let our foot off the gas. But this MUST have a treatment and remediation found BEFORE ISS ends.
- This will recur for Mars transit.

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.

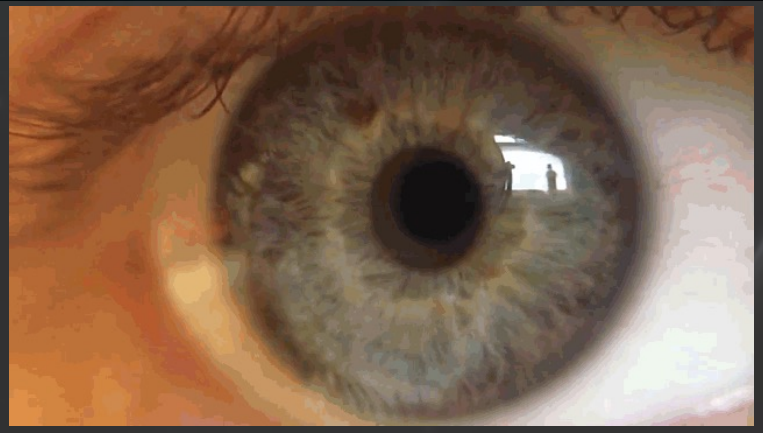
May increase intracranial hypertension or be result of venous stasis due to compression of veins from intracranial hypertension.

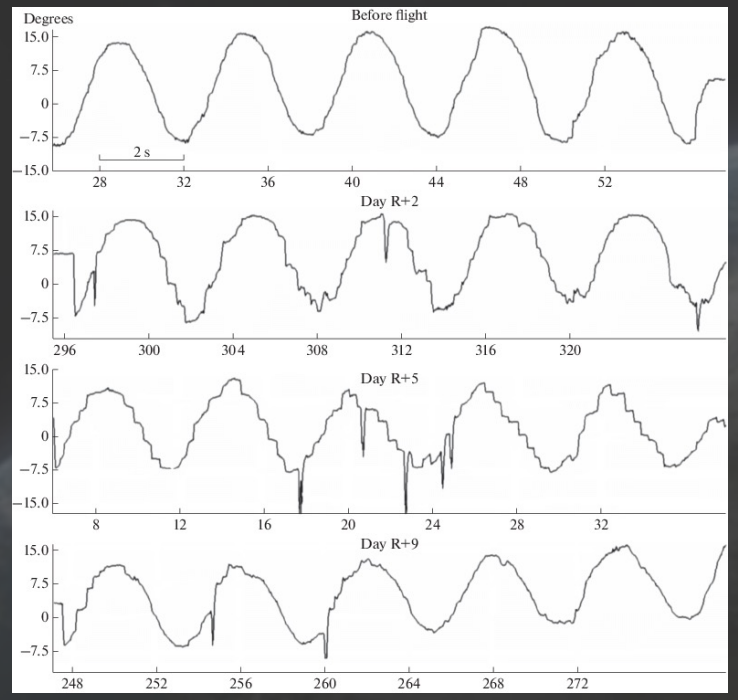
Astronauts are checked for Protein C, S and Factor V Leiden.

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

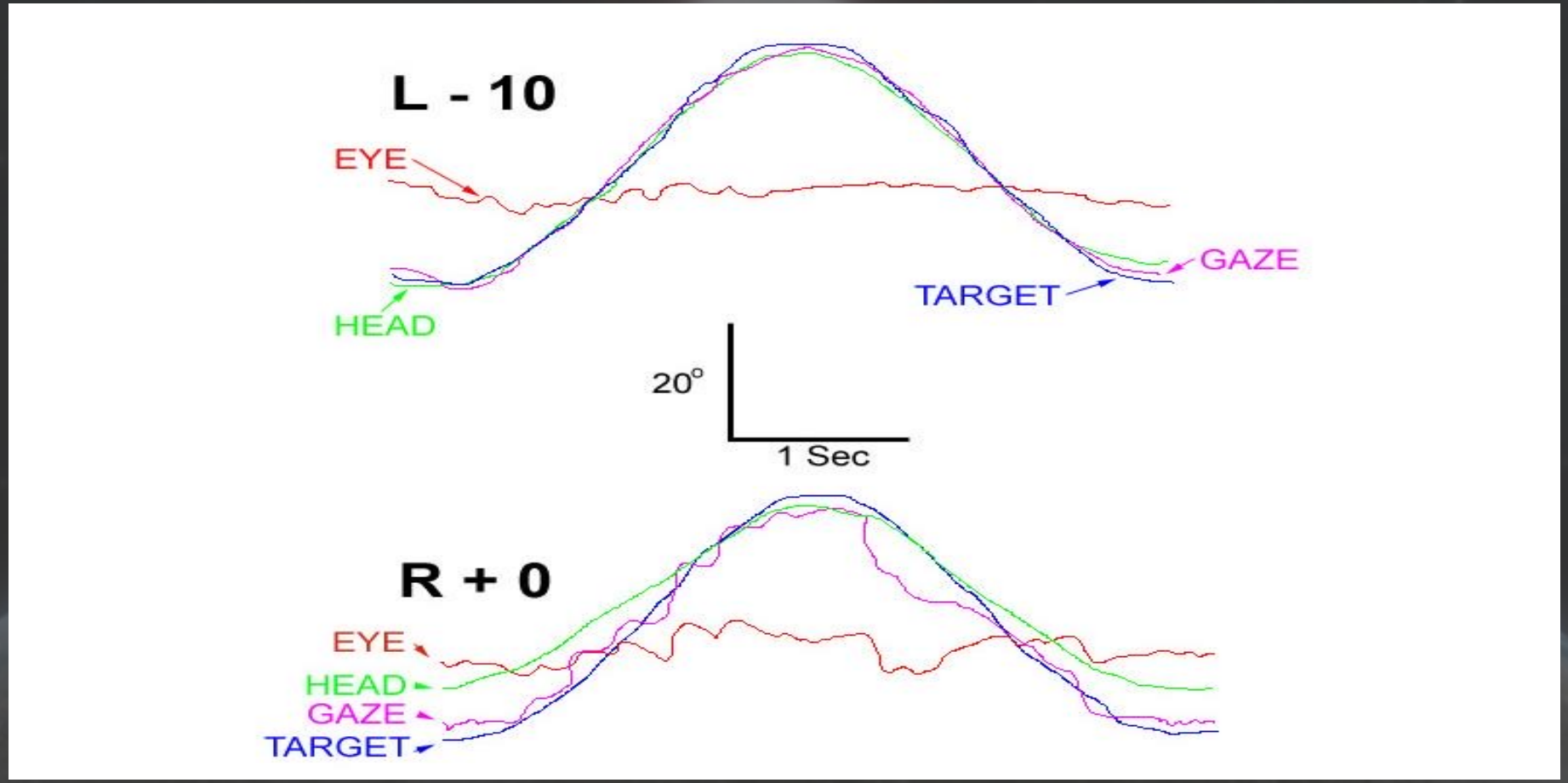
Treatment: LMWH, Lovenox (inj), Xarelto/Eliquis (oral)

