



WHAT HAPPENS TO THE HUMAN BODY IN MICROGRAVITY ?



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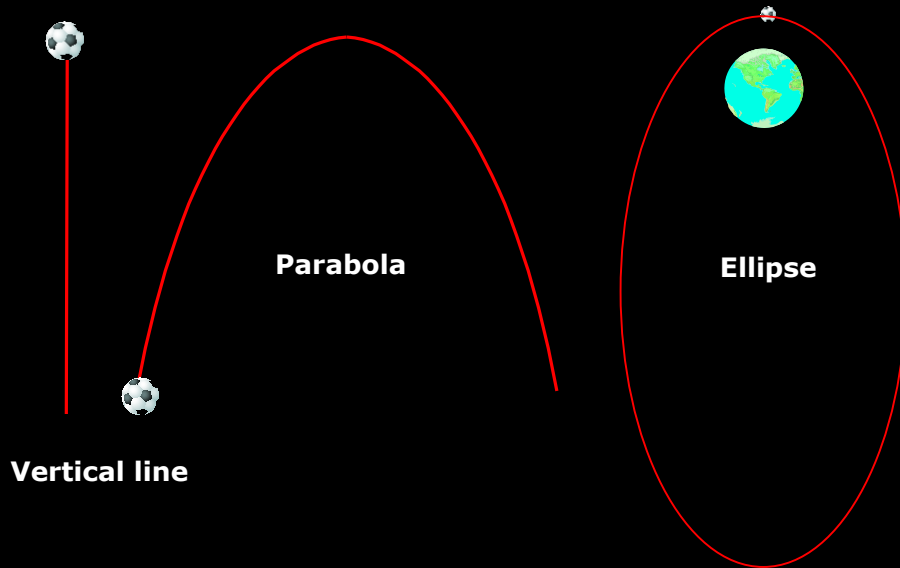
European Space Agency (1985-2016)

