Effects of Microgravity "Space" Environment on Physiologic Homeostasis

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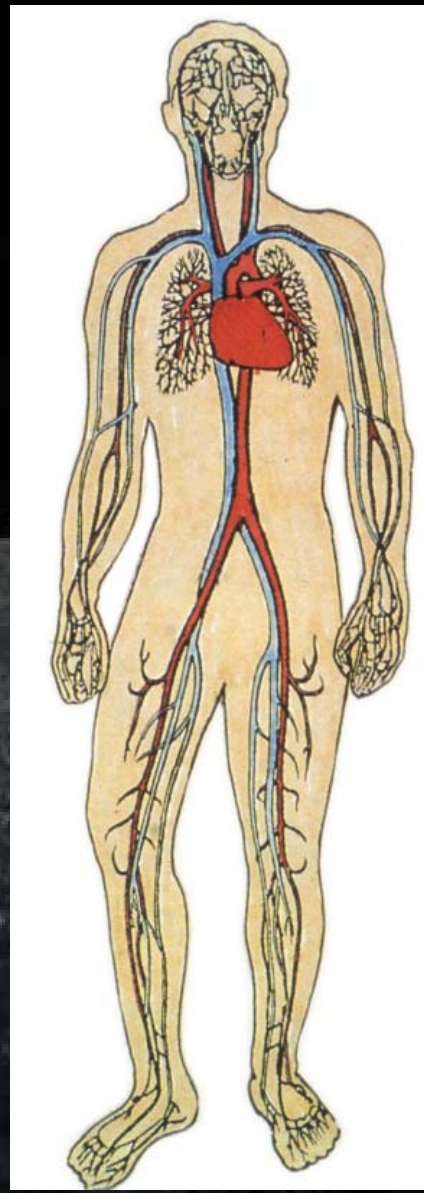


Courtesy: ASGSB

Most nurses never consider that they could some day work in a microgravity environment

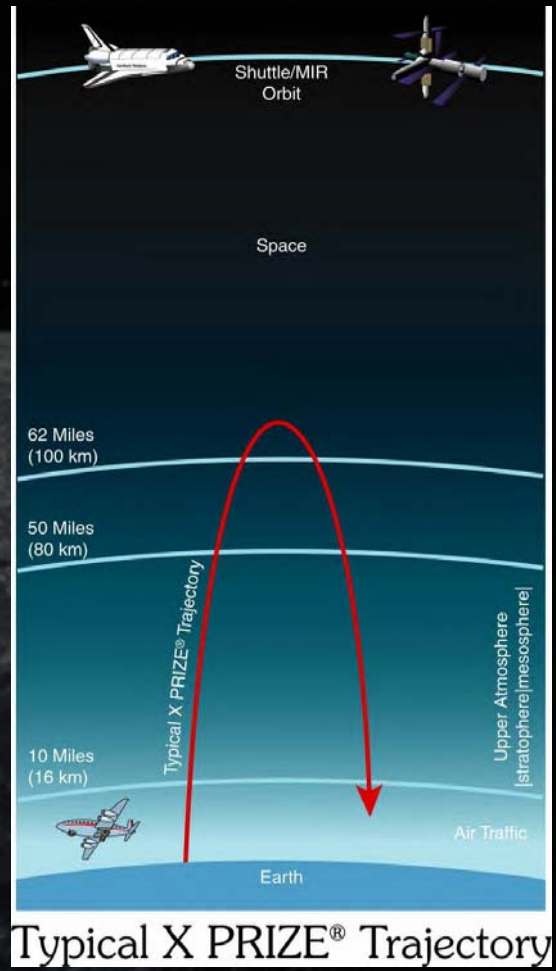
- Currently under-staffed
- Heavy patient loads
- Drowning in paperwork, no time to think about the future of nursing
- Never occurred to them
- Don’t believe that space applies to their everyday nursing practice

Microgravity Environment

Humans have evolved inside a narrow atmospheric shell, held on the Earth by gravity

It is useful to think of the atmosphere in layers:

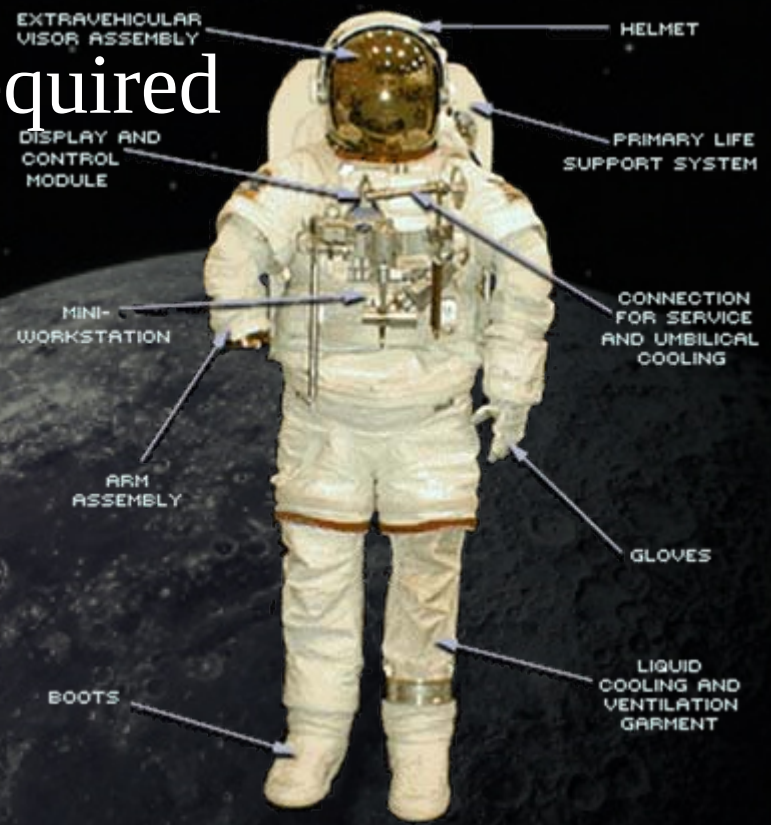
- Oxygen required above 10,000 ft
- Oxygen limit with pressure mask: 8 miles
- Weather limit: 9 miles
- Physiological limit (pressurized cabin required or blood boils out of the body) : 12 miles
- Von Karman Line: 50 miles
- “Edge of Space”: 125 miles
- “Space Vacuum” occurs at 435 miles



Typical X PRIZE® Trajectory

Currently most space travelers are limited to low earth orbit (LEO)

- Shuttle & International Space Station orbits
- Protective environment required
  - O_2
  - Pressurization
  - Temperature
  - Radiation exposure



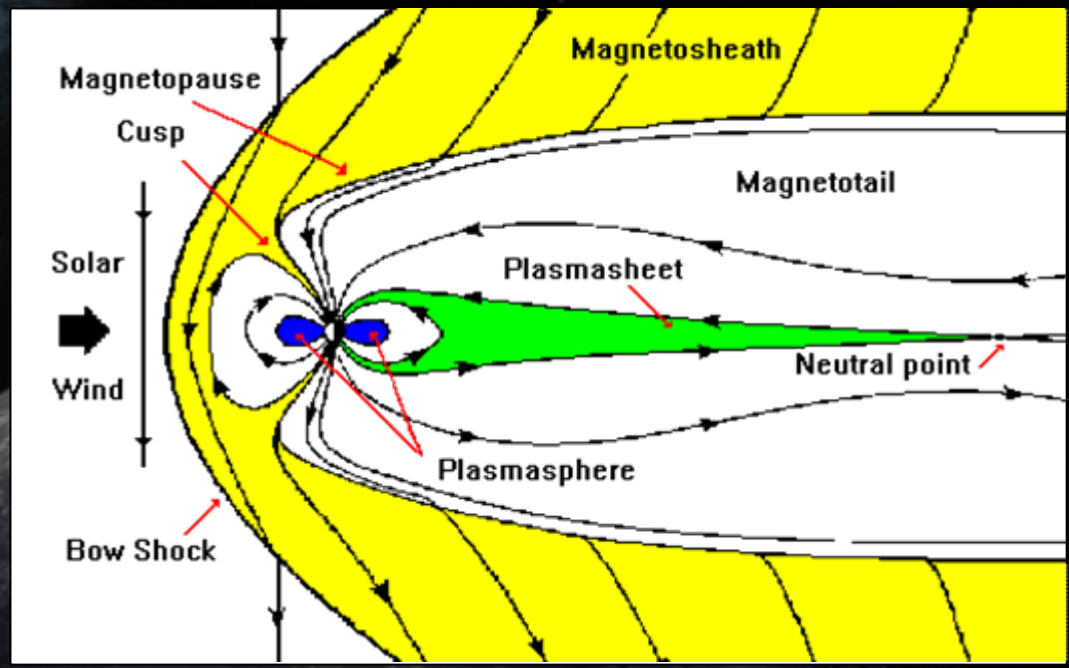
http://www.hightechscience.org/eva_suit.htm

