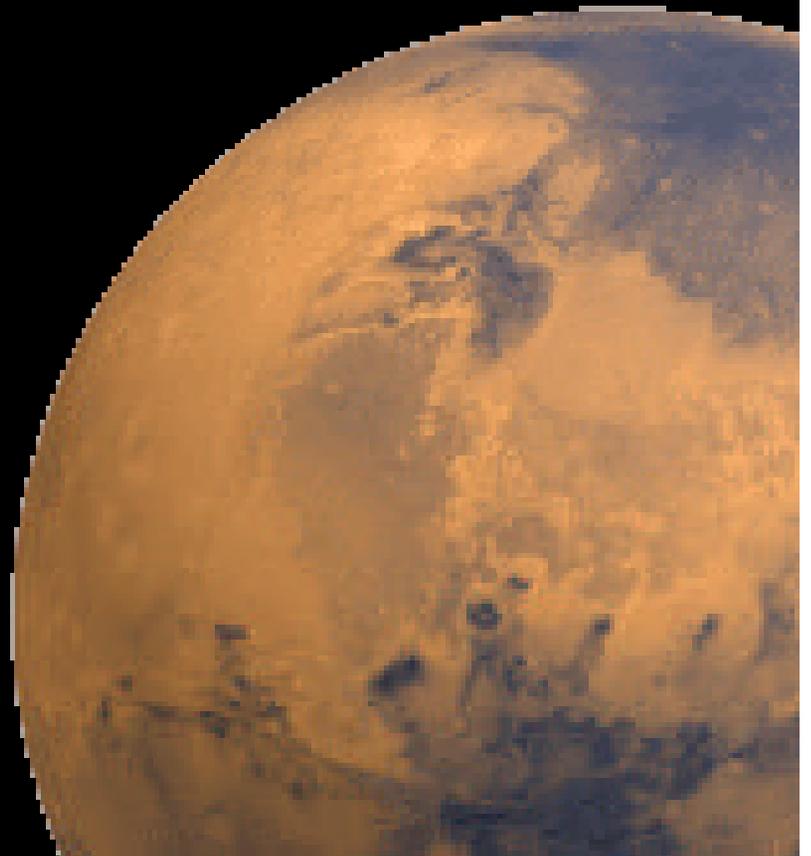


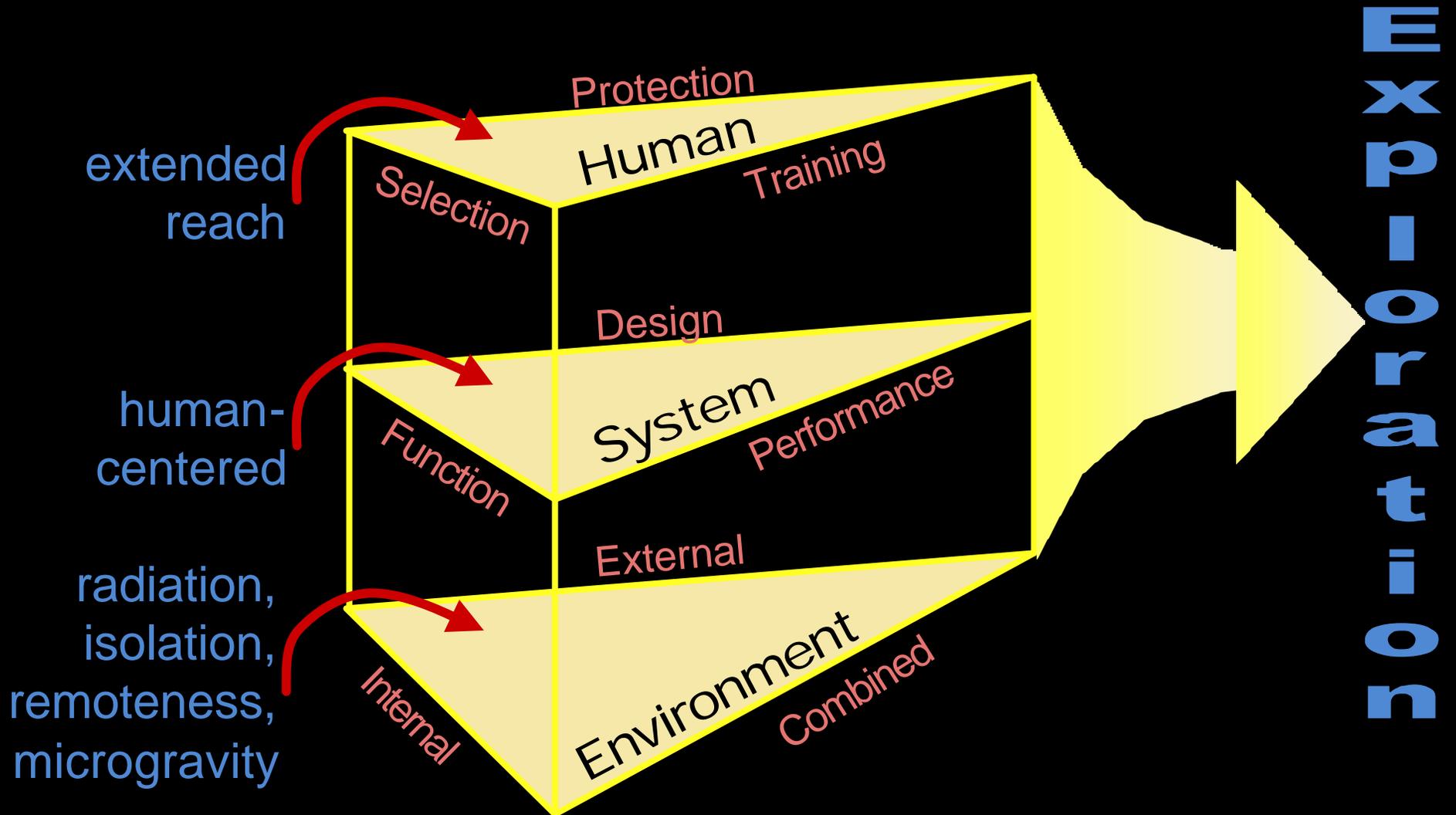


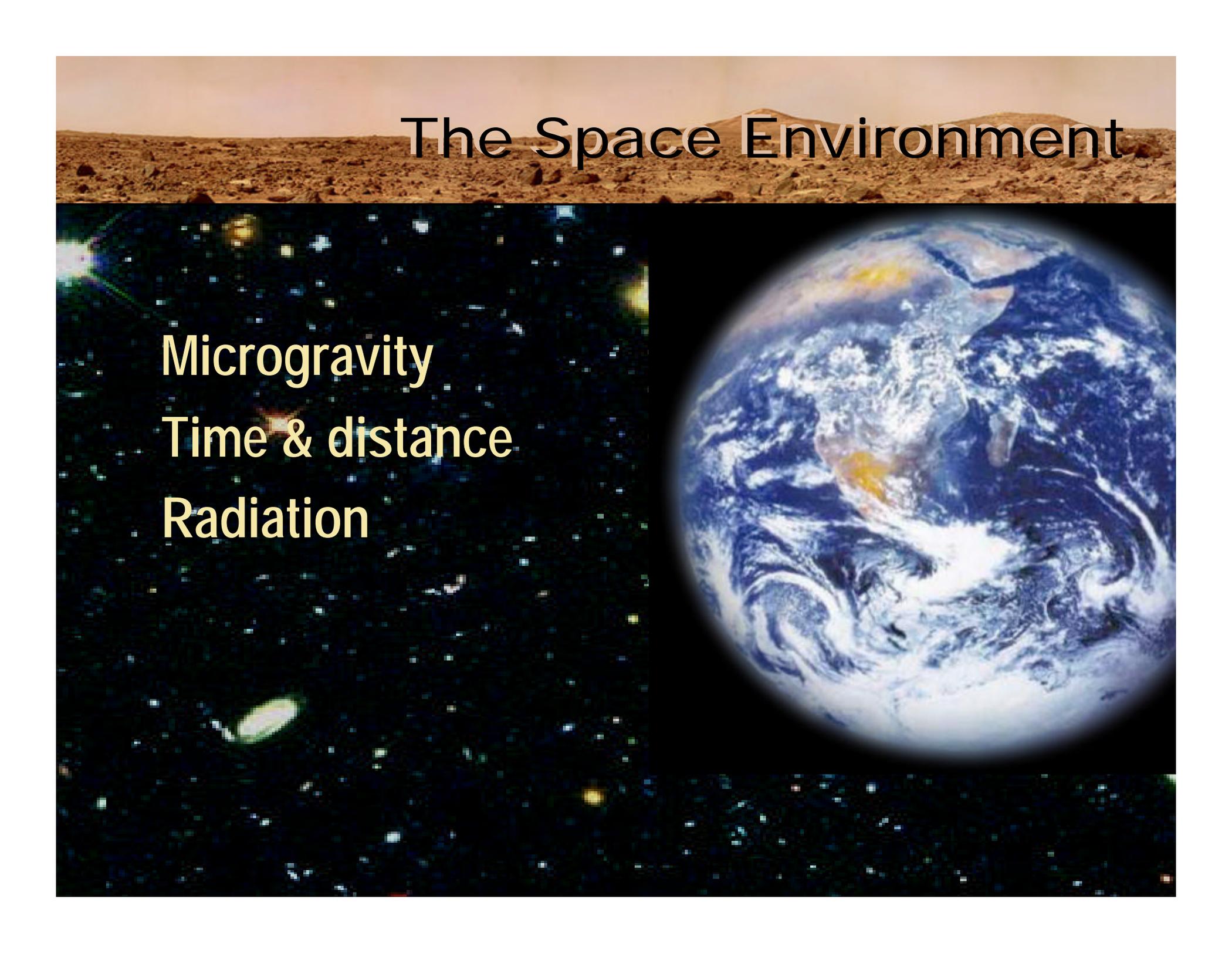
Arnauld E. Nicogossian, MD
Associate Administrator
NASA Office of Life & Microgravity Sciences & Applications

Medical Considerations for Planetary Missions



Mission Design





The Space Environment

Microgravity

Time & distance

Radiation

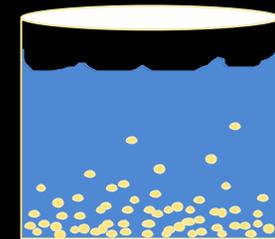
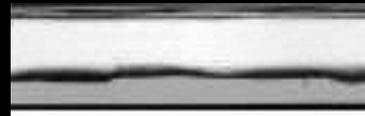
Attributes of Microgravity