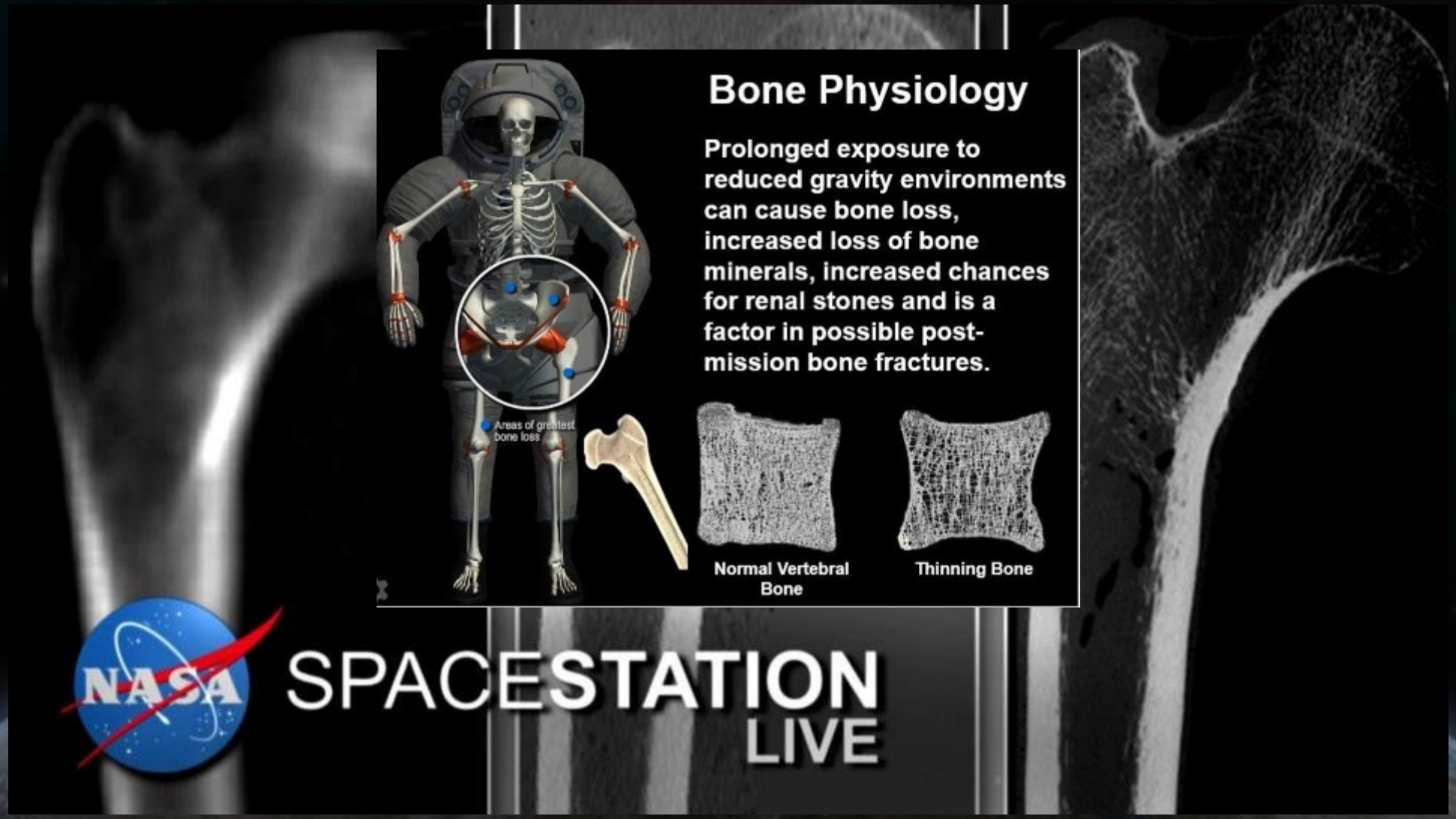
Optimizing Function





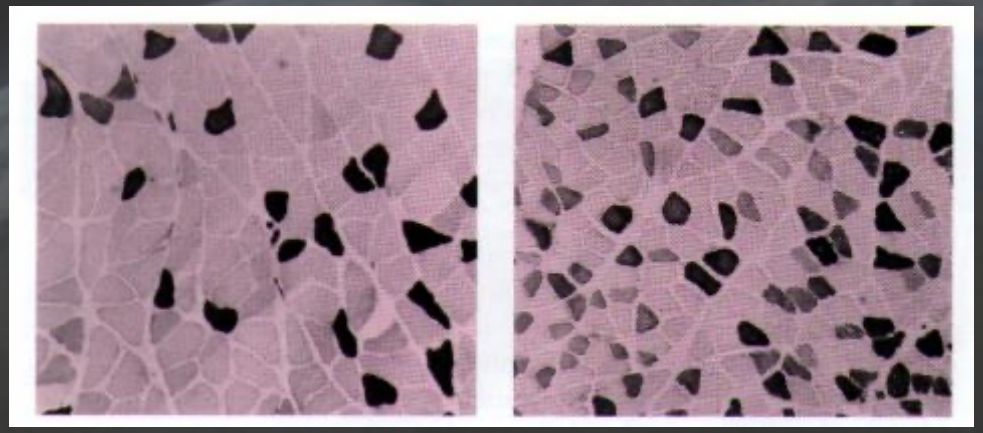
Vertical Pursuit Tracking with Head and Eye



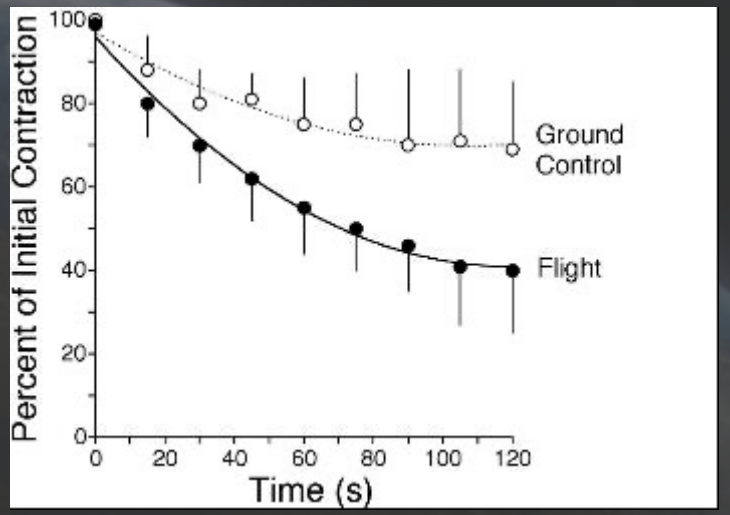

Bone Physiology
Prolonged exposure to reduced gravity environments can cause bone loss, increased loss of bone minerals, increased chances for renal stones and is a factor in possible post-mission bone fractures.
Areas of greatest bone loss
Normal Vertebral Bone
Thinning Bone
SPACESTATION LIVE

