

# Lunar Horizon and Biomedical Research



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# Problems in Space Travel

- Space Adaptation Syndrome
- Syncope on return to  $G=1$
- Osteoporosis (kidney stones)
- Muscle atrophy
- Anemia
- Psychological

# Biomedical Research: Why the Moon?



# Biomedical Research

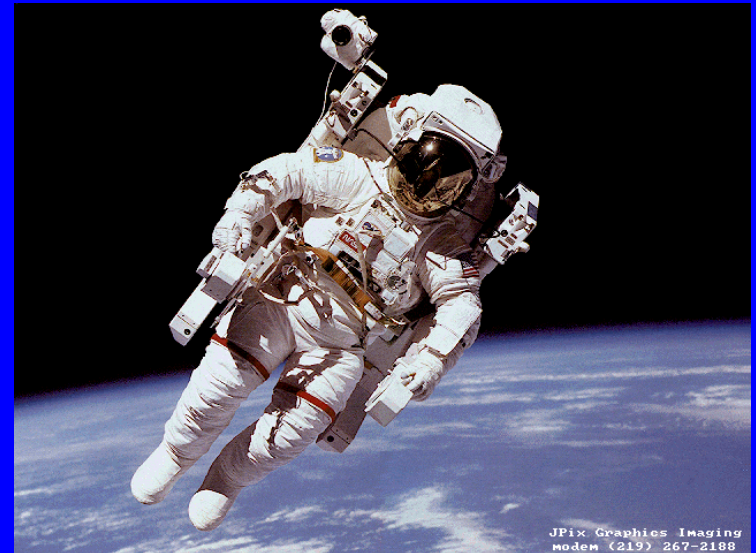
## Why the Moon?



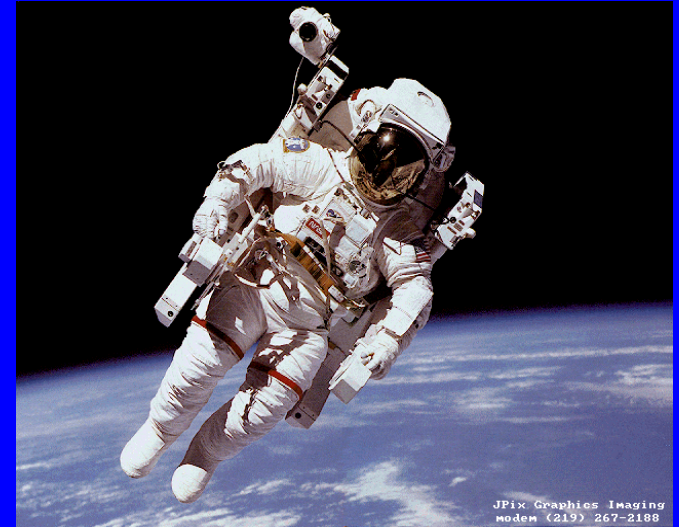
- It is close to Earth (3 days)
- Its gravity is optimal for many studies
  - 1/6 the gravity of Earth
  - 1/2 the gravity of Mars
  - Not too low and not too high
- Laboratory for all other space exploration

# Lunar-Based Biomedical Research

- Microgravity (ISS)
  - $G \sim 1/10,000$
- Parabolic Flight (KC-135)
  - $G \sim 1/10$  (15 sec)
- Hypogravity (Moon)
  - $G \sim 1/6$
- Hypogravity (Mars)
  - $G \sim 1/3$



# Biomedical Research in Microgravity: Priorities



- Understanding the Medical Problems of Human Space Exploration
- Preventing or Attenuating these Medical Problems
- Elucidating the Effect of Gravity on Biological Processes from Basic Sciences to Clinical Research

# Plants and Gravity

- Plant Physiology
- Gravity and Plant Processes
- Lunar Horticulture



*Arabidopsis*

# Reproduction and Development

- Many generations of model microorganisms
- Multiple generations of model plants
  - Arabidopsis
- Multiple generations of model animals
  - Mice
  - *Caenorhabditis elegans*
  - Zebrafish

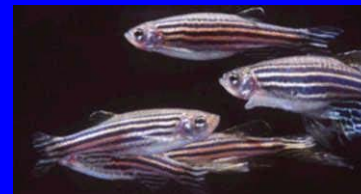


Image source: Jürgen Berger & Ralf Sommer, Max-Planck Institute for Developmental Biology

# Radiation Hazard

- Fred Singer presentation



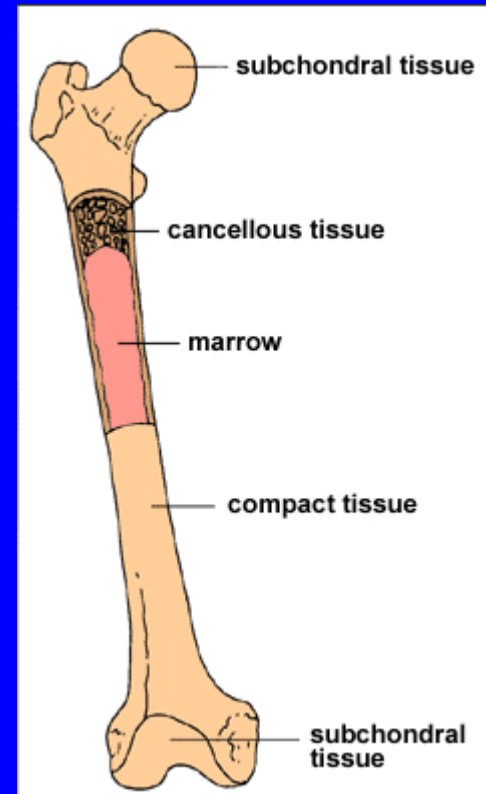
# Bone Physiology

- Gravity Mechanical Effects
- Bone Remodeling
  - Bone Formation (osteoblasts)
  - Bone Resorption (osteoclasts)
- Calcium Loss
  - As much as 1% per month



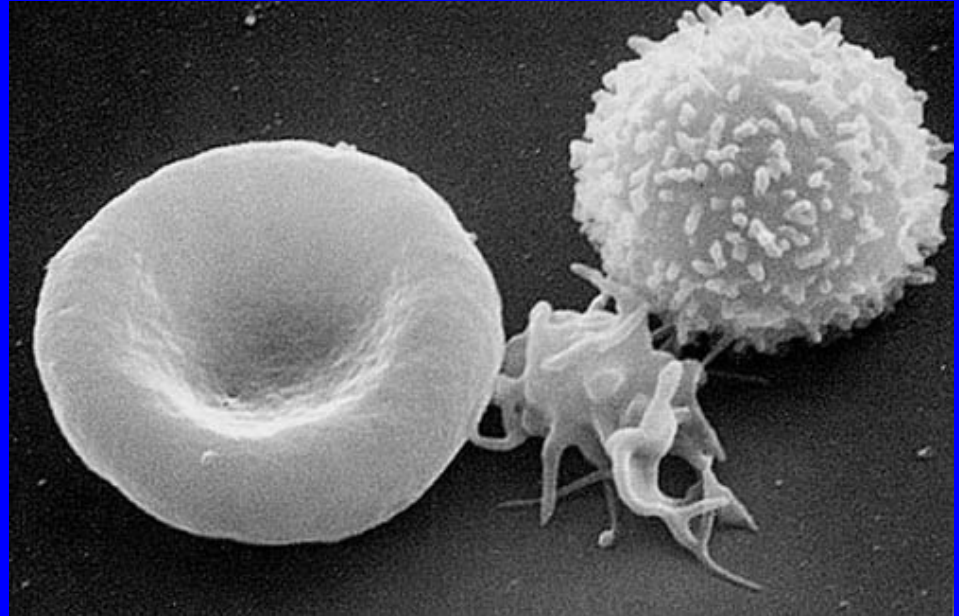
# Bone Research

- Mechanistic studies addressing hypogravity effect on bone
- Mechanistic and applied countermeasures against bone loss