Convection

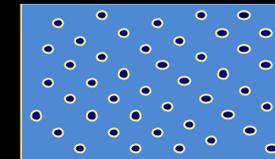
Buoyancy

Sedimentation

Earth

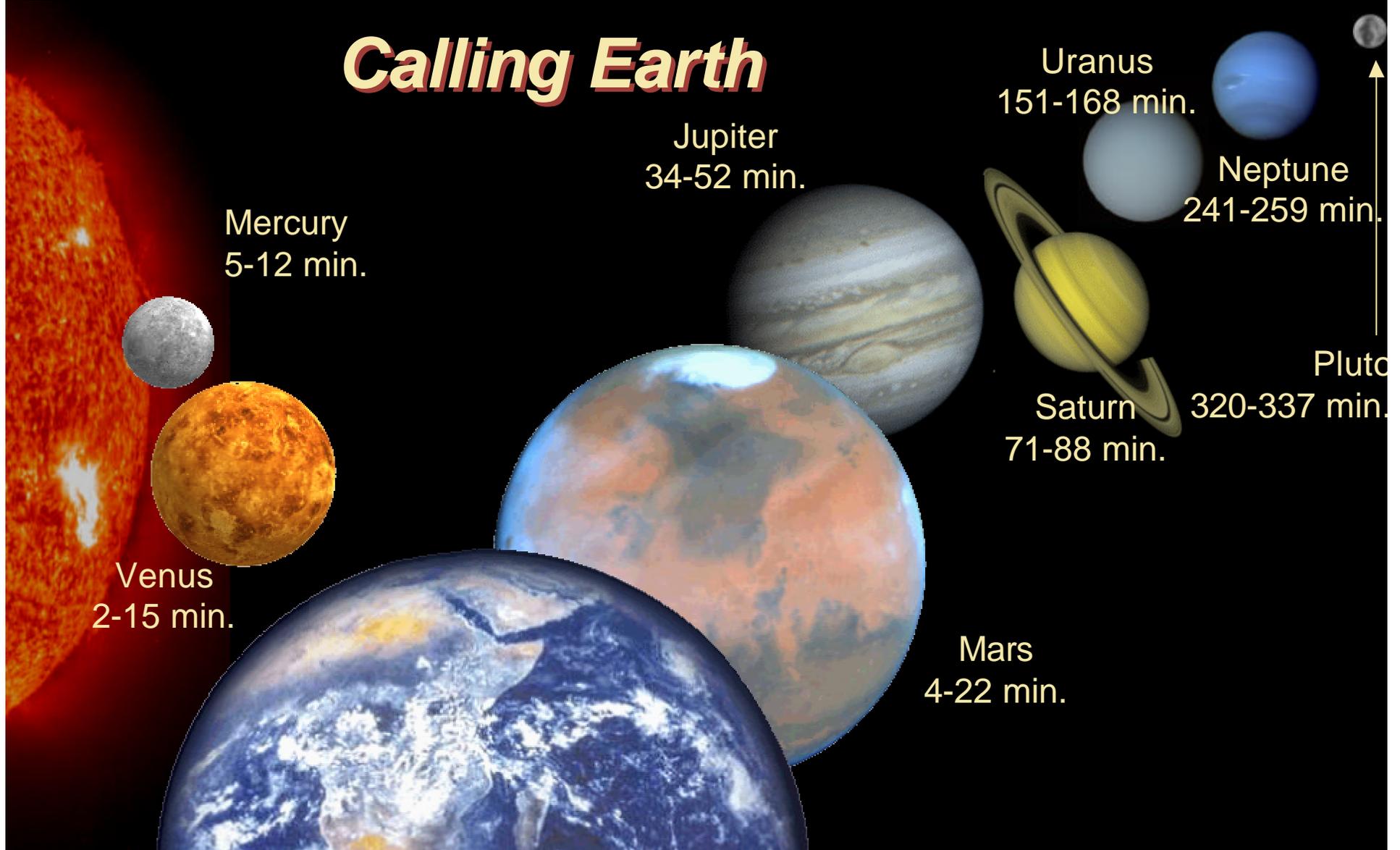


Space



Time/Distance

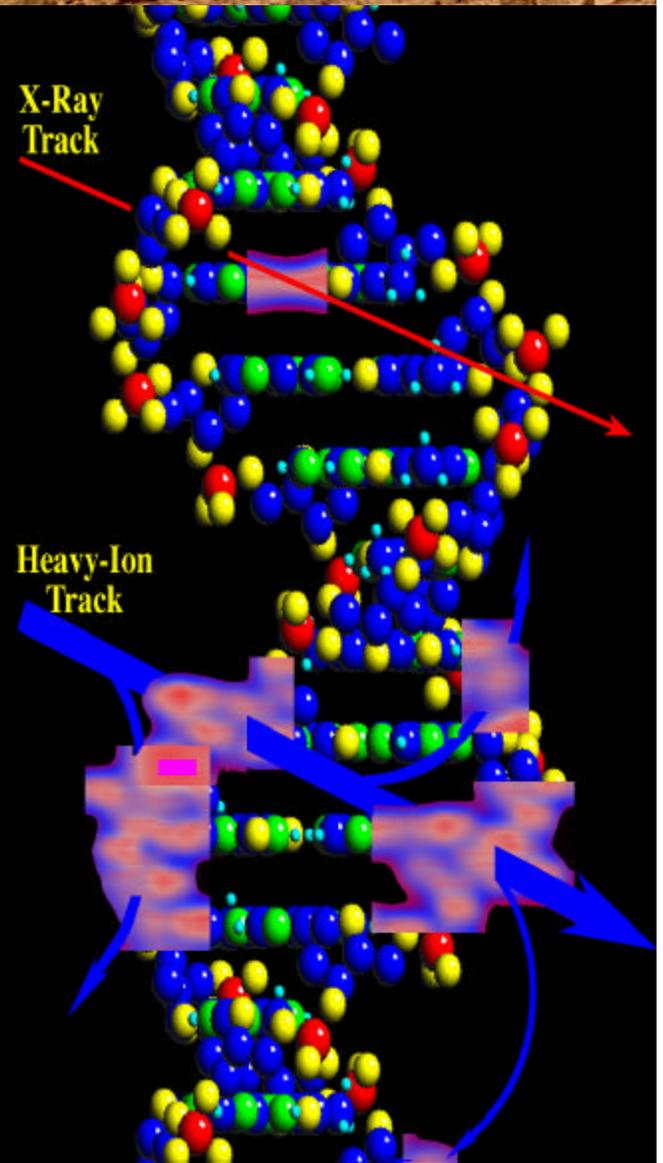
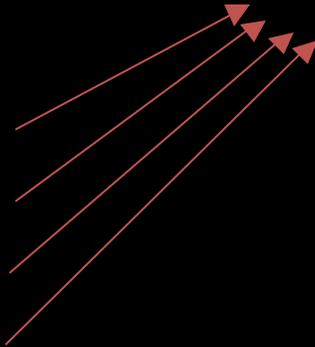
Calling Earth