Maintaining Strength

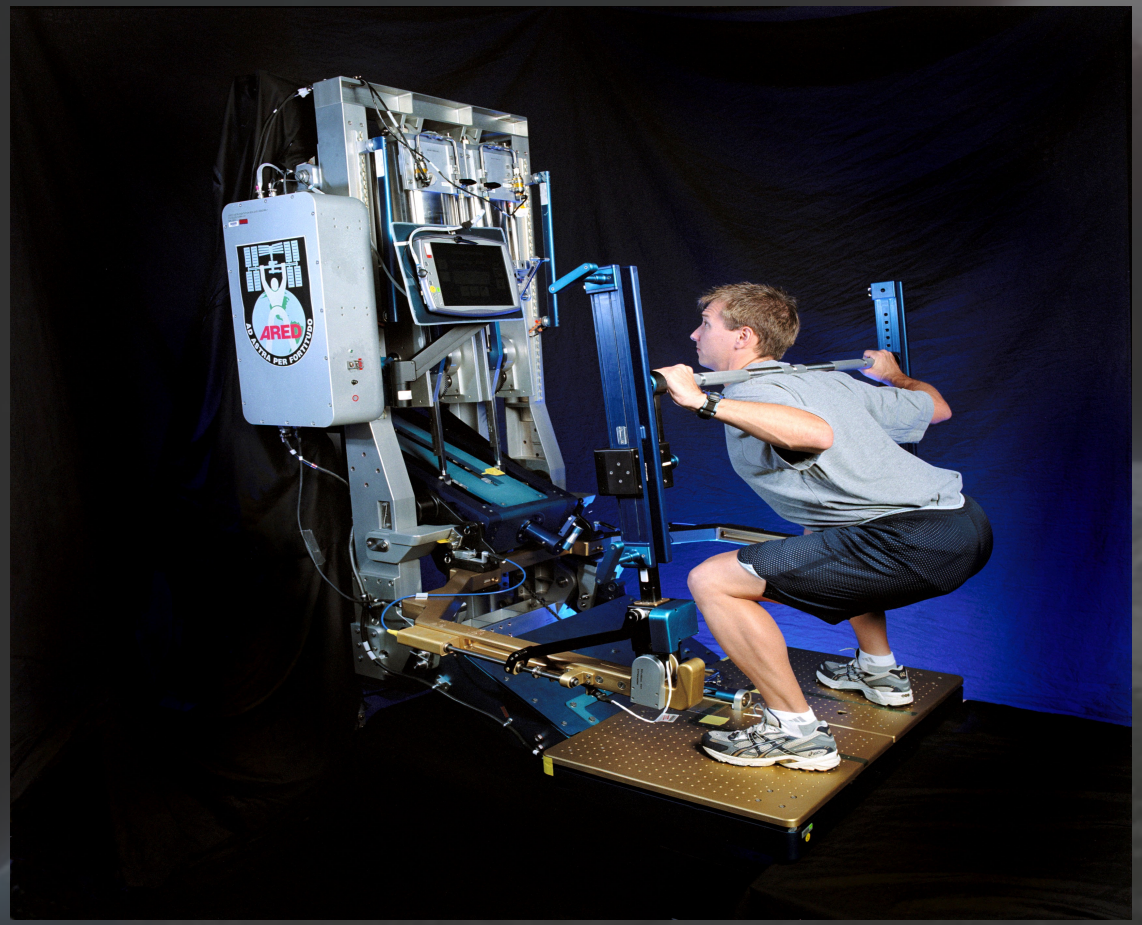
- **<u>Will not have the mass and volume of the ISS for exercise equipment</u>**
- Decrease in **body mass**
- Decrease in **leg volume**
- Atrophy of the **antigravity** muscles (thigh, calf)
  - Decrease in leg strength
  - **Extensor** muscles more affected than flexor muscles
- Increase in number of **Type II**, “fast twitch” muscle fibers (those which are useful for quick body movements but more prone to fatigue)