Weightlessness

To be weightless = To be in free fall

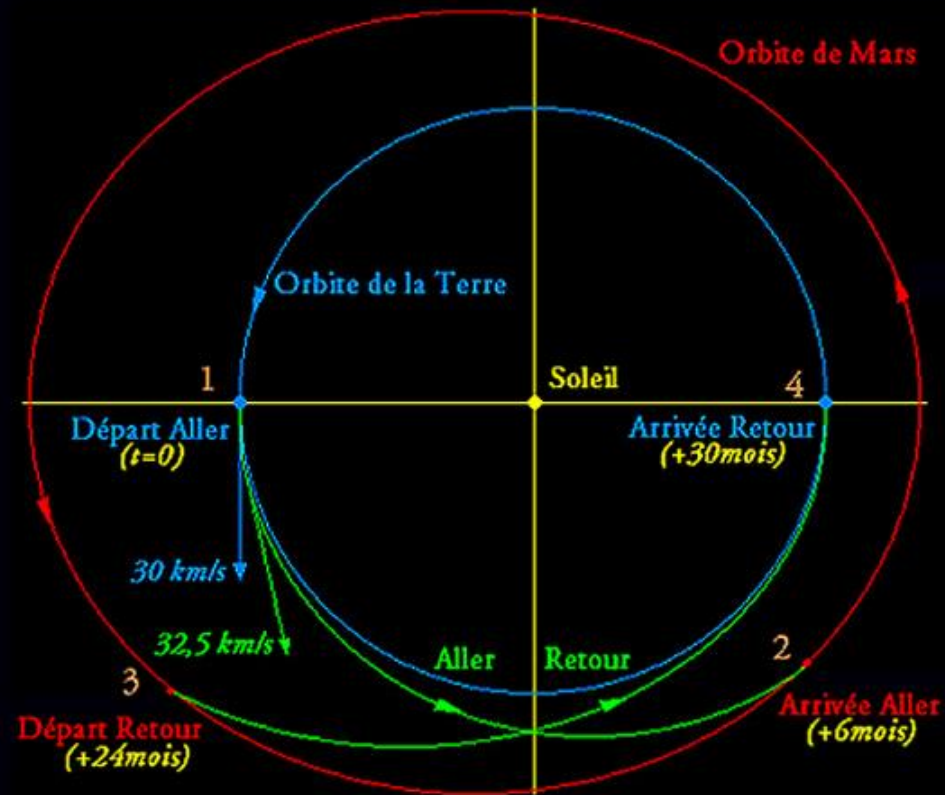
To be in FREE FALL =

WEIGHT is the only resulting force



Interplanetary Trajectories

- 1) Hohmann's elliptical transfer (low mass but 6 to 8 months 0g)
- 2) Propelled accelerated trajectory (faster but high fuel mass)



La Terre : un tour en 365 j

Mars : un tour en 687 j

Période favorable au voyage : tous les 26 mois

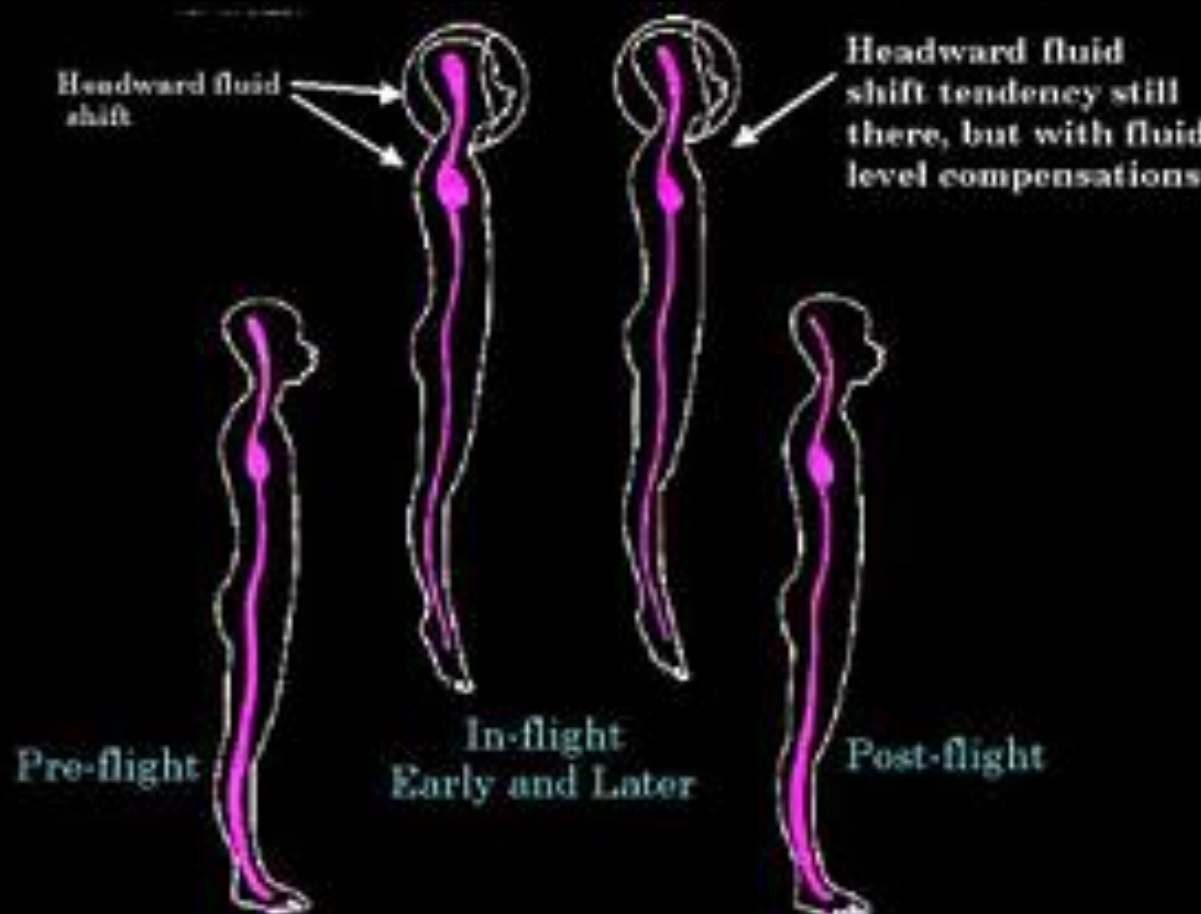
PHYSIOLOGICAL PROBLEMS IN MICROGRAVITY (1)