Radiation

Secondaries

Heavy particles
Protons
Neutrons
Electrons



The Human Element

Health

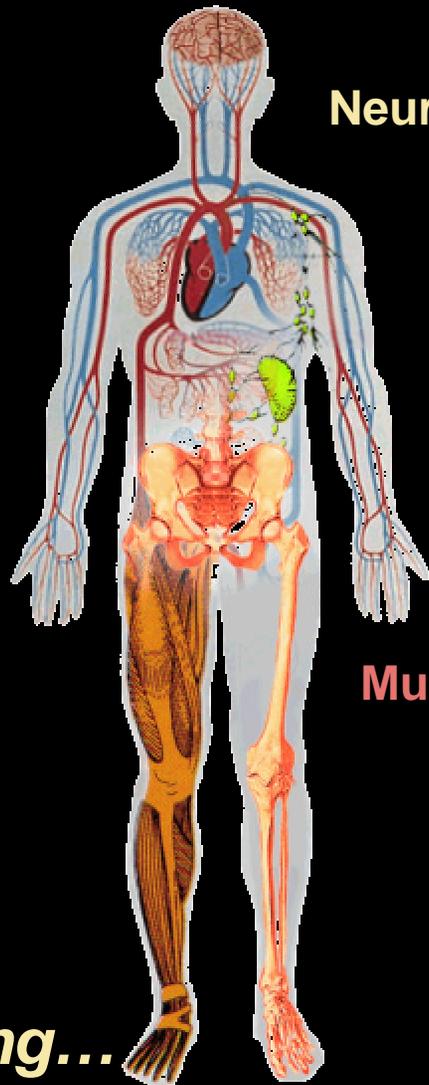
Psychosocial

Cultural



System-level Responses to μg

- Adaptive
- Pathological



Neurosensory & neuromotor

Cardiovascular/
Pulmonary

Endocrine

Musculoskeletal

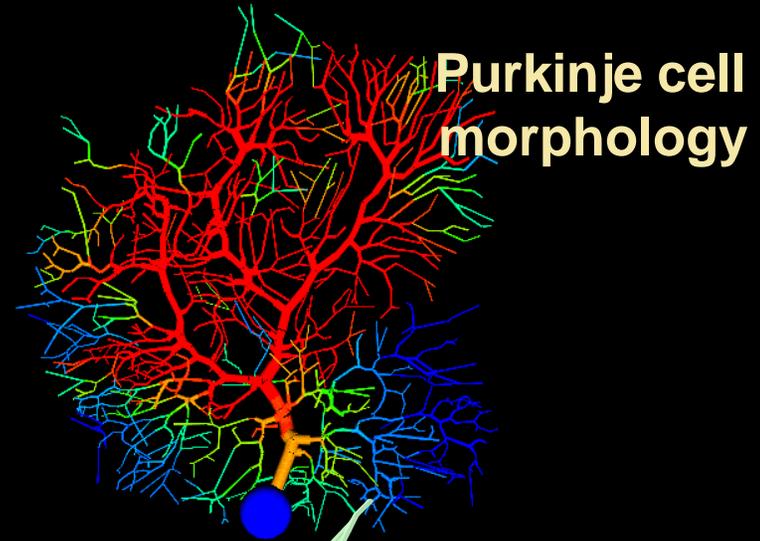


parallels with aging...

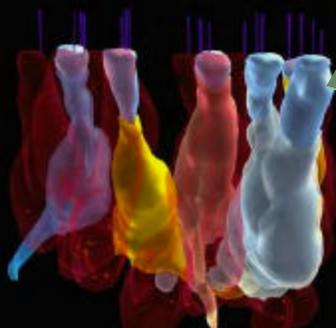


Plasticity

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



Type of Response



Ataxia
SMS
Ocular

Development

**Key developmental
processes in
mammals require
gravity stimuli**

**Locomotion
behavior**



Bone Response

Bone
Formation

Earth

PTH
&
IGF-I



Osteoprogenitor
Number &
Bone
Mineralization

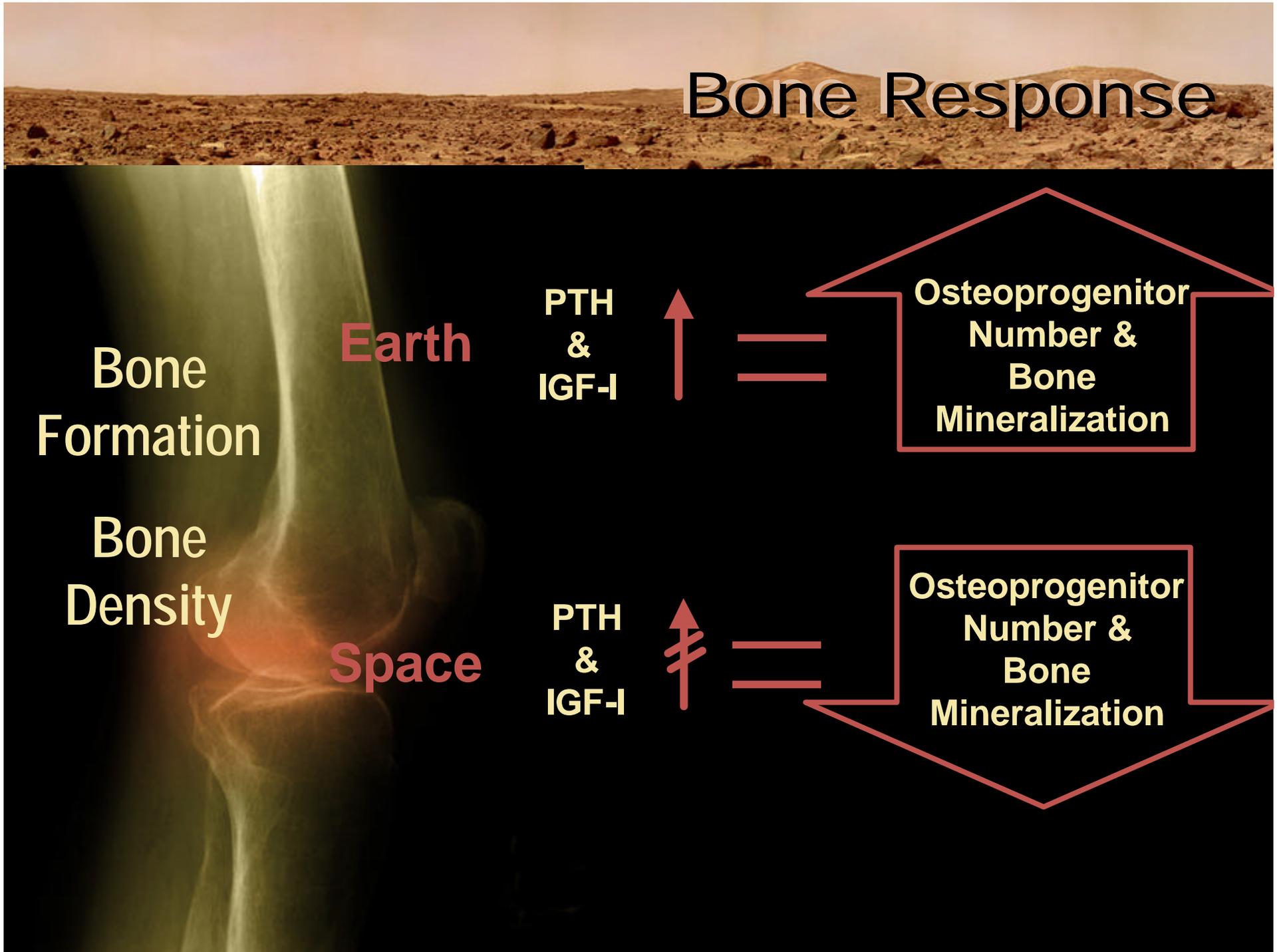
Bone
Density

Space

PTH
&
IGF-I



Osteoprogenitor
Number &
Bone
Mineralization



Muscular Response

Earth

TSH

+

IGF-1
receptor?

