National Aeronautics and Space Administration

The Digital Astronaut Project (DAP) Computational Modeling of Space Physiology

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Human Research Program Mission

To enable space exploration beyond low Earth orbit by reducing the risks to human health & performance through a focused program of:

- Basic, applied, and operational research

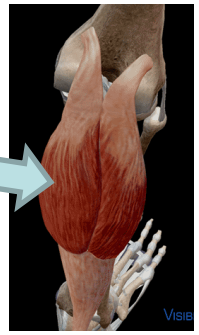
Leading to the development and delivery of:

- Human health, performance, and habitability standards
- Countermeasures and risk mitigation solutions
- Advanced habitability and medical support technologies

The NASA Digital Astronaut Project (DAP)

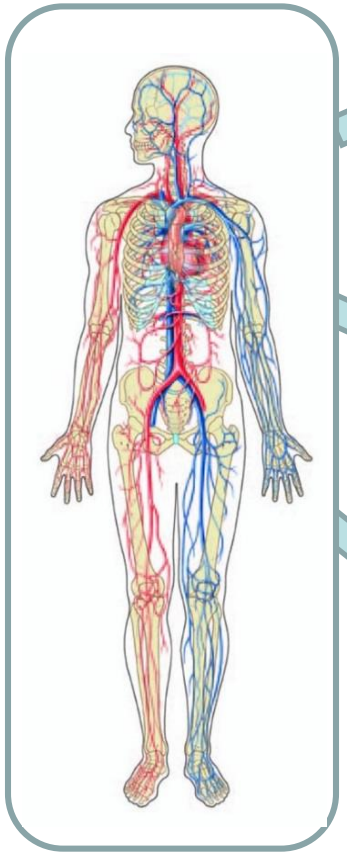
- **Develops and utilizes computational modeling in the mitigation of human health and performance risks associated with long-duration spaceflight**
- **Supplements space physiology research by informing experimental design**
- **Informs design and predicts efficacy of spaceflight countermeasure devices**
- **Project team:**
  - Kelly Gilkey, NASA GRC
  - Beth Lewandowski, NASA GRC
  - John DeWitt, KBRWyle
  - Jerry Myers, NASA GRC
  - Emily Nelson, NASA GRC
  - Jim Pennline, NASA GRC
  - Bill Thompson, NASA GRC
  - Chris Gallo, NASA GRC
  - Drayton Munster, NASA GRC
  - Aaron Godfrey, ZIN Technologies
  - Brad Humphreys, ZIN Technologies
  - Chris Werner, ZIN Technologies
  - Kathy Jagodnik, Baylor College of Medicine
  - Mo Kassemi, CWRU

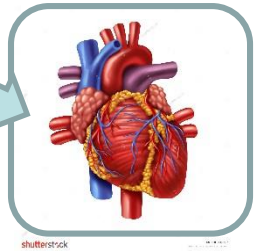
DAP Models of Physiological Systems and Organs

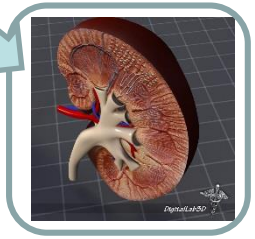


Musculoskeletal system

Biomechanical analysis;
Bone and muscle

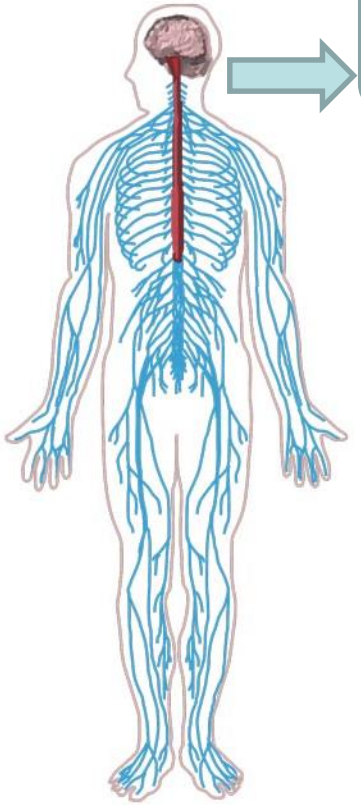


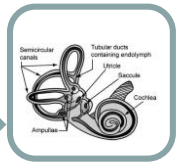




Lumped-parameter whole body model

Vasculature, cerebral spinal fluid, interstitial fluid and lymphatic fluid; heart, eye, kidney



