



# Human Responses to Space Flight and

# STS-95:

A Collaboration  
Between NASA  
and NIH

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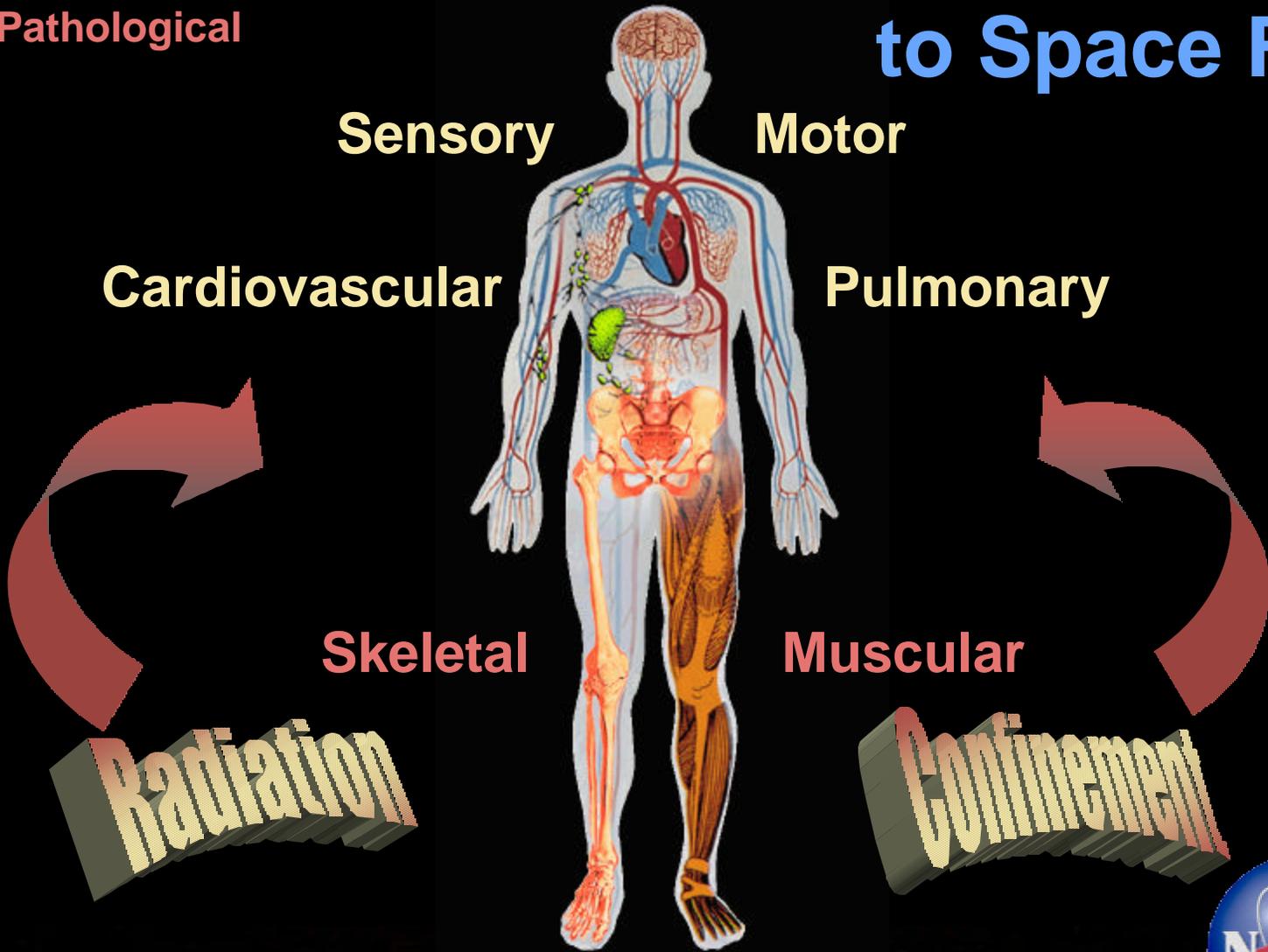
*Associate Administrator*

*NASA Office of Life & Microgravity Sciences &  
Applications*



# Human Response to Space Flight

- Adaptive
- Pathological



**Radiation**

**Confinement**



Rapid changes  
in function and  
structure to high  
or low  
acceleration  
forces