=

Slow and
Fast-twitch
Muscle Fiber
Development

Proposed causal pathway

TSH

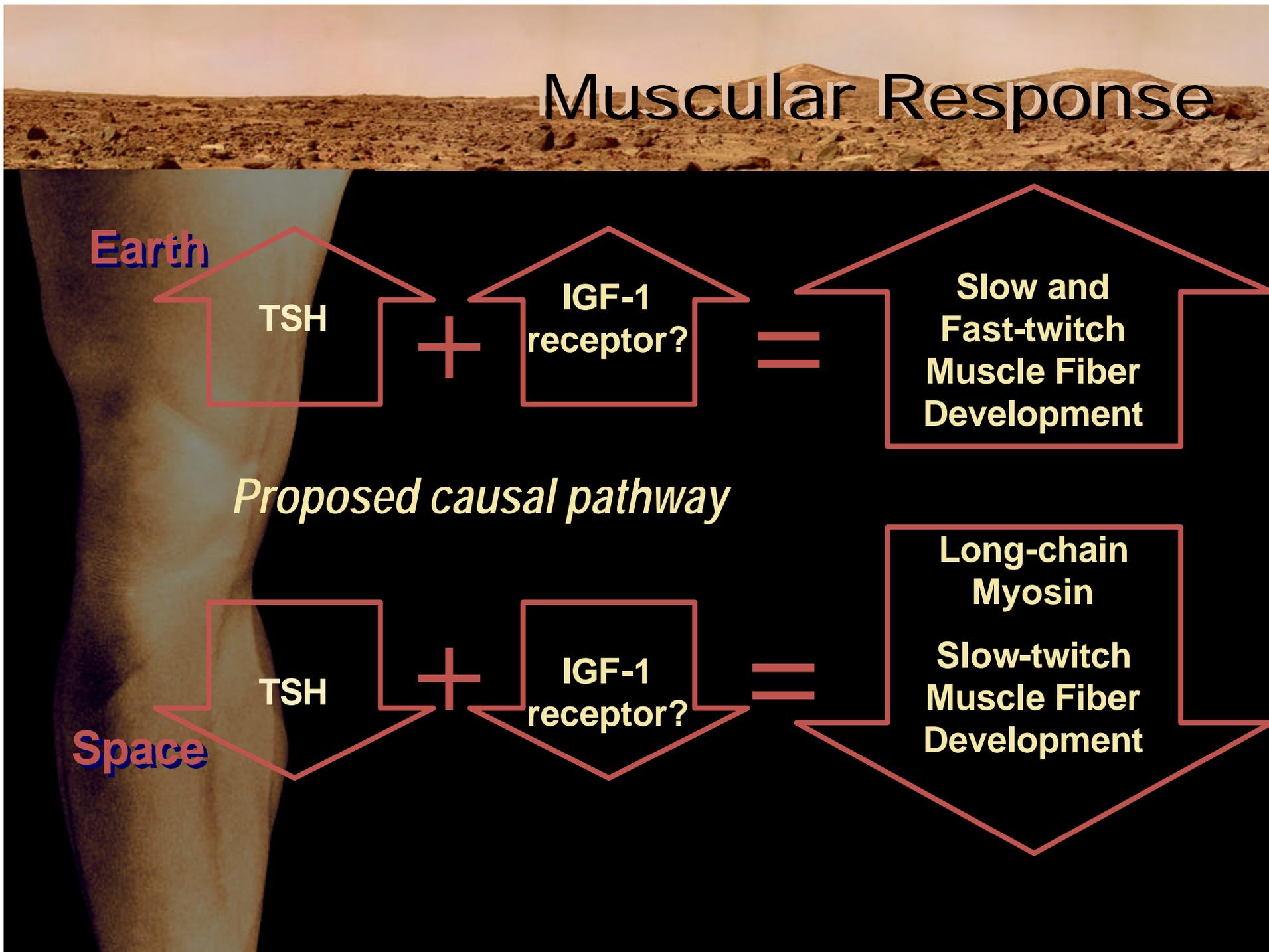
+

IGF-1
receptor?