Ground control Flight



Countermeasures



Para-Astronaut

Risks For Spaceflight

Osteopenia, high blood pressure, phantom pain,

Shrinking of extremity (poor fit of prosthetic)

Skin breakdown, Cleaning of prosthetic

Material cert for 100% oxygen in the suit

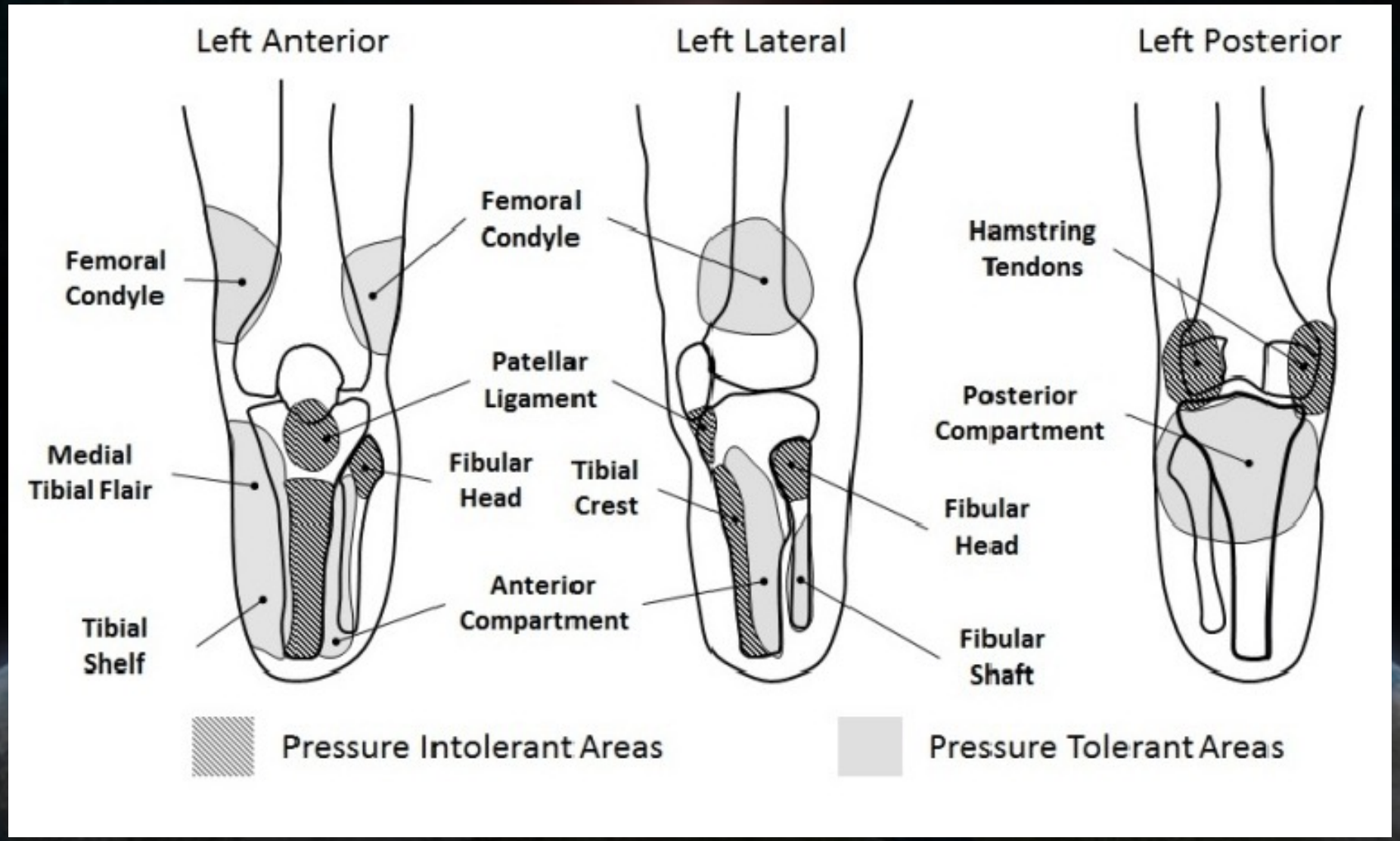
Exercise


Unity

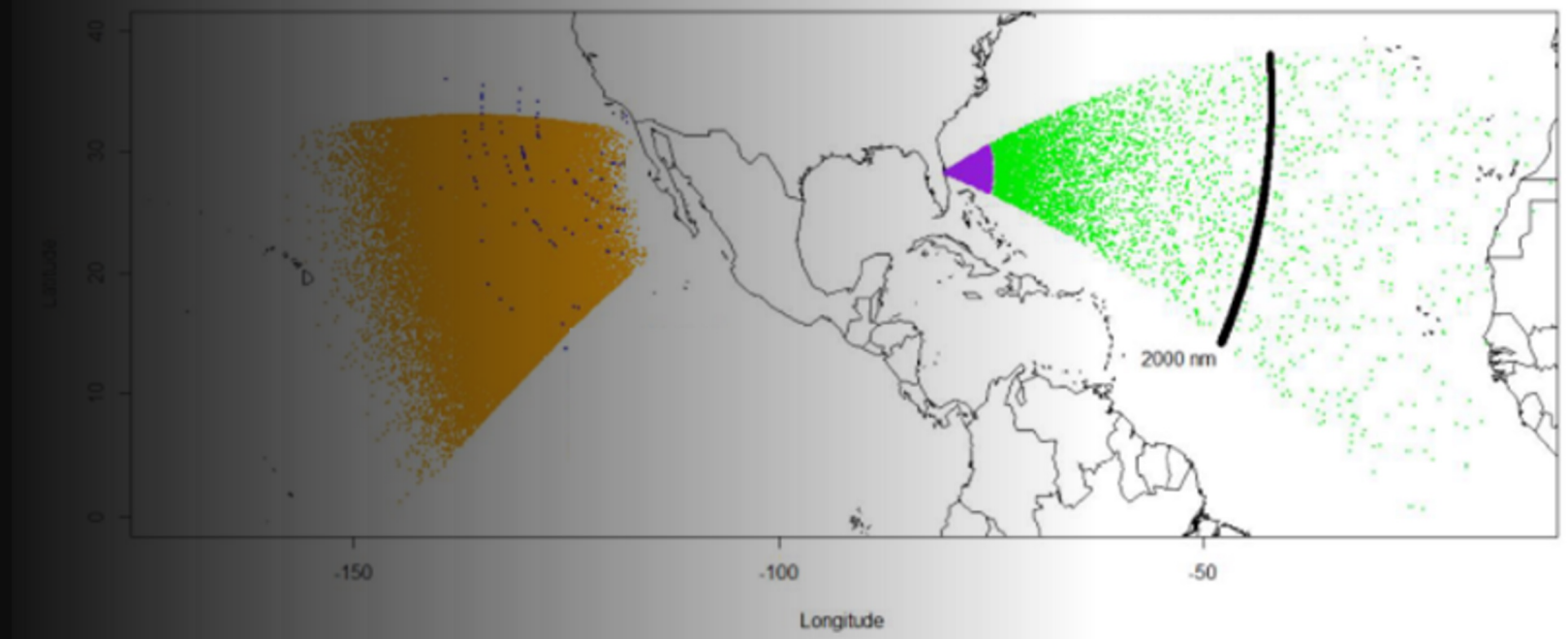

ICEROSS•COMFORT
