Thursday, 28 October 2021
Department of Family Medicine

A Primer in Space Medicine

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Faculty, Institute for Earth and Space Exploration, Western University

Planning Committee Members

Dr. Stephen Wetmore

Dr. Scott McKay

Dr. Richard Pawliszyn

Sheena Blasing, Program Coordinator

Program Learning Objectives

1. To transmit pertinent and relevant clinical practice knowledge and guidelines to primary care physicians including a forum for discussion and critical appraisal;
2. Identify and discuss current evidence supporting treatment of common conditions in primary care; and
3. Discuss challenges family medicine physicians face in their current practices.

Disclosure of Financial Support

- This program has received no financial support from any organization or sponsor.
- This program has received no in-kind support from any organization or sponsor.

Mitigating Potential Bias

- **Presenters received a detailed letter from the Organizing Committee outlining the learning objectives and content expectations for each presentation.**
- ***Conflict of Interest*** **disclosure forms have been completed by all presenters and reviewed by the Organizing Committee.**

Mitigating Potential Bias

- Presentations have been reviewed by a member of the Organizing Committee to ensure balance in content and the absence of bias.

Faculty/Presenter Disclosure

- **Planning Committee Member: Dr. Scott McKay**
  - **Financial compensation:**
    - **London Health Sciences Centre**
      - **Stipend for Medical Advisory Committee Chair & Associate Chief of Family Medicine**
      - **Associate Chief of Family Medicine**
    - **Western University, Department of Family Medicine**
      - **Stipend for Undergraduate Education Director**

Faculty/Presenter Disclosure

Presenter: Dr. Adam Sirek

- **Financial compensation**
    - **Director, Leap Biosystems Inc.**

Outline

1. What is Aerospace Medicine?
2. Space Missions & Architecture
3. Human Health Hazards of Spaceflight
4. You’re the Flight Surgeon

Learning Objectives

1. Identify the differences between traditional terrestrial medicine and aerospace medicine environments
2. Identify the five hazards to human spaceflight
3. Relate space medicine to corollary terrestrial environments

What is Aerospace Medicine?

Traditional Aerospace Medicine Paradigms

Medical Discipline	Physiology	Environment
Traditional Medicine	Abnormal	Normal
Aerospace Medicine	Normal/Abnormal	Abnormal