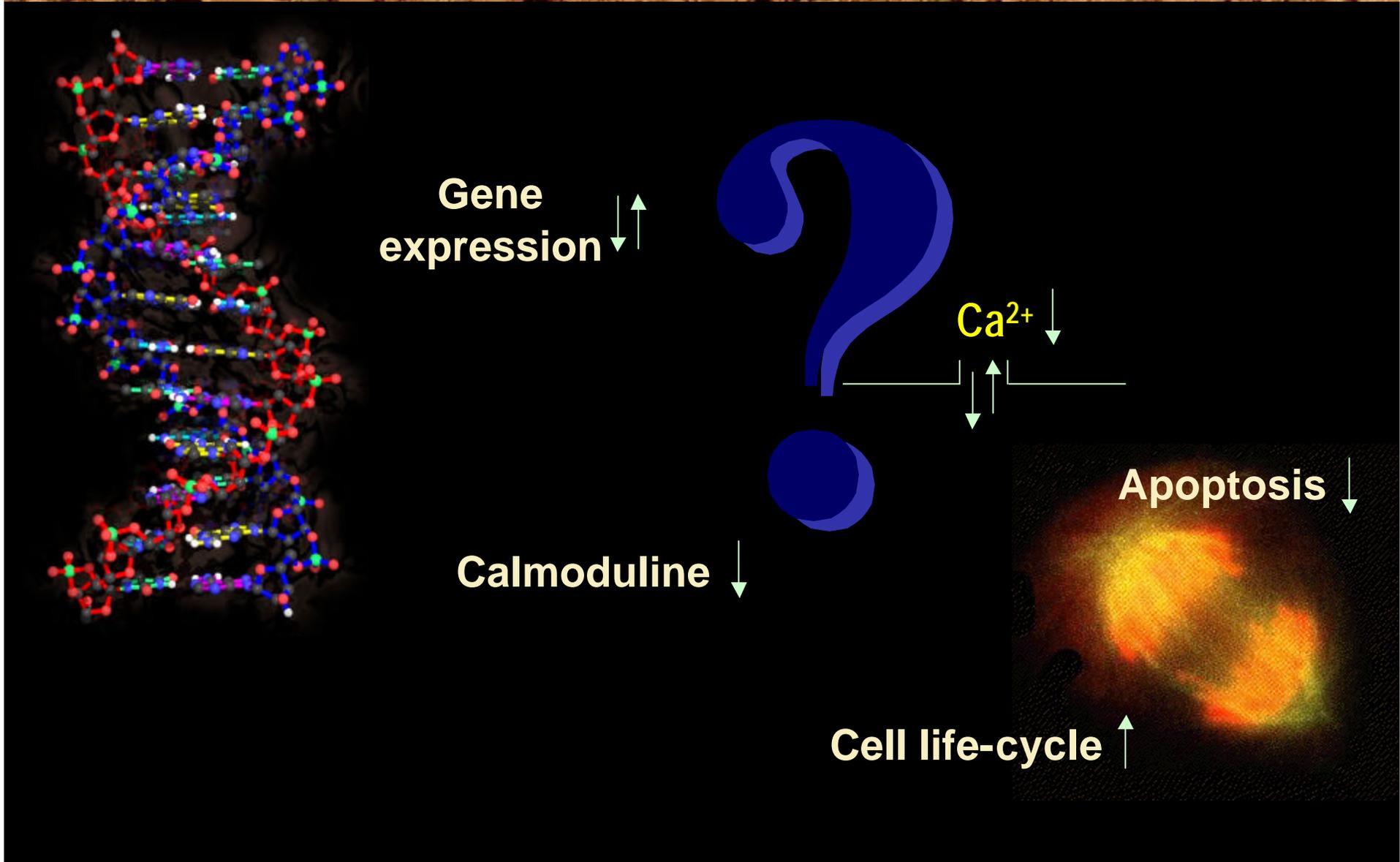
=

Long-chain
Myosin
Slow-twitch
Muscle Fiber
Development

Space



Potential Molecular Responses



Isolation & Confinement



- Multicultural
- Societal
- Psychological



Human-Centered System Solutions

Countermeasures

Medical care

Life support



Countermeasures

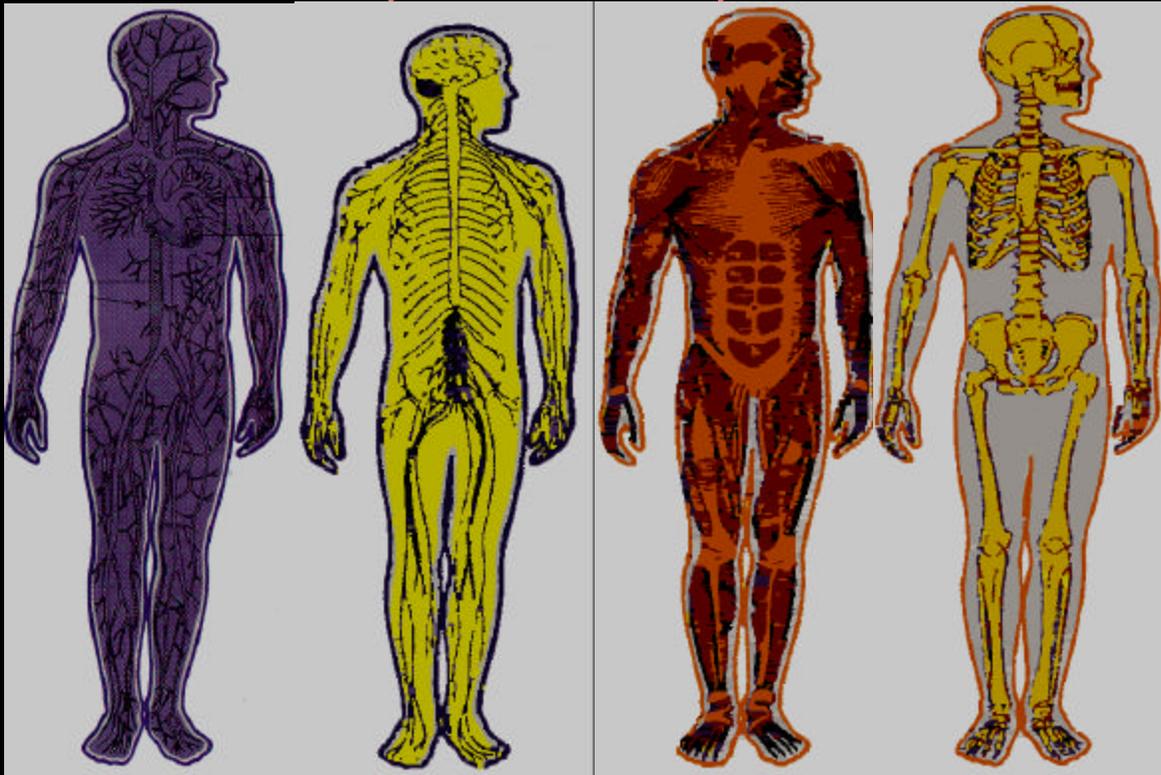
Mechanism

Plasticity

Receptor
adjustment

Long chain
myosin

Bone
formation



Manifestation

Ataxia

Fluid loss
Blood pressure
control

Reduction in
muscle
strength

Reduction
1% a month

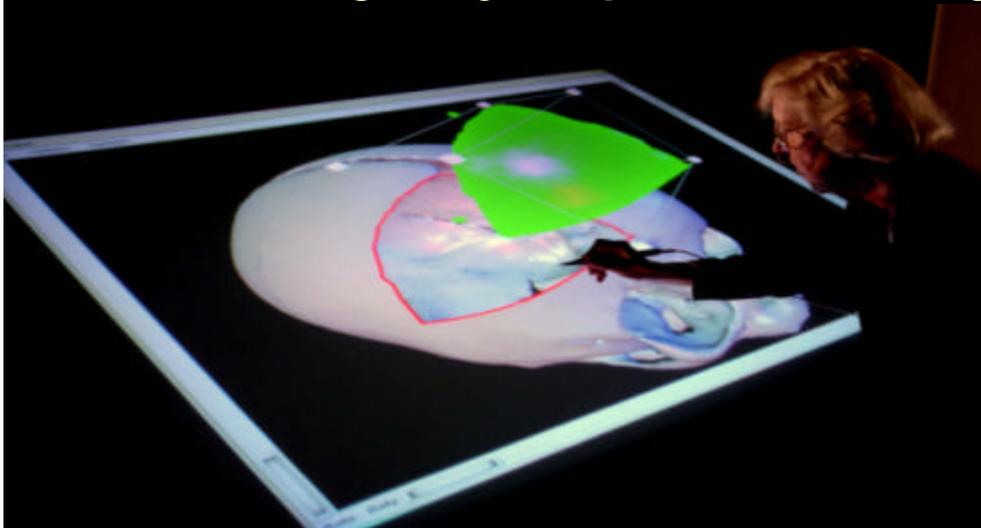
Countermeasures

- Artificial gravity
- Exercise
- Nutrition
- Fluids
- Pharmacological supplements

Medical Care