**In Flight**

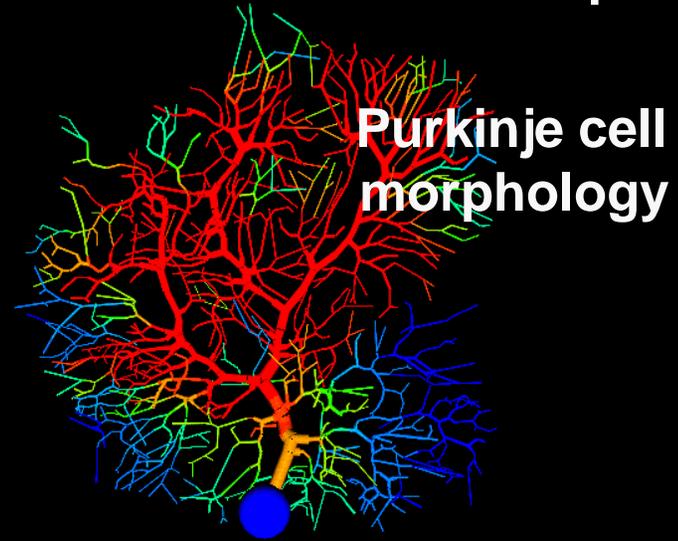
*Space Motion  
Sickness*



**Synapses**

**Adaptation**

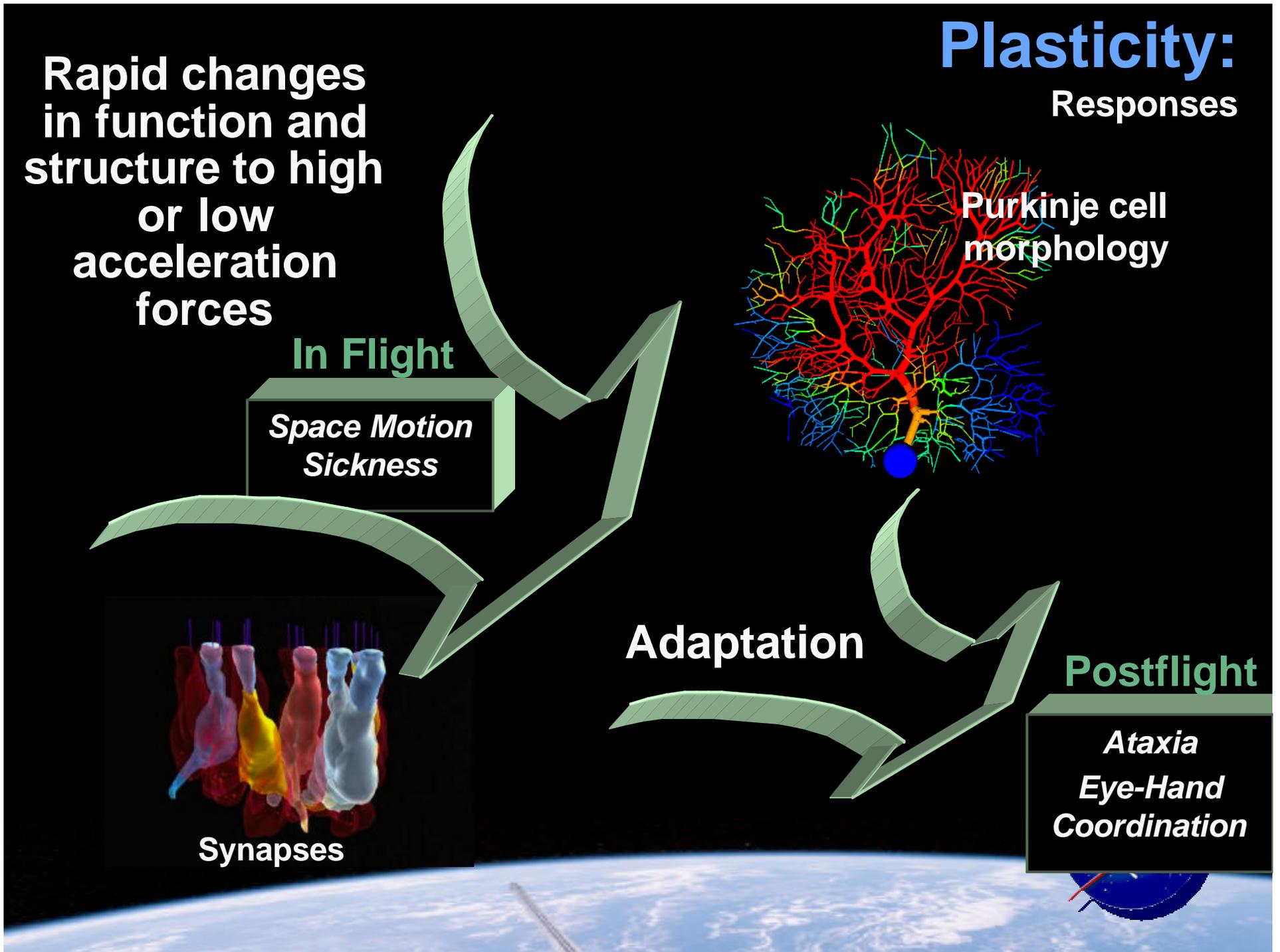
**Plasticity:**  
Responses



**Purkinje cell  
morphology**

**Postflight**

*Ataxia  
Eye-Hand  
Coordination*



# Orthostatic Intolerance:

Hypothesis

**Preflight**

Muscle  
sympathetic  
nerve activity

+

Norepinephrine  
spillover &  
clearance

=

Standing &  
posture

Fluids  
+muscle  
sympathetic  
nerve activity

+

Norepinephrine  
spillover &  
clearance

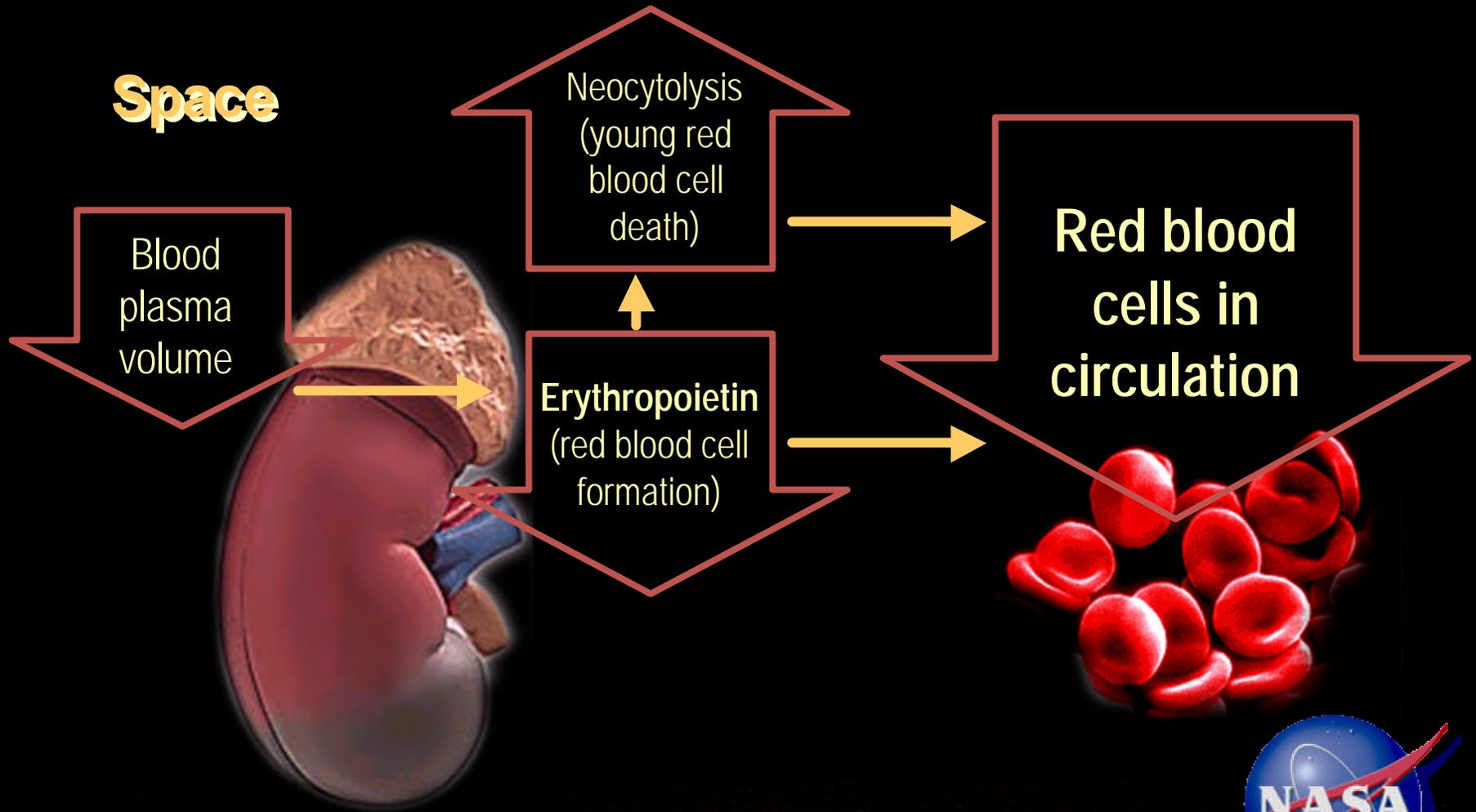
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Dizziness  
upon  
standing

**Postflight**



# Red Blood Cell Response



# Muscle Fiber Response

Earth

TSH

+

IGF-1  
receptor?

=

Slow and  
Fast-twitch  
Muscle  
Fibers

*Proposed causal pathway*

TSH

+

IGF-1  
receptor?

=

Slow-twitch  
Muscle Fiber

Space



# Bone Formation & Density

Earth

PTH  
&  
IGF-I

Osteoprogenitor  
Number &  
Bone  
Mineralization

Space

PTH  
&  
IGF-I

Osteoprogenitor  
Number &  
Bone  
Mineralization



# Changes Induced by Space Flight

## *In Flight*

- Muscle & bone loss

## *Postflight*

- Balance disorders
- Cardiovascular deconditioning

*Adaptation to microgravity and readaptation to 1 g parallel some aging processes without chronic disease manifestation.*

