Department of Medical Physiology

Space Physiology

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Space Physiology

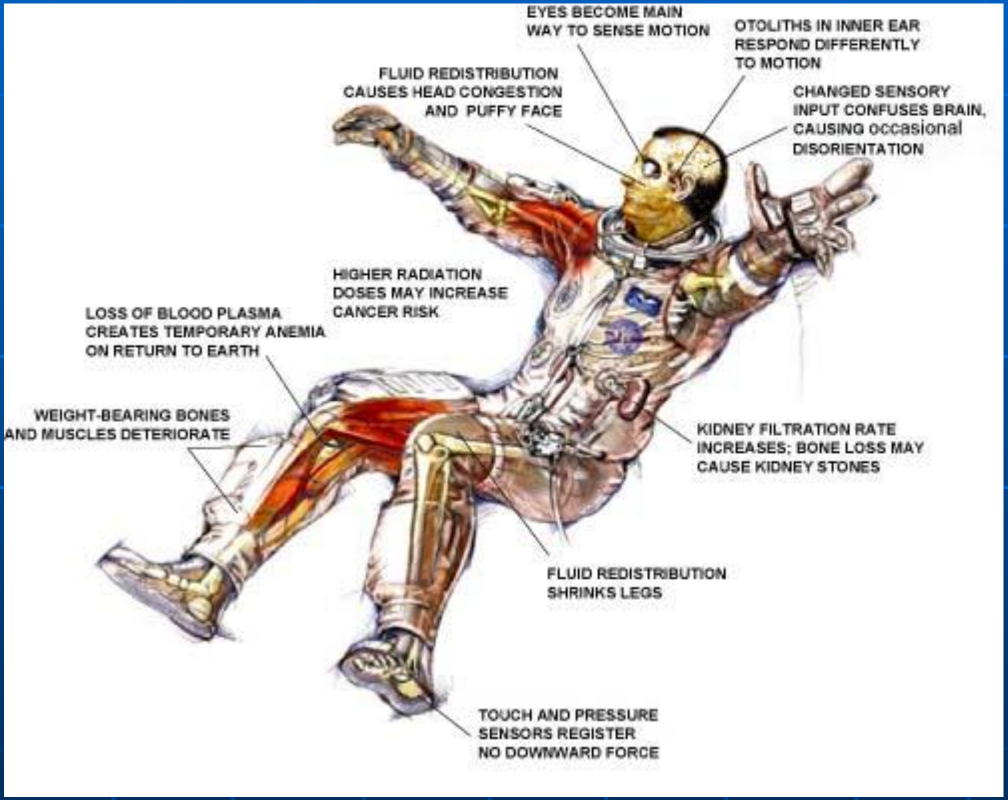
Buzz Aldrin on the Moon (July 1969)

- Space travel became a reality in 1961
- Since then, more than 500 people have been to space, and the duration of stays have increased from 2 hours to more than a year
- In the 21st Century common citizens will soon be able to travel and sight-see, or to live in space

Effect of Gravity I

- Before space can become a safe, habitable place we must solve many problems
- Space Medicine establishes the countermeasures to overcome the physiological effects of space

Effect of Gravity II



- Strange things happen to the human body when people venture into space and the familiar pull of gravity vanishes
- Gravity is a signal that tells the body how to act

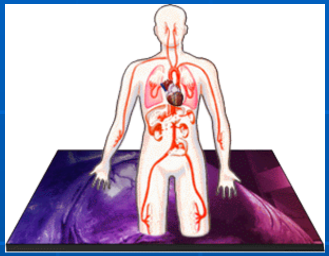
Effect of Gravity III

Astronauts on the International Space Station

- Weightlessness (more correctly termed microgravity) looks fun but it places demands on your body
- Initially you feel nauseated, dizzy, and disoriented
- Your head and sinuses swell and your legs shrink
- In the long-term your muscles weaken and your bones become brittle