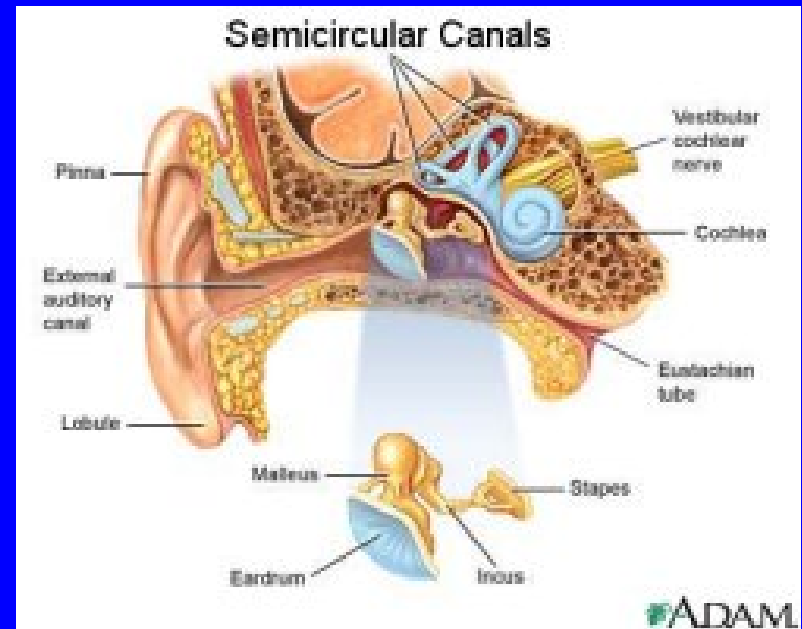


# Immunology

- Is Immune Function Altered in Hypogravity?



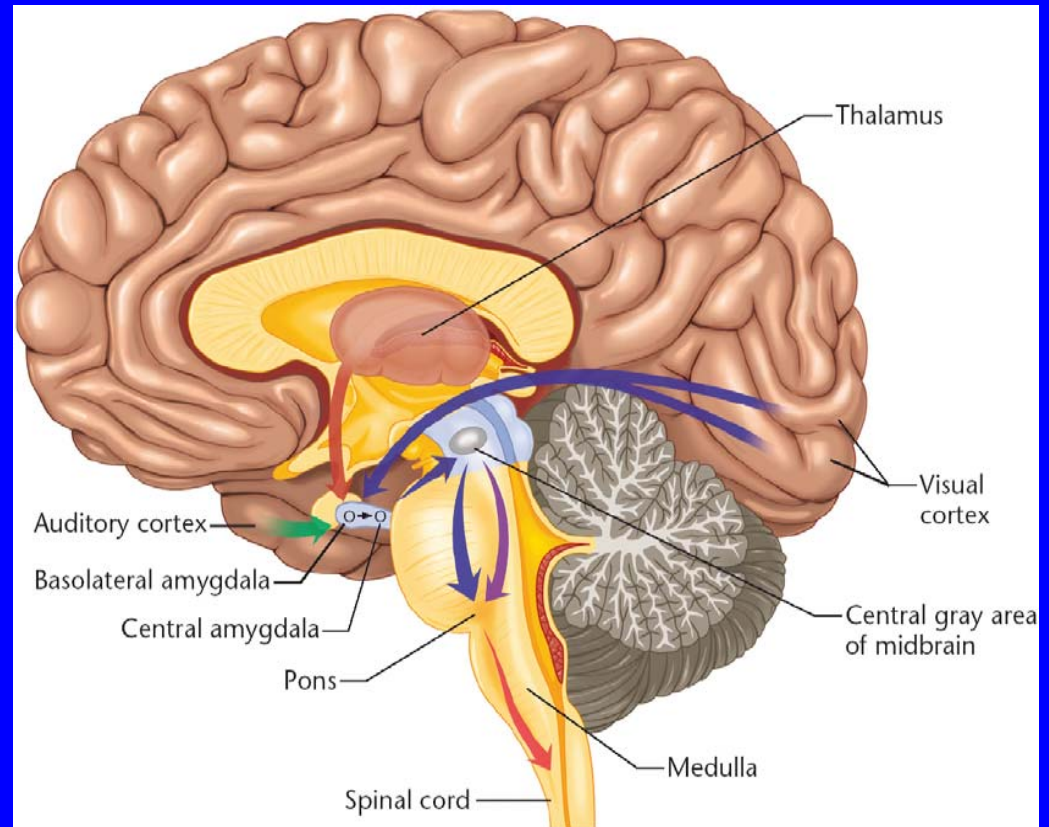
# Vestibular Function



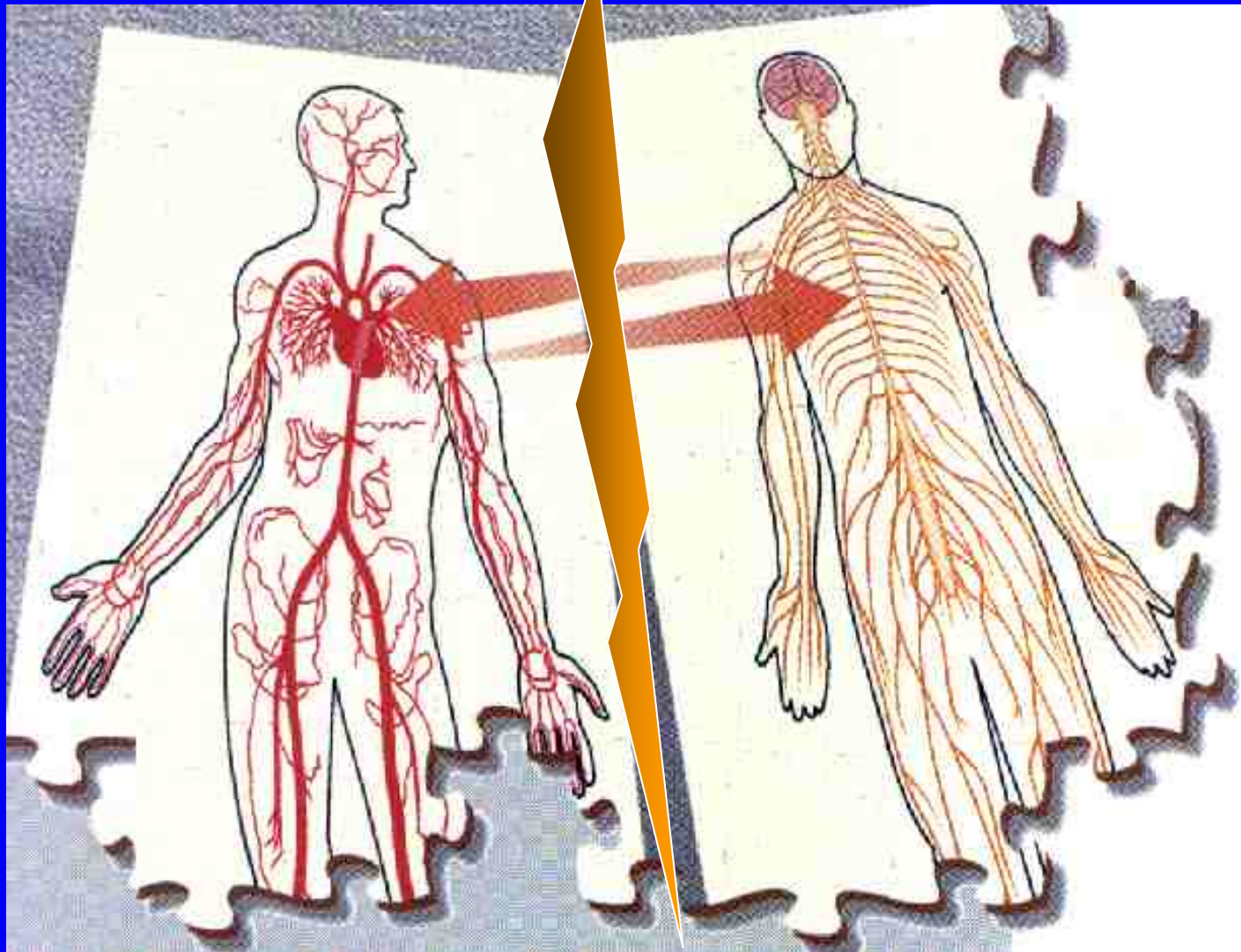
- Normal Function at 1 G
- Impairment in Microgravity
- Is it a Problem in Hypogravity?