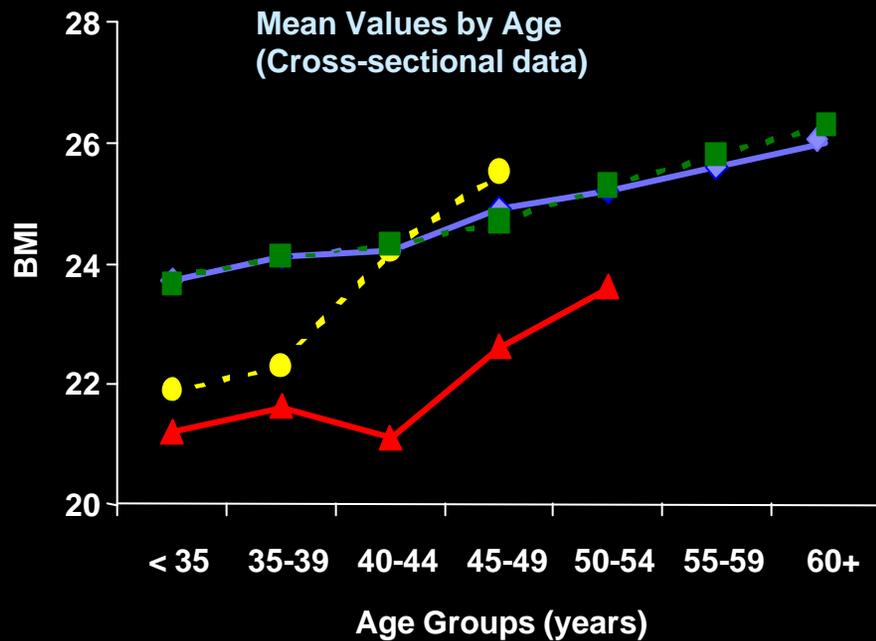


John Glenn from 1964

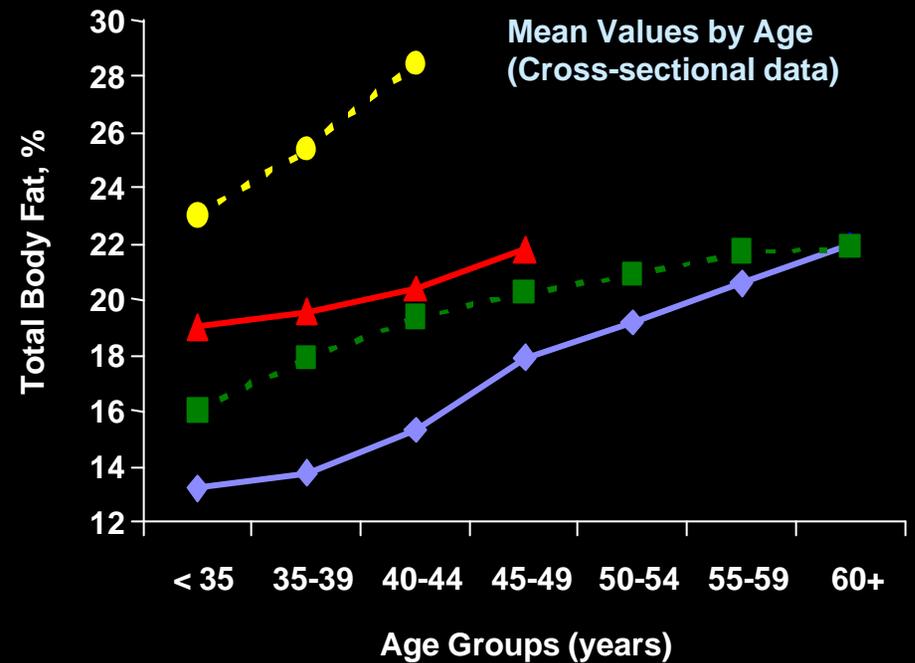


# Baseline Data from LSAH

## Body Mass Index (BMI)



## Total Body Fat

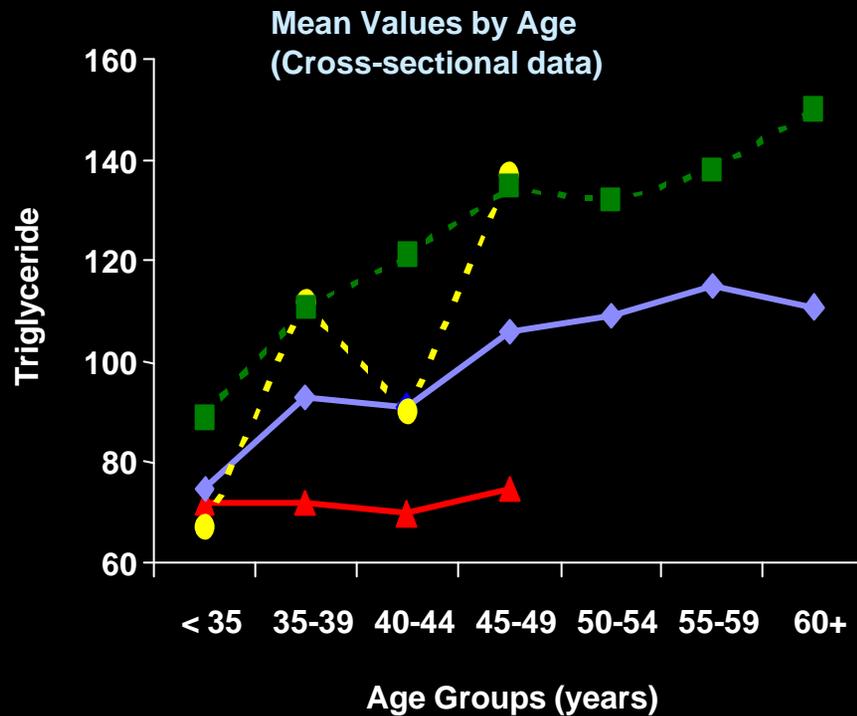


▲ Female Astronauts  
◆ Male Astronauts

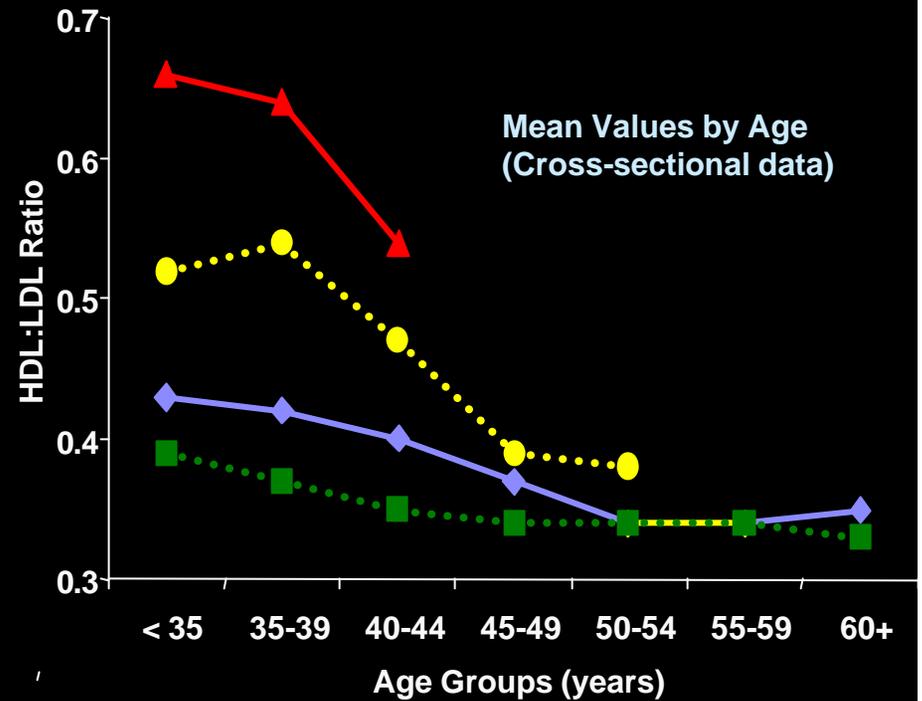
● Female Comparisons  
■ Male Comparisons



## Triglyceride



## HDL:LDL Ratio

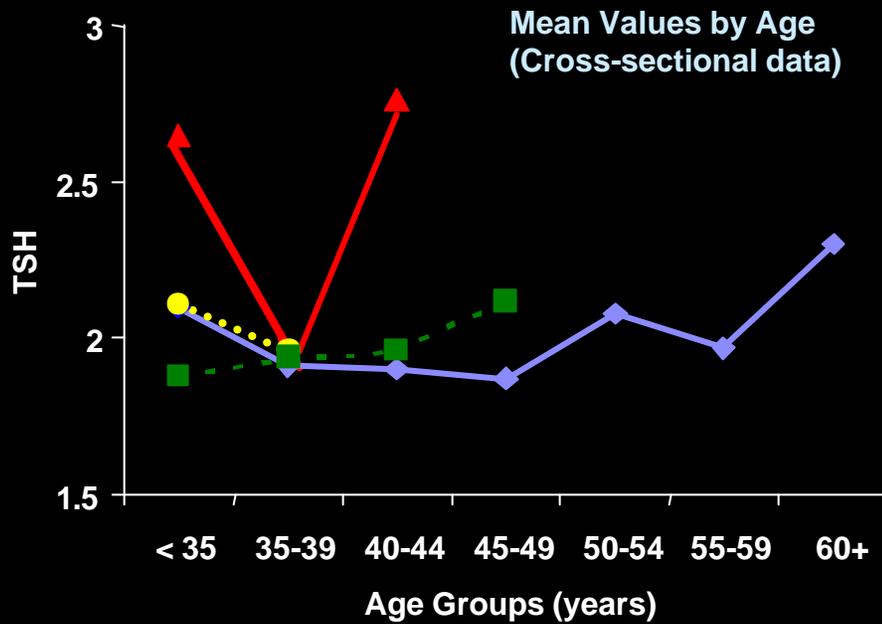


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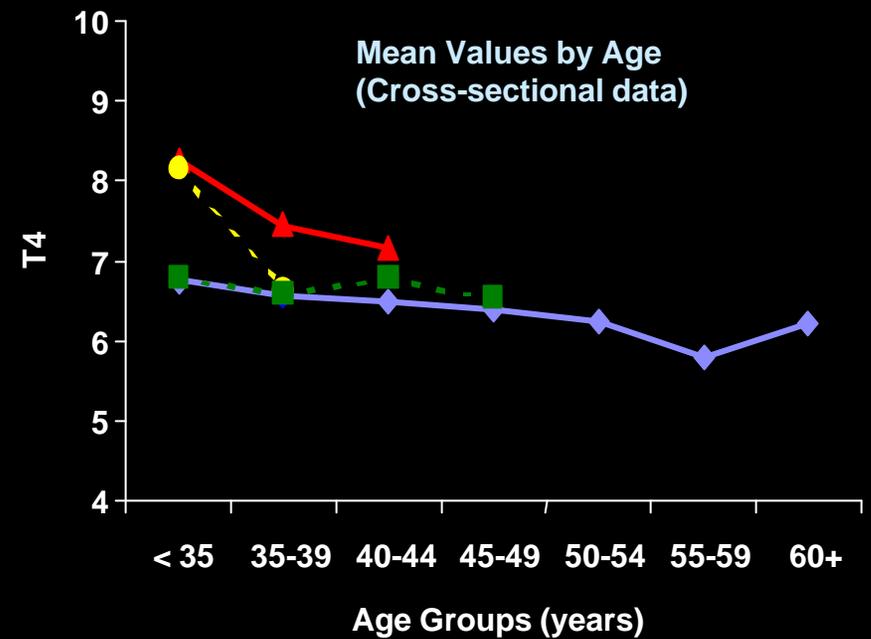
● Female Comparisons  
■ Male Comparisons