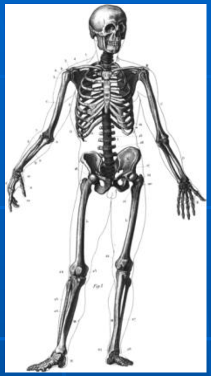
Space: systemic changes

Space Sickness

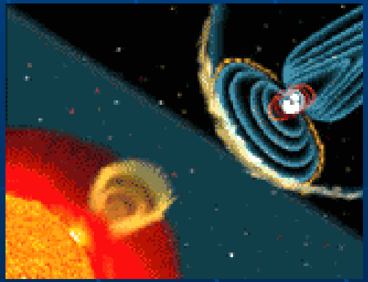


Circulatory System

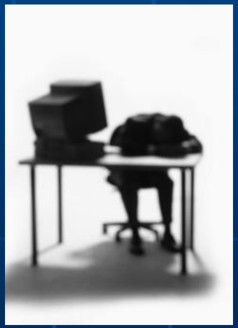
Muscles



Bones



Space Radiation



Stress and Fatigue

Recovery

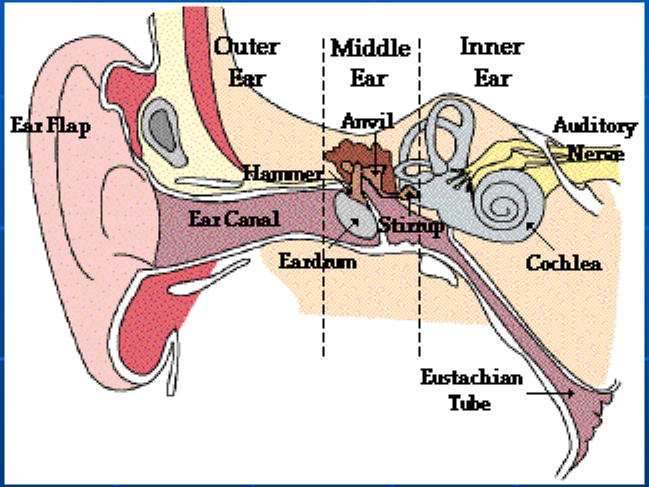
Future Space Travel

Space motion sickness

One astronaut lifting another with her finger
(photo courtesy of NASA)

- Space motion sickness is caused by conflicting information that your brain receives from your eyes and the vestibular organs in your inner ear
- Your eyes can see which way is up and down inside the space shuttle
- However the sensors in your vestibular system rely on the pull of gravity to tell you up versus down

Vestibular system 'malfunction'



The vestibular system is a fluid filled network of canals and chambers in the ear that help us keep our balance and know which way is up

- If you close your eyes in space how do you determine which way is up?
- With your eyes closed you can't tell
- The vestibular system doesn't sense the familiar pull of gravity and the world can seem topsy-turvy
- You can become confused and disoriented in an alien world where up and down have no meaning

Astronauts on the International Space Station posing upside-down (or is it right side up?)

- Your brain gets confused and produces nausea and disorientation which may lead to vomiting and loss of appetite
- Fortunately after a few days your brain adapts by relying solely on the visual inputs and you begin to feel better
- 60-70% of the astronauts experience these symptoms

An astronaut on Skylab

- In microgravity there is no natural “up” and “down” determined by our senses
- You don’t know the orientation of parts of your body, especially your arms and legs, because they have no weight for you to feel in space

Skylab 2 commander Charles Conrad submits to a dental Exam by Medical Office Joseph Kerwon

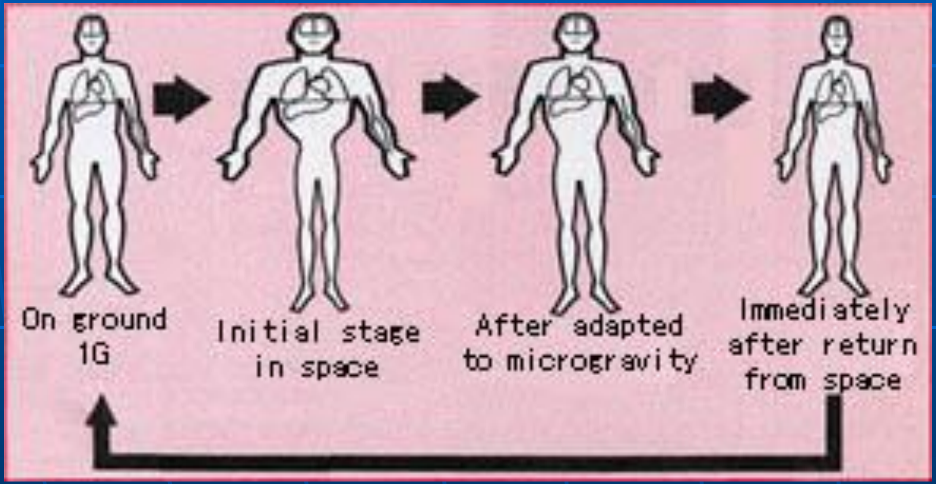
- The proprioceptive system, the nerves in the joints and muscle that tell us where our arms and legs are without having to look, can be fooled by the absence of weight
- One Gemini astronaut woke up in the dark during a mission and saw a disembodied glow-in-the-dark watch floating in front of him
- He realized moments later that the watch was around his own wrist