Modern Commercial Aerospace Medicine Paradigms

Medical Discipline	Physiology	Environment
Aerospace Medicine	Abnormal ⟷	Abnormal

Space Missions

MISSION DURATION

ISS/LEO

Duration: 3-6 mo

Crew: 3-6

Transit Time: 6 hrs - 2 d

Communication Delay: 0.001 sec

Distance from Earth: 408 Km

CIS-LUNAR

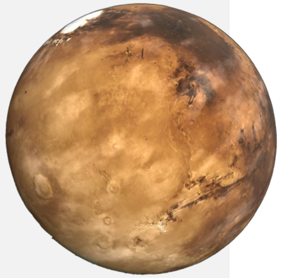
Duration: 3 mo

Crew: 4-6

Transit Time: 3 d

Communication Delay: 1.25 sec

Distance from Earth: 384,400 Km



DEEP SPACE

Duration: 3 yrs

Crew: 4-6

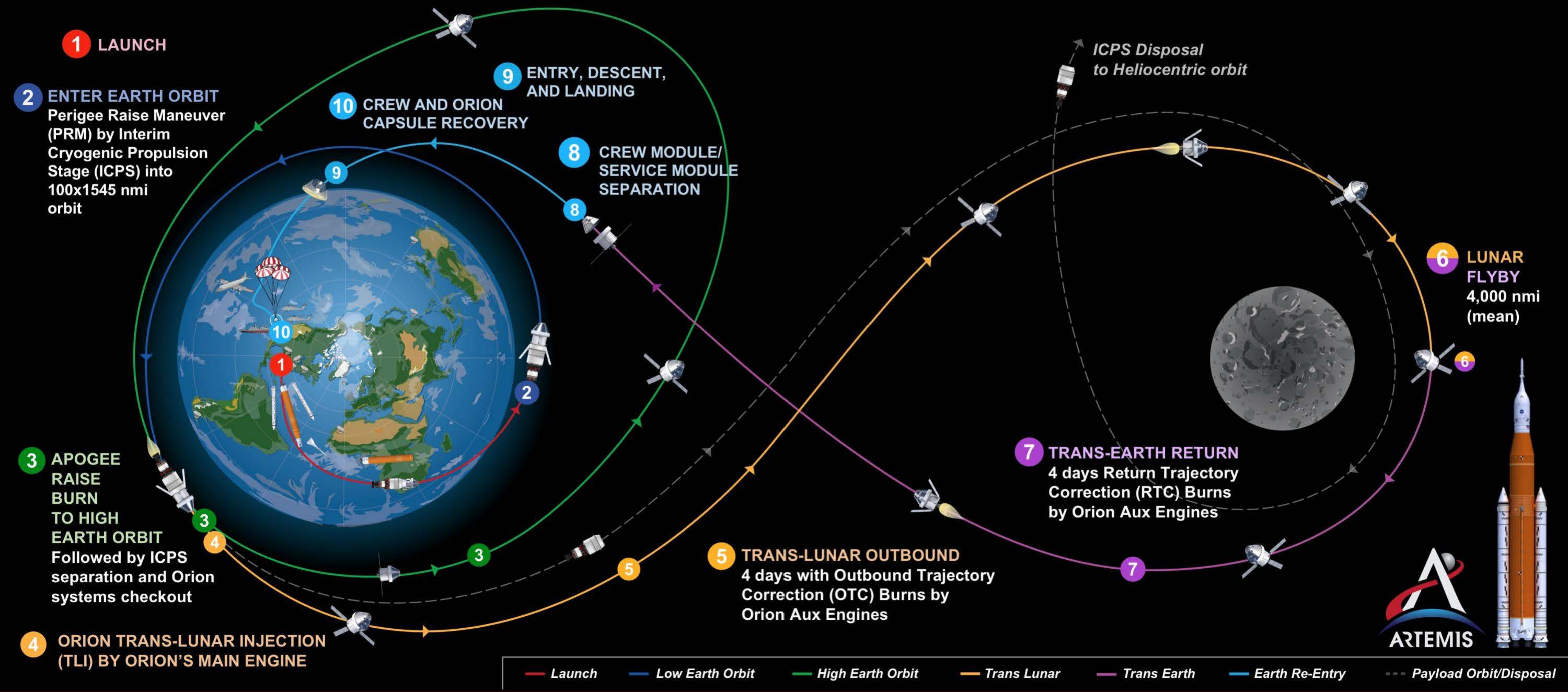
Transit Time: 150-300 d

Communication Delay: 14 min

Distance from Earth: 54.6M Km

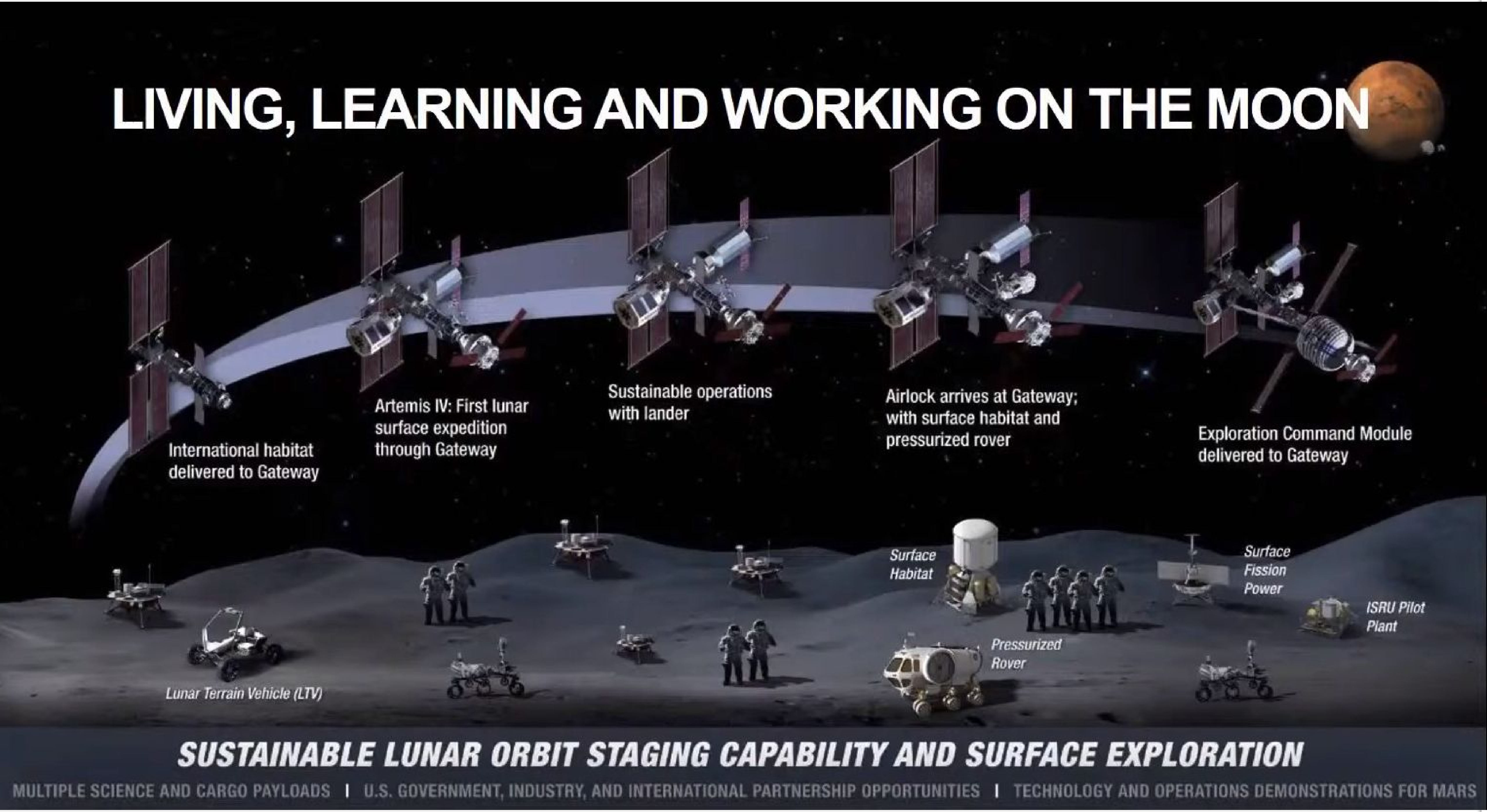
ARTEMIS II

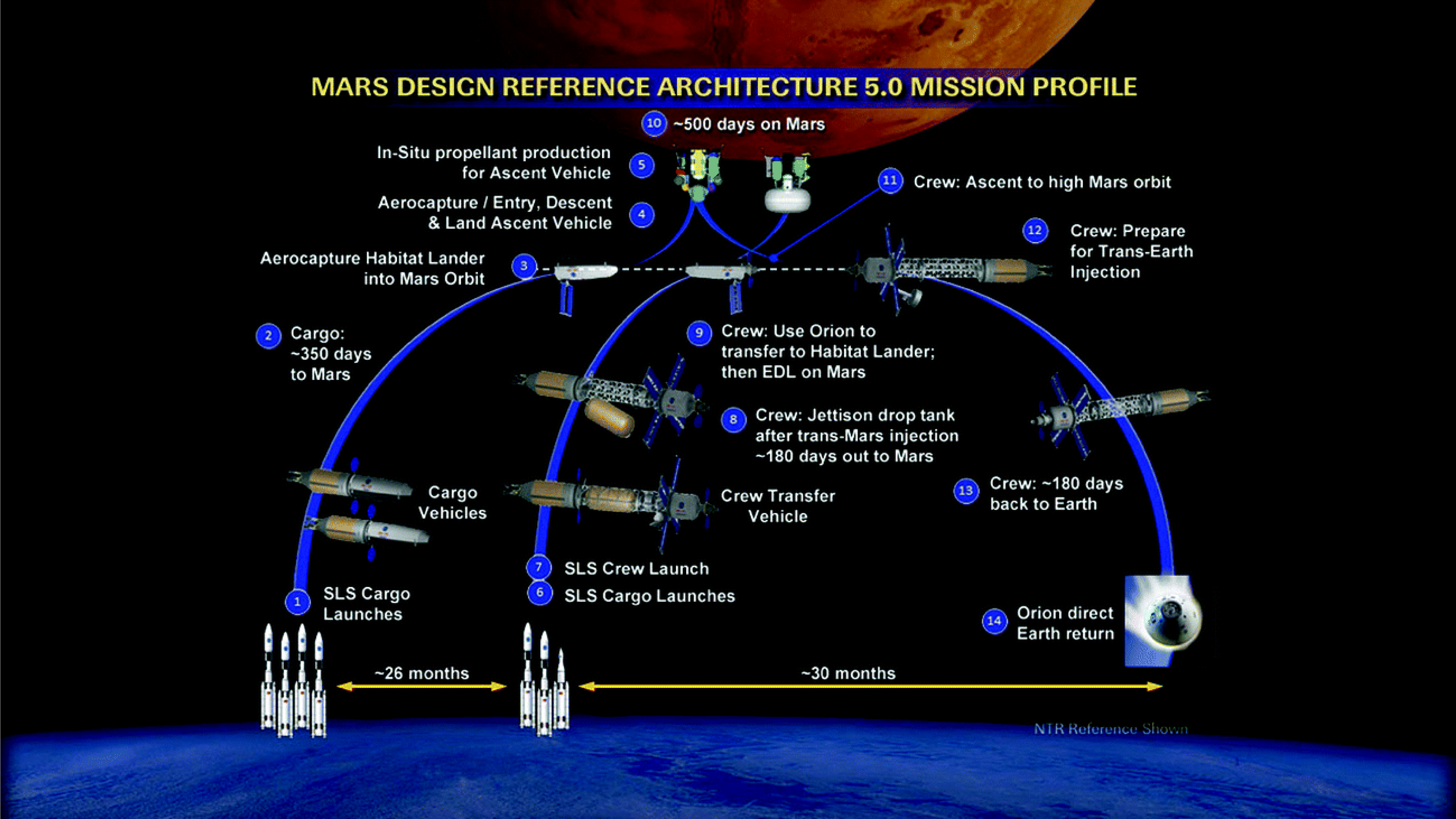
Crewed Hybrid Free Return Trajectory, demonstrating crewed flight and spacecraft systems performance beyond Low Earth Orbit (LEO)



SLS Configuration (Block 1) with Human Rated ICPS | 15x1200 nmi (27.8x2222.4 km) insertion orbit | 28.5 deg inclination

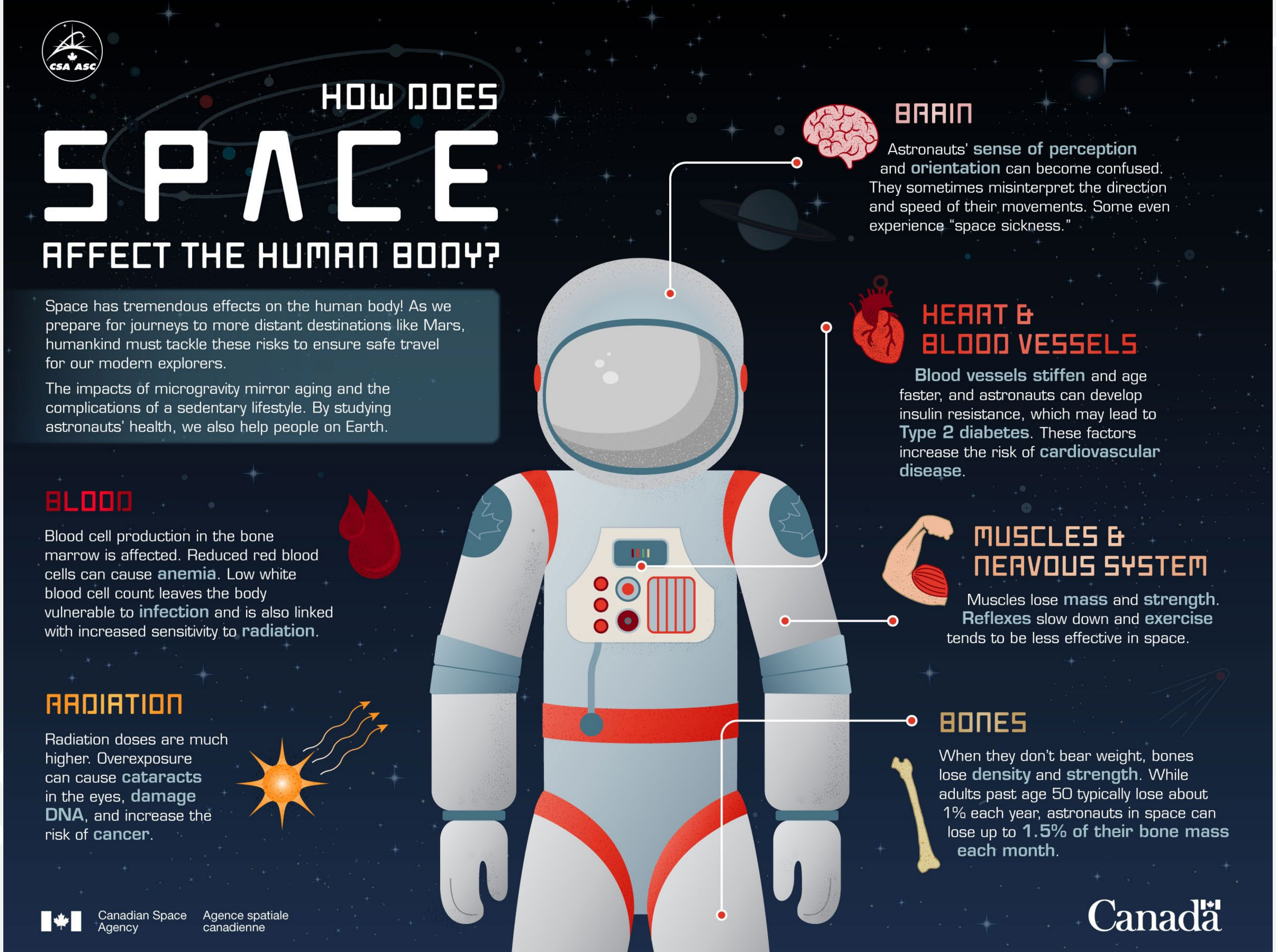
4 astronauts | Mission duration: 10 Days | Re-entry speed: 24,500 mph (Mach 32)


LIVING, LEARNING AND WORKING ON THE MOON
International habitat delivered to Gateway
Artemis IV: First lunar surface expedition through Gateway
Sustainable operations with lander
Airlock arrives at Gateway; with surface habitat and pressurized rover
Exploration Command Module delivered to Gateway
Surface Habitat
Surface Fission Power
ISRU Pilot Plant
Pressurized Rover
Lunar Terrain Vehicle (LTV)
SUSTAINABLE LUNAR ORBIT STAGING CAPABILITY AND SURFACE EXPLORATION
MULTIPLE SCIENCE AND CARGO PAYLOADS | U.S. GOVERNMENT, INDUSTRY, AND INTERNATIONAL PARTNERSHIP OPPORTUNITIES | TECHNOLOGY AND OPERATIONS DEMONSTRATIONS FOR MARS