# Stress

- Neuronal
- Endocrine
- Psychological

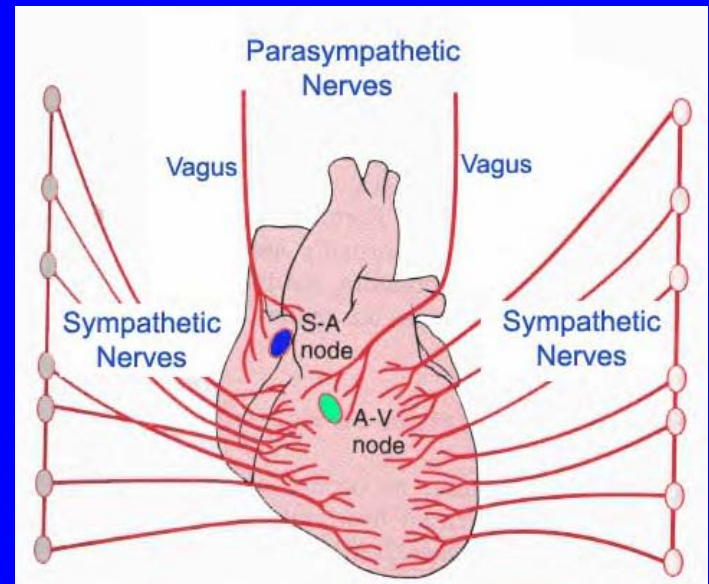


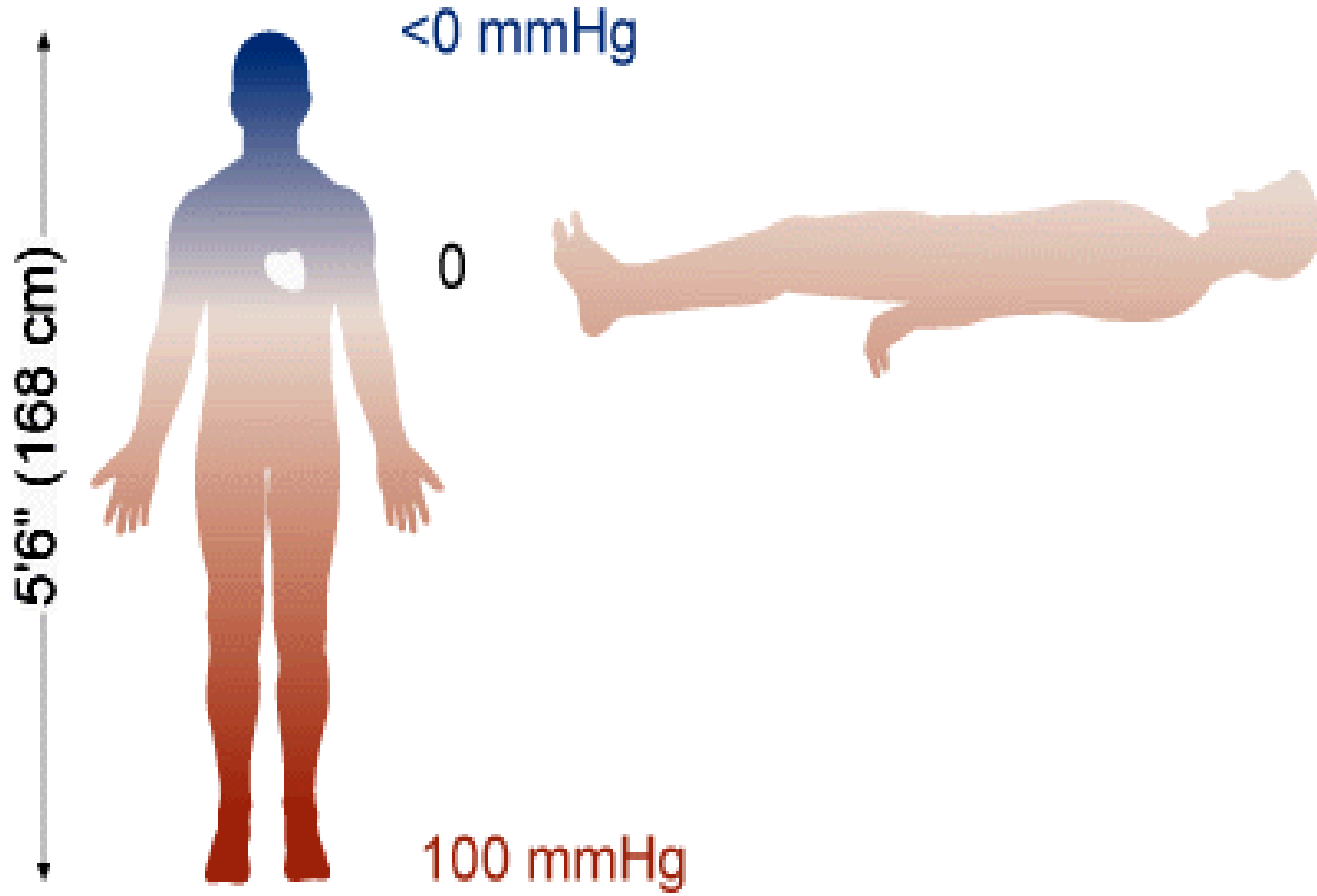
# Autonomic Nervous System and Cardiovascular System