## Thyroid Stimulating Hormone (TSH)



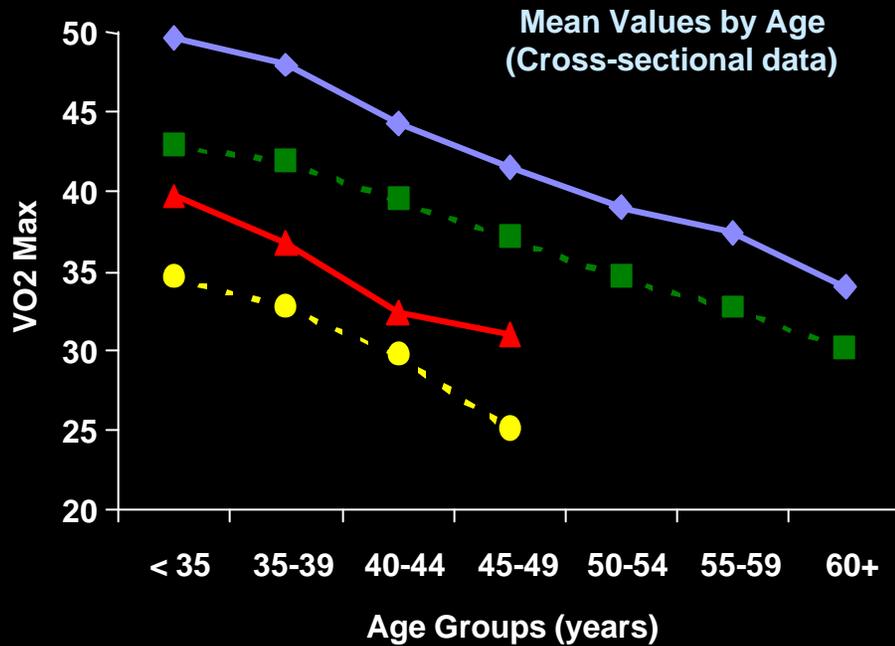
## Thyroxine (T4)



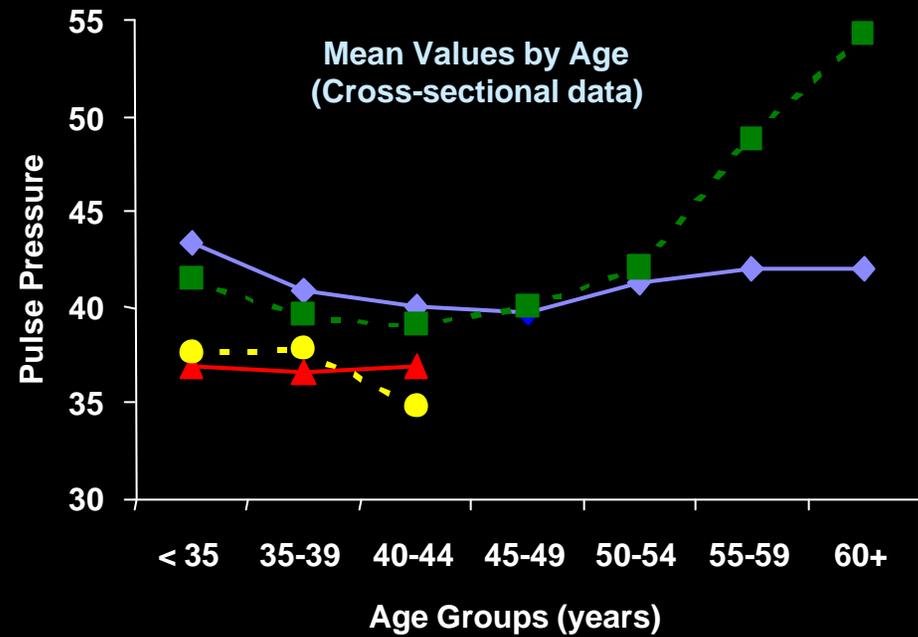
- ▲ Female Astronauts
- ◆ Male Astronauts
- Female Comparisons
- Male Comparisons



## VO<sub>2</sub> Max



## Pulse Pressure



▲ Female Astronauts

◆ Male Astronauts

-●- Female Comparisons

-■- Male Comparisons



# October 29, 1998



**Commander:** Curtis L. Brown

**Pilot:** Steven W. Lindsey

**Mission Specialist 1:** Stephen K. Robinson

**Mission Specialist 2:** Scott E. Parazynski

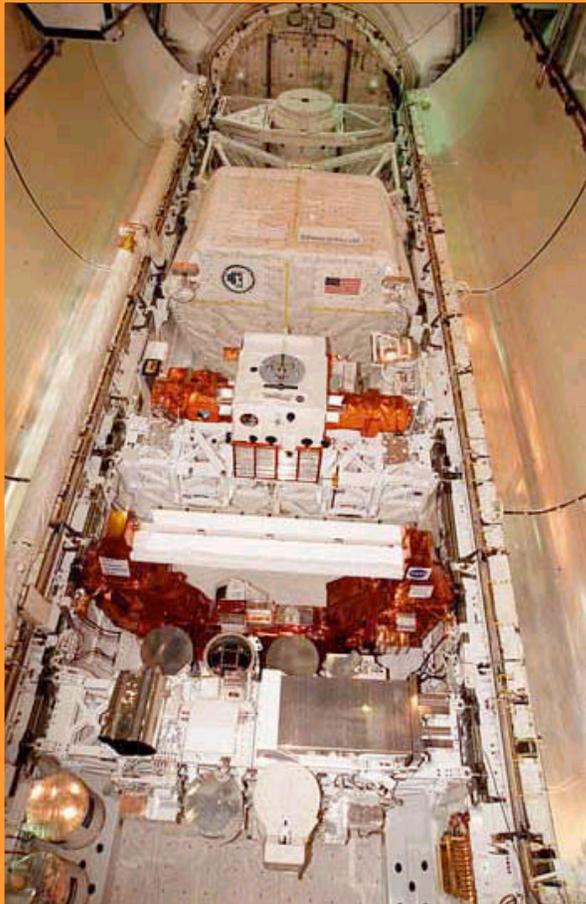
**Mission Specialist 3:** Pedro Duque

**Payload Specialist 1:** Chiaki Mukai

**Payload Specialist 2:** John H. Glenn

# STS-95 Research Agenda

*A view of the SPACEHAB module on STS-95*



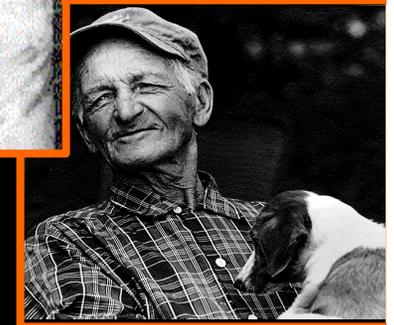
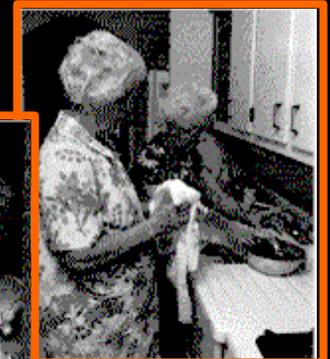
## *Investigations included:*

- Life Sciences
  - Collaboration with NIH/NIA
  - Baltimore Longitudinal Study on Aging
- Astronomy
- Commercial

*SPACEHAB, Inc., initiated a buyback program, whereby payload space was sold to commercial interests for stowage in its pressurized module.*

# STS-95 Goal

*To expand scientific understanding in the life and physical sciences, including an examination of the parallels between aging and spaceflight (short-duration missions)*



***By the year 2050, 100 million Americans will be 65 or older; 18.9 million will be 85 or more.***



# Balance Disorders



- Elderly Americans fall more often.
- They suffer from gait and postural disorders.

## Study Results

Following a short-duration mission, Senator Glenn adapted to sensory motor stress; recovery was similar to astronauts half his age.



Why does this happen, and can we lessen, prevent or reverse it?



# Cardiovascular Deconditioning

Elderly Americans are also prone to cardiovascular deconditioning and heart rhythm changes.



## Study Results

There appears to be no significantly greater cardiovascular stress in an elderly person during short-duration space flight.

? Can conditioning be used successfully in the elderly?





# Muscle Atrophy

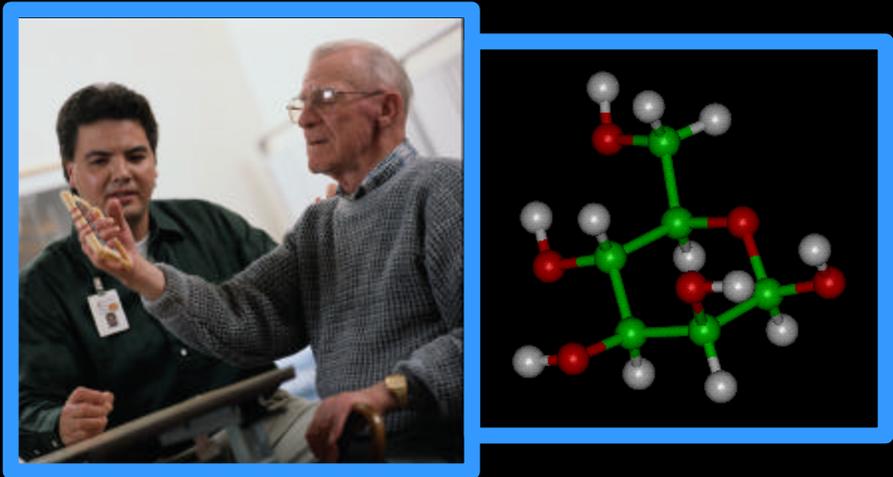
In the elderly insufficient exercise, paralysis, weakness, injury, or prolonged bedrest causes a downward spiral in an individual's health over time.

## Study Results

Senator Glenn did not exhibit any significant atrophy or change in relaxation time in the studied muscles.