1. Body fluids and cardiovascular system

- On Earth (1g), heart acts as a pump to distribute blood evenly in whole body with typical pressures 1 in heart, 2 in feet and 2/3 in head
- In 0g, body fluids no longer attracted downward and rushing in torso and head yielding a temporary hypervolemia of blood in upper body.
- After adaptation to 0g and natural elimination of body fluids by urine, a new equilibrium attained after few days
- Upon return to Earth or landing on Mars, body fluids again attracted downward (toward feet) and astronauts readapt to new g environment

Problems:

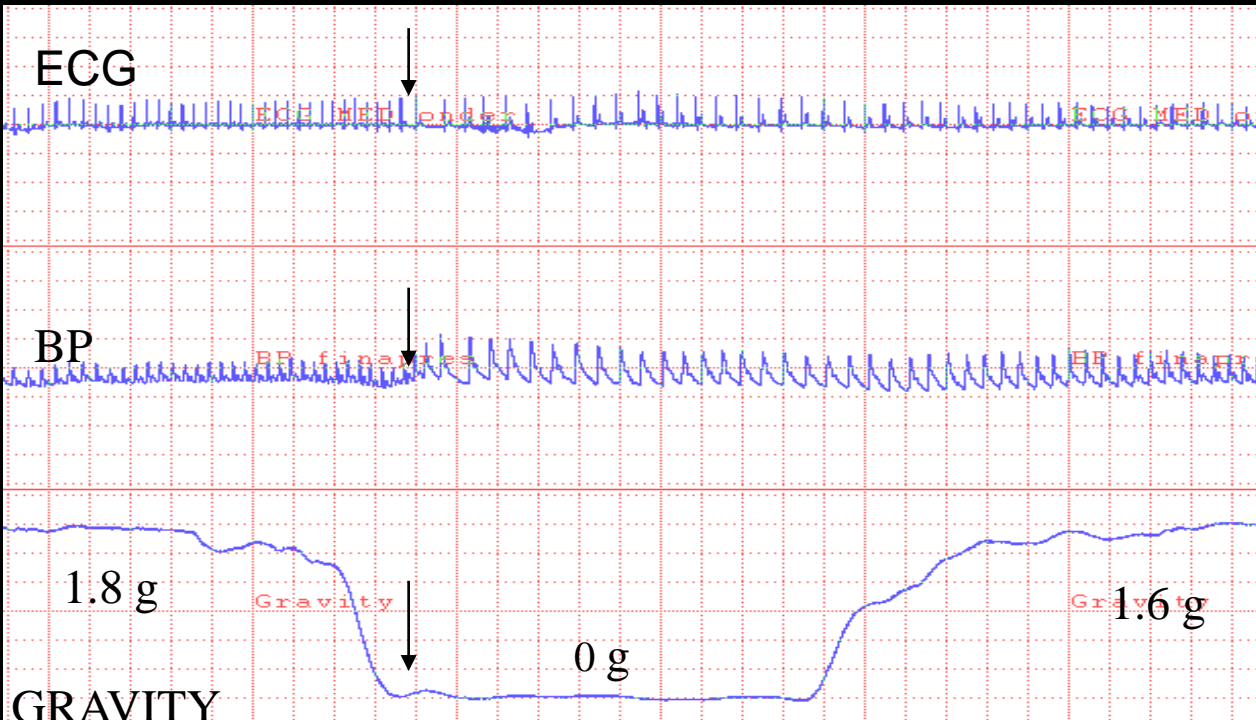
- In-flight: overpressure in head and in eyes (Spaceflight-neuro-ocular syndrome)
- Post-flight: orthostatic intolerance and light headed



