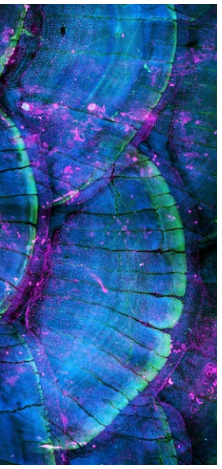
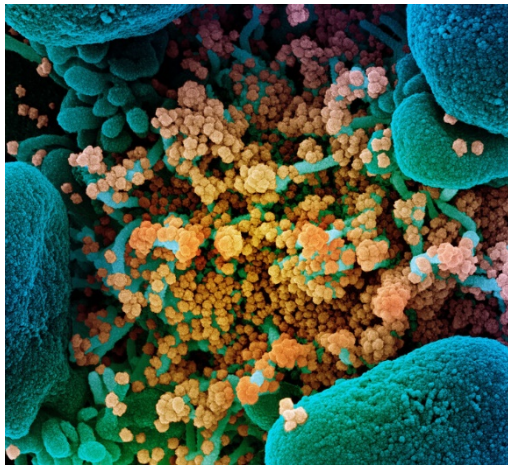
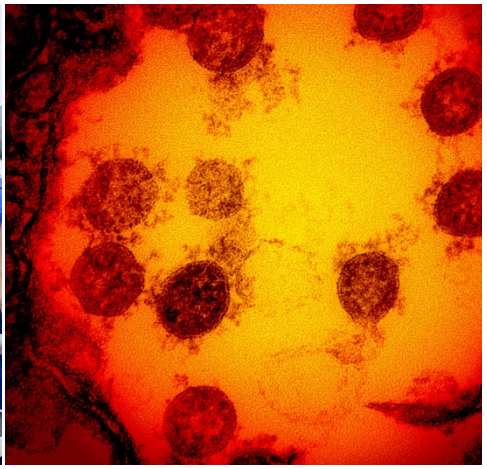
Physics Research at NIH

National Academy of Sciences' Board on Physics and Astronomy
Spring 2024 Meeting
May 8, 2024