? What are the prerequisites for slowing the aging effect?





# Lowered Protein Synthesis

## Study Results

Senator Glenn lost no lean body mass. However, blood chemistry changes suggest he might tend to lose lean body mass faster than a younger person during a longer mission.

On Earth, the elderly exhibit decreased protein synthesis, which contributes to the loss of lean body mass seen in the older population.

 Can protein synthesis be stabilized as aging occurs?



# Bone Loss



On Earth, the elderly population experiences bone and mineral loss, leading to increased risk of fractures and injuries.

## Study Results

Short-duration space flight did not affect bone loss or strength in crew members.

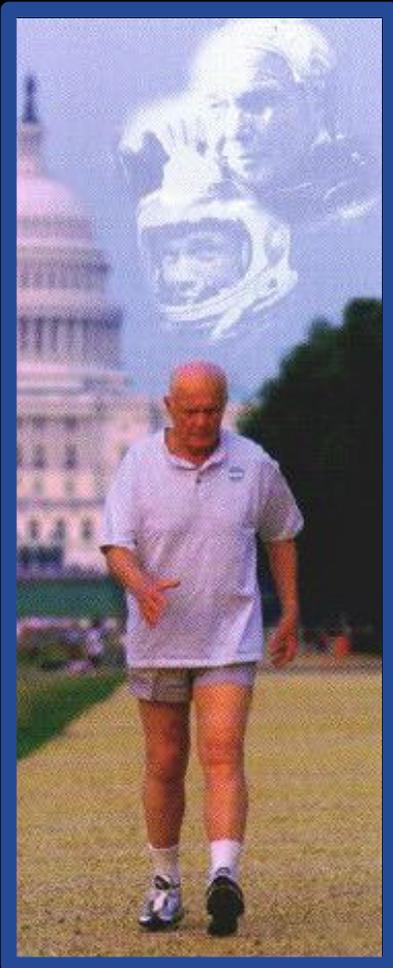
? What are the diagnostic and preventative measures?



# Conclusion

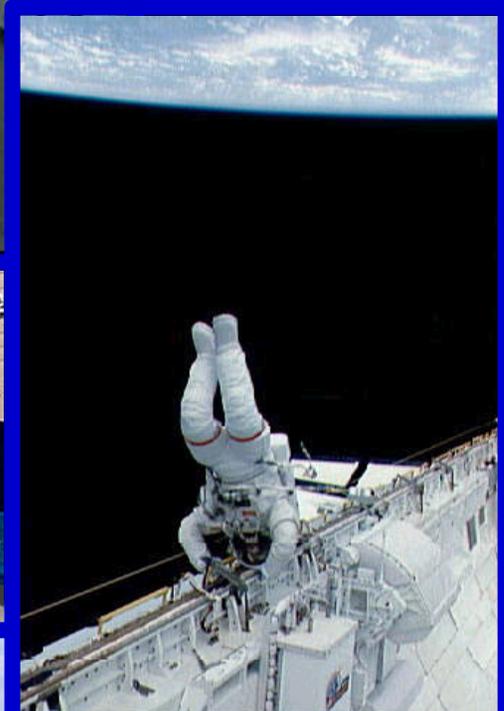
*STS-95 raises some interesting questions...*

- Is Senator Glenn a unique experimental subject? What is the role of genetic predisposition vs. conditioning?
- Can we use surrogates in space flight for further aging research?
- Are there more similarities between space flight and aging?
- By what means do we measure aging in space flight and on Earth?



# *Back-up Slides*





## ...and Vice Versa

*Understanding the aging process on Earth may help improve the living and working environment for astronauts today and on future exploration missions*



# Why Senator Glenn?

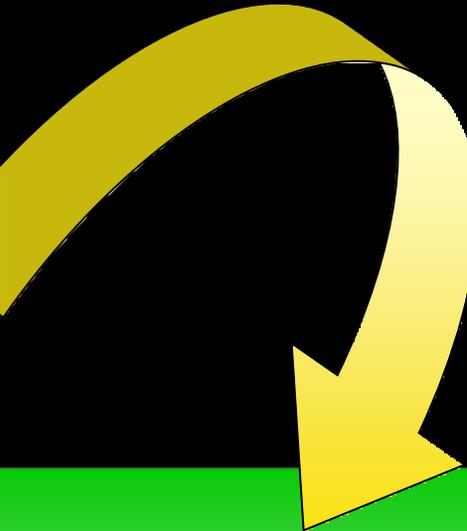
*We may gain insight by including a person who has already undergone much of the aging process*

- Has space flight experience
- Meets the standards
- Has a lifelong, controlled database
- Represents a unique longitudinal perspective spanning varied environments



# Balance Preflight Data

Test Condition			Normative Population		
Test	Vision	Proprioception	Young Normals (20–59 yrs)	Young Astronauts (32–50 yrs) (n=45)	Elderly Normals (75–79 yrs)
SOT 1	EO	fixed	94, 90	94, 88	92
SOT 2	EC	fixed	92, 85	89, 79	91
SOT 3	sway-ref	fixed	91, 86	92, 84	91
SOT 4	EO	sway-ref	82, 70	89, 78	77
SOT 5	EC	sway-ref	69, 52	76, 60	55
SOT 6	sway-ref	sway-ref	67, 48	75, 53	54

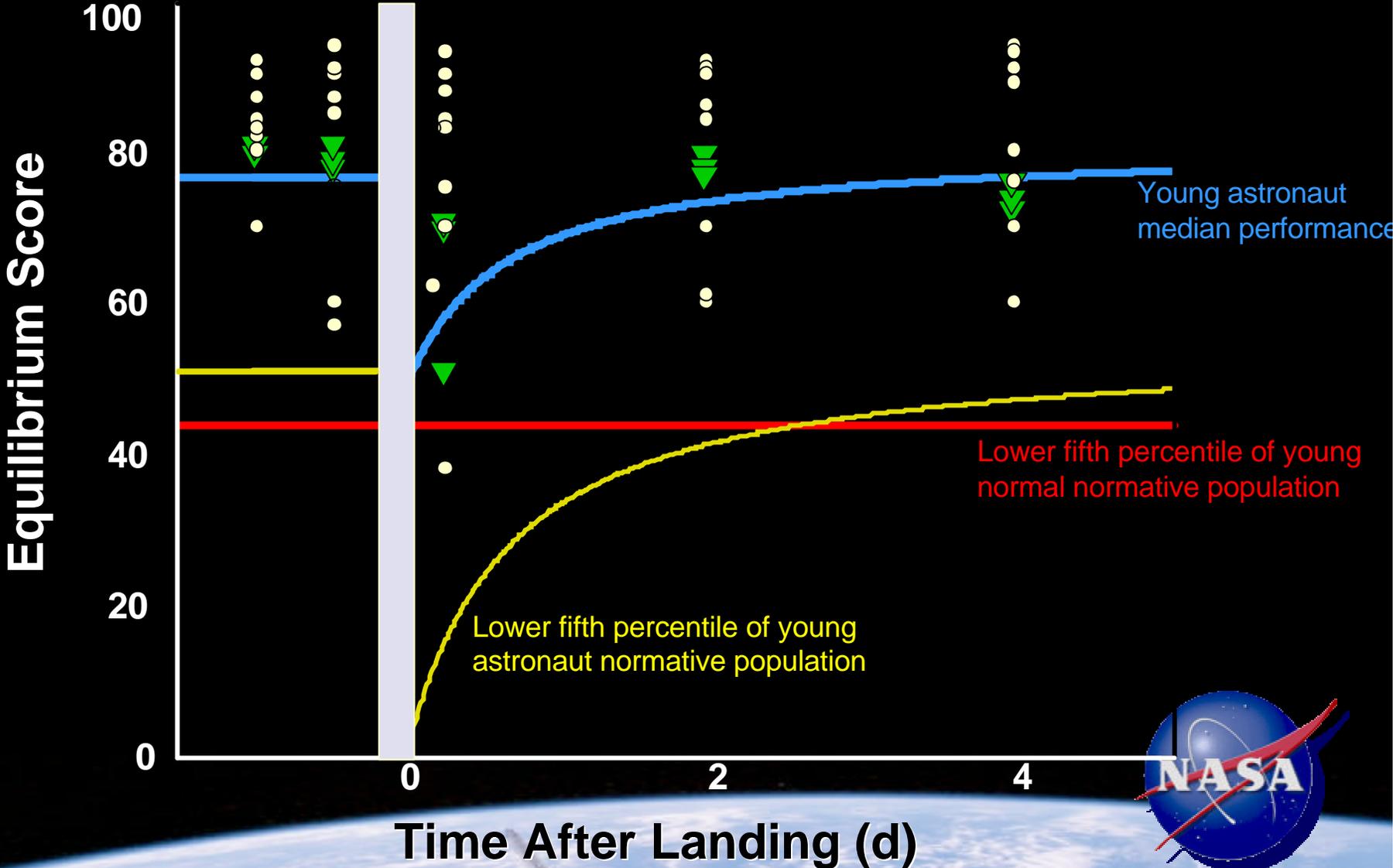


Test	Elderly Astronaut (77 yrs) (n=1)	Control Astronauts (37–42 yrs) (n=3)
SOT 1	91 ± 2.2	96 ± 2.2
SOT 2	87 ± 2.7	92 ± 2.4
SOT 3	91 ± 2.8	94 ± 2.2
SOT 4	85 ± 1.9	94 ± 1.6
SOT 5	75 ± 4.7	80 ± 7.4
SOT 6	79 ± 3.1	83 ± 10.9



