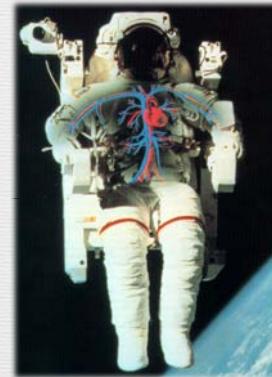




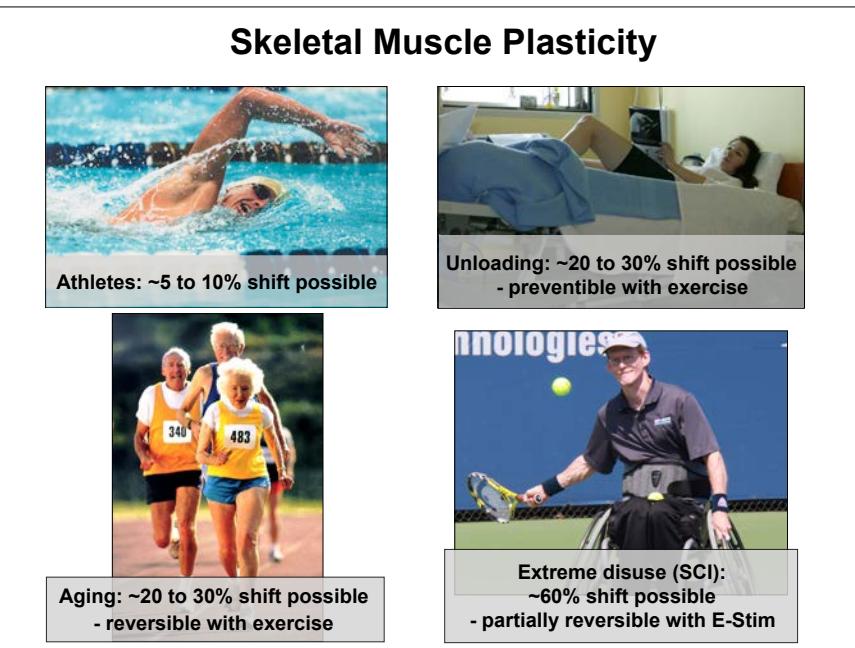
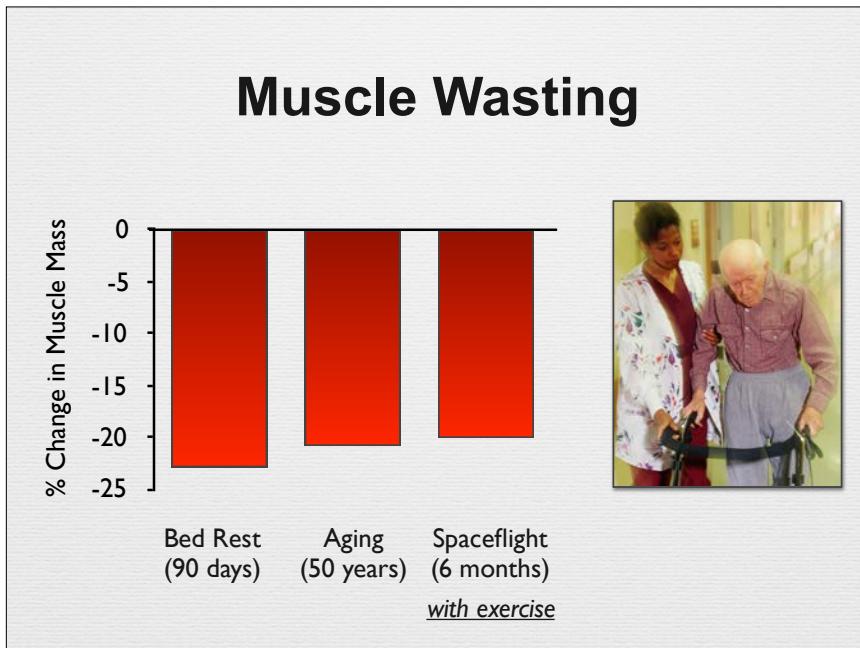
Physical Deconditioning with Space Flight