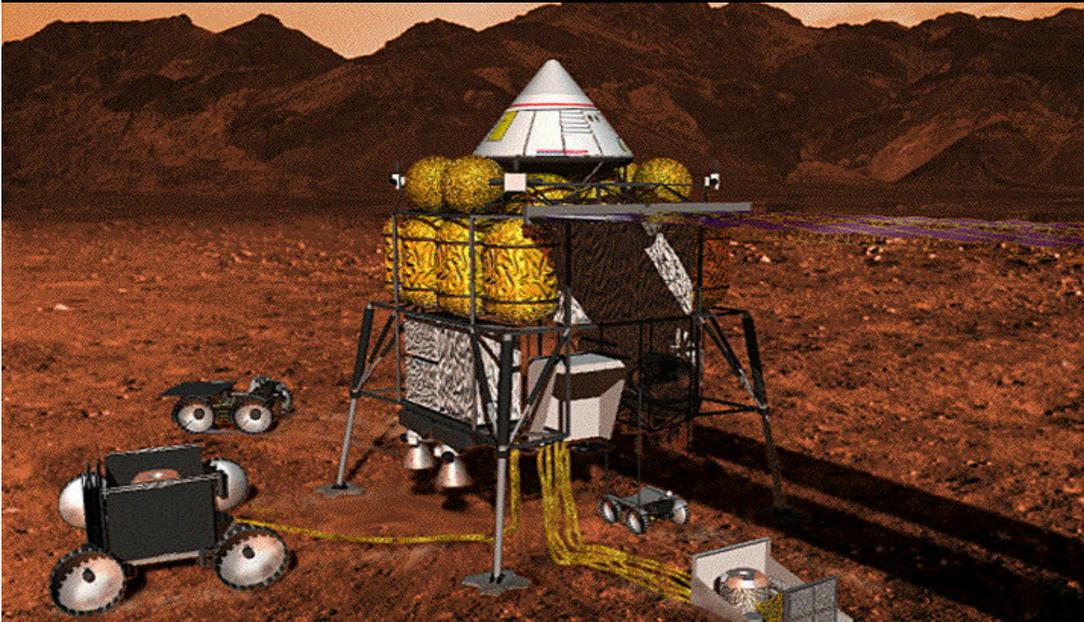
Solutions to overcome time and distance

- Miniaturization
- Portability
- Virtual reality
- Haptic "smart" systems
- Biologically-inspired technologies



Life Support

- Atmosphere
- Comfort/control
- Nutrient supply
- Waste management



Exploration Tools of the 21st Century

Convergence of...

- Informatics
- Nanotechnology
- Biology / Medicine



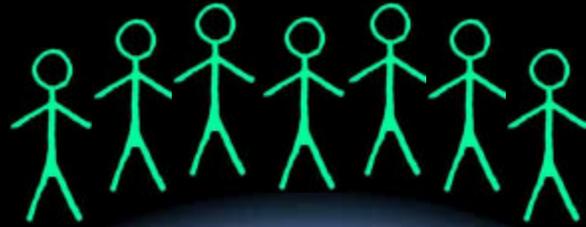
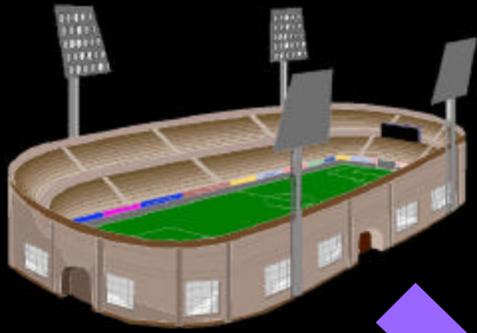
The International Space Station

The ISS is a testbed for:

- Exploration technology demonstration
- Applying space technologies to health care on Earth

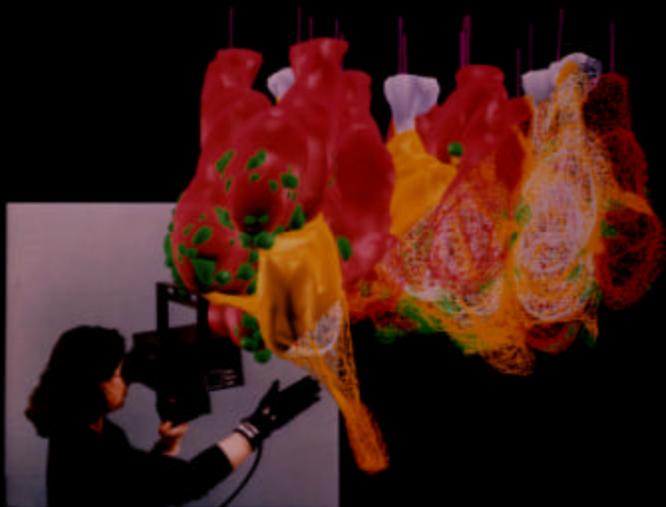
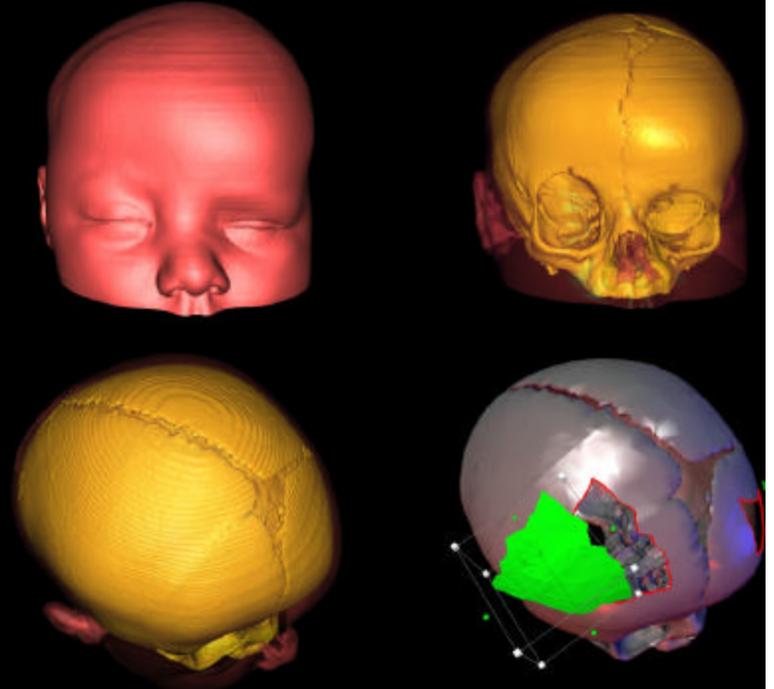