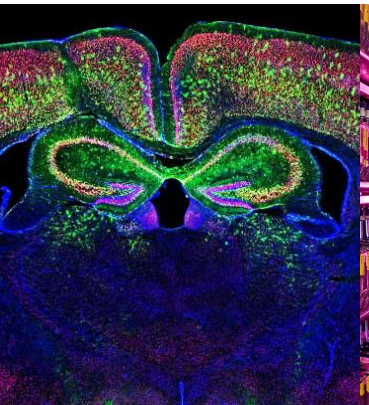


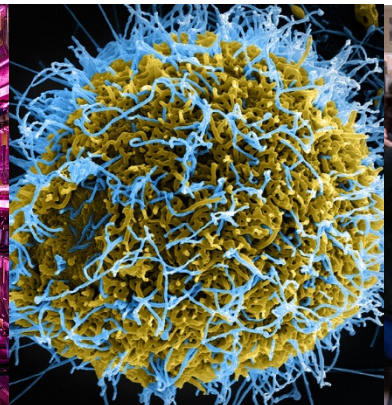


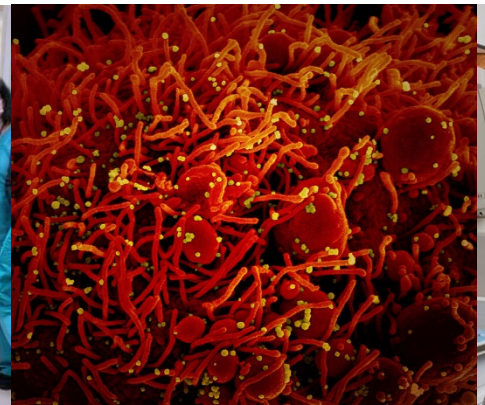
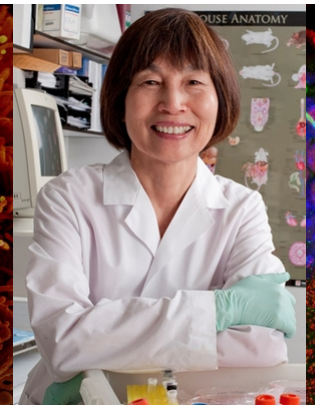
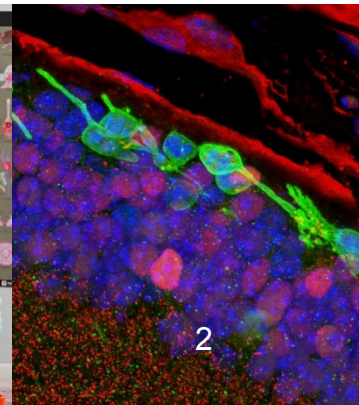

Lawrence A. Tabak, DDS, PhD
Principal Deputy Director, NIH
Department of Health and Human Services

Topics for Today

- Overview of NIH and its Priorities
- Portfolio of NIH-Funded Physics Research
- NCATS Collaboration with NASA
- Q&A



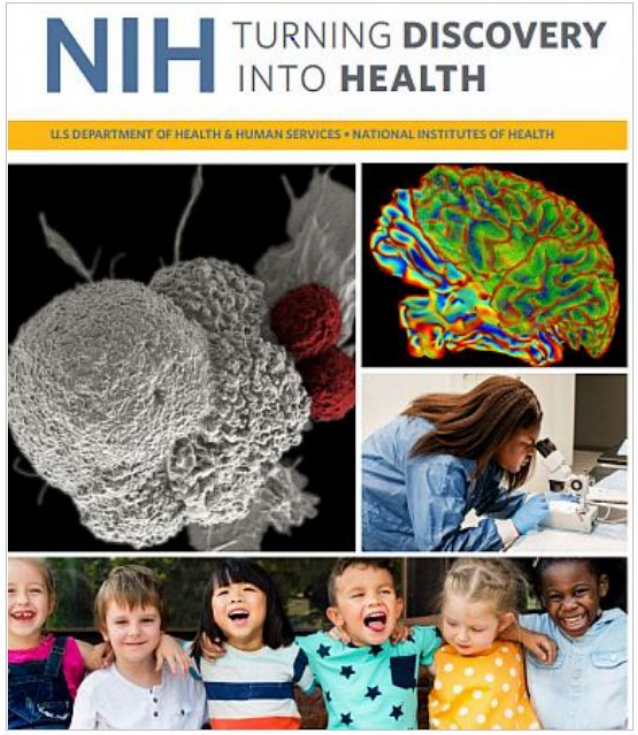


Physics Research at NIH

- **Overview of NIH and its Priorities**
- Portfolio of NIH-Funded Physics Research
- NCATS Collaboration with NASA
- Q&A