MARS DESIGN REFERENCE ARCHITECTURE 5.0 MISSION PROFILE
10 ~500 days on Mars
5 In-Situ propellant production for Ascent Vehicle
4 Aerocapture / Entry, Descent & Land Ascent Vehicle
3 Aerocapture Habitat Lander into Mars Orbit
11 Crew: Ascent to high Mars orbit
12 Crew: Prepare for Trans-Earth Injection
2 Cargo: ~350 days to Mars
9 Crew: Use Orion to transfer to Habitat Lander; then EDL on Mars
8 Crew: Jettison drop tank after trans-Mars injection ~180 days out to Mars
Cargo Vehicles
Crew Transfer Vehicle
13 Crew: ~180 days back to Earth
7 SLS Crew Launch
6 SLS Cargo Launches
1 SLS Cargo Launches
14 Orion direct Earth return
~26 months
~30 months
NTR Reference Shown

Human Health Hazards in Spaceflight


CSA ASC
HOW DOES
SPACE
AFFECT THE HUMAN BODY?
Space has tremendous effects on the human body! As we prepare for journeys to more distant destinations like Mars, humankind must tackle these risks to ensure safe travel for our modern explorers.
The impacts of microgravity mirror aging and the complications of a sedentary lifestyle. By studying astronauts' health, we also help people on Earth.
BLOOD
Blood cell production in the bone marrow is affected. Reduced red blood cells can cause anemia. Low white blood cell count leaves the body vulnerable to infection and is also linked with increased sensitivity to radiation.
RADIATION
Radiation doses are much higher. Overexposure can cause cataracts in the eyes, damage DNA, and increase the risk of cancer.
BRAIN
Astronauts' sense of perception and orientation can become confused. They sometimes misinterpret the direction and speed of their movements. Some even experience "space sickness."
HEART & BLOOD VESSELS
Blood vessels stiffen and age faster, and astronauts can develop insulin resistance, which may lead to Type 2 diabetes. These factors increase the risk of cardiovascular disease.
MUSCLES & NERVOUS SYSTEM
Muscles lose mass and strength. Reflexes slow down and exercise tends to be less effective in space.
BONES
When they don't bear weight, bones lose density and strength. While adults past age 50 typically lose about 1% each year, astronauts in space can lose up to 1.5% of their bone mass each month.
Canadian Space Agency
Agence spatiale canadienne
Canada

5 Hazards of Human Spaceflight


Radiation


Isolation


Distance from Earth


Gravity Fields


Hostile Closed Environments

Radiation

Origin	Particle or wave type	Energy range	Comments
Solar Particles/continually streaming solar wind	Protons Electrons	100 eV - 3.5 KeV	Moderate flux, low energy; effectively shielded by minimal structure
Solar particle events (solar flares, CME)	Protons Electrons	100 eV - 3.5 KeV	Large flux, high energies; potentially very dangerous to crew
Solar wave radiation	Xray Gamma Ray	KeV range MeV range	Energy varies inversely with wavelength
Geomagnetically trapped particles	Protons Electrons	600 MeV 5-7 MeV	Flux increases with altitude and inclination for LEO
Galactic cosmic rays (GCR)	98% Baryons (mass > proton) --Proton 85% --Alpha particle 14% --Heavy nuclei 2% electrons	Wide range of energies dependent on mass up to 10 GeV	Smaller flux, larger energy; isotropic distribution, significant source of IR to crew
Secondaries for particle collision with structure	Neutrons	1 – several 10s MeV	Short lived, 11-min half-life; deep-tissue penetration

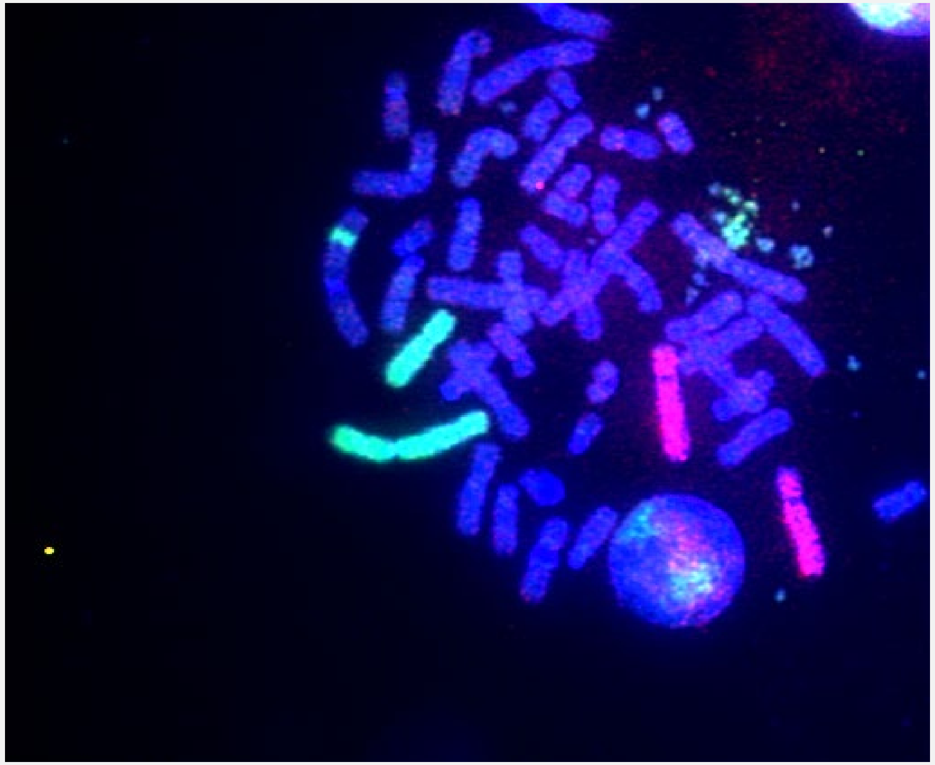
Ionizing

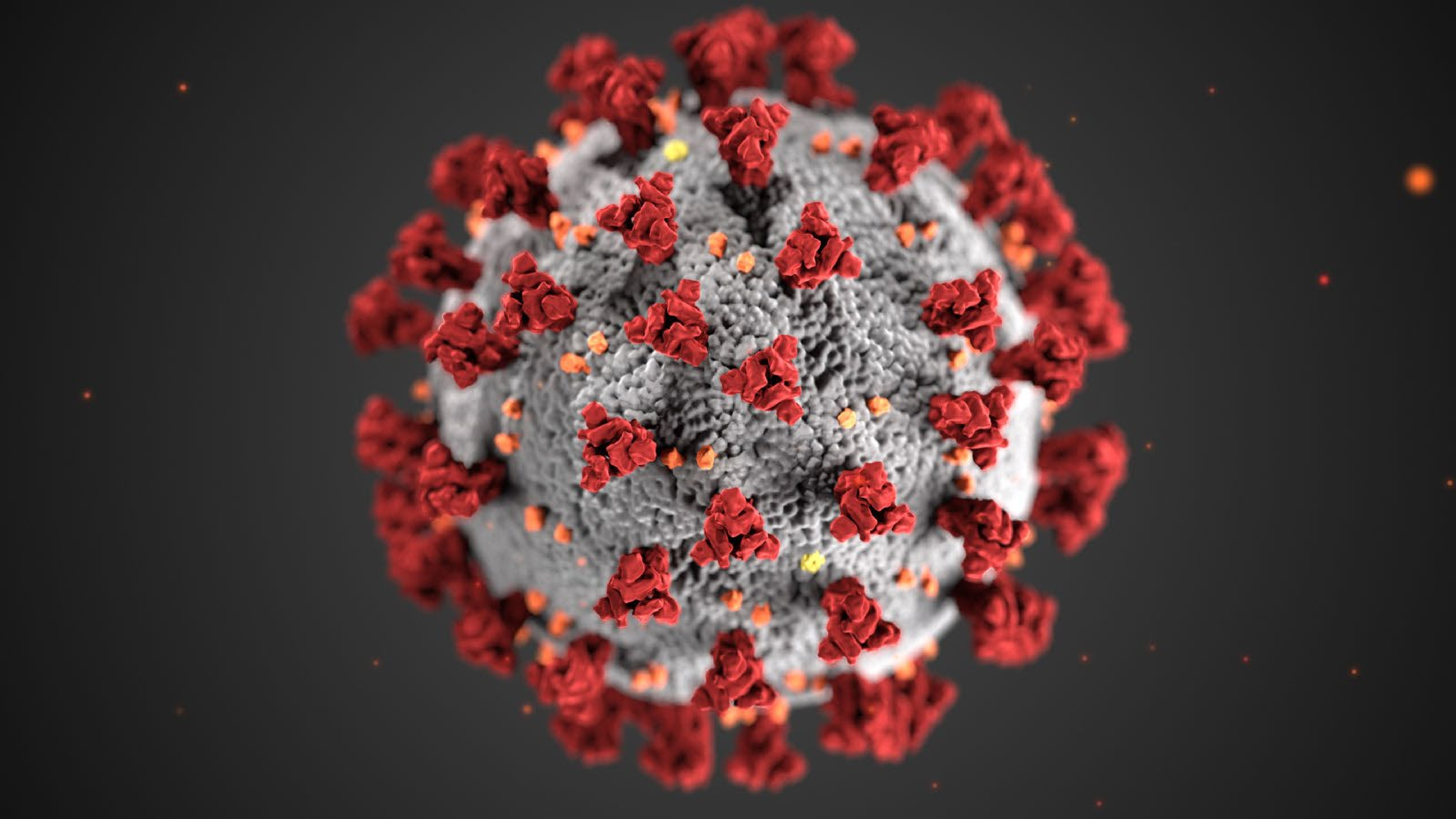
Radiation

Dose Limit (Sv)