PHYSIOLOGICAL PROBLEMS IN MICROGRAVITY (2)

Cardiovascular system

- Heart rate decreases at 0g onset (lengthening in time between successive peaks), corresponding to increased vagal modulation of the heart rate
- Blood pressure increases at 0g onset (difference between max. and min. pressure) indicating an increase in stroke volume
- Experiments conducted in parabolic flights and in space



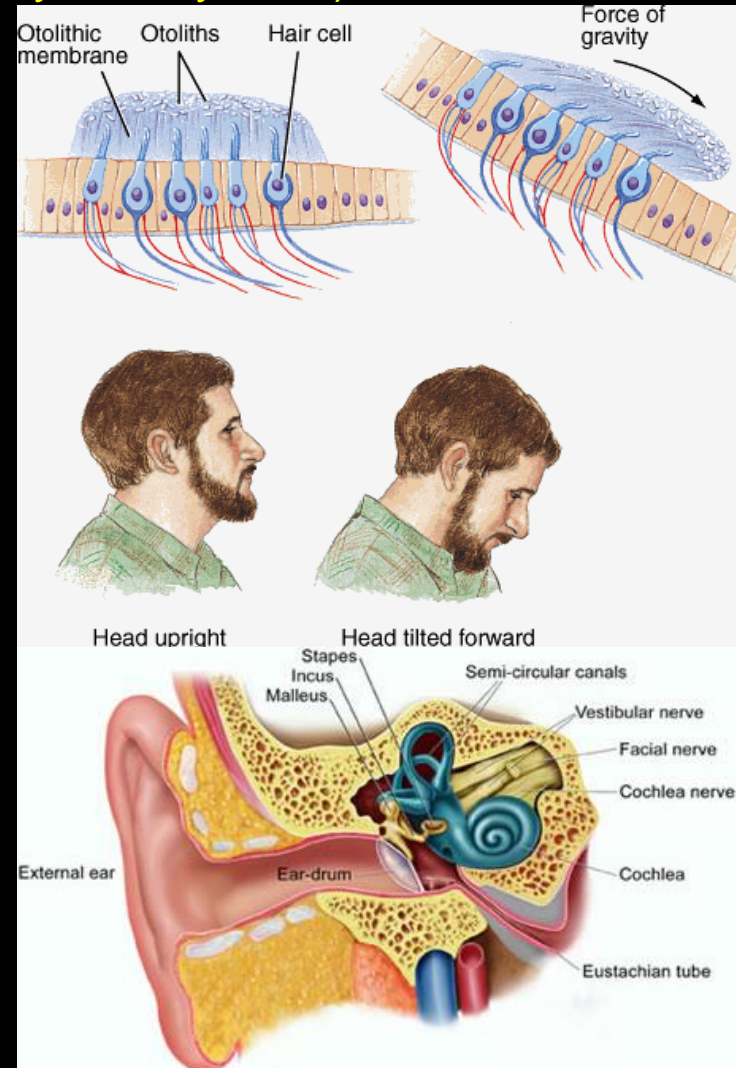
PHYSIOLOGICAL PROBLEMS IN MICROGRAVITY (3)

2. Balance, orientation and vestibular system

- Three sources of information for body spatial position:
 1. inner ear vestibular system,
 2. visual system, and
 3. proprioceptive system (muscle and tendons in body, mainly neck)
- Vestibular system is double, located in the inner ear:
 - Otoliths: small crystals of CaCO_3 on a membrane with nervous endings
 - Semi-circular canals: 3 canals in perpendicular planes with liquid moving by inertia stimulating nervous endings in canals

Problems: "space sickness"