Cardiovascular Deconditioning



Musculoskeletal Wasting



Current Generation Exercise Program



Exercise Astronauts
Like Athletes



Single Muscle Fiber Performance

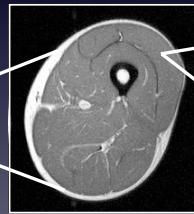
Size Strength Speed **Power**

Single Muscle Fiber Technique

Human Muscle Function with Space Flight



Whole Muscle → Single Fiber



Human Muscle Fiber
Magnified 400 times

Slow and fast fibers respond differently
to exercise and space flight



Meb Keflezighi
Boston Marathon Winner

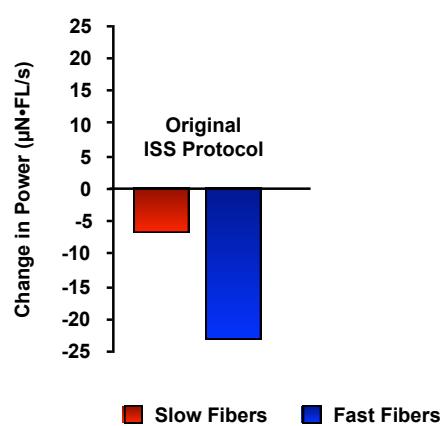


Colin Jackson
World Champion Sprinter

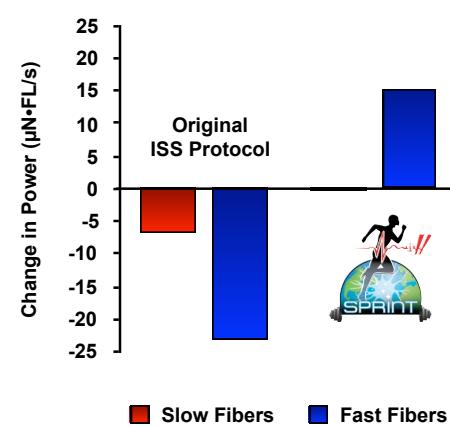
Mostly Slow Fibers

Mostly Fast Fibers

Single Muscle Fiber Power with Space Flight



Single Muscle Fiber Power with Space Flight