Age (years)	Female	Male
25	0.4	0.7
35	0.6	1.0
35	0.9	1.5
55	1.7	3.0

- Daily ISS dose rates range from 0.4 - 0.6 mSv (80% GCR)
- A 6-month tour on ISS = 0.11 Sv
- Mars transit (outbound and inbound) (360 days) = 0.662 Sv
- Mars surface stay (500 days) = 1.01 Sv
- Mars transit + surface (3 year) = 1.67 Sv





Distance from Earth

ISS/LEO

- Duration: 3-6 mo
- Crew: 3-6
- Transit Time: 6 hrs - 2 d
- Communication Delay: 0.001 sec
- Distance from Earth: 408 Km

CIS-LUNAR

Duration: 3 mo

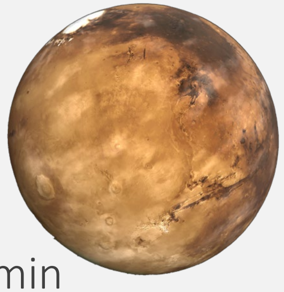
Crew: 4-6

Transit Time: 3 d

Communication Delay: 1.25 sec

Minimum Distance from Earth: 356,700 Km

DEEP SPACE



- Duration: 3 yrs
- Crew: 4-6
- Transit Time: 150-300 d
- Communication Delay: 14 min
- Minimum Distance from Earth: 54.6M Km