Radiation Issues & Limits

- Because of long term or delayed radiation exposure risks, career limits of exposure have been developed for astronauts
- Astronaut at age 25 at first exposure has a limit of 150 REM
- Astronaut at age 55 at first exposure has a limit of 400 REM

Radiation in the Space Environment

- Van Allen Belts
- S. Atlantic Anomaly
- Types of radiation
  - GCR
  - solar flares



Radiation Dose & Exposures

Most familiar unit of measurement is the REM

(1 REM=100erg/gram=0.01Sv)

(1 Sievert=1 joule/kilogram)

- Chest X-ray =0.039 REM
- Natural background radiation=0.28 REM
- Space Exposures
  - Trip to Moon= 25 REM
  - Trip to Mars= 50+ REM
  - Solar flares deliver minimal to >1000 REM

Radiation Exposure

- Radiation effects are defined as acute or delayed.
  - Acute: occur within a few hours to days of exposure. Associated with high radiation doses over a short period of time.
  - Delayed:
- “Radiation Sickness”

Radiation Doses & Consequences

- 100-200 REM are considered “low doses”
  - usually cause nausea and vomiting within a few hours
  - some abdominal discomfort, loss of appetite
  - fatigue
  - death is rare
- 200-1000 rem are very serious and require medical attention.
  - Similar symptoms to low dose exposure
  - But serious damage has been done to hematopoeitic system
- >600 REM universally lethal