Heterogeneity in Skeletal Muscle



New Astronaut data slide to be made

Astronaut Health for a Mars Mission



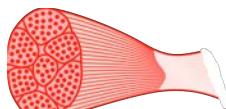
The Health Benefits of Exercise



Heart Health



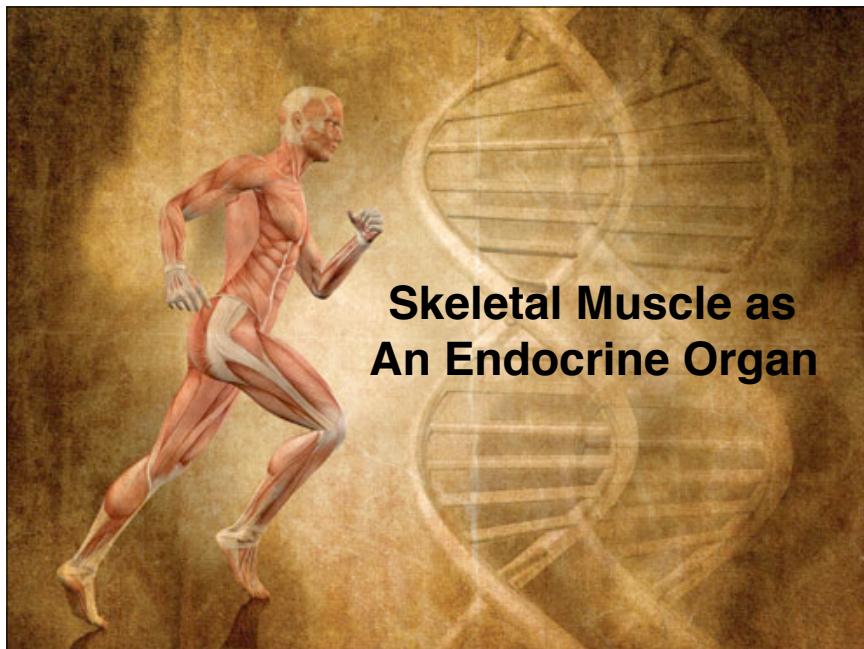
Brain Health



Skeletal Muscle Health

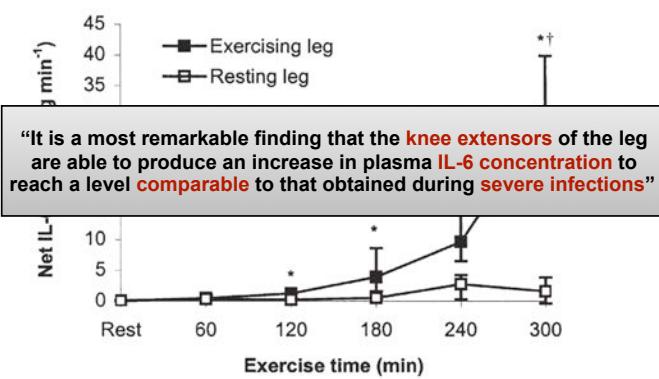


Bone Health



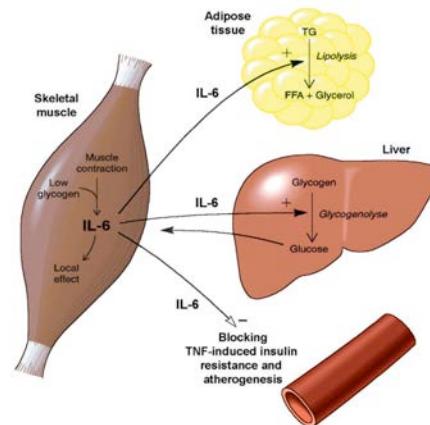
Skeletal Muscle as An Endocrine Organ

Skeletal Muscle Contraction Induced IL-6 Release



J Physiol 529: 237-244, 2000

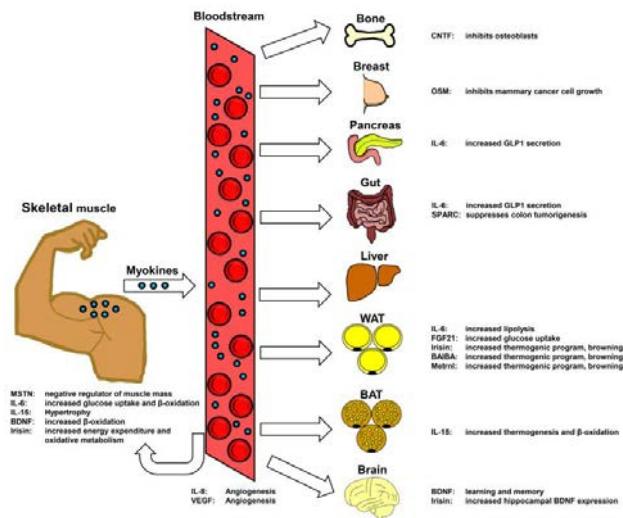
Muscle-Derived IL-6: A Biological Role?



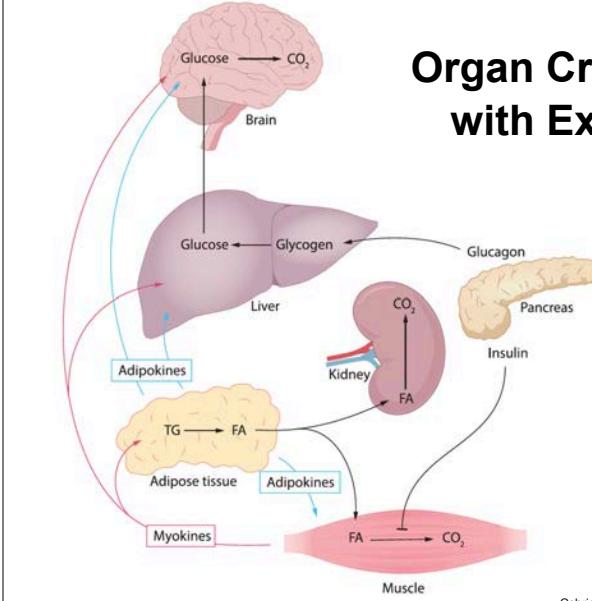
Muscle-derived IL-6 purported to work in a hormone-like fashion, contributing to maintenance of glucose homeostasis during exercise