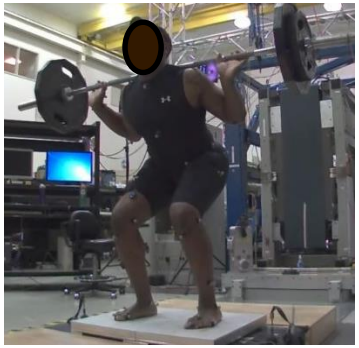


Central nervous system

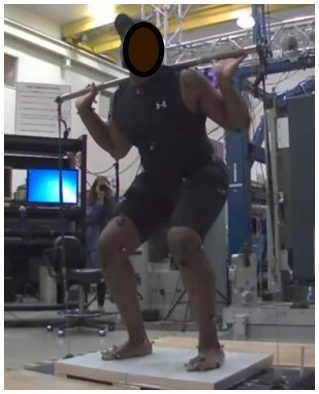
Vestibular organs

Biomechanical Modeling

- **Biomechanical data collection capabilities within the NASA GRC Exercise Countermeasures Lab**
- **Biomechanical analysis with the open source biomechanical simulation software OpenSim (Stanford University)**
- **Example Analyses:**
  - Biomechanical characterization of spaceflight exercise devices
  - Operational volume analyses
  - Interface loads analyses