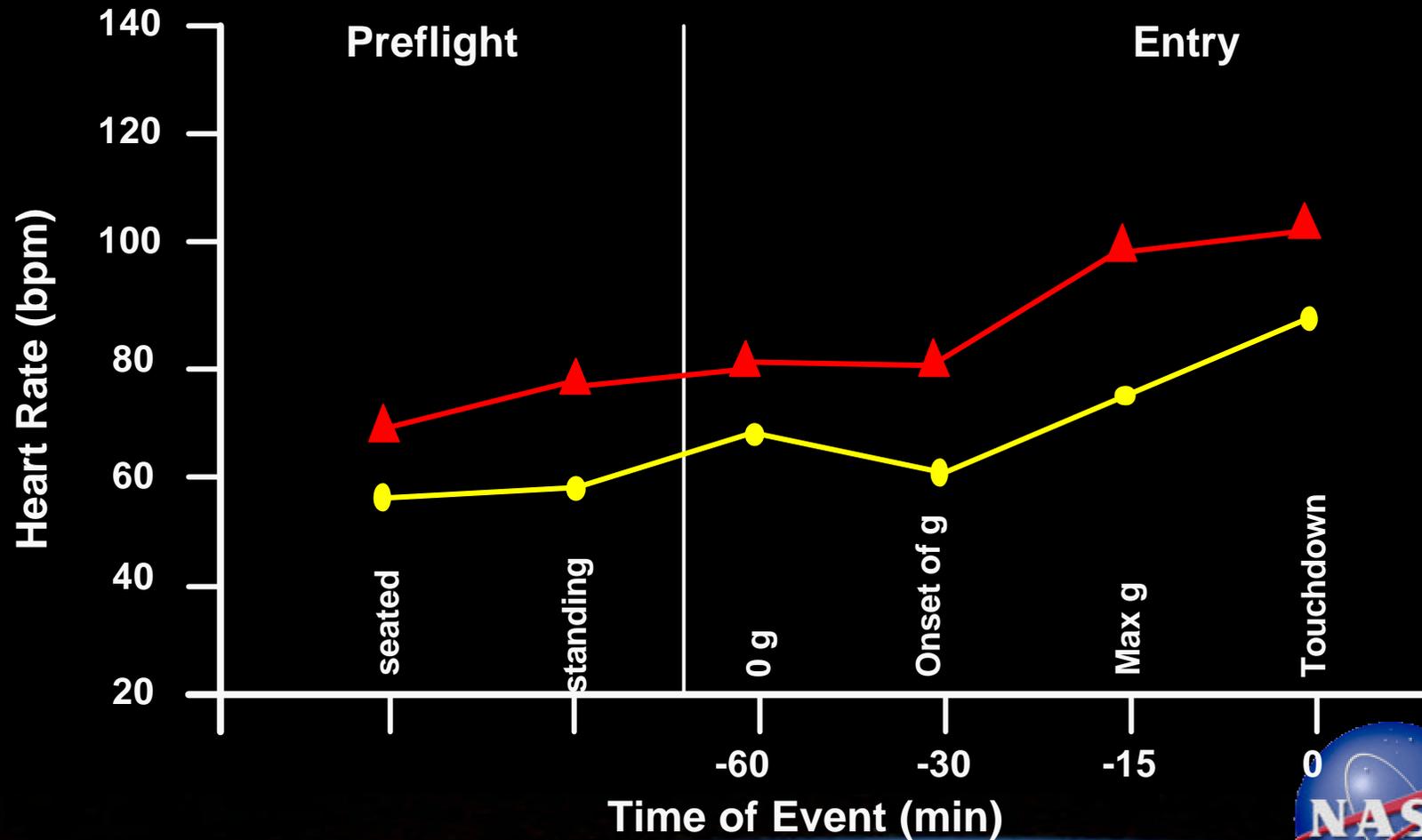
# Postflight Data

- ▼ Senator Glenn
- 3 control crewmembers

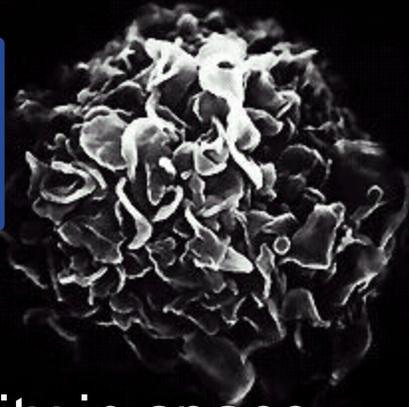
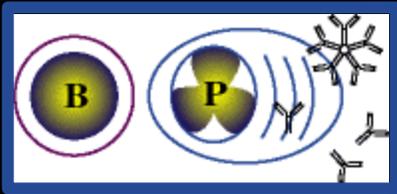


# Heart Rate Response During Entry and Landing

- ▲ Group N=34
- Septuagenarian N=1



# Decreased Immune Function



- Immunity in space travelers decreases due to combined effects of microgravity and stress.
- Models of age-related changes in immune function are difficult to find, so microgravity may be a very useful model.

## Study Results

Stress decreases immune function preflight, but the greatest decrease occurs in flight.

Senator Glenn's leukocyte levels at landing differ from young astronauts; however, as the length of flight increases, the hormonal profiles and leukocyte levels become similar.



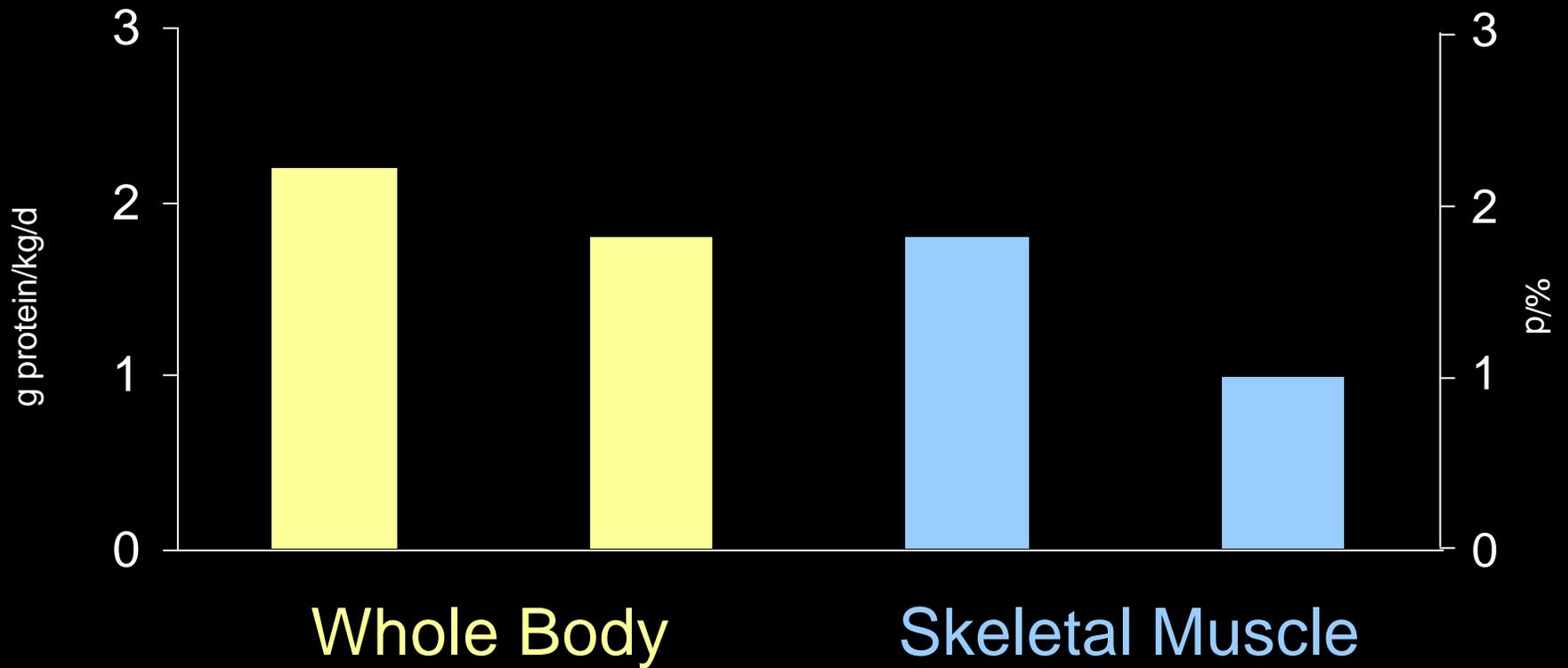
# Muscle Strength Changes with Space Flight