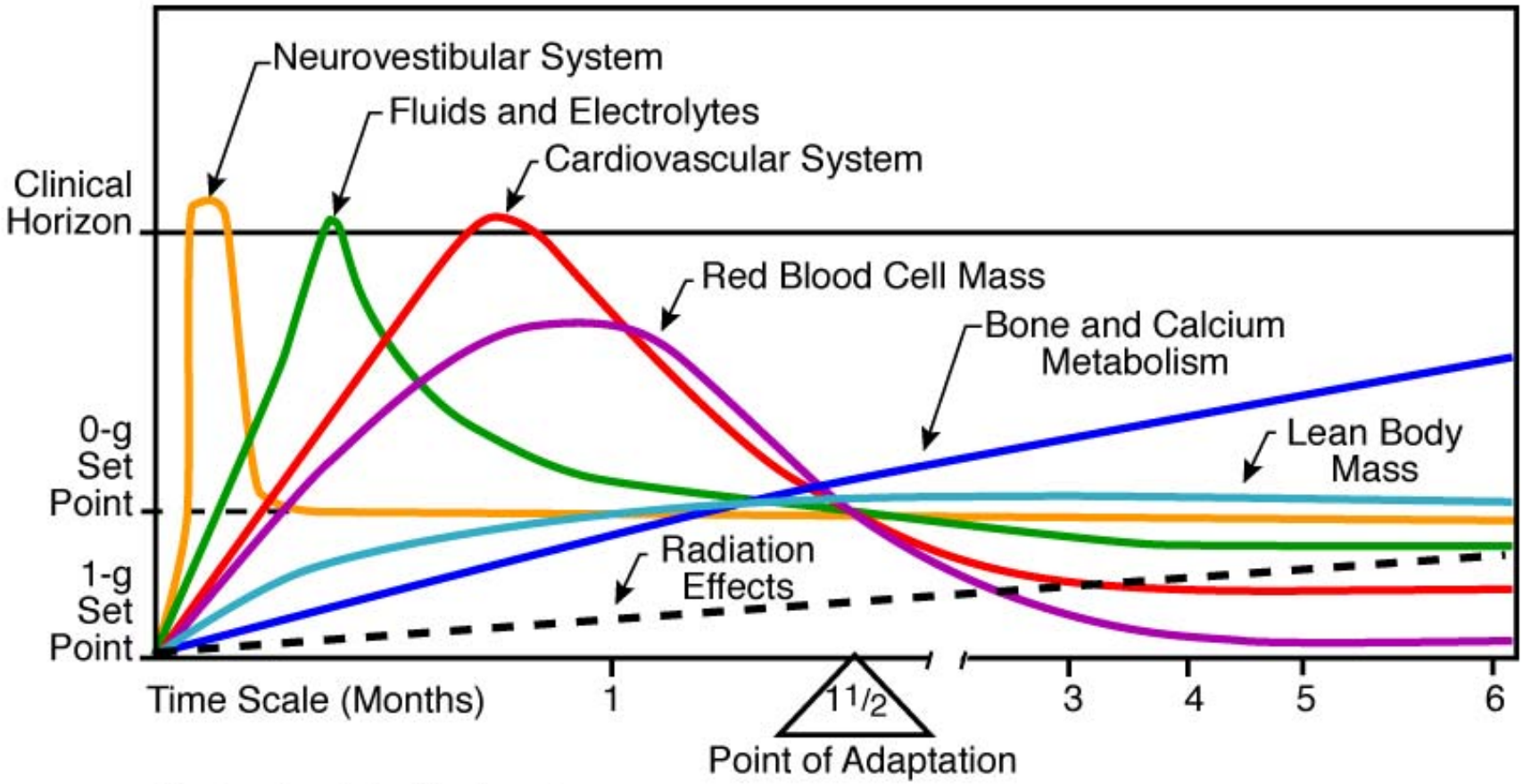
Relative Absence of Gravity

- “Freefall” vs “weightlessness” vs “microgravity”
- Practical issues
  - --drains don’t drain
  - --toilets do not flush
  - --IV fluids do not drip
  - --particles remain suspended in cabin air

Human Adaptation to Freefall

2 phases

- 1st phase: represents readjustments in all body systems that occurs in the first 3-6 weeks of spaceflight
- 2nd phase: begins after several months in space and is characterized by regional losses of muscle and bone mass, changes in neurotransmitter and receptor functions, decreased immune responses and changes in CNS function.