- Many apes have their internal organs tethered at the top and bottom so when they swing from trees or hang upside down the organs stay in place
- Human organs are tethered mainly at the top so in microgravity they tend to shift around and that can make us nauseous

Space motion sickness

- Astronauts suffering from space motion sickness may get a headache, lose their appetite, feel there is a "knot" in their stomach and find it difficult to work efficiently
- Some astronauts get sick and vomit
- Fortunately for most astronauts these effects last for only the first few days

Body Fluid Shift in space I



Fluid shift caused by space flight

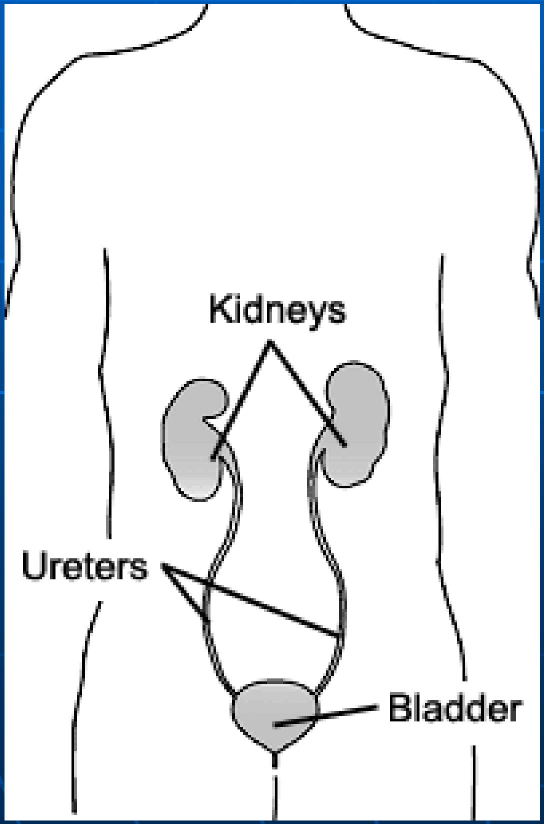
- On Earth gravity pulls on your blood causing it to pool in your legs
- In microgravity the blood shifts from your legs to your chest and head causing your legs to shrink in size
- This is called a "fluid shift"

Body Fluid Shift in space II

Astronaut Susan Helms on Earth (left) and in space (right)

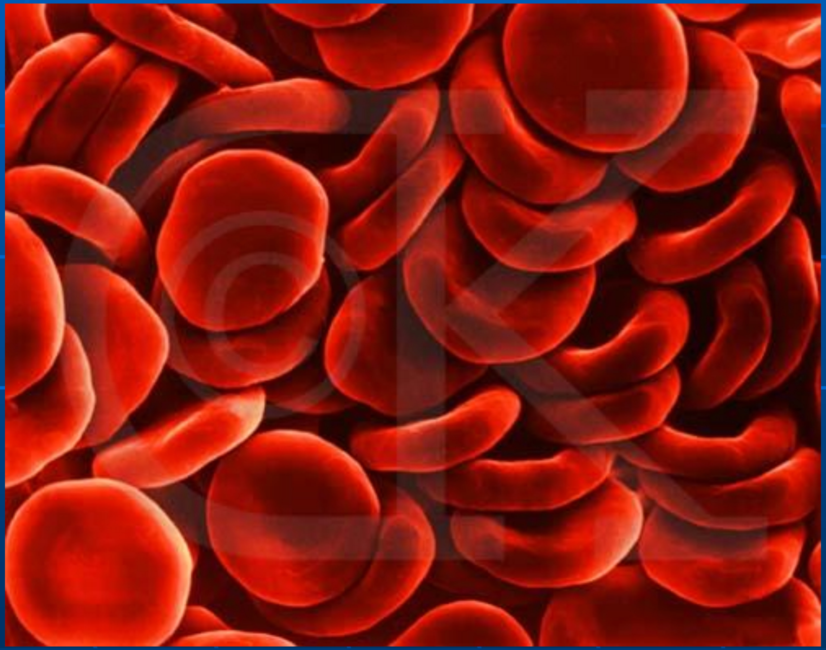
- In microgravity your face will feel full, your sinuses will feel congested, and you may get a headache
- You feel the same way on Earth when you bend over or stand upside down, because the blood rushes to your head