<u>Mission</u>	<u>Duration</u>	<u>Measure</u>	<u>%D*</u>
Salyut 7	7 days	Plantar flexion	-20
Skylab 3	59 days	Arm flexion,	-5
		leg flexion,	-20
		leg extension	-25
<i>Mir</i>	110-237 days	Dorsiflexion,	-33
		plantar flexion	-26

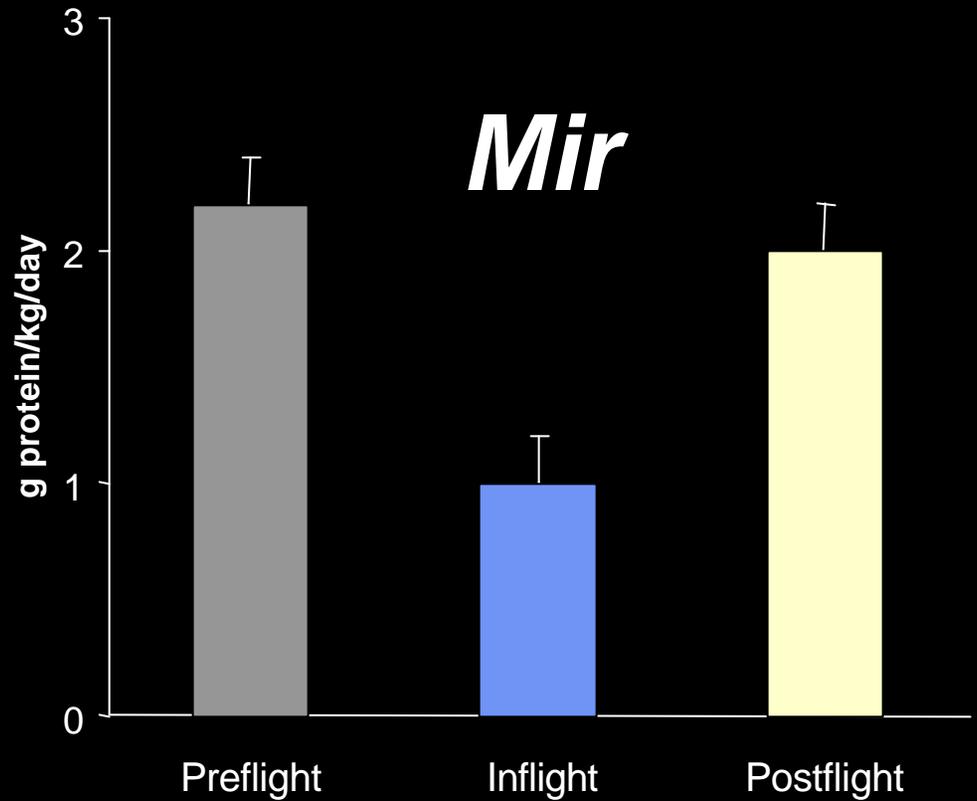
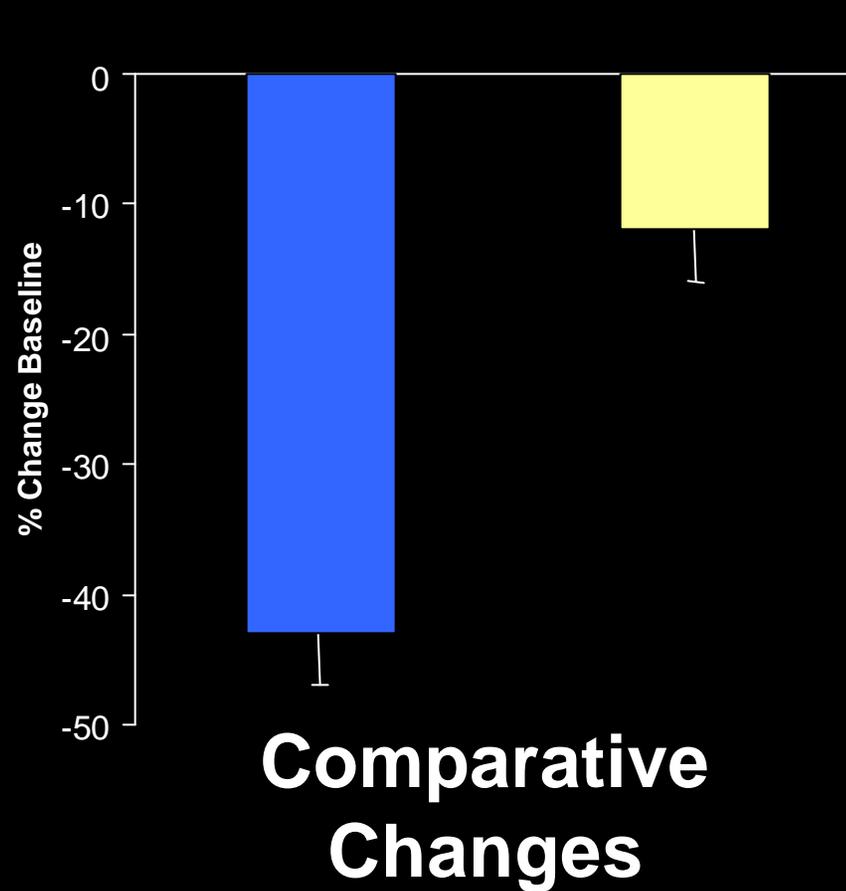
\*from baseline



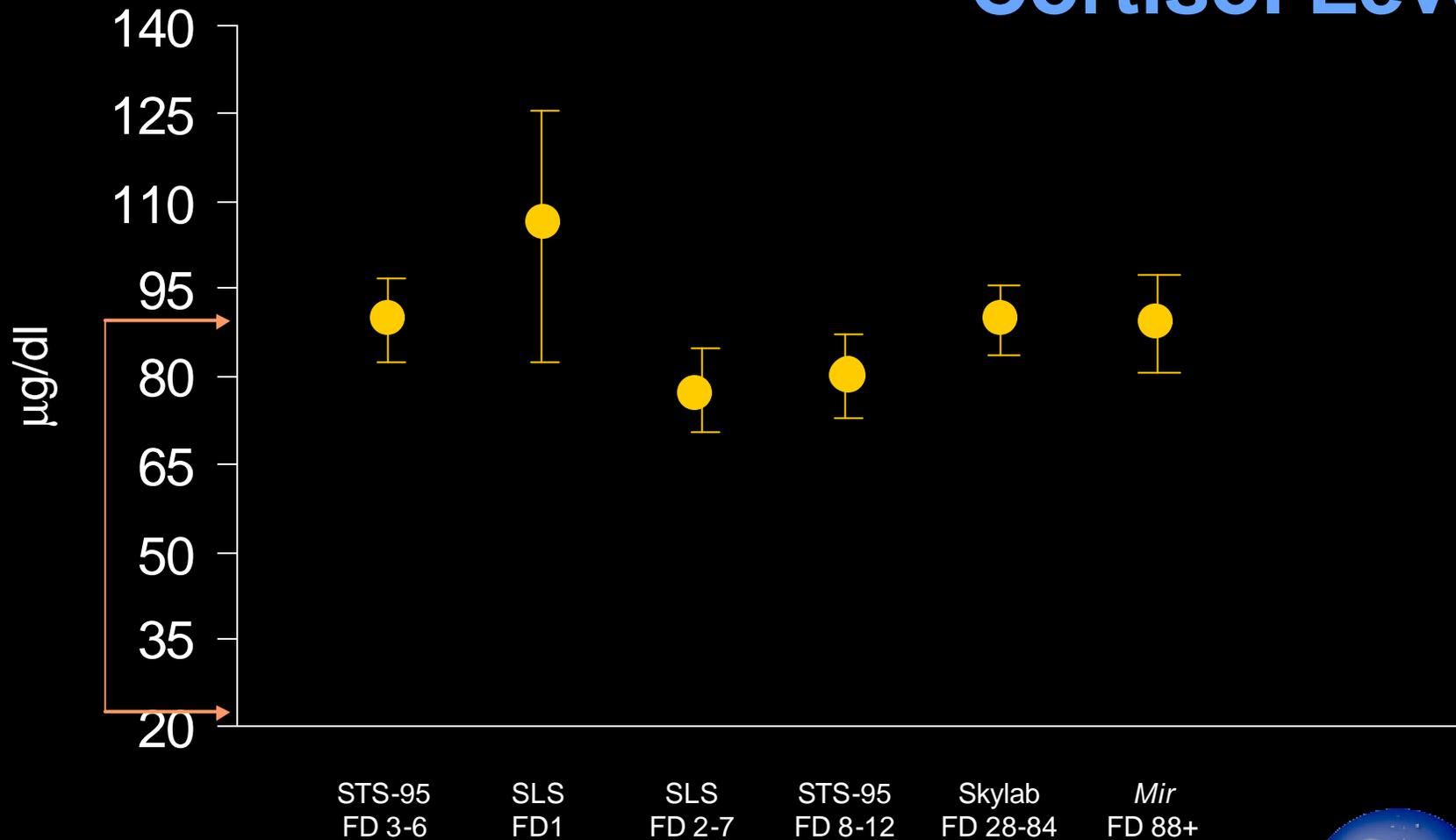
# Changes in Protein Synthesis During Bed Rest