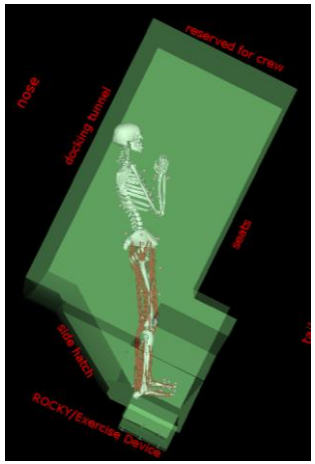


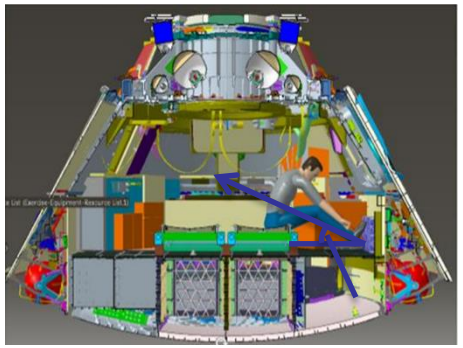
Barbell Free Weight



HULK Long Bar

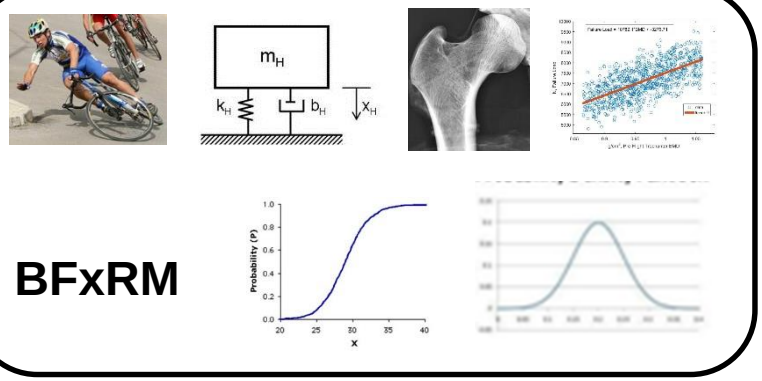
HULK Yo-Yo Harness



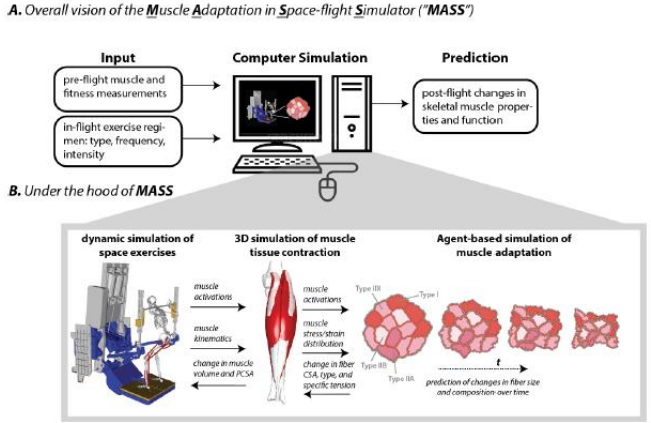


Musculoskeletal Modeling

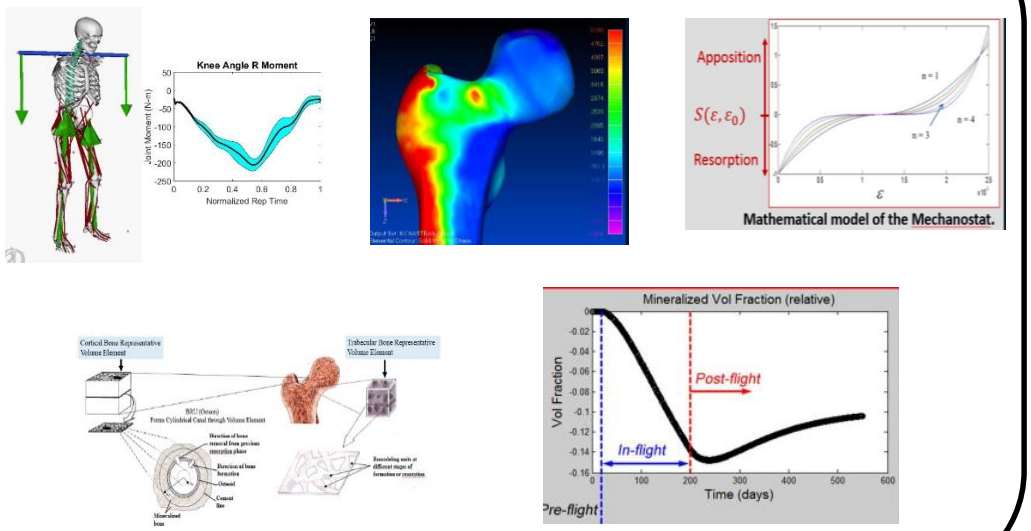
- **Bone Fracture Risk Module (BFxRM) for fracture probability calculations**
- **Bone physiology model to predict changes in bone mineral density**
- **Muscle atrophy space-flight simulation through a grant to University of Virginia**