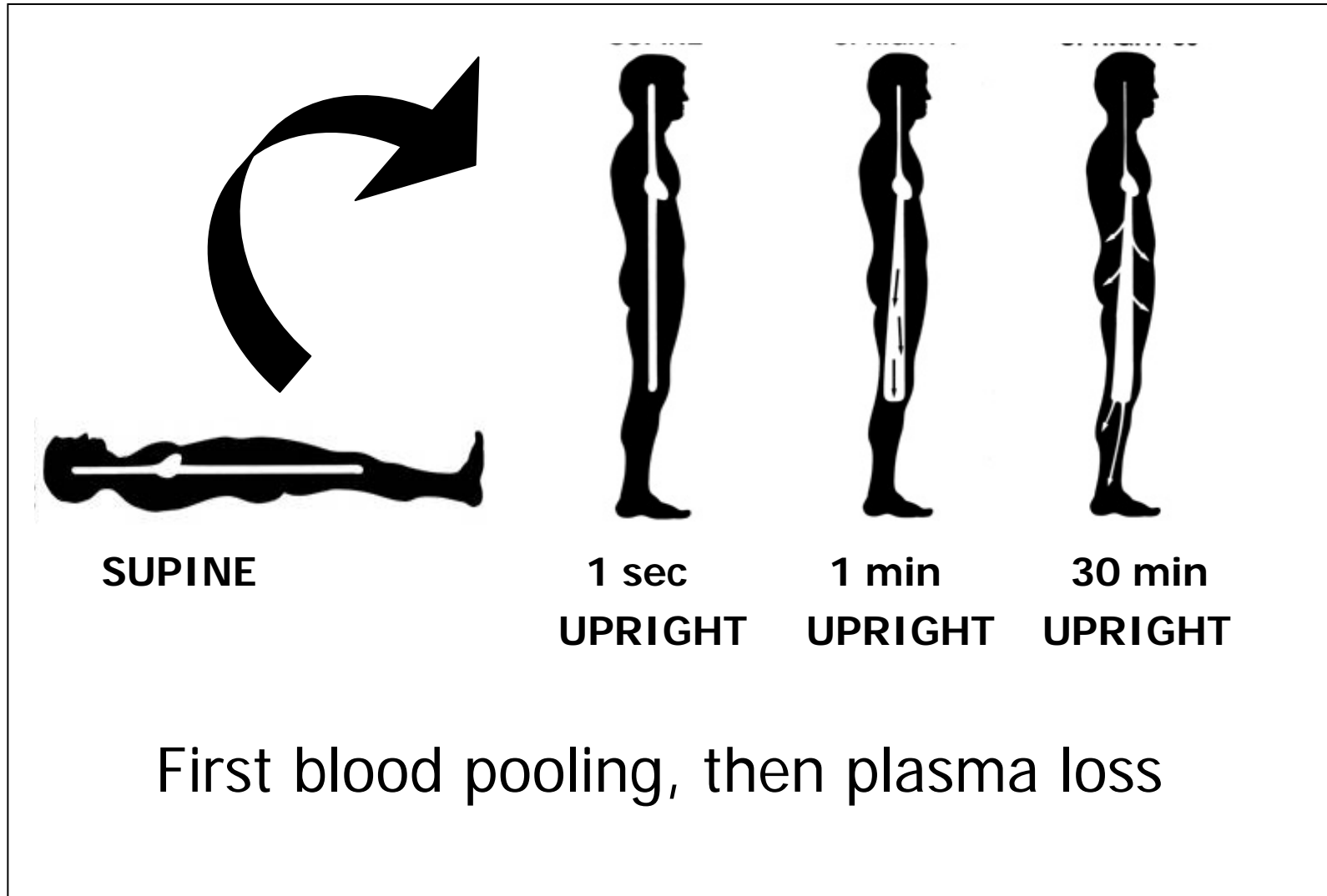
# Cardiovascular Risk

- Cardiac Arrhythmia
- Stress Intolerance
- Diminished Cardiac Function
- Impaired Vascular Function
- Orthostatic Intolerance