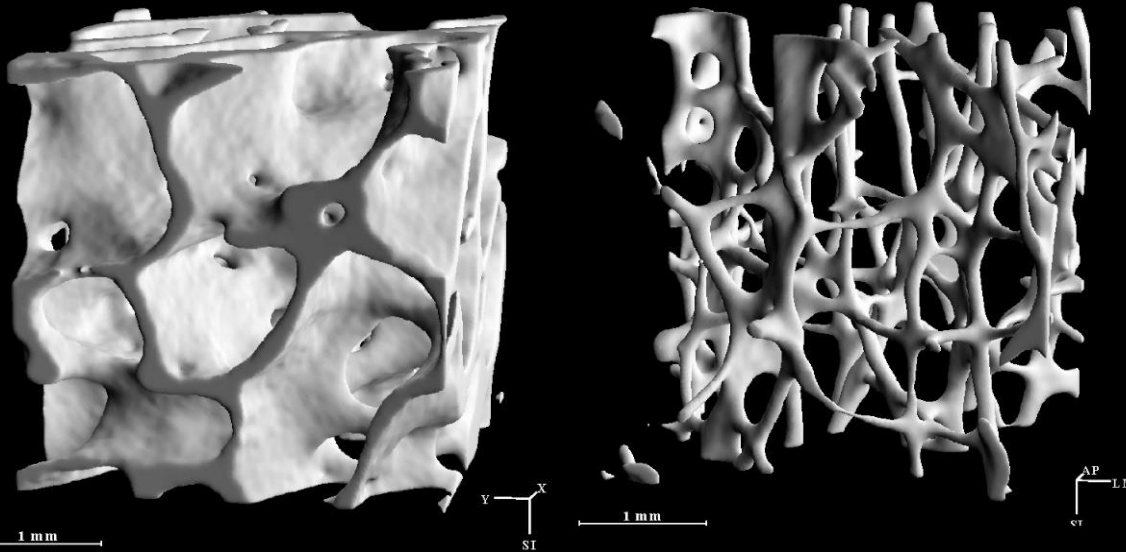
- In 0g, vestibular system no longer stimulated but visual and proprioceptive systems still working, creating conflicting information to the brain, yielding dizzy spells, nausea, vomiting
- Usually gets better after few days, but astronaut schedule is kept light on first few days
- After flight, back to normal rather quickly.



PHYSIOLOGICAL PROBLEMS IN MICROGRAVITY (4)

3. Bone demineralisation

- Major problem
- In 0g, after few weeks, demineralization of bone structure, i.e. loss of calcium and phosphorus. Why? Still not known exactly.
- Loss of calcium (approx. 100 mg/day) after few months could mean that astronauts could not return to Earth or land on Mars
- Two competitive processes: osteoclastic cells remove old bone cells, osteoblastic cells produce new bone cells. Experiments show sometime conflicting results.
- Problem much more complicate, as it involves shocks on some bones (heel while walking/running), recalcification of upper body bones, etc.
- Resemble osteoporosis of elderly people on Earth
- Need drastic countermeasure like 2 h/day of exercising or artificial gravity