LINERS
ÖSSUR
619


CROSSFIT


InTek
25
25

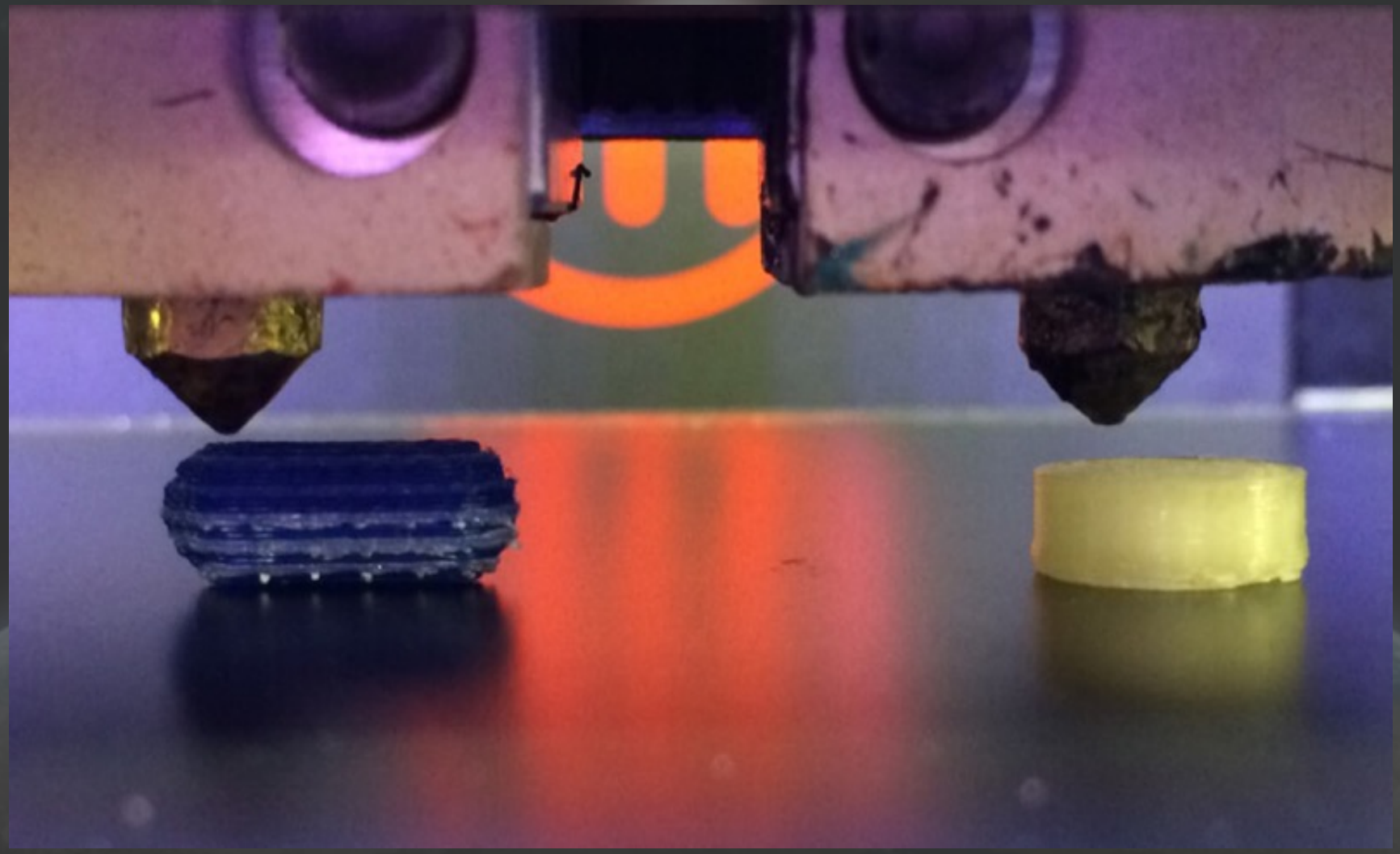

Left Anterior
Left Lateral
Left Posterior
Femoral Condyle
Femoral Condyle
Patellar Ligament
Medial Tibial Flair
Fibular Head
Tibial Crest
Tibial Shelf
Anterior Compartment
Hamstring Tendons
Posterior Compartment
Fibular Head
Fibular Shaft
Pressure Intolerant Areas
Pressure Tolerant Areas