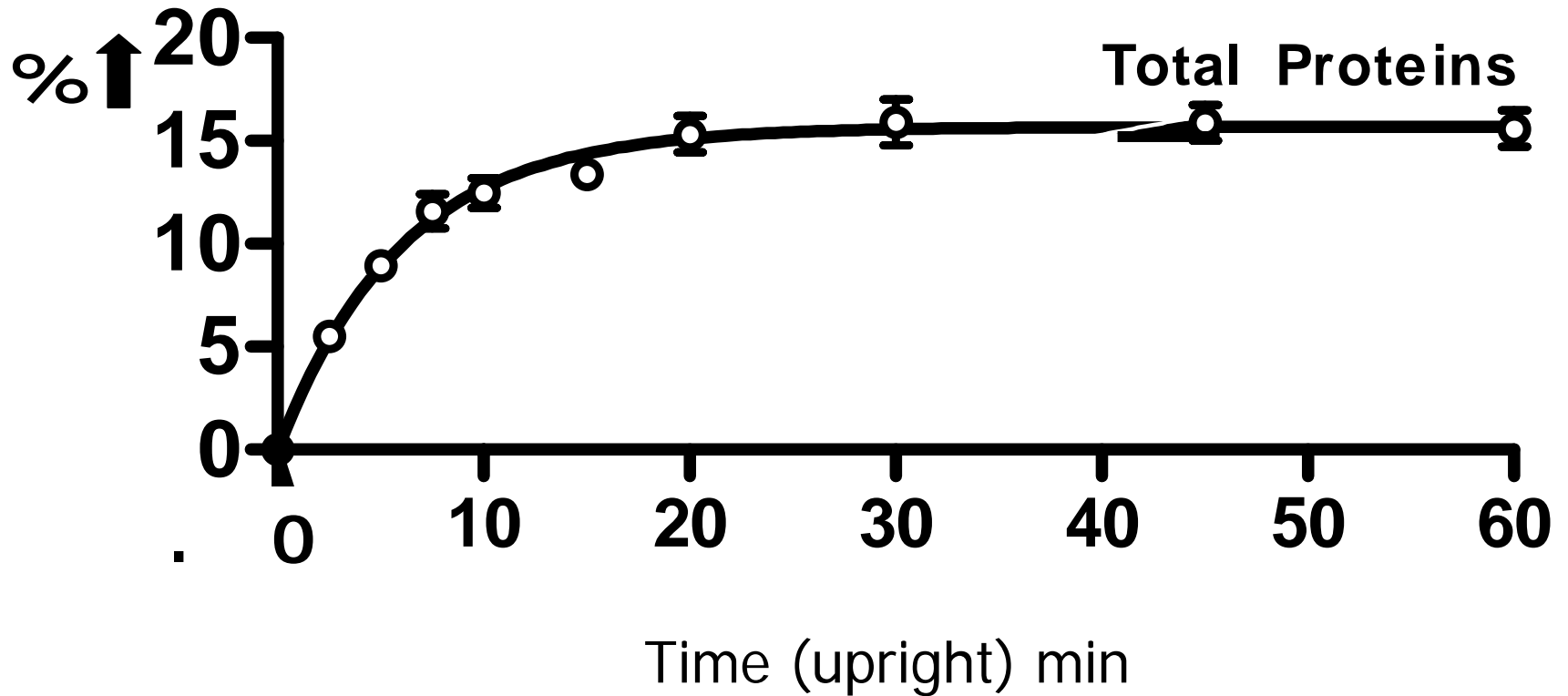




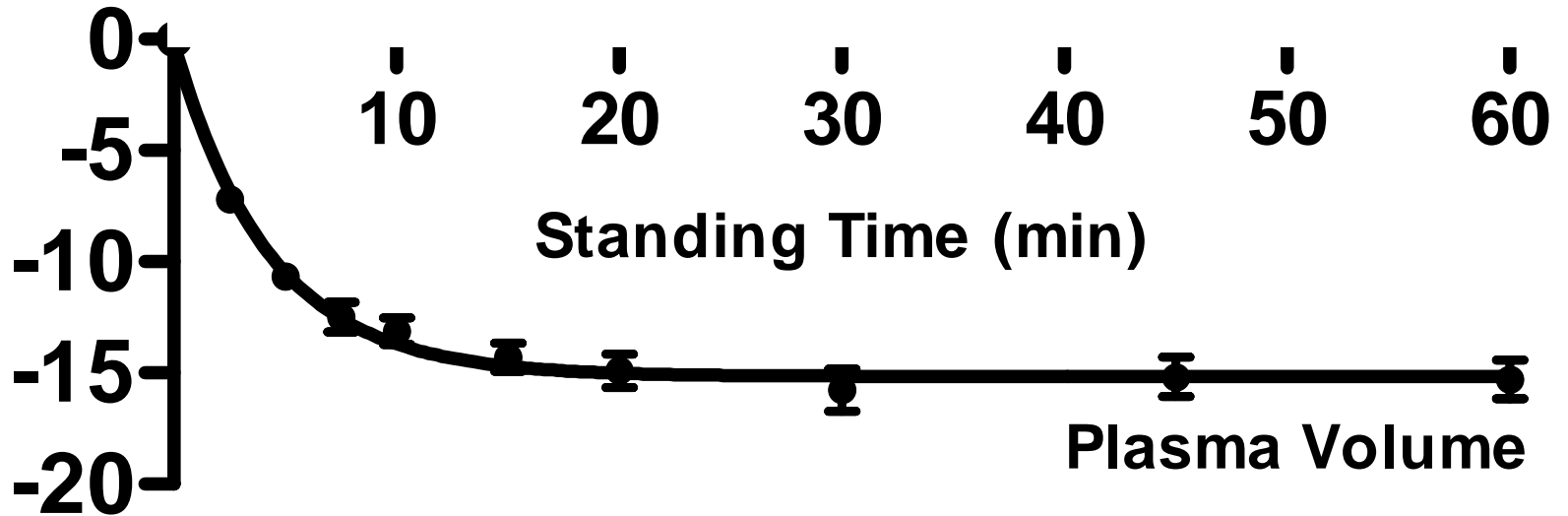
# Postural Hemodynamics



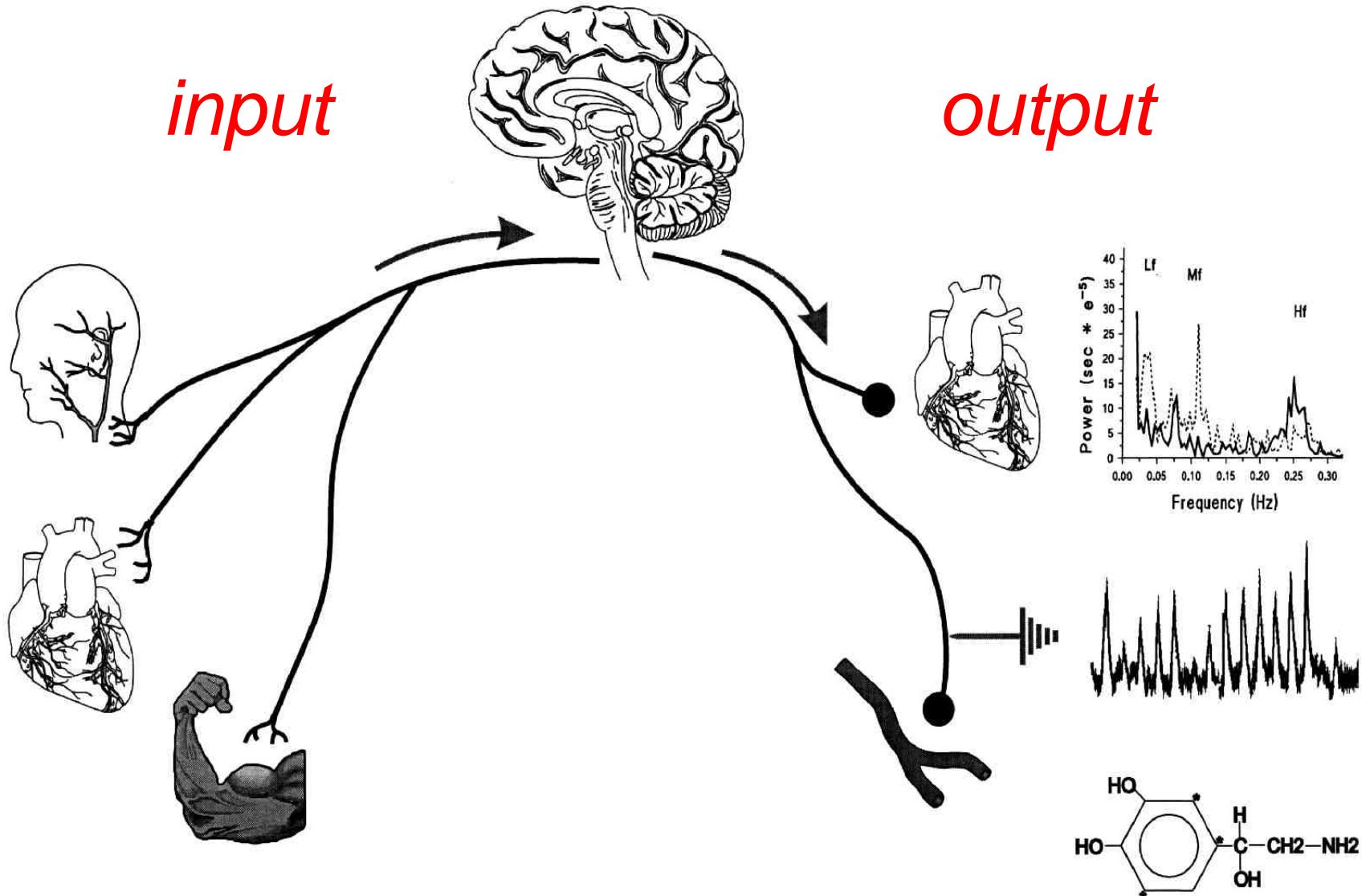
# Plasma Protein Increase on Standing



# Gravity-Induced Plasma Volume Loss With Standing

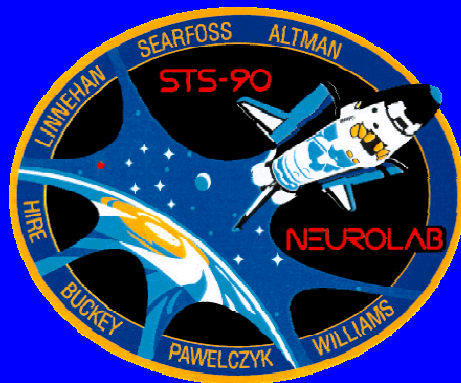