Courtesy of IBT/ETH Zürich

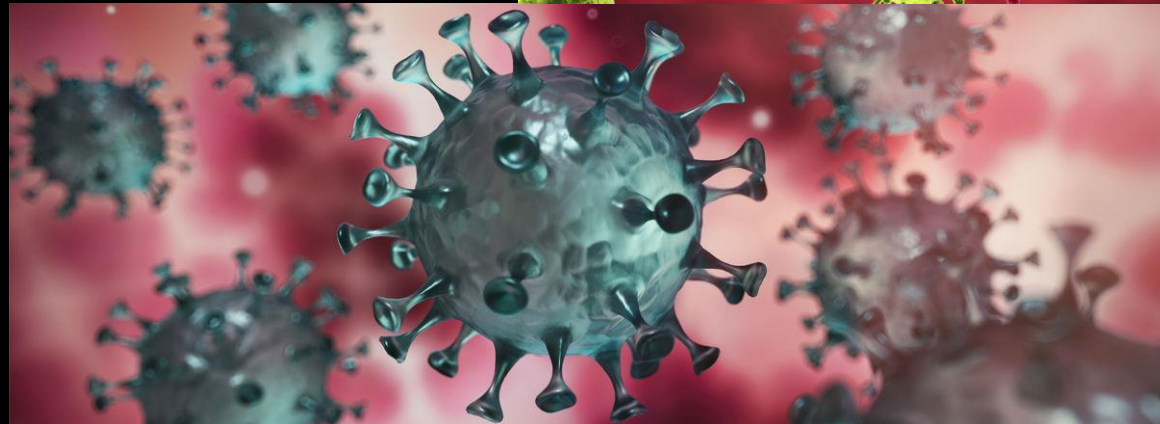
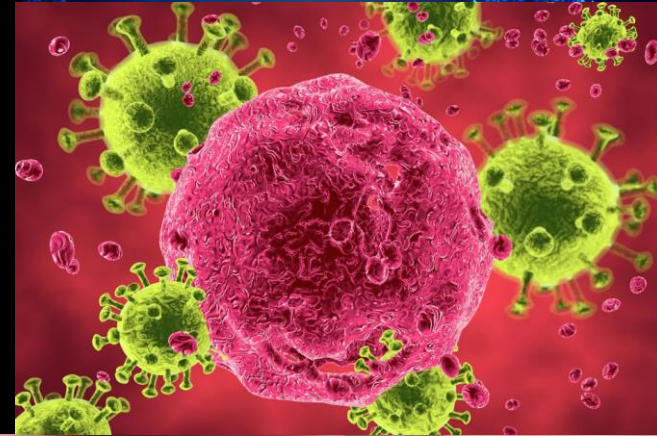
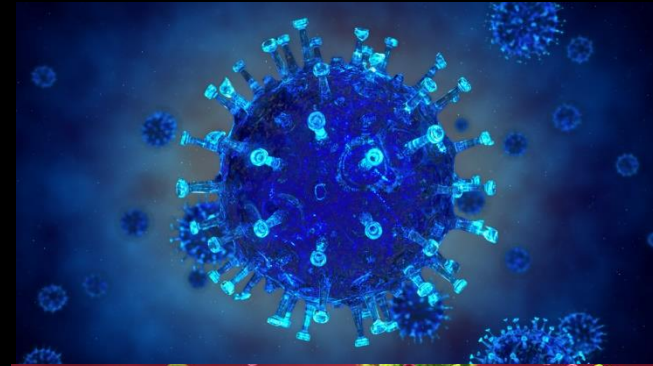
Courtesy of IBT/ETH Zürich



PHYSIOLOGICAL PROBLEMS IN MICROGRAVITY (5)

4. Immunodeficiency

- Major problem
- In 0g, after few weeks, dysregulation of immunological response and reactivation of latent herpes virus
- Long exposure to 0g :
 - reduces T lymphocyte counts (white blood cells) that intervene in immune responses and in antibodies production,
 - attenuates cytotoxic function, and
 - reactivate viral infection
- Interest for this research is high: understanding human defense mechanisms and role of gravity, or its absence, can shed light on fundamental properties of immune system and on reaction to viral infections, like e.g. HIV/AIDS, COVID



CONCLUSIONS

1. Human Physiology Research in Microgravity

- Bed Rest Analogues: bed tilt typically 4 to 6° head down for several months, simulates headward body fluid shifts
- Parabolic Flights : 0g for 20s on board laboratory aircraft
- Orbital Space Stations: study human physiology for several weeks/months/years



2. Developing countermeasures

- Artificial gravity, by centrifugation, either entire vehicle or just astronaut
- Improved physical training systems (treadmill, squats, ...)
- Pharmacopeia to counter bone demineralisation and immunodeficiency



MOON, MARS, HERE WE COME !