Contingency Preparation



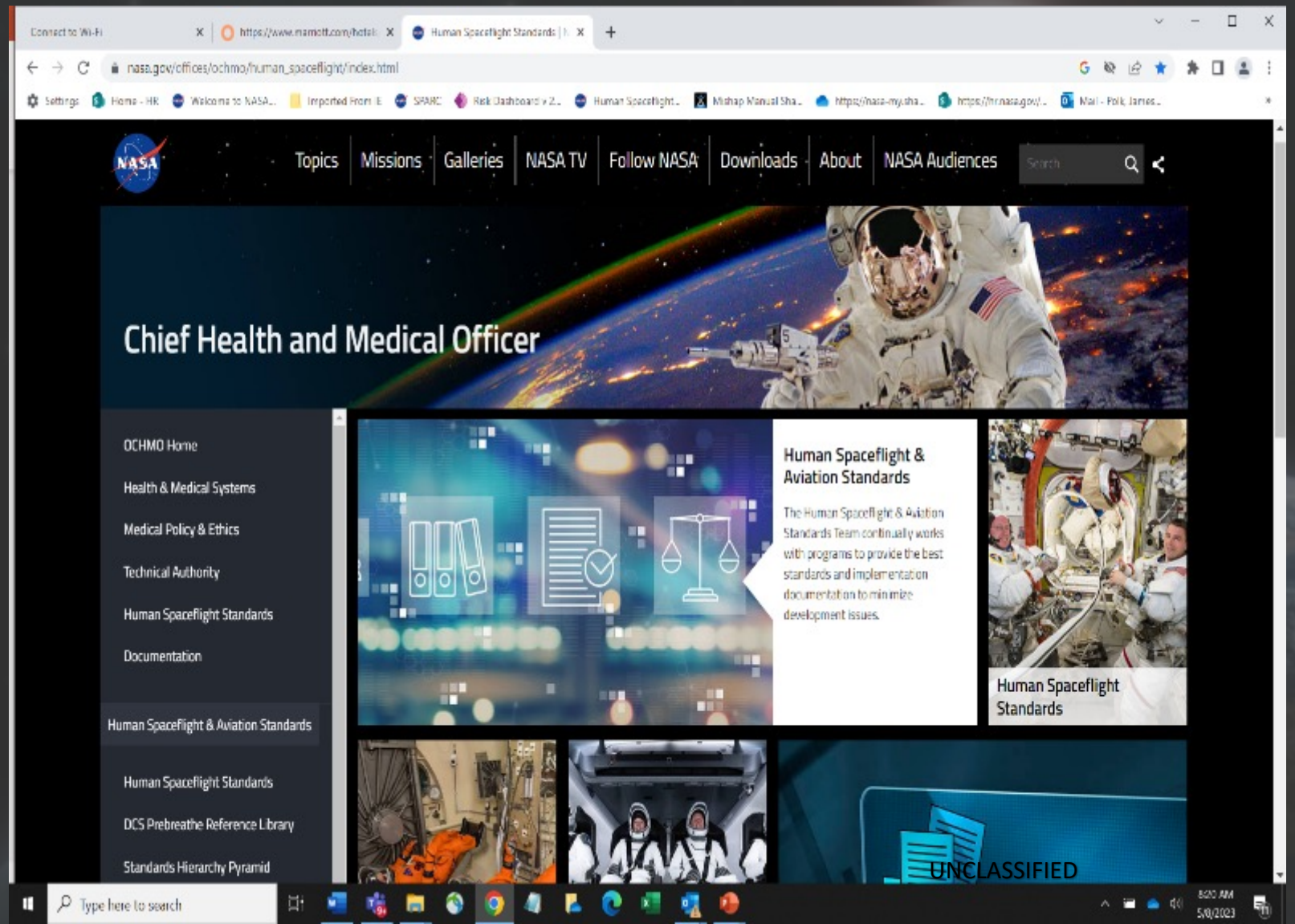
Deep Dive into Apollo

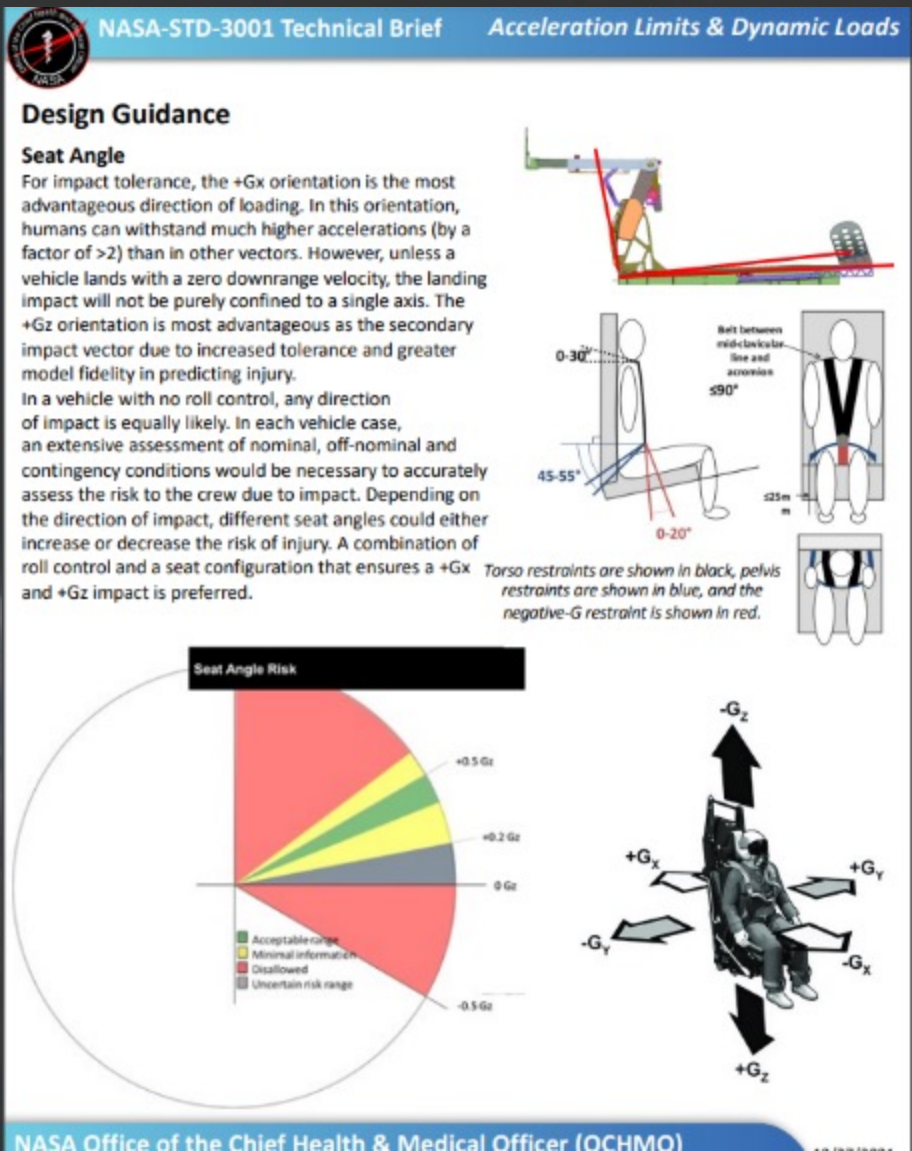
Forward Technologies



Training

Transparency and Educating Commercial and Private on NASA's Lessons Learned





Questions

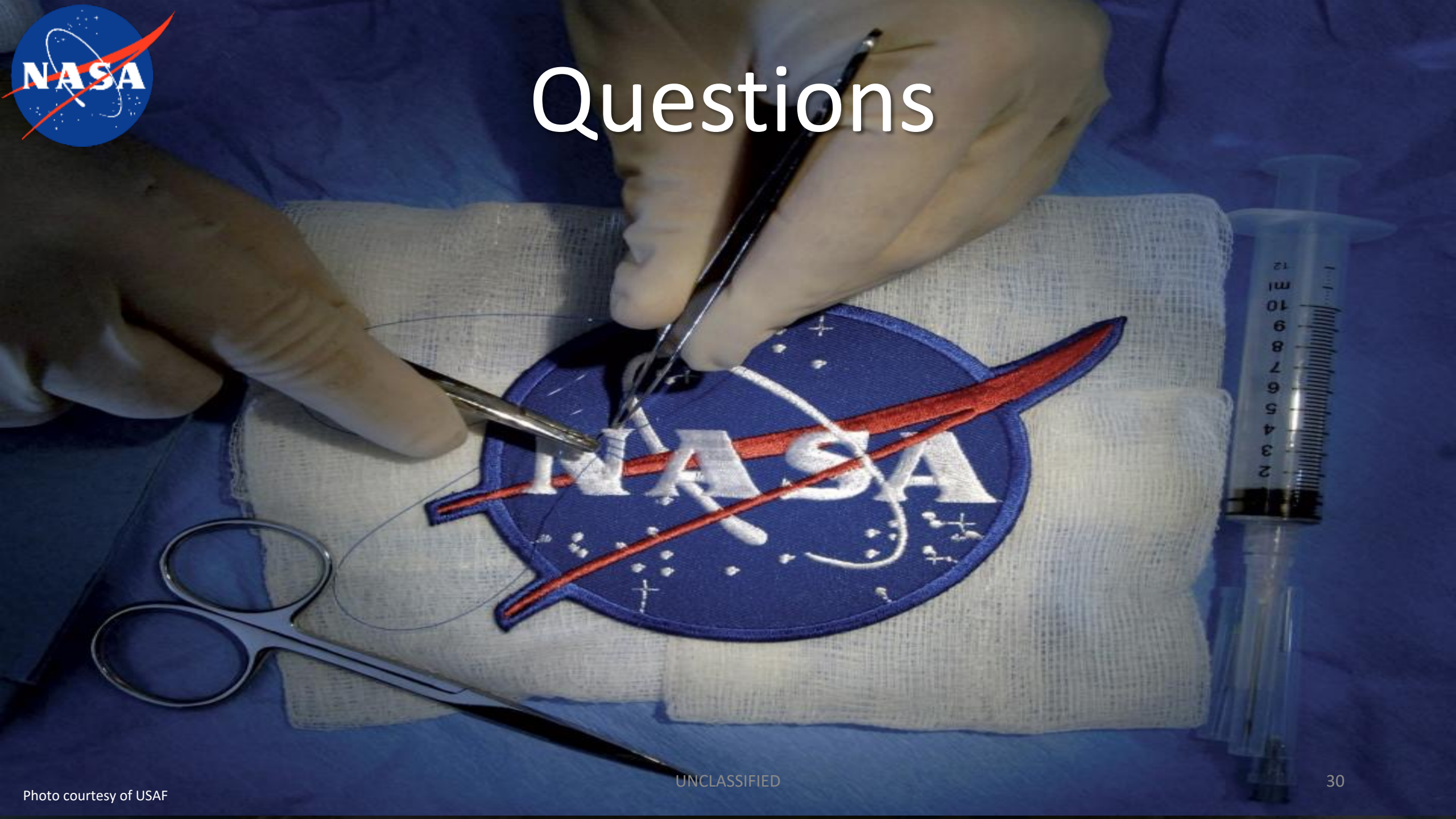


Photo courtesy of USAF

Back Up

Relevant Case Studies (Pilots)

Air Force Capt. Ryan McGuire

- First amputee to ever complete Air Force pilot training
- Injury in Sept. 2009, graduated from training in May 2011, in between he competed in the inaugural Warrior Games and completed the Air Force Marathon.
- Awards and Recognitions
  - 2010 - Air Education and Training Command Male Athlete of the Year title for 2010
  - May 2011 - Daedalian Award of graduating class 11-09
  - October 2011 - finished C-17 Globemaster III qualification training

Air Force Maj. Christy Wise

- 6th pilot and first female to return to flight with the most recently deployment to Iraq in 2019
- Returned to flight in 2016 following 8 months of rehabilitation and recertifications after losing her right leg above the knee