# Sympathetic Cardiovascular Regulation

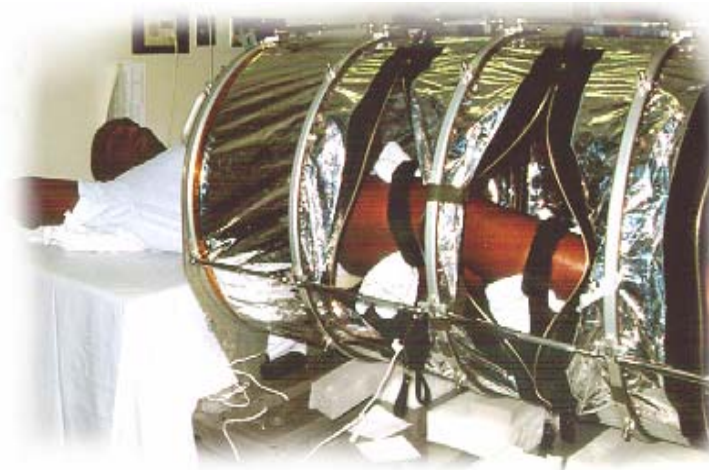
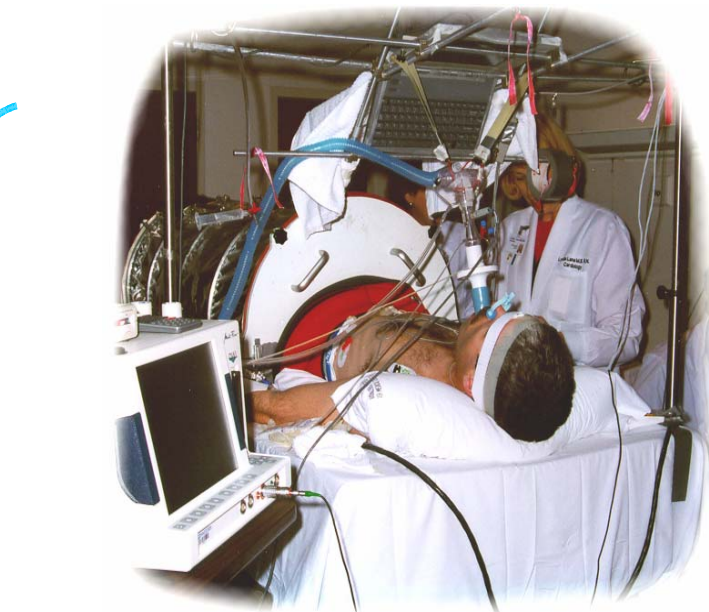
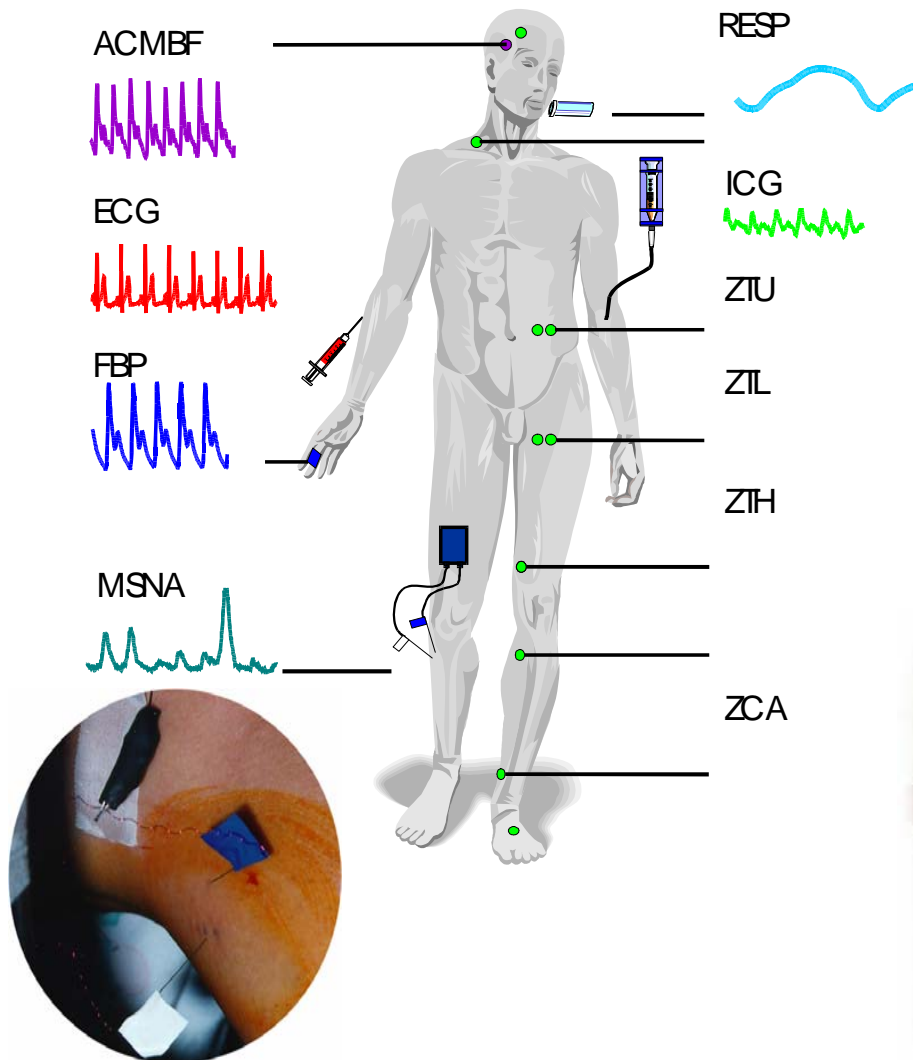




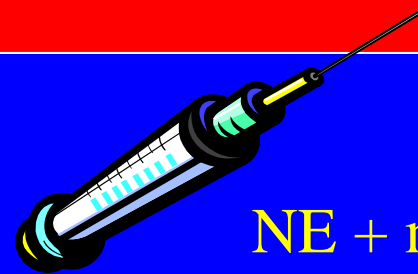
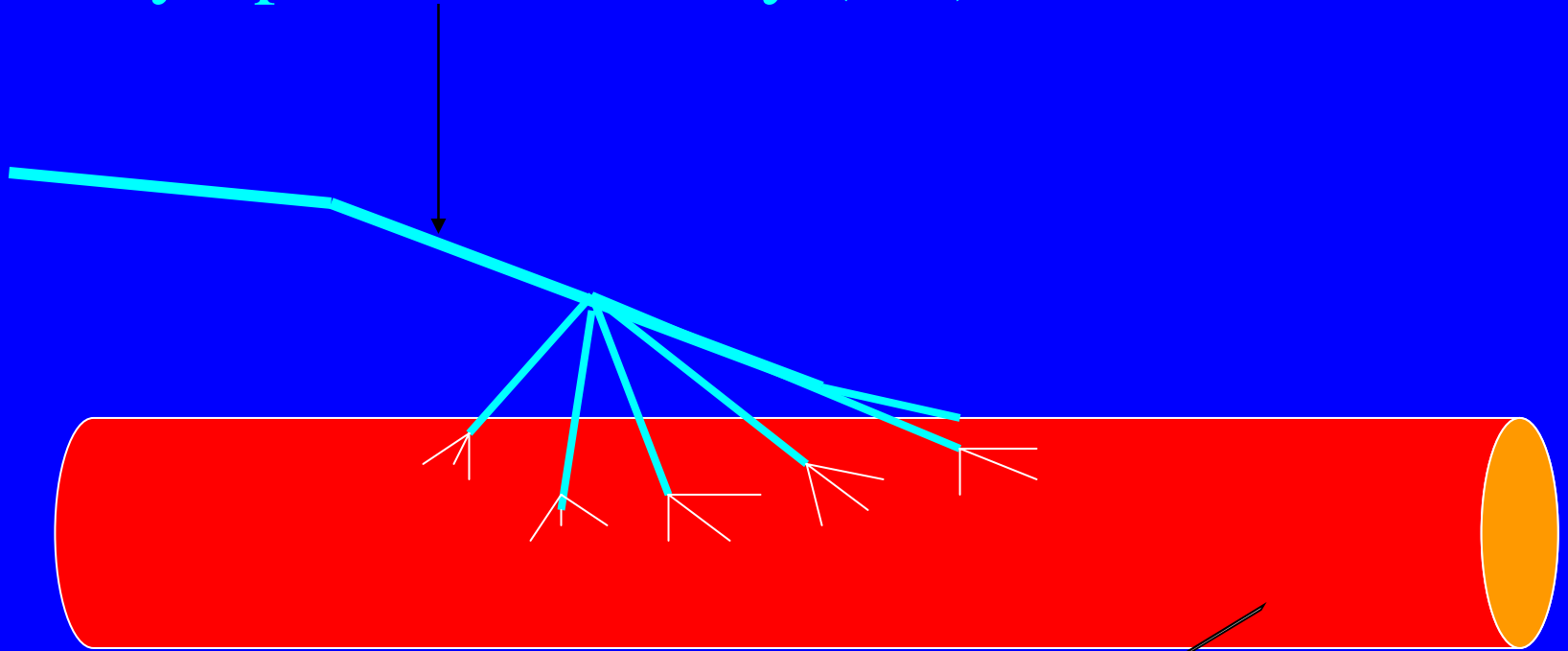
# *Neurolab - A study of the nervous system in space*