24

Gravity Fields

1 g

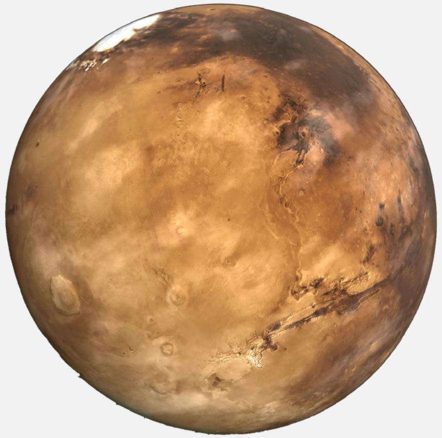
50 Kg = 50 Kg

≈ 1/6 g

50 Kg ≈ 8.3 Kg

≈1/3 g

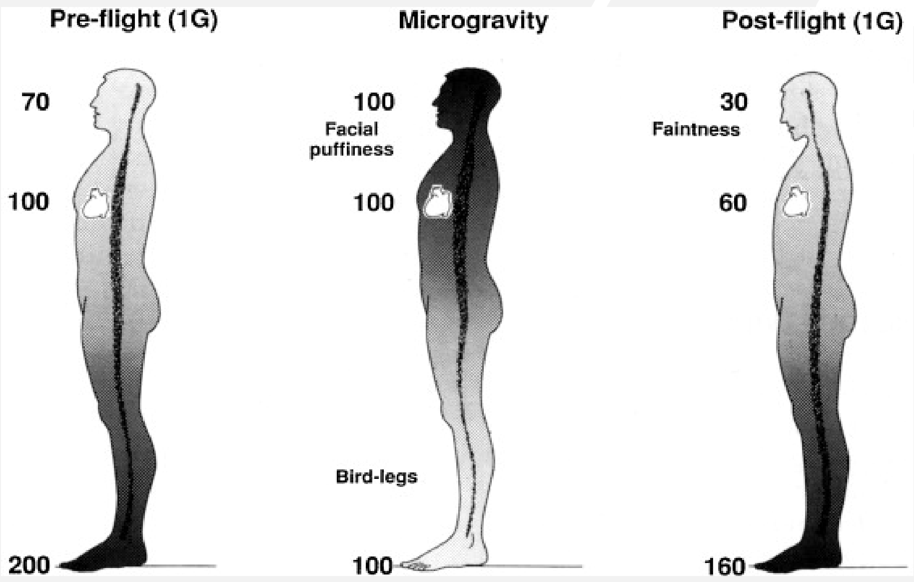
50Kg ≈ 16.7 Kg

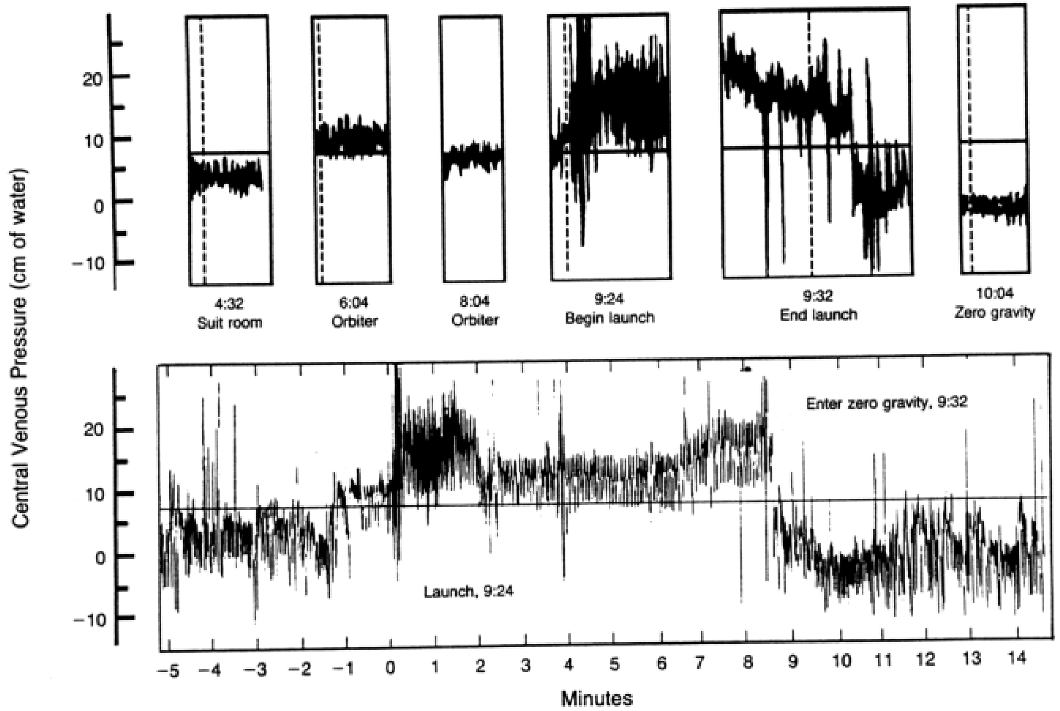


Gravity Fields

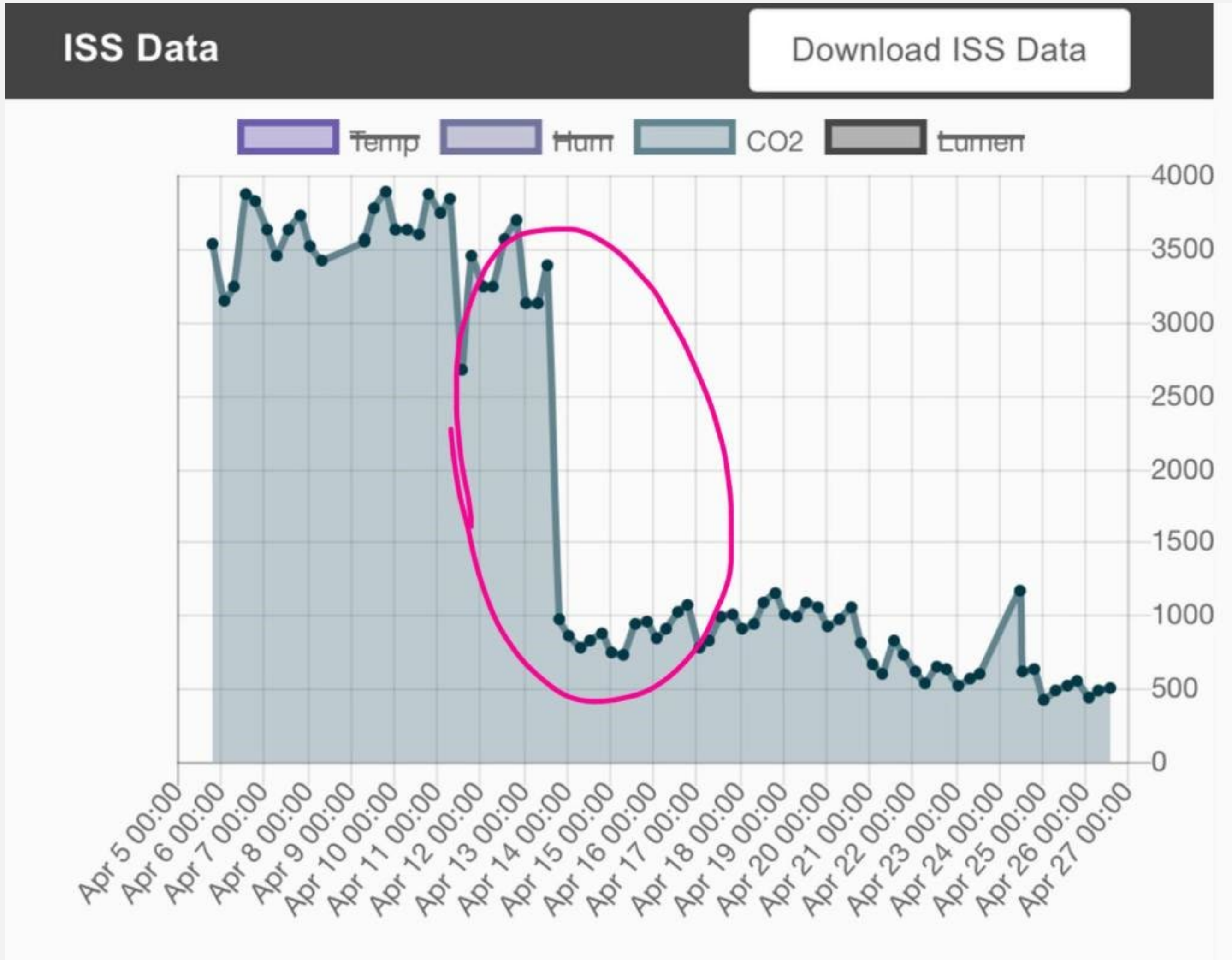
3 Noteworthy phenomena

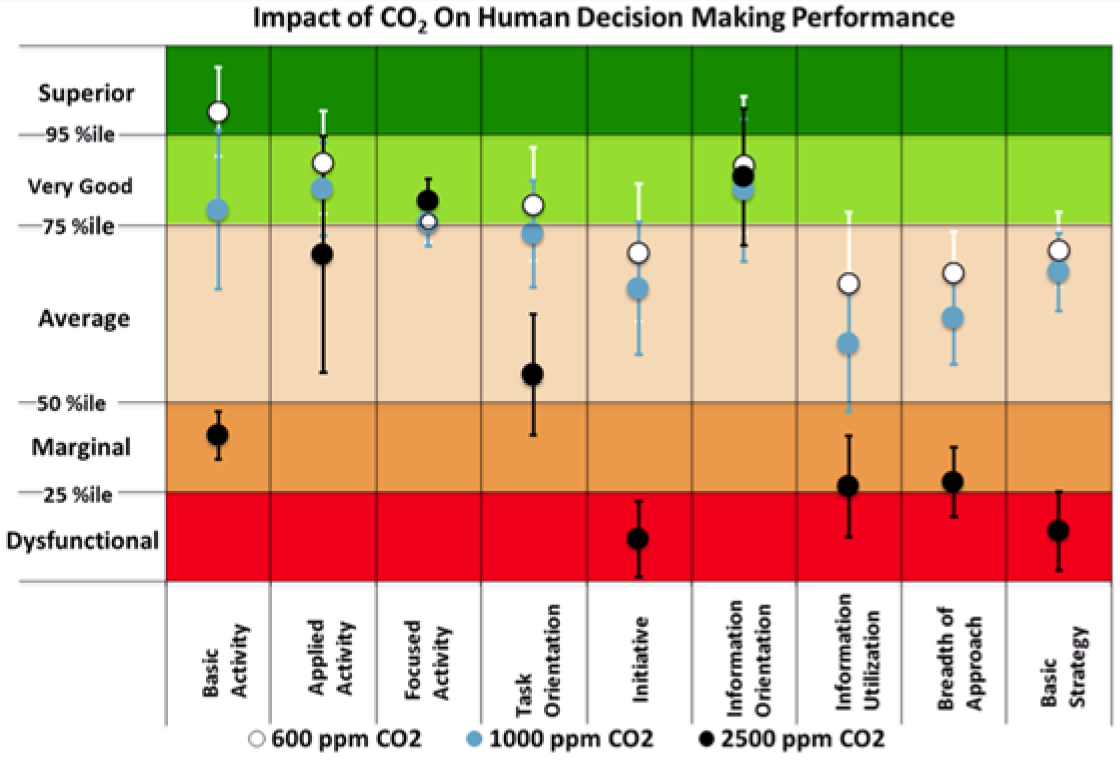
Sensorimotor effects	Anthropomorphic response	Fluid shifts





Hostile Closed Environments





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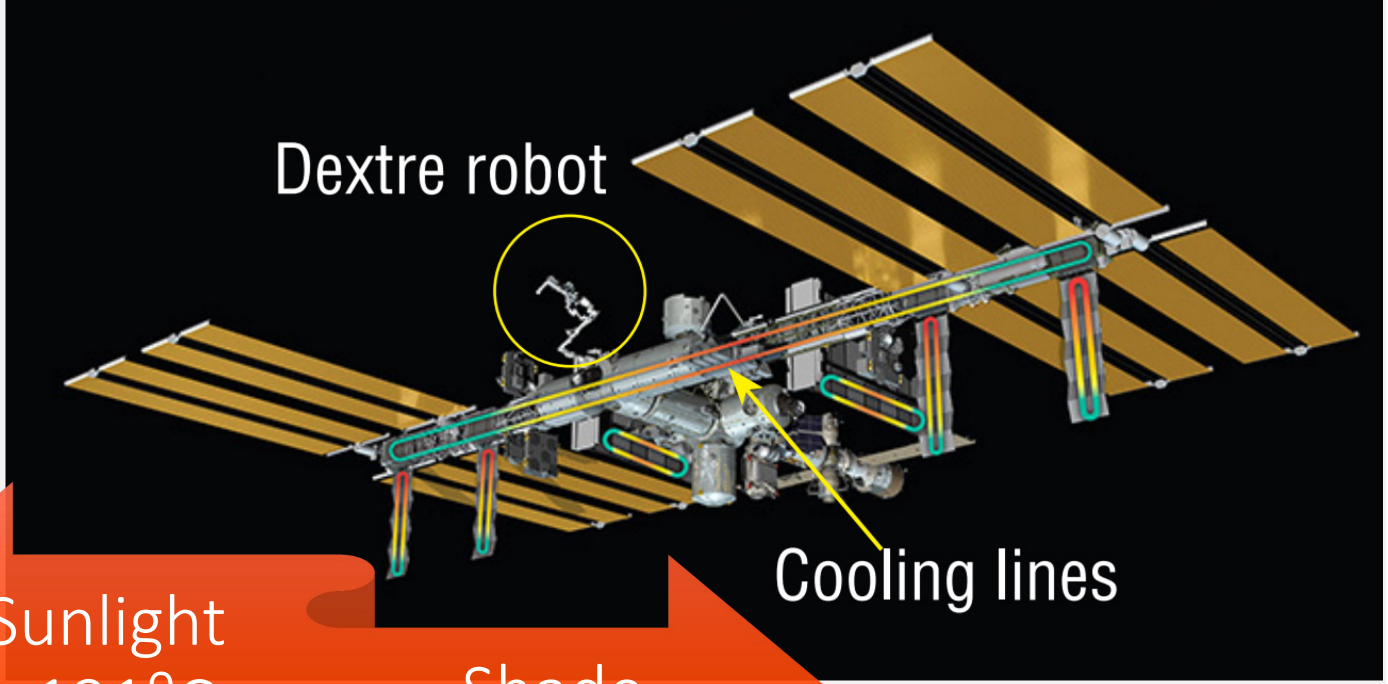
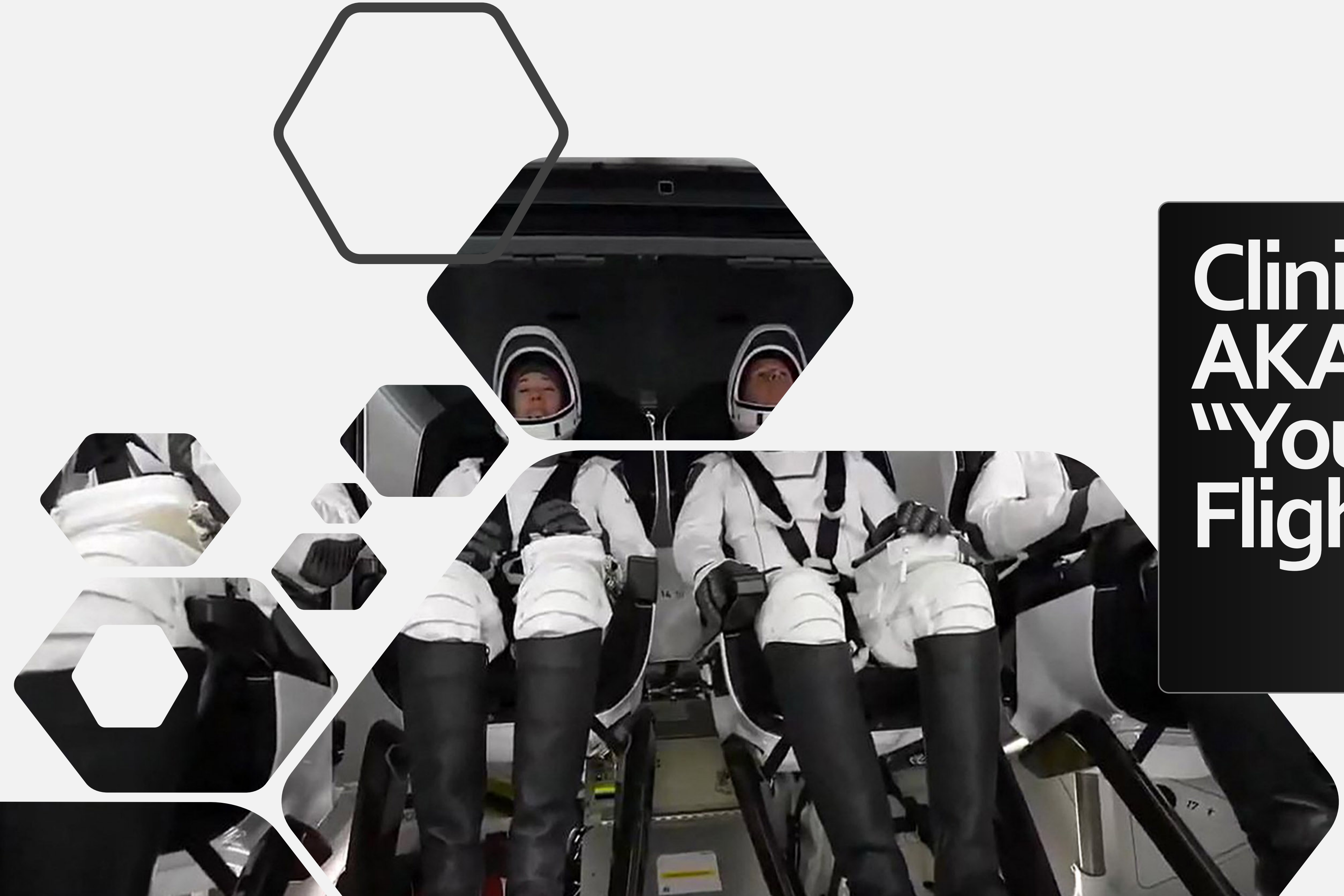