J Physiol 536: 329-337, 2001

Myokines are Pluripotent

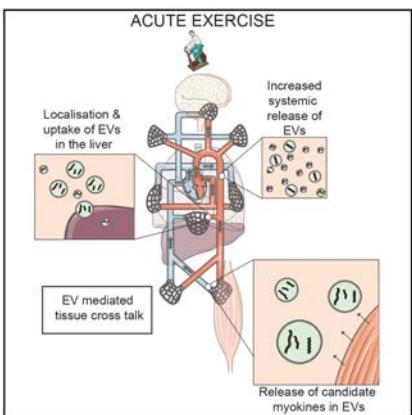


Organ Cross-Talk with Exercise



Gabriel & Zierath *Cell Metabolism* 25: 1000-1001, 2017

Exosome Biology and Exercise

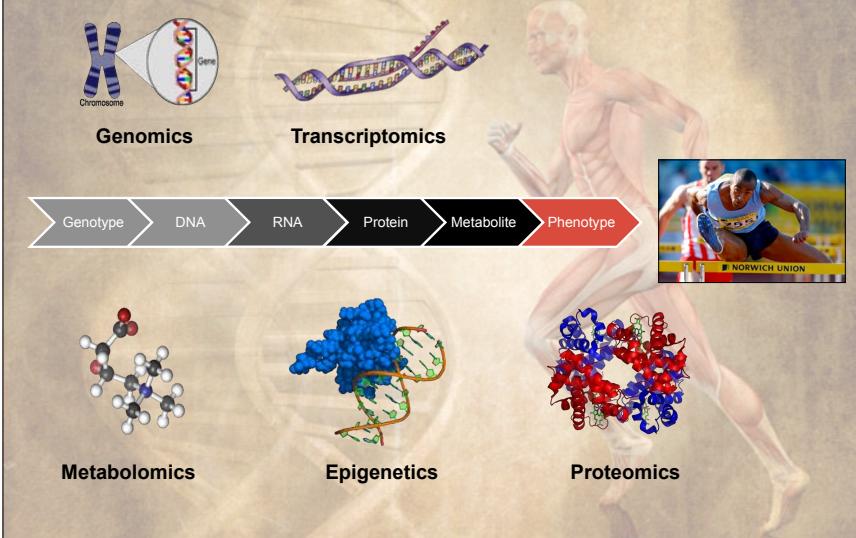


What Are Exosomes?

- Exosomes are small vesicles
- Released from skeletal muscle into circulation with exercise
- Carry cargo (i.e. proteins and myokines) to other tissues
- Novel and powerful communication network

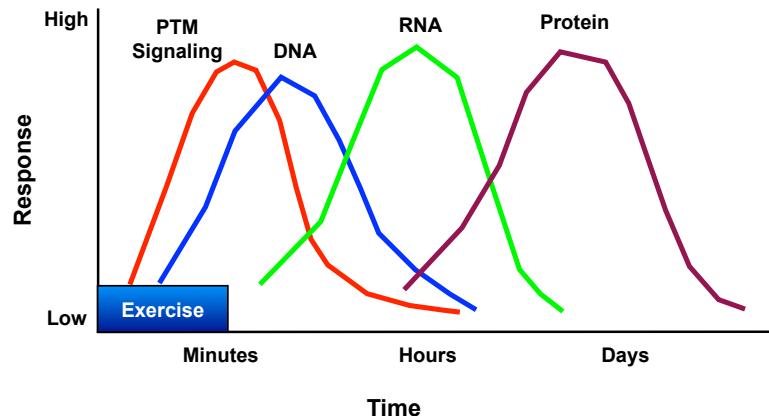
Whitham *Cell Metabolism* 27: 237-251, 2018