# Instrumentation

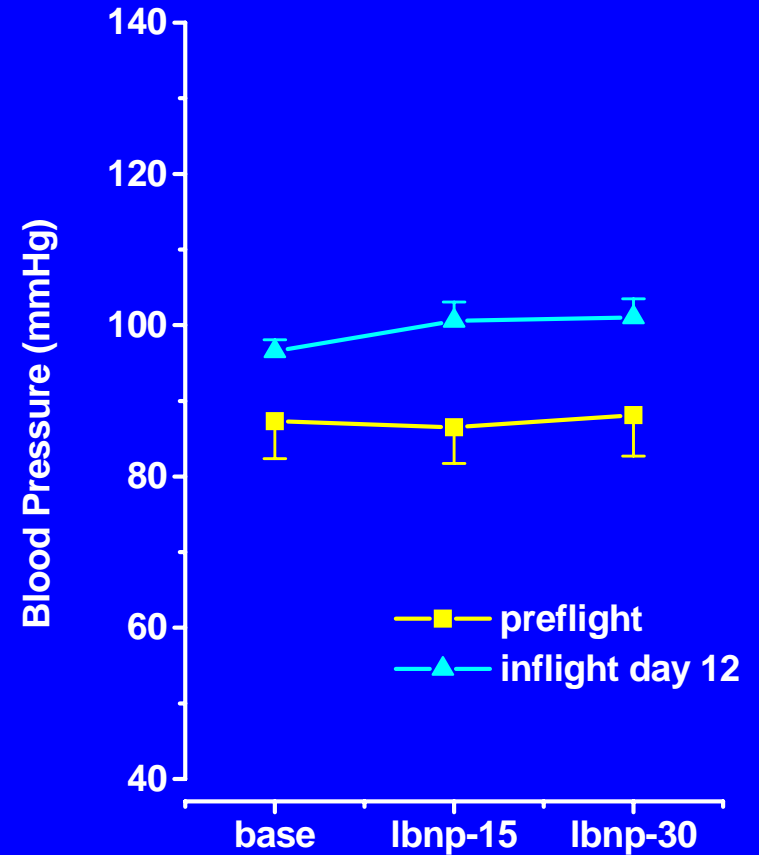
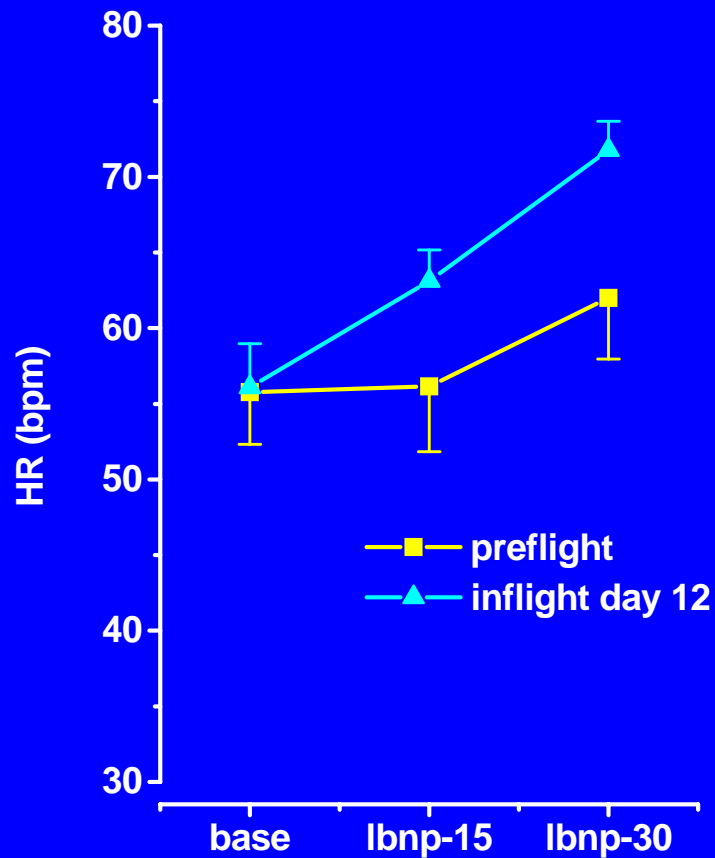