Body Fluid Shift in space III



- Your body senses an overabundance of fluids in the chest and head area and sends a message to the kidneys to eliminate the excess fluid by producing more urine
- Also you do not feel thirsty and decrease your fluid intake
- The result is up to a 22% loss of blood volume

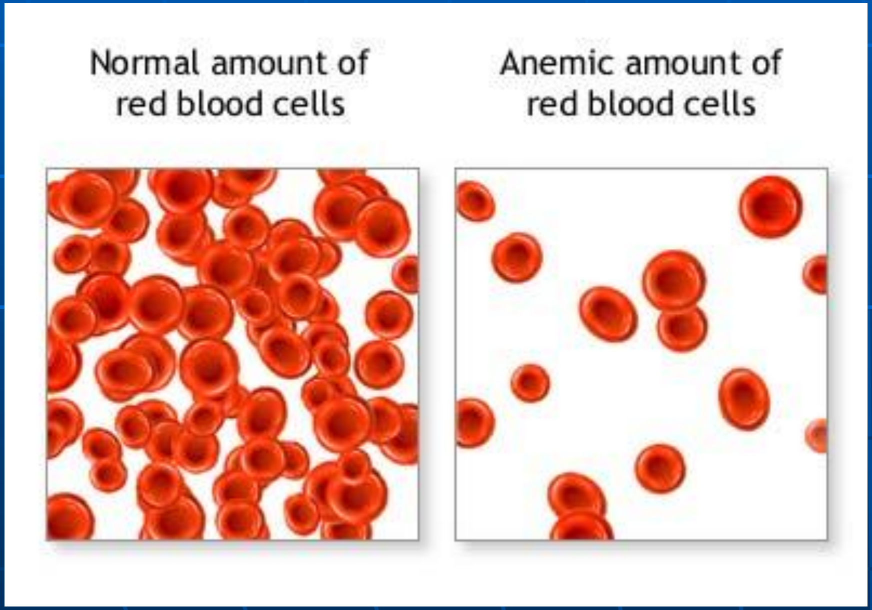
Anaemia: Renal Function



Red blood cells

- As your kidneys eliminate excess fluid, they also decrease their secretion of erythropoietin, a hormone that stimulates red blood cell production by bone marrow cells
- Anemia, the decrease of red blood cells in the blood, is observed within 4 days of spaceflight

Anaemia: Renal Function II



- The number of red blood cells will decrease by about 15% after a 3-month stay
- Upon returning to Earth your erythropoietin levels and red blood cell count will return to normal
- The activity of bacteria fighting lymphocytes (white blood cells) is slightly reduced but this rarely causes problems

Cardiac changes

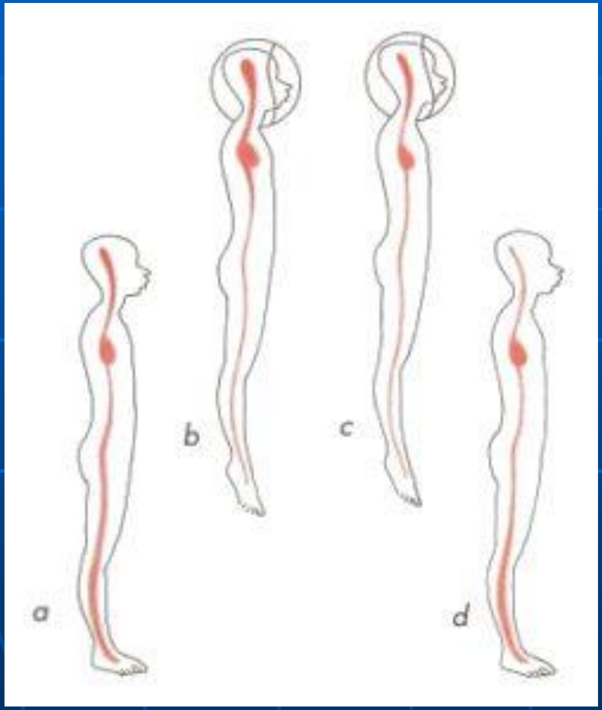
- The change in blood volume affects your heart, too
- If you have less blood volume then your heart doesn't need to pump as hard
- It also takes less energy to move around the spacecraft
- Because it no longer has to work as hard, your heart will shrink in size