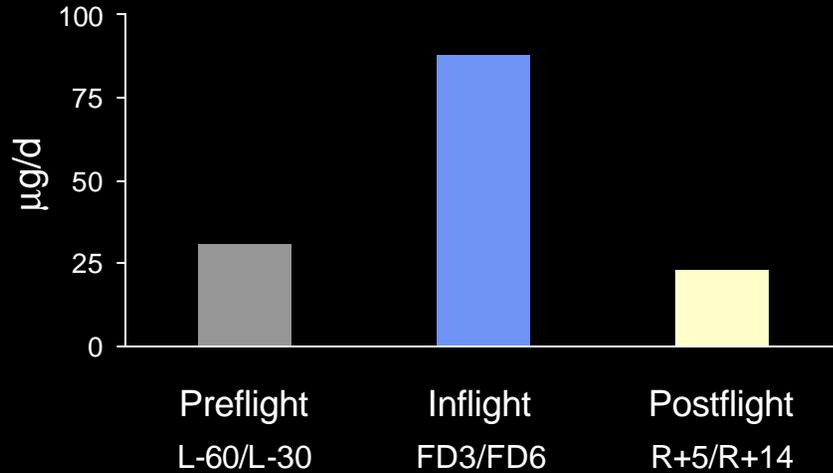
# Whole-Body Protein Synthesis



# 24-hour Urinary Cortisol Levels

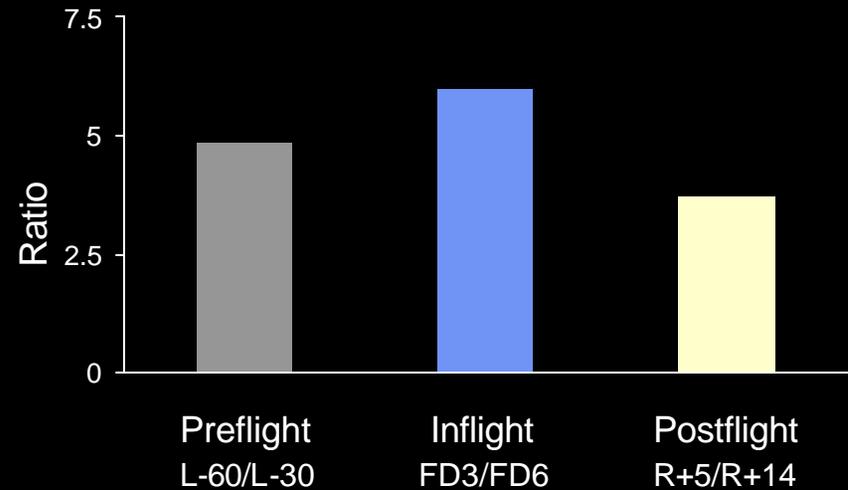


# STS-95 Cortisol Levels

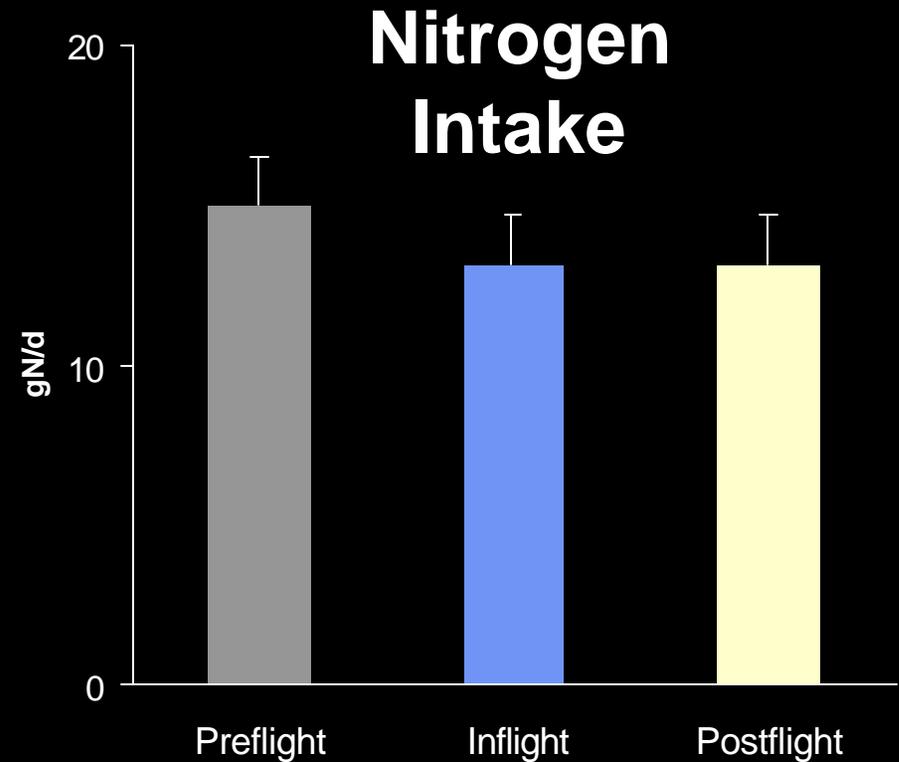
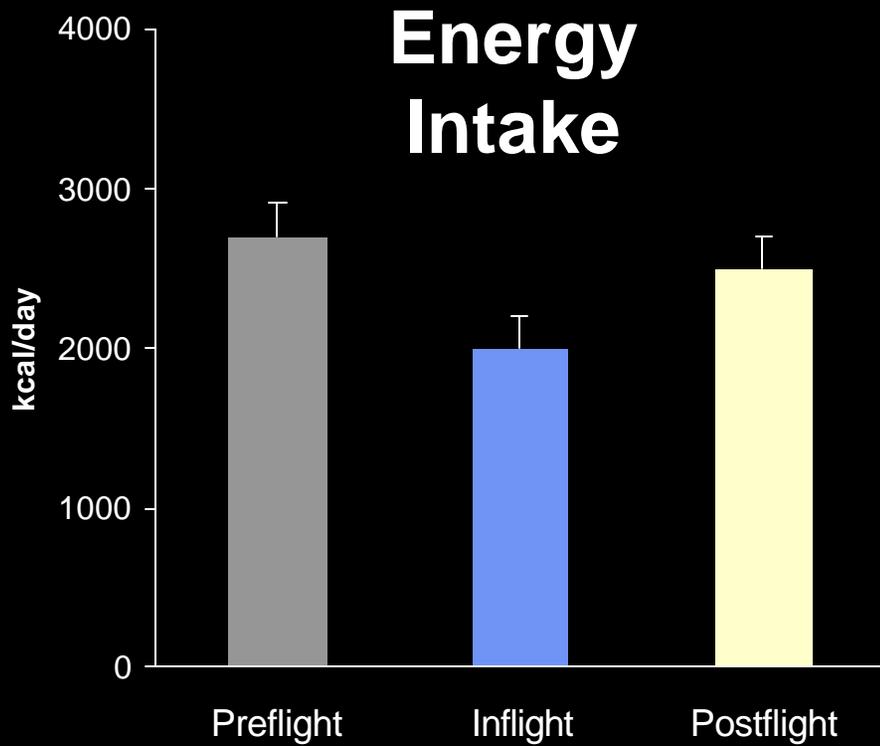


**Urinary  
Cortisol  
Excretion**

## Blood Cortisol/ Testosterone



# Mir Dietary Intake (>3 months in orbit)



# Breaking New Ground

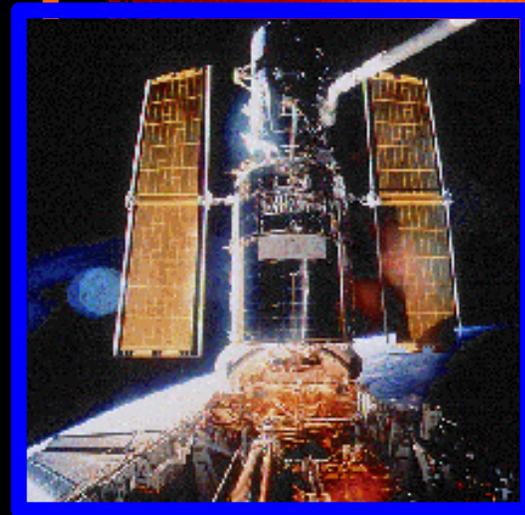


- A partnership between NASA and the National Institute on Aging (NIA)
- A septuagenarian crewmember in examining physiological changes which are common to both space flight and aging
- A nine-day mission focused with > 80 experiments ranging from understanding the Sun to human adaptation to space



# Astronomy Payload

- SPARTAN 201-5
- Hubble Space Telescope Orbital Systems Test (HOST)
- International Extreme Ultraviolet Hitchhiker (IEH-3)





# Space Product Development Program

Astroculture

Aerogel

Advanced Separations Systems

Commercial Generic  
Bioprocessing Apparatus

Commercial ITA Biomedical  
Experiment (CIBX)

Commercial Protein Crystal  
Growth (CPCG)

Vapor Diffusion Apparatus

Microencapsulation Electrostatic  
Processing System

*partnership  
between NASA,  
academia, and  
private industry*