Sunlight
+121°C

Shade
-151°C



Clinical Scenarios AKA “You’re the Flight Surgeon”

Scenario 1

"A Mutiny in Space"

- 43 year old previously healthy male calls the flight surgeon with symptoms of stuffy nose, dry nostrils, and nasal congestion.
  - No relief with blowing nose
  - Refusing to eat
- Reduced voiding and stool due to difficulty using plastic bags to collect waste and smell from bags (crew of 3 used 12 bags in 11 days)

SLAYTON: Did you conclude you could not get helmets on? Is that the problem?

SCHIRRA: No, we can get them on; we can't get them off.

SLAYTON: Okay. But the mode we wanted was to have them on without being latched down to the neckring.

SCHIRRA: Deke, I can't get my hand in there, besides a handkerchief, and we're not at all safely braced for landing. We'll evaluate as carefully as we can.

SLAYTON: Okay. I think you ought to clearly understand that there is absolutely no experience at all with landing without the helmet on.

SCHIRRA: And there is no experience with the helmet either on that one.

SLAYTON: That one we've got a lot of experience with, yes.

SCHIRRA: If we had an open visor, I might go along with that.

SLAYTON: Okay. I guess you better be prepared to discuss in some detail when we land why we haven't got them on. I think you're too late now to do much about it.

SCHIRRA: That's affirmative. I don't think anybody down there has worn the helmets as much as we have.

SLAYTON: Yes.

SCHIRRA: We tried them on this morning.

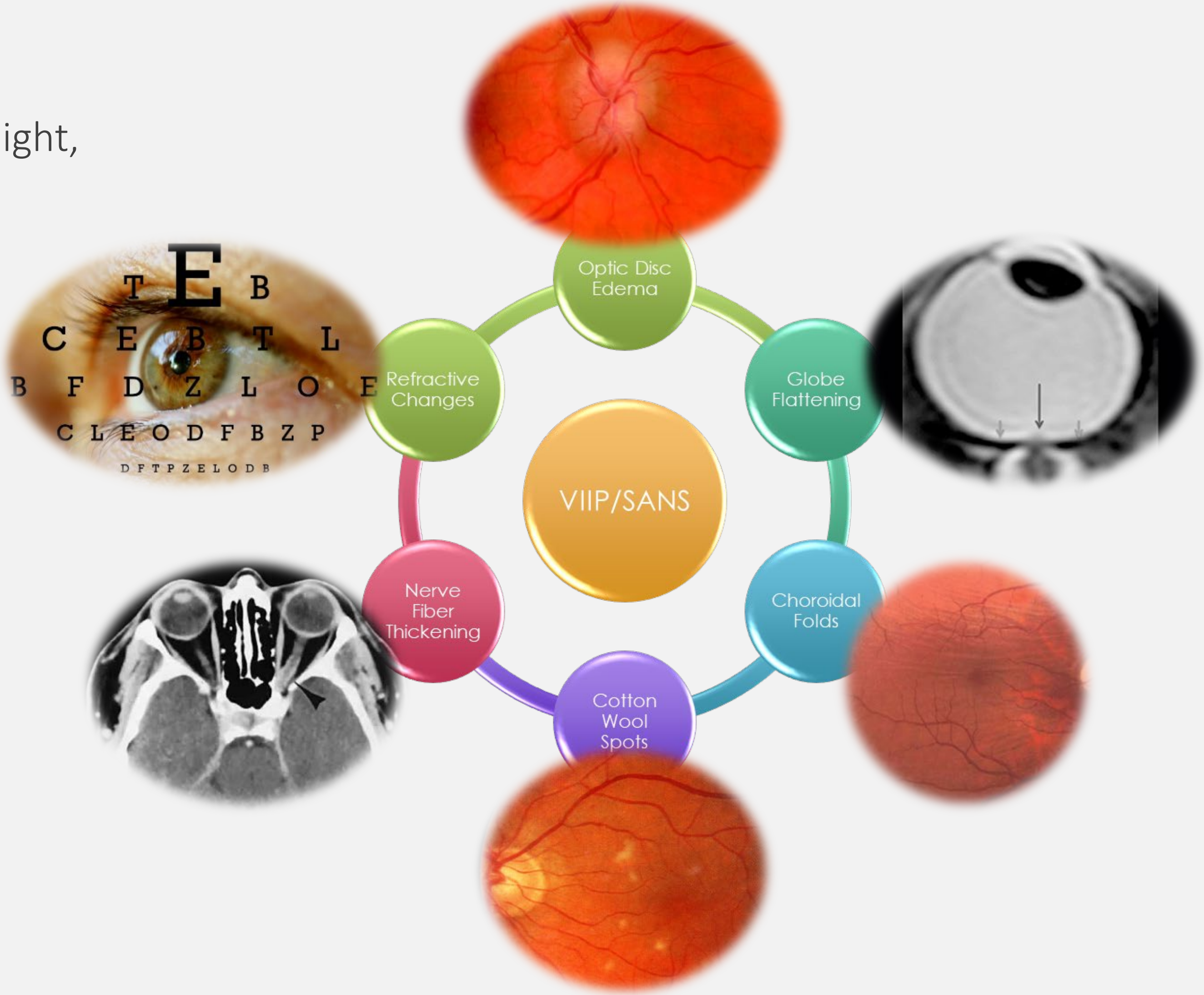
SLAYTON: Understand that. The only thing we're concerned about is the landing. We couldn't care less about the reentry. But it's your neck, and I hope you don't break it.

SCHIRRA: Thank you, babe.

Scenario 2

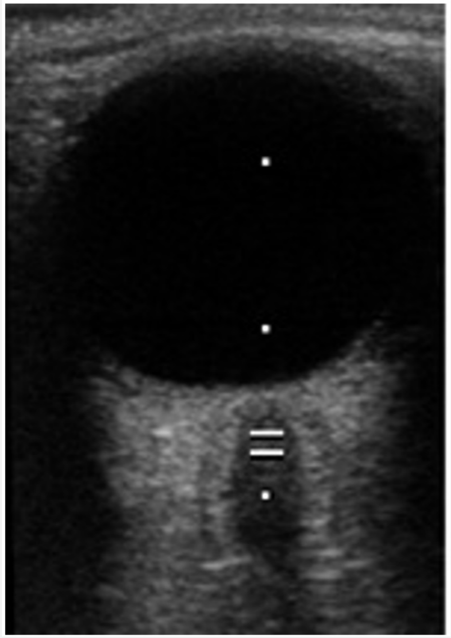
"I Can't See"

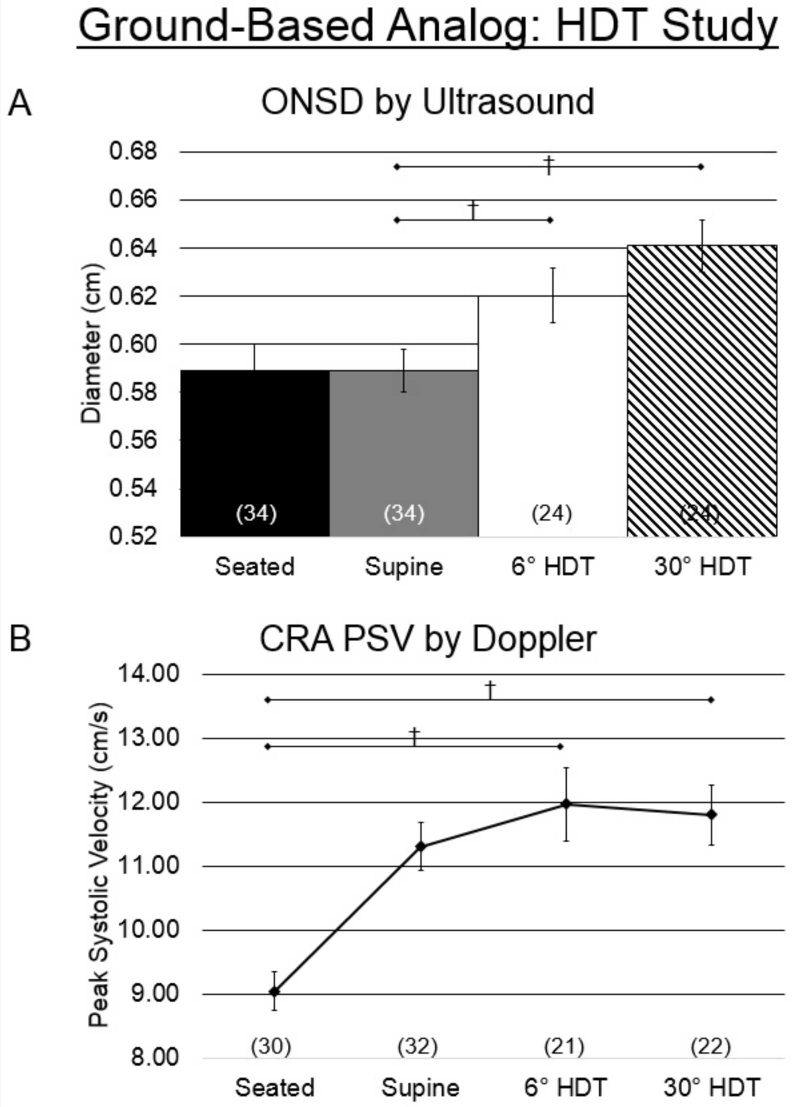
- 6 months following long duration (6 month) spaceflight, 7 astronauts demonstrated:
  - consisting of disc edema in 5 astronauts
  - globe flattening in 5 astronauts
  - choroidal folds in 5 astronauts
  - cotton wool spots in 3 astronauts
  - nerve fiber layer thickening by OCT in 6 astronauts
  - decreased near vision in 6 astronauts