  - Had to pass same physical fitness tests, flight checks, and emergency procedure drills that all other pilots undergo, including proving she "can get out of the aircraft quickly on the ground if there's a fire or something"

Relevant Case Studies cont. (Paratroopers)

Sgt. First Class Dana Bowman

- Lost both legs (one above the knee, one below) in a skydiving accident in February 1994 during the annual Golden Knights Training Exercise
- 9 months later, became the first double amputee to re-enlist, parachuting into his commissioning ceremony with his commander
- Recently received a 2019 Distinguished Service Award from the Military Officers Association of America

Lt. Joshua Pitcher

- Lost left leg below the knee in combat in April 2012
- Received his prosthetic in July and began walking on it in just 1 week, then ran the Army 10-miler on it in October with a 50 lbs. backpack
- Completed his qualifying fitness test in January 2013 and passed in the top 10% of all active duty soldiers
- In June 2013, became first amputee from the 82nd to requalify as an Airborne paratrooper perfectly sticking the landing of an 800 ft. Jump and began leading a troop of 21 paratroopers in Afghanistan

Relevant Case Studies cont.

Army Capt. Daniel Luckett

- Double amputee who returned to Afghanistan in 2010, 2 years after his injury, following an interim 8-month rehabilitation
- Upon returning to active duty, took four new custom-made sockets and three different legs on deployment
- Following his injury Captain Luckett attained the Expert Infantryman's Badge
  - Required 12-mile run in under three hours with a 35-pound backpack (overall success rate 20-50%)

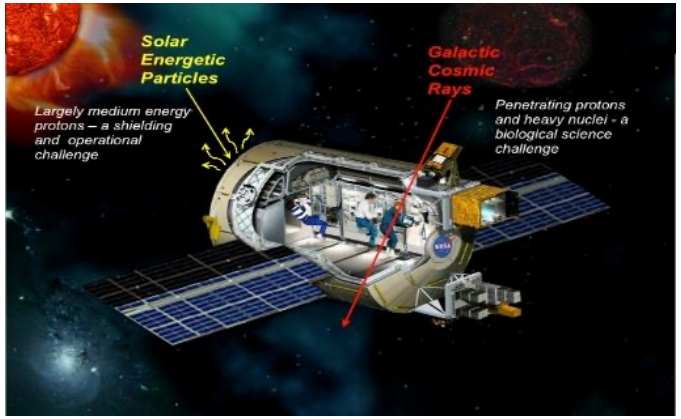
Sgt. Zachary Foster

- Congenital amputee who joined the California State Military Reserve (Army Reserve) at Joint Forces Training Base, Los Alamitos
- Required personal approval from the California State Military Reserve Commander

Mars Primary Space Radiation Mitigations

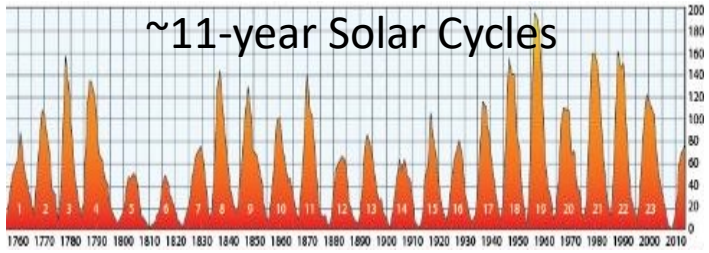
Optimized Spacecraft Shielding/Storm Shelters Can Protect Crew Against Solar Particle Events (SPEs)

- 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.