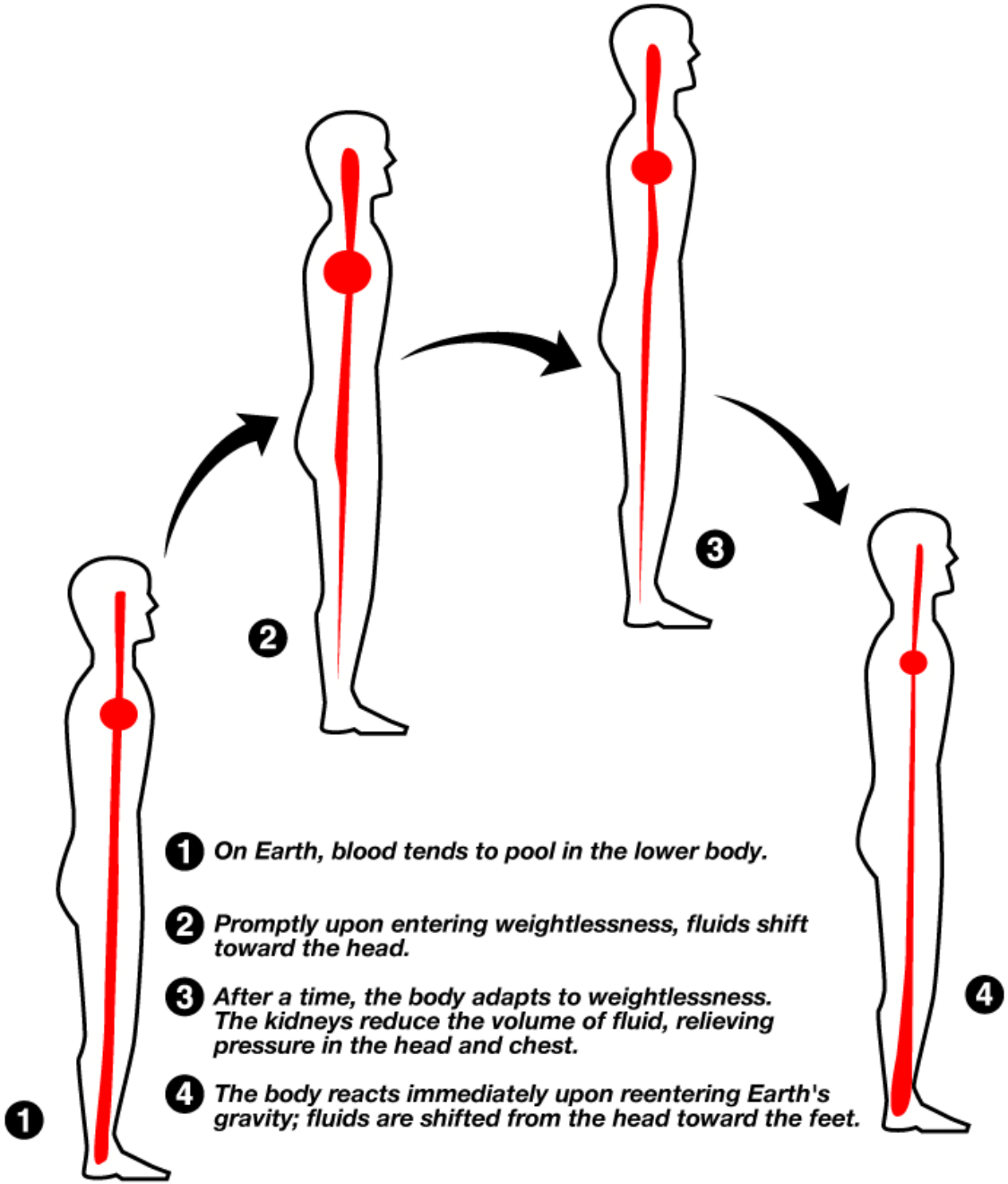


Each physiological system acclimates to microgravity at a different rate

Courtesy: ASGSB

Fluid Shifts in Space

- Upon reaching LEO the body becomes “confused”.
- Mechanisms that usually counter the effects of gravity suddenly find that 2000cc of fluid (900cc+ of blood; remainder ECF) rapidly shifts headward (cephalid shift).
  - Redistribution is compete in 6-10 hours of exposure to microgravity



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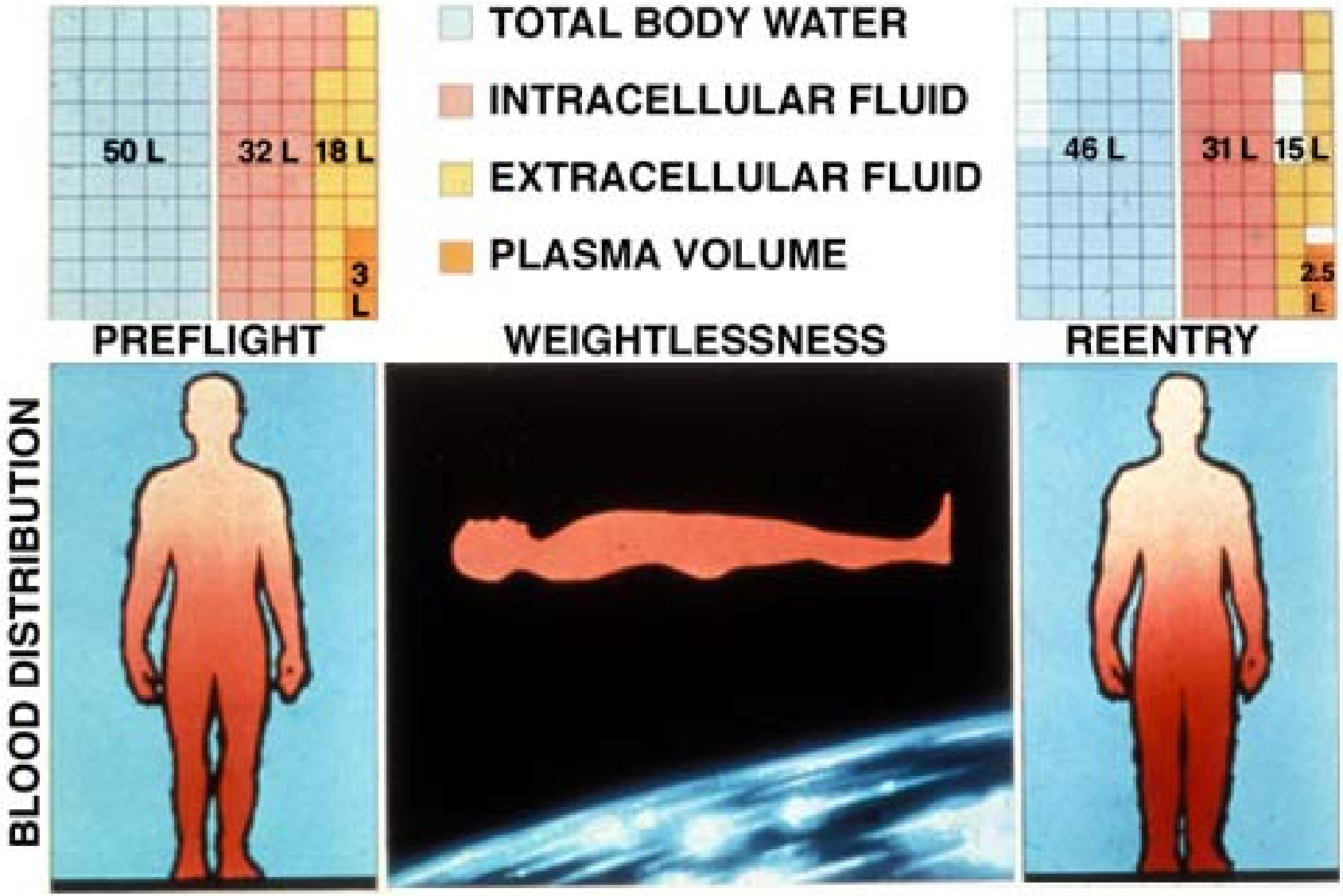