Functional Genomics and Health

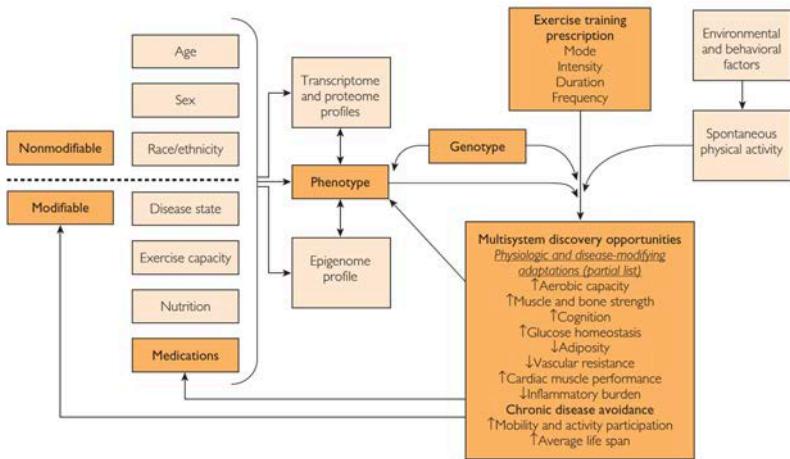


Molecular Transducers with Exercise

Conceptual Framework from Available Data



Exercise Biology Discovery



The Athlome Project Consortium

Athlome Project Consortium

Elite performance, Training response, Injury, Genetic modification



A Concerted Effort to Discover Genomic and other "OMIC" Markers of Athletic Performance



Molecular Transducers of Physical Activity Consortium (MoTrPAC)



National Institutes of Health
\$170 Million (2017-2023)

Largest, most complex and highly coordinated human exercise physiology training study in the history of the field





Goal: Assemble a genetic map of the health benefits of exercise



56 years of Exercise in Space



John Glenn
First Exercise in Space
Bungee Device
2/20/1962



Skylab - 1970's
First Multifaceted Exercise Program



Space Shuttle Era
More Complex Measures
More Organ Systems

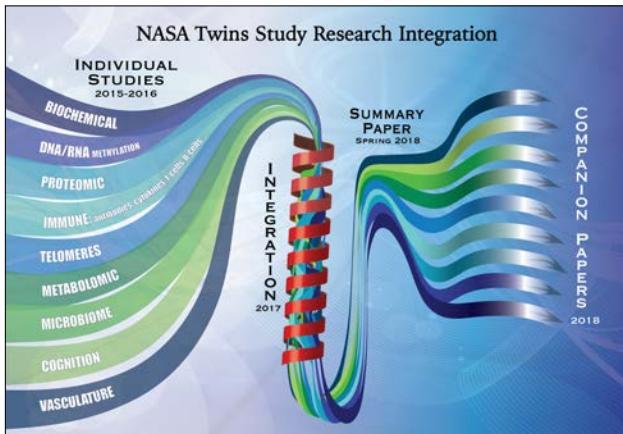
<10 Physiological Variables Measured

100's of Physiological Variables Measured

1000's of Physiological Variables Measured



New Frontiers in Space Medicine



100,000's of Physiological Variables Measured

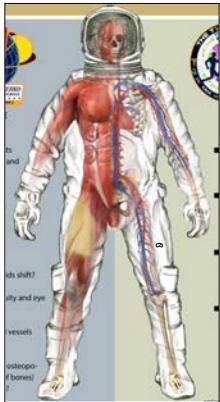


Take Home Message

- High degree of plasticity (all organs)
- Skeletal muscle is an endocrine organ
- Exercise triggers biological events lasting from minutes to hours to days
- Exercise stimulates numerous organ systems (pluripotent and multi-system cross-talk)
- Molecular transducers (“-omics”) is an emerging and maturing frontier of discovery



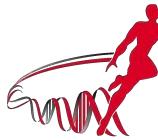
Exercise is Medicine



Whole body to Gene

- ✓ Exercise Heterogeneity
- ✓ Exercise Dose Response
- ✓ Organ Cross-Talk
- ✓ Functional Genomics

Health Effects Observed on Earth and in Space



Human Performance Laboratory Ball State University



Funding & Collaborators



Robert Fitts and Danny Riley

Lilly

Shawn Estrem, Hui-Rong Qian
Leah Helvering, Rosamund Smith



Alex Freeman, Nigel Walk
Colin Jackson



Per Tesch and Bjorn Alkner

[ISS and Bed Rest Teams](#)

Hargens Team
Biolo Team
Muscle Team
MEDES Team
Wyle Laboratories
MRI Technicians
Exercise Trainers
Simone Thomas - NASA