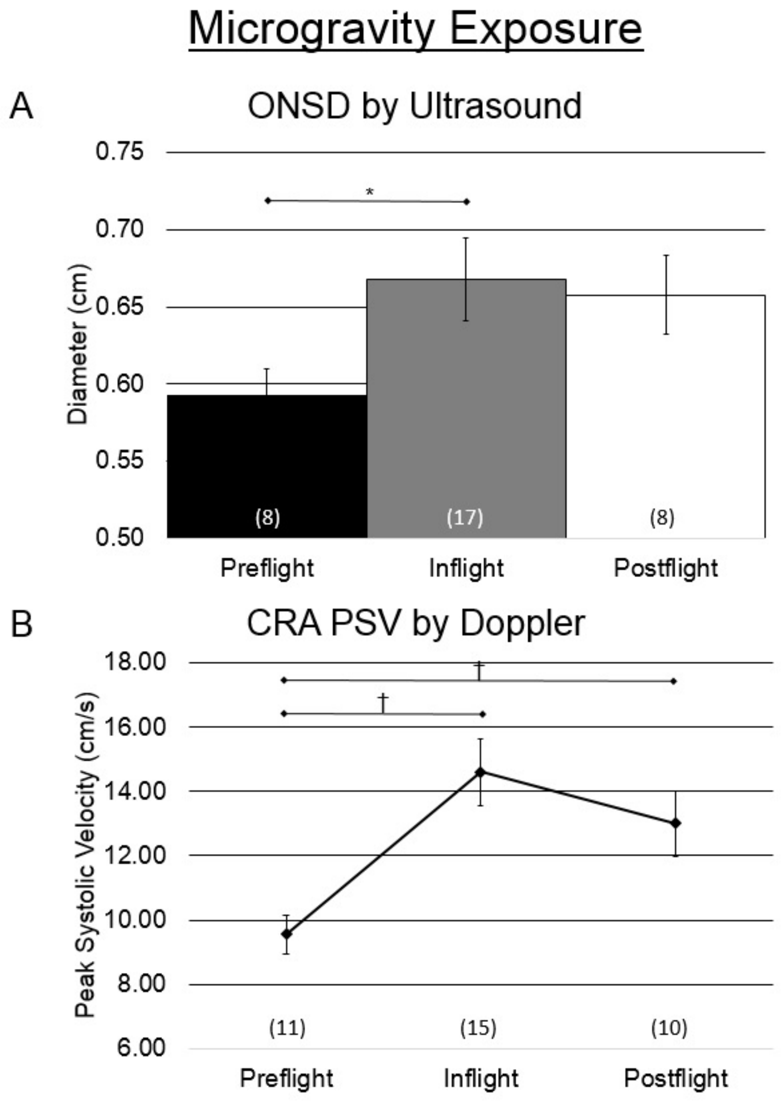


Scenario 2

"I Can't See"







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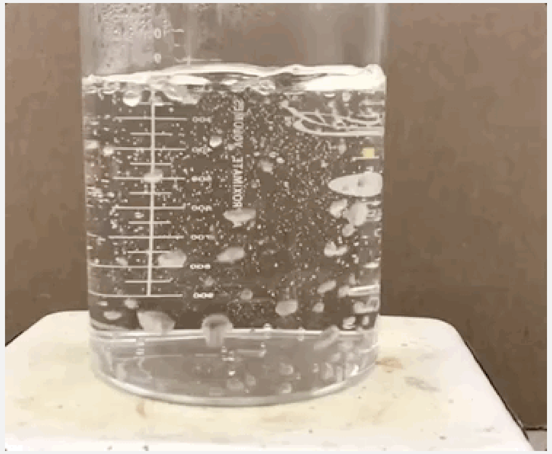
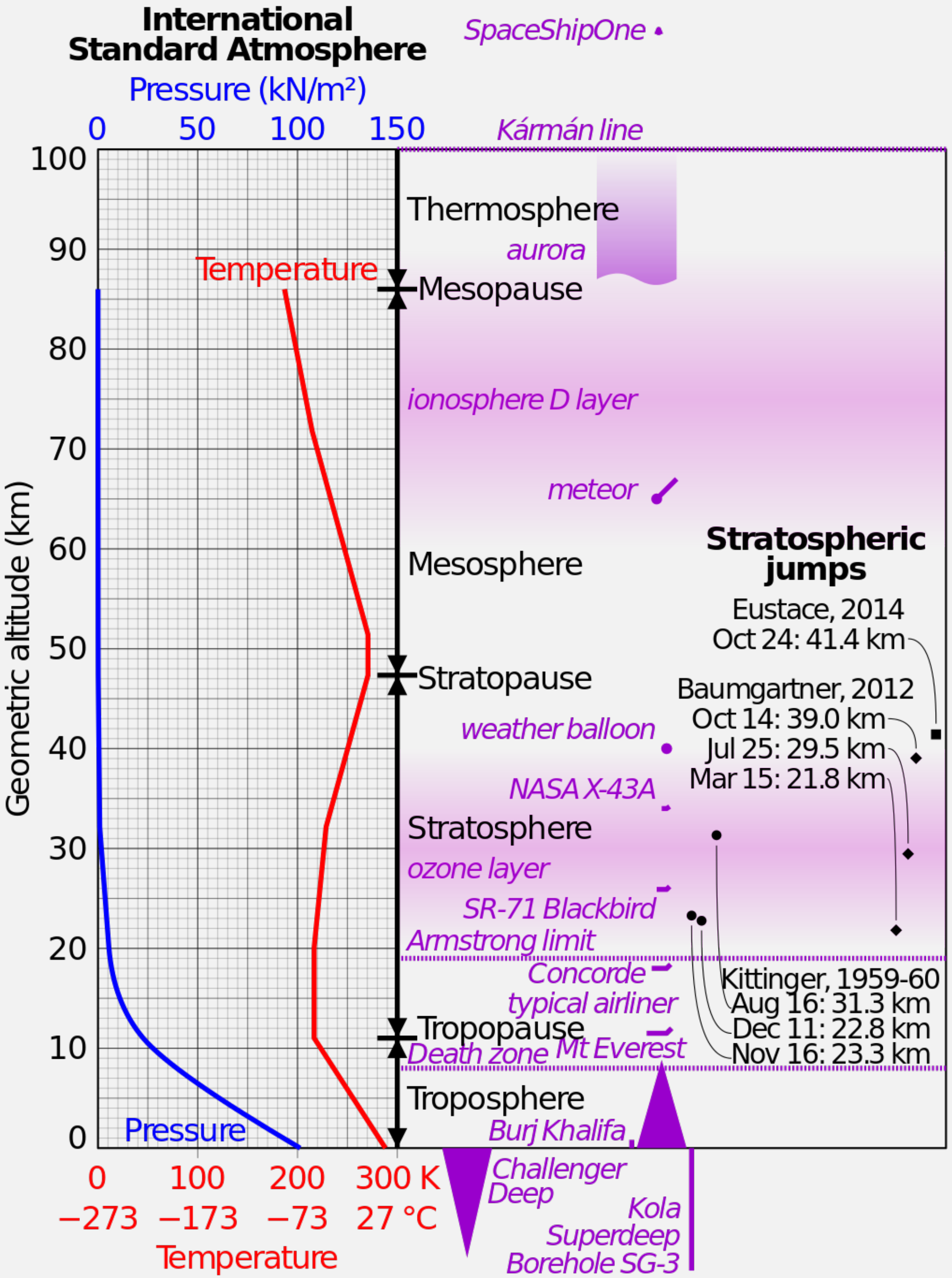
Scenario 3

"My Hand Hurts"

- 32 year old male reports hand edema, severe pain, parasthesias following a parachute jump.
- Reports that his right glove pressure seal failed during a balloon ascent to 102,800 ft (31,333 m) taking 1 hour and 31 minutes.