Courtesy: ASGSB

Fluid Shifts con't

- Rise in abdominal pressures
- Increased renal perfusion
- Increased arterial pressure
- Decreased PVR
- Increased SV
- Decreased HR
- Cardiac "overfill" due to cephalid fluid shifts leads to diuresis & mild dehydration

Fluid Shift Symptoms

Astronauts initially complain of*:

- Headaches
- Head & sinus congestion
- Engorged neck veins
- Increased urine output

Courtesy: ASGSB

** Overtime the symptoms abate*

Treatment for Fluid Shifts

Courtesy: ASGSB

- Symptoms abate during flight
- Upon return to Earth (1G) astronauts experience dizziness, orthostatic hypotension, possible syncope
  - Due to fluid redistribution to lower extremities
  - Flight rule: astronauts are required to drink 2 liters of salt solution prior to deorbit to potentially mitigate postflight orthostatic intolerance

Blood, Electrolytes, & Other

BLOOD

- Hgb & Hct unchanged
  - yet, hemoconcentration would be expected due to mild dehydration in-flight?
- RBCs decrease (“space anemia”)
  - mechanism is not completely understood
  - possible decrease in EPO production
  - another theory discusses loss of tissues with high O_2 requirements (e.g. muscle)

Blood, Electrolytes, con't

ELECTROLYTES

- information limited
- 6.3% loss of exchangeable K+
- net negative Na+ balance
- very low urine Na+ and K+
- http://www.femsinspace.com
  - William Rowe, MD (space enthusiast)
  - Mg++ discussion relative to spaceflight

Blood, Electrolytes, con't

- Plasma cholesterol & triglycerides decreased
- Plasma glucose decreases in longer duration spaceflights for 2 months then levels off
  - no serious reports of hypoglycemia in-flight
- Plasma alpha2-globins occasionally elevated, as well as IgA and C3 factor.

Considerations for the Infusion Nurse

- IV solutions do not drip
  - No gravity feed for infusions
- Active pump device required
- Delineated air-fluid lines nonexistent
  - air bubbles significant concern
- Mixed formulations can be prone to foaming

Considerations for IV Nurse con't

- Patients will need to be strapped to the wall; IV lines etc. tend to float
- Establishing IV lines will be a challenge
  --extremity vessels will be hard to locate due to fluid shifts and dehydration
  --engorged neck veins present a diagnostic challenge

Considerations for IV Nurse con't

- Infection control issues

  --no one knows how long an IV line can safely be left in place in space.

  --we do know that bacteria in space grow more rapidly and require larger doses of antibiotics to control their growth

  --increased infection concerns may increase line changes relative to Earth norms

Considerations for IV Nurse con't

- Medication stability

  ---radiation exposure may alter drug stability

  ---lack of refrigeration on ISS limits types of drugs that can be taken

  ---will drugs degrade more rapidly in space? Very likely, based on preliminary evidence!

Invitation to join the space experience

- Challenges of space exploration are significant
- However, every nursing specialty has something that it can contribute
- Although the opportunities in the US Space program are limited at this time, there are other ways to get involved

  ---the Space Nursing Society

  www.spacenursingsociety.com

  --- other space organizations (NSS, Mars Society)