The Multipurpose International Space Station



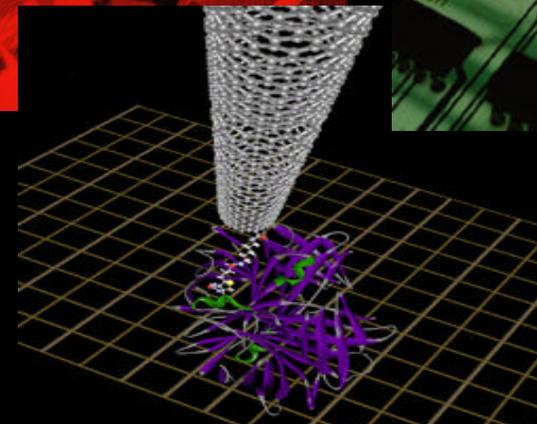
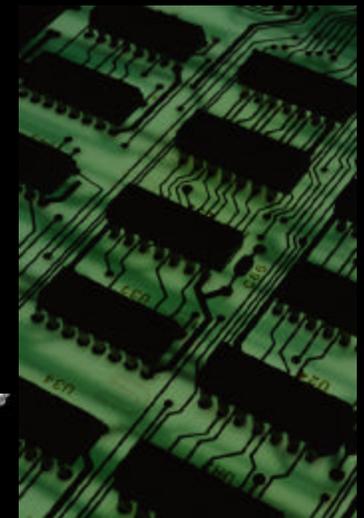
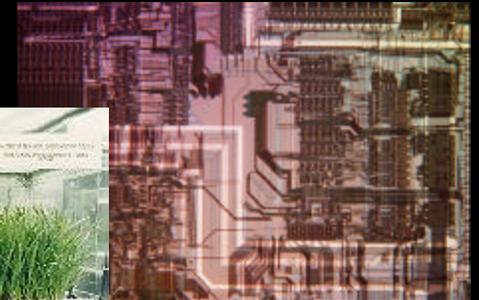
Informatics

- Biocomputation
- Imaging
- Training and simulation
- Telemedicine



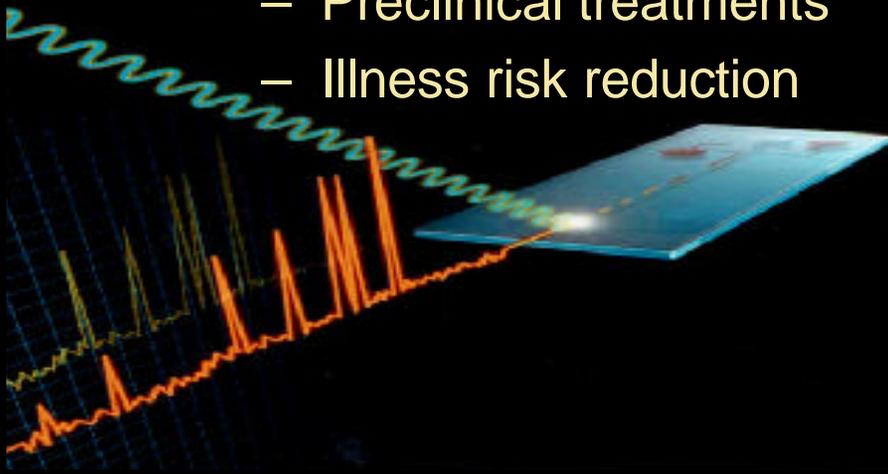
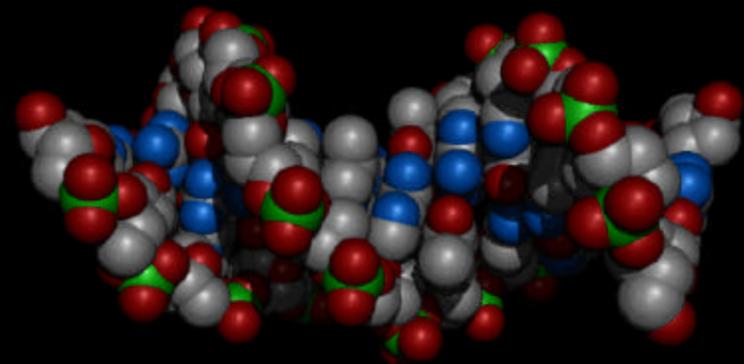
Nanotechnology

- **Medical care**
 - Diagnostic probes
 - Treatment and delivery systems
 - “Keyhole” surgery
 - Tissue replacement
- **Life support**
 - Sensors and effectors
 - Bioregeneration
 - “Humans-on-a-chip”
 - Biological niches



Biology / Medicine

- Genetic profile of travelers
 - Tailored medical preparations
 - Individual health maintenance
- DNA therapies
 - Countermeasures
 - artificial gravity as a medical tool
 - Preclinical treatments
 - Illness risk reduction



Conclusion

- Understand the human and its environment
- Leverage research to improve health on Earth
- Apply technology to challenging environments on Earth