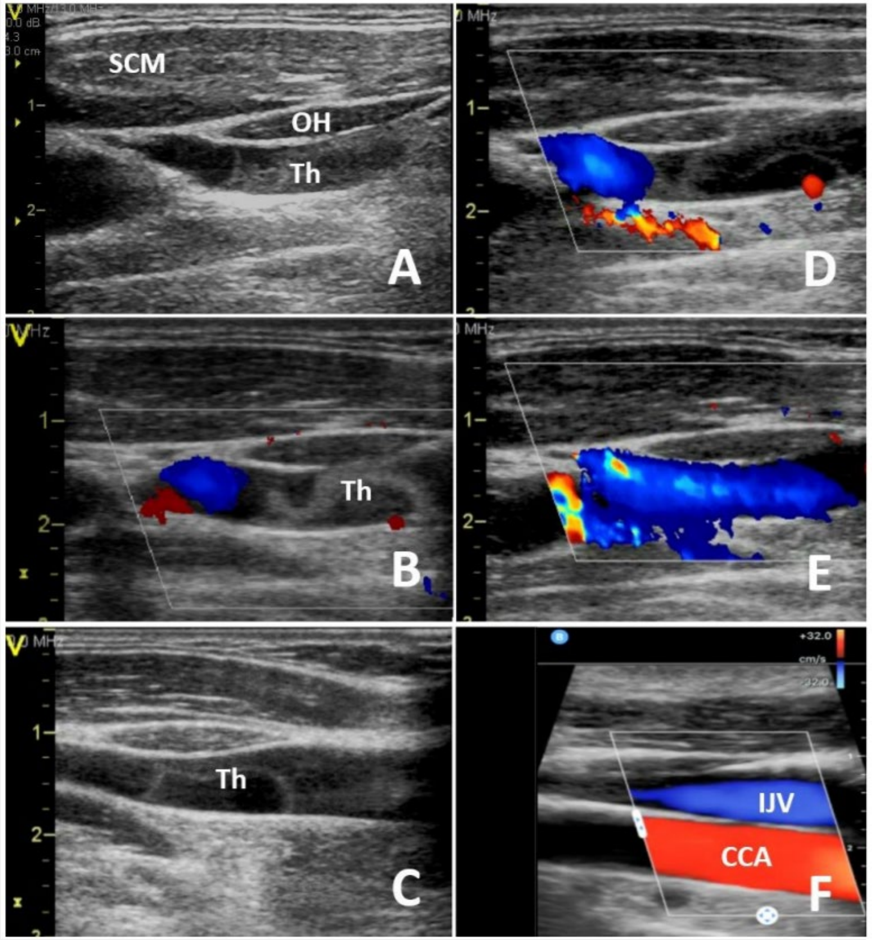




Scenario 4

"What's That?"

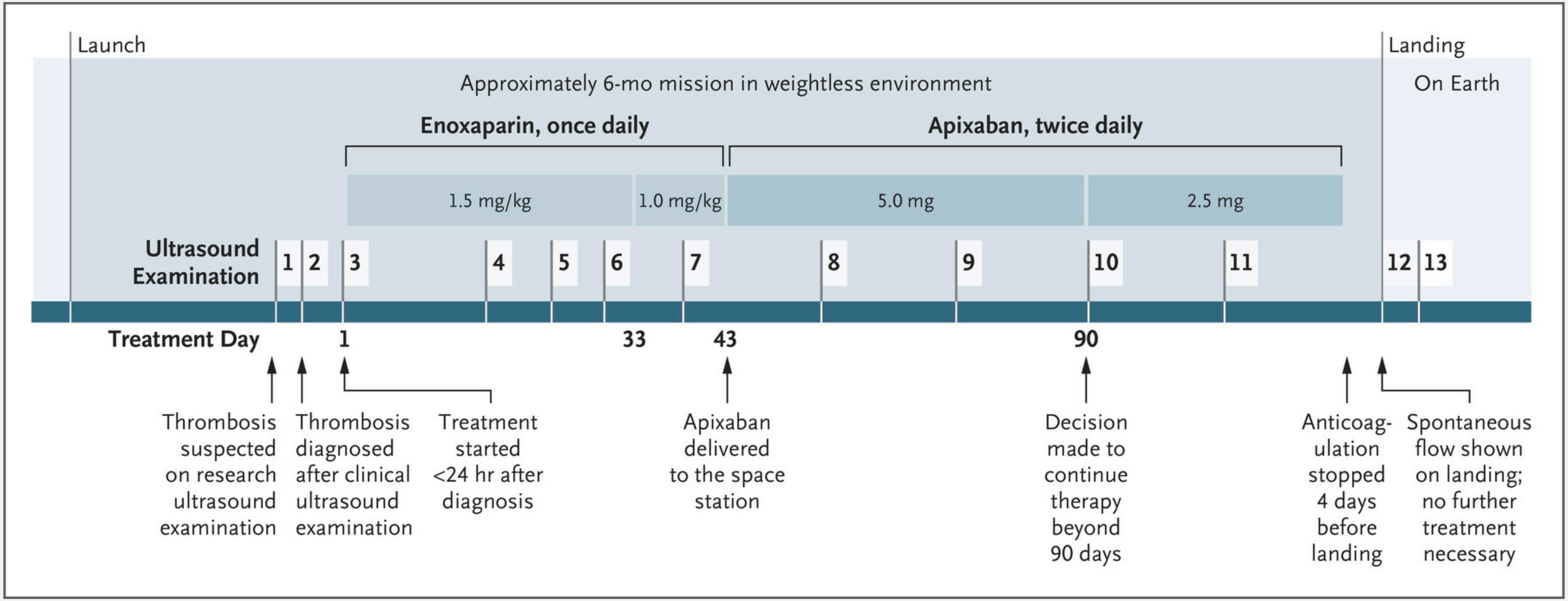
- 42-year-old female astronaut was found to have an incidental obstructive left internal jugular venous thrombosis during an ultrasound examination that was performed as part of a vascular research study
- The individual reported no headache or worsening of the facial plethora that is common in conditions of weightlessness
- There was no personal or family history of venous thromboembolism
- The physical examination revealed a prominent ipsilateral external jugular vein



Auñón-Chancellor SM, Pattarini JM, Moll S, Sargsyan A. Venous Thrombosis during Spaceflight. N Engl J Med. 2020 Jan 2;382(1):89-90. doi: 10.1056/NEJMc1905875. PMID: 31893522.

Scenario 4

“What’s That?”



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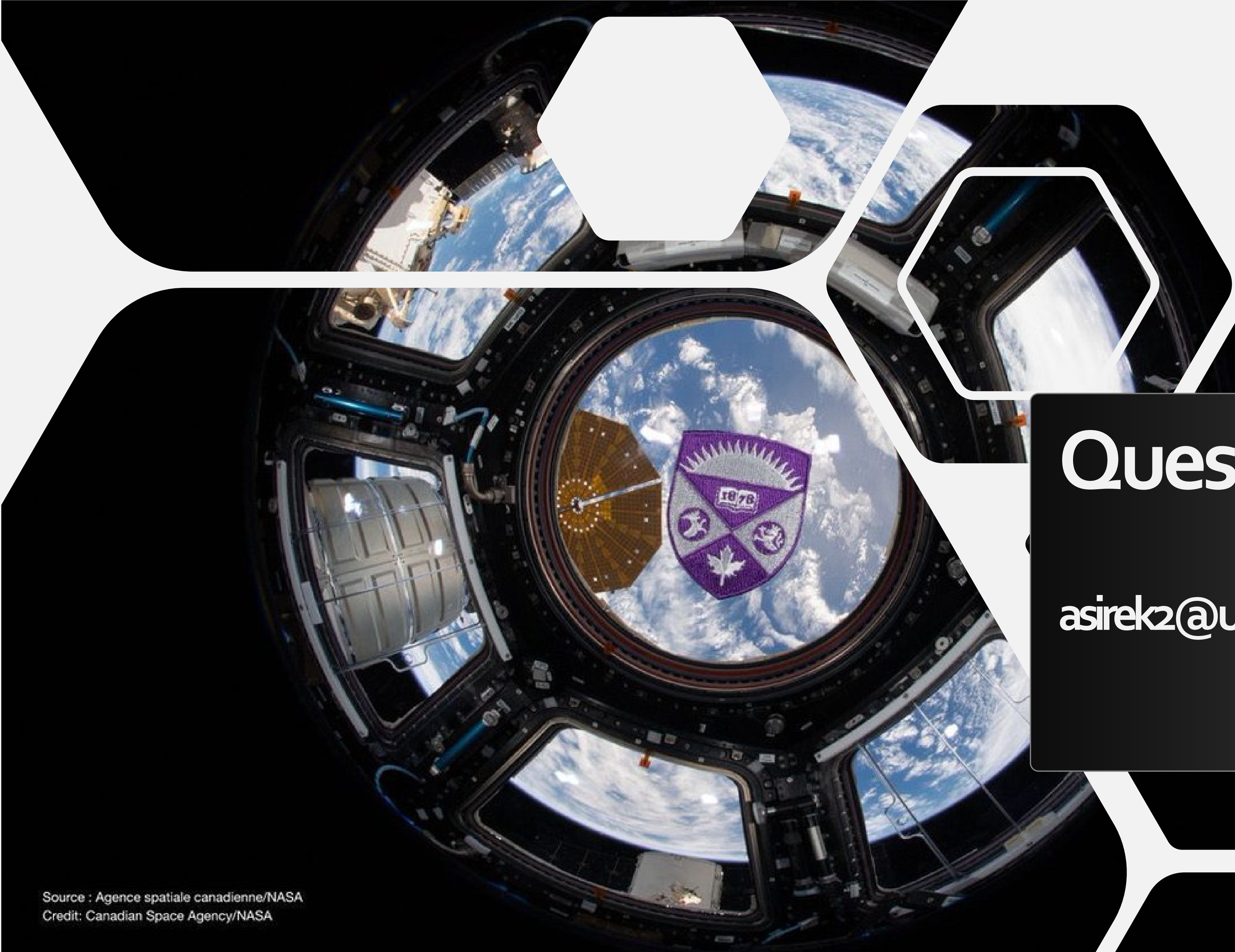

Source : Agence spatiale canadienne/NASA
Credit: Canadian Space Agency/NASA

Questions?

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