Lower Body Negative Pressure

Test of the LBNP device
(photo courtesy of NASA)

- One way to deal with fluid loss in space is with a device called Lower Body Negative Pressure (LBNP)
- This device applies a vacuum-cleaner-like suction below your waist to keep fluids down in the legs
- In space you may spend 30 minutes a day in the LBNP to keep the circulatory system in near-Earth condition

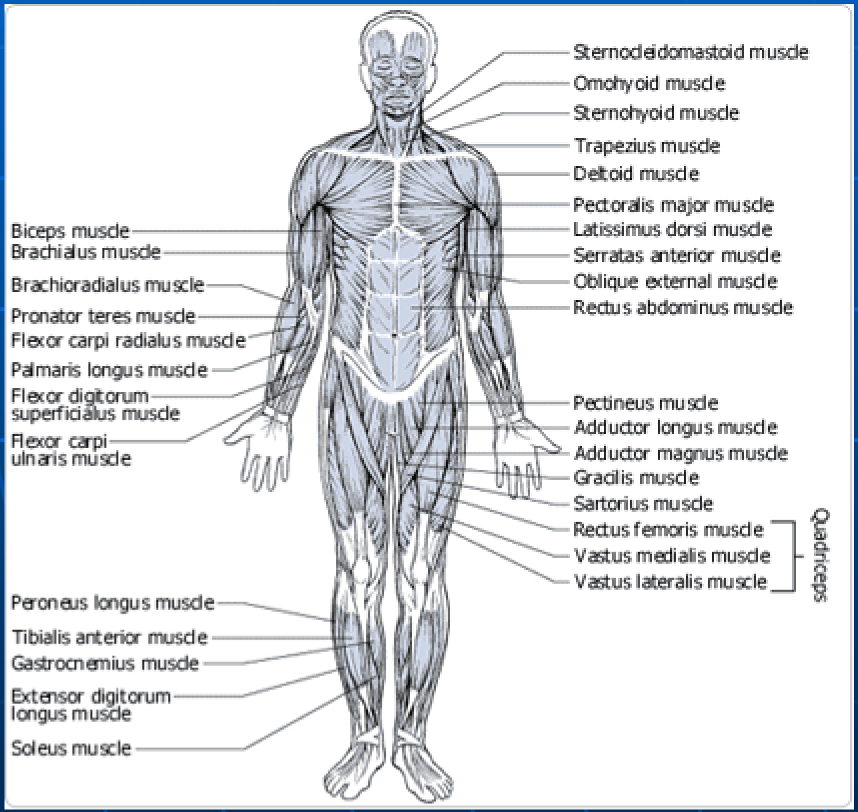
Return to Earth Changes



a. Fluid distribution on Earth
b. In microgravity fluids redistribute
c. Kidneys eliminate fluids
d. Returning to Earth

- Upon returning to Earth, gravity will pull those fluids back down to your legs and away from your head causing you to feel faint when you stand up
- But you will also begin to drink more and your fluid levels will return to normal in a few days

Microgravity: Effects on muscles



- In microgravity your muscles atrophy quickly because your body perceives it does not need them
- The muscles used to fight gravity and maintain posture can vanish at the rate of 5% a week

Physical exercise training

Astronaut exercising in space

- Exercise is the key
- But exercising in space differs from exercising on Earth
- On Earth the pull of gravity provides a resistive force that maintains muscles and bones
- In space even if you do the same amount of exercise you are missing that gravity component

The Neurolab crew floats on the Space Shuttle Columbia in May 1998 (photo courtesy of NASA)

- Much more research needs to be done to develop countermeasures to the body’s changes in microgravity
- This research must be conducted both on Earth and in outer space
- The results will help to improve the health of astronauts and pave the way for long-term space exploration, such as a trip to Mars