MASS

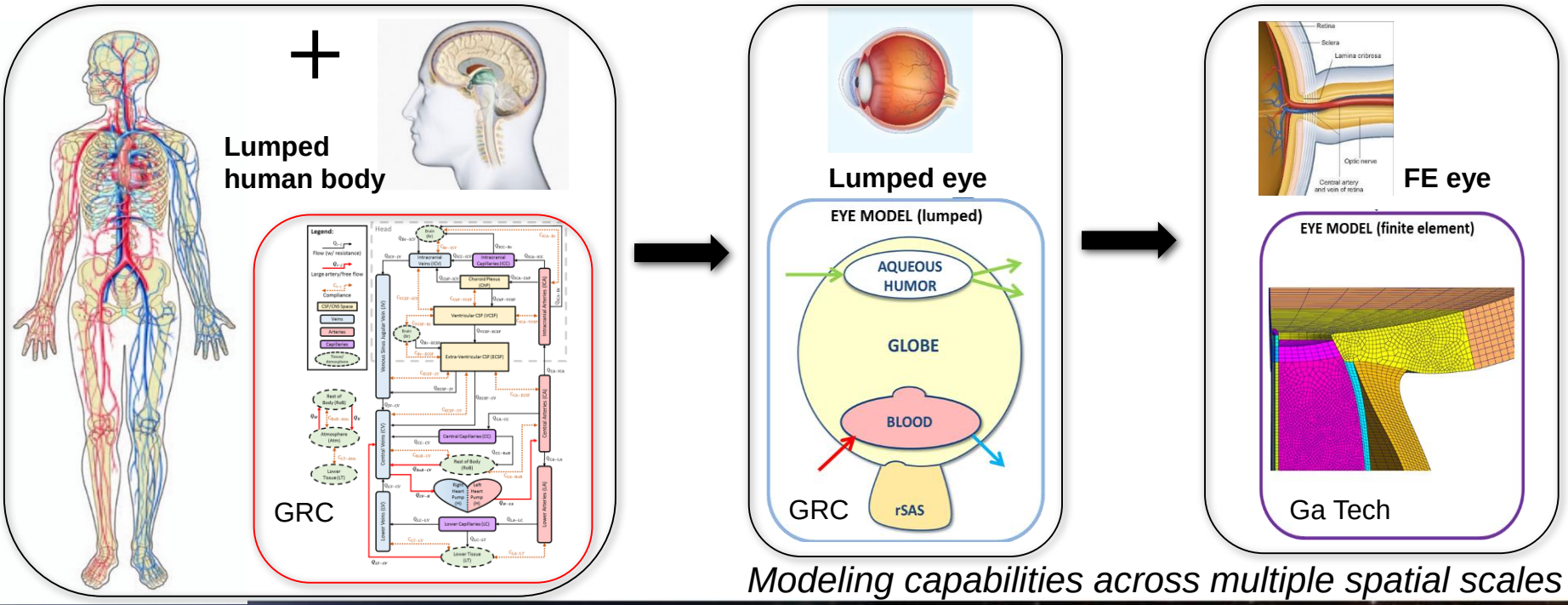


Bone Physiology Model



Cardiovascular and Ocular Modeling

- A human body model of cardiovascular, cerebral spinal, interstitial and lymphatic fluids provides mean arterial pressure (MAP) and intracranial pressure (ICP) in response to gravity-driven fluid shifts
- A lumped eye model provides intraocular pressure (IOP) and globe and blood volume estimates
- A finite element model of the optic nerve head includes tissue properties for tissue strains estimation when subjected to different MAP, ICP and IOP developed through a grant to the Georgia Institute of Technology
- Models are used in the research of Visual Impairment and Intracranial Pressure (VIIP) syndrome



Modeling capabilities across multiple spatial scales

NASA Human Research Program

- **The Digital Astronaut Project is within the Human Health and Countermeasures Element of the Human Research Program (HRP)**
  - https://www.nasa.gov/hrp
- **HRP has established a risk reduction strategy for human space exploration**
  - https://humanresearchroadmap.nasa.gov/
  - Studies and tasks are performed to reduce the risk
- **NASA funding opportunities are available through NSPIRES**
  - https://nspires.nasaprs.com/external/
  - HRP funding opportunities are listed as Human Exploration Research Opportunities (HERO)
  - Other information on research opportunities within HRP: https://www.nasa.gov/hrp/research/opportunities
- **New collaborative institute – Translational Research Institute**
  - https://www.bcm.edu/centers/space-medicine/translational-research-institute
  - Replacing National Space and Biomedical Research Institute

Thank You!!