# Sympathetic Activity (SA)

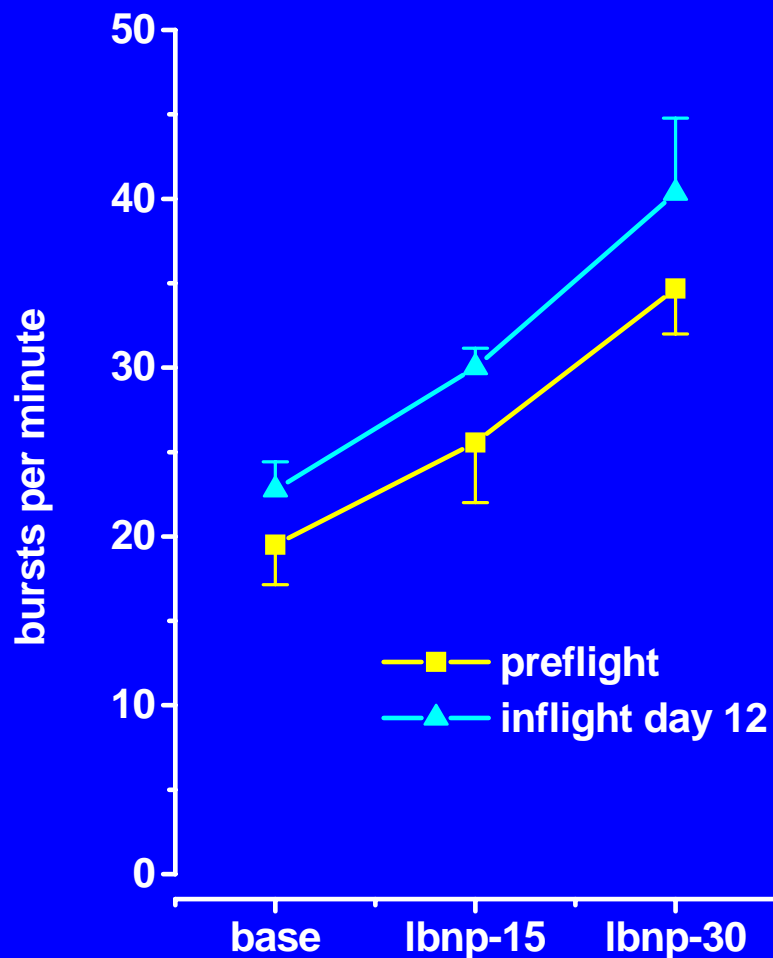


NE + metabolites

# *Heart rate and blood pressure during LBNP, preflight and inflight day 12*



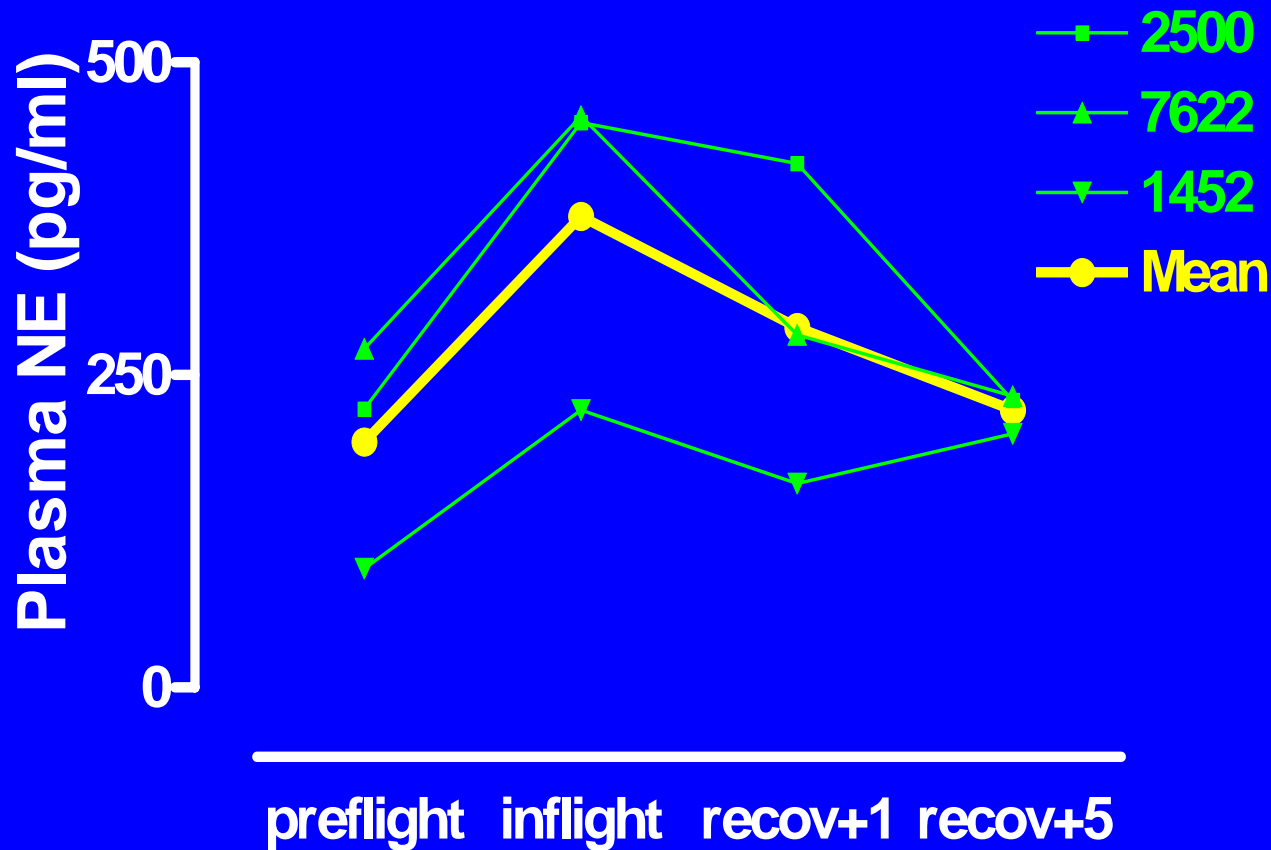
# *Muscle sympathetic nerve activity during LBNP, preflight and inflight day 12)*



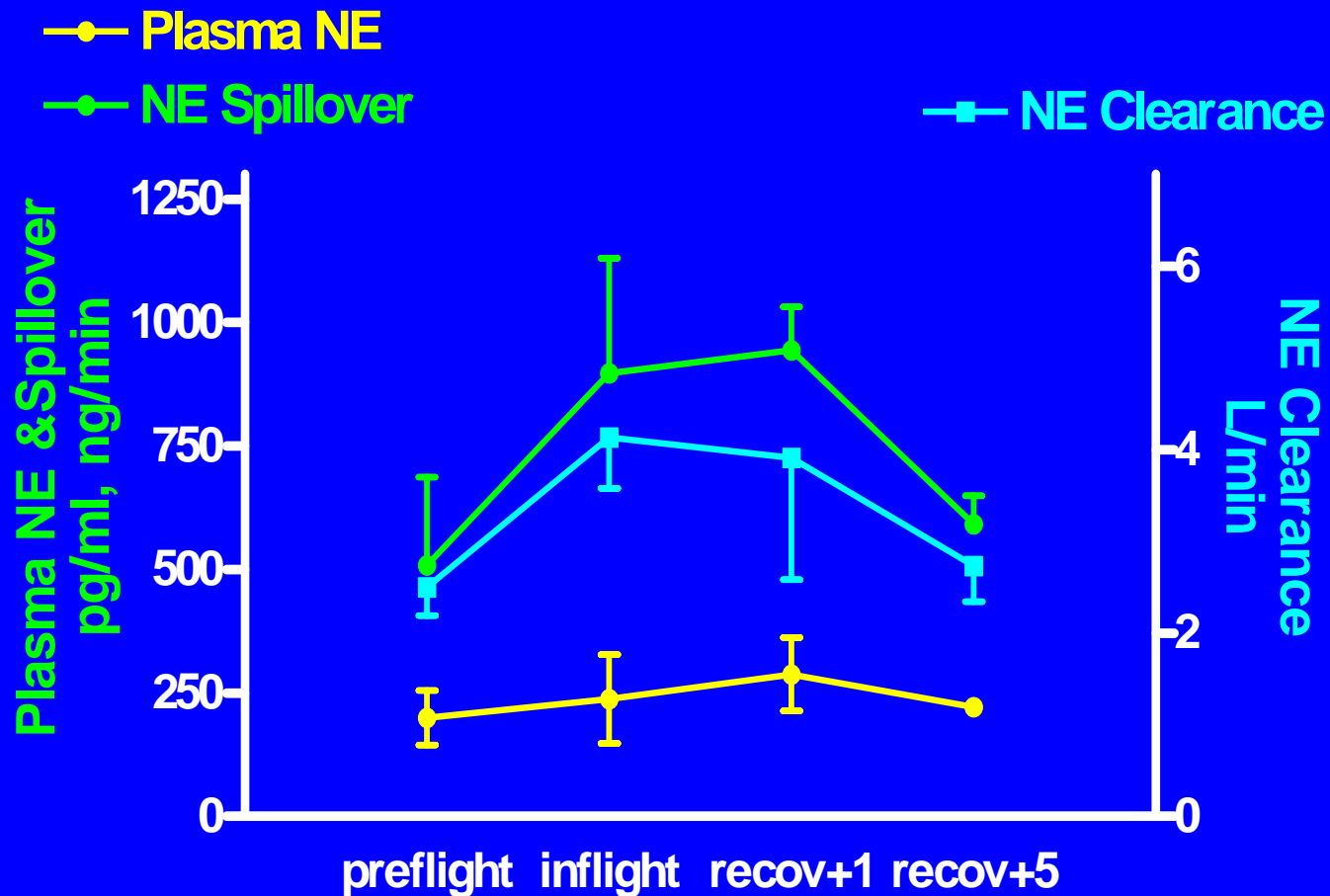
Mean/SE n=3



# *Effect of Space Flight on Plasma Norepinephrine at Rest*



# *Plasma Norepinephrine, Clearance and Spillover preflight, inflight (day 12), and postflight recovery (days 1 and 5)*



# *Neurolab*

- Autonomic function is altered in space.
- Sympathetic activity, as determined by muscle sympathetic nerve traffic and NE spillover, is increased.



# *Shuttle Scientific Missions*

- Plasma volume is reduced ~10% in space.
- These adaptive changes are evident upon return to 1 G, and recover within five days.



# Cardiovascular Countermeasures 1

- Artificial Gravity
- G Suit
- Lower Body Negative Pressure
- Exercise
- Impedence Threshold Device
- Respiratory Maneuvers

# Cardiovascular Countermeasures 2

- Saline Loading
- Water Loading
- Fludrocortisone
- Midodrine

# Conclusions

- A lunar base can provide a unique environment for biomedical research.
- It can yield a long-term hypogravity ( $1/6$  G) signal that can aid in calibrating physiological effects of gravity.
- The gravity “dose” on the moon may have special relevance for the mean gravity dose that will be experienced on the mission to Mars.



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