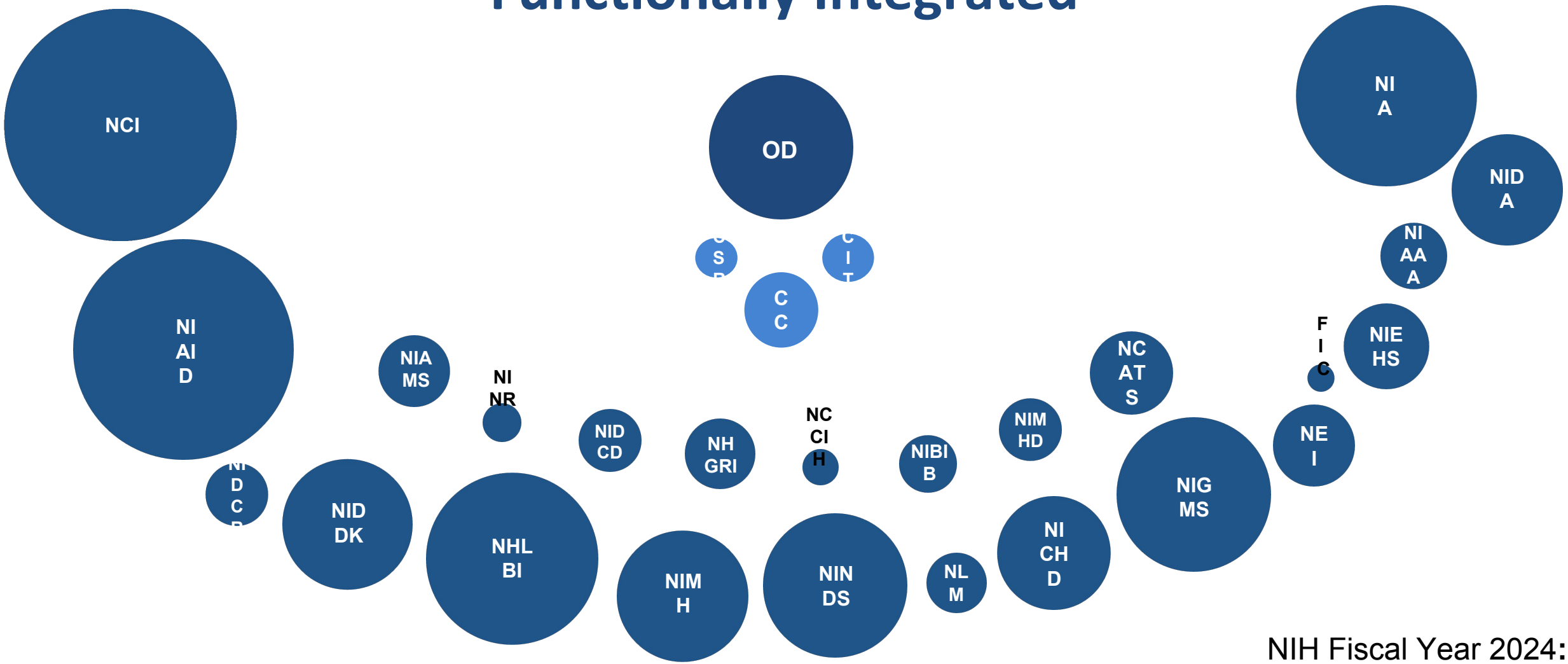
NIH Conducts and Supports Research and Research Training (Est. 1887)



NIH supports:

- **Basic research**...to fuel progress
- **Translational research**...to move basic discoveries forward
- **Clinical research**...to turn discoveries into prevention, treatments, and cures
- A **creative and diverse workforce**...since people are our most important resource
- A **balanced research portfolio**...to ensure high return on investment for U.S. taxpayers

NIH: Legally Decentralized but Functionally Integrated



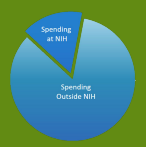
Integrated Policies and Infrastructure

NIH Fiscal Year 2024:

~$47.4 Billion

NIH Extramural Program by the Numbers

Generates 2.6 X budget in new economic activity



> 80% of budget funds grants and contracts in all 50 states and DC

~80,000 Applications of many types reviewed

Recruits ~ 28,000 reviewers

>2,800 NIH-funded institutions

~350,000 NIH-supported researchers

>29,000 Postdocs

~35,000 Grad Students

171 Nobel Prize winners

Dr. Monica Bertagnolli sworn in as 17th NIH Director

National Institutes of Health

Guiding Principles Articulated by NIH Director

- Our work is not finished when we deliver scientific discoveries. Our work is finished when all people are living long and healthy lives.
- NIH research encompasses the laboratory, the clinic, and the community.
- Progress is accelerated when advanced scientific methods, such as new data analytics, are applied to data that includes everyone, and when new discoveries are rapidly and equitably adopted in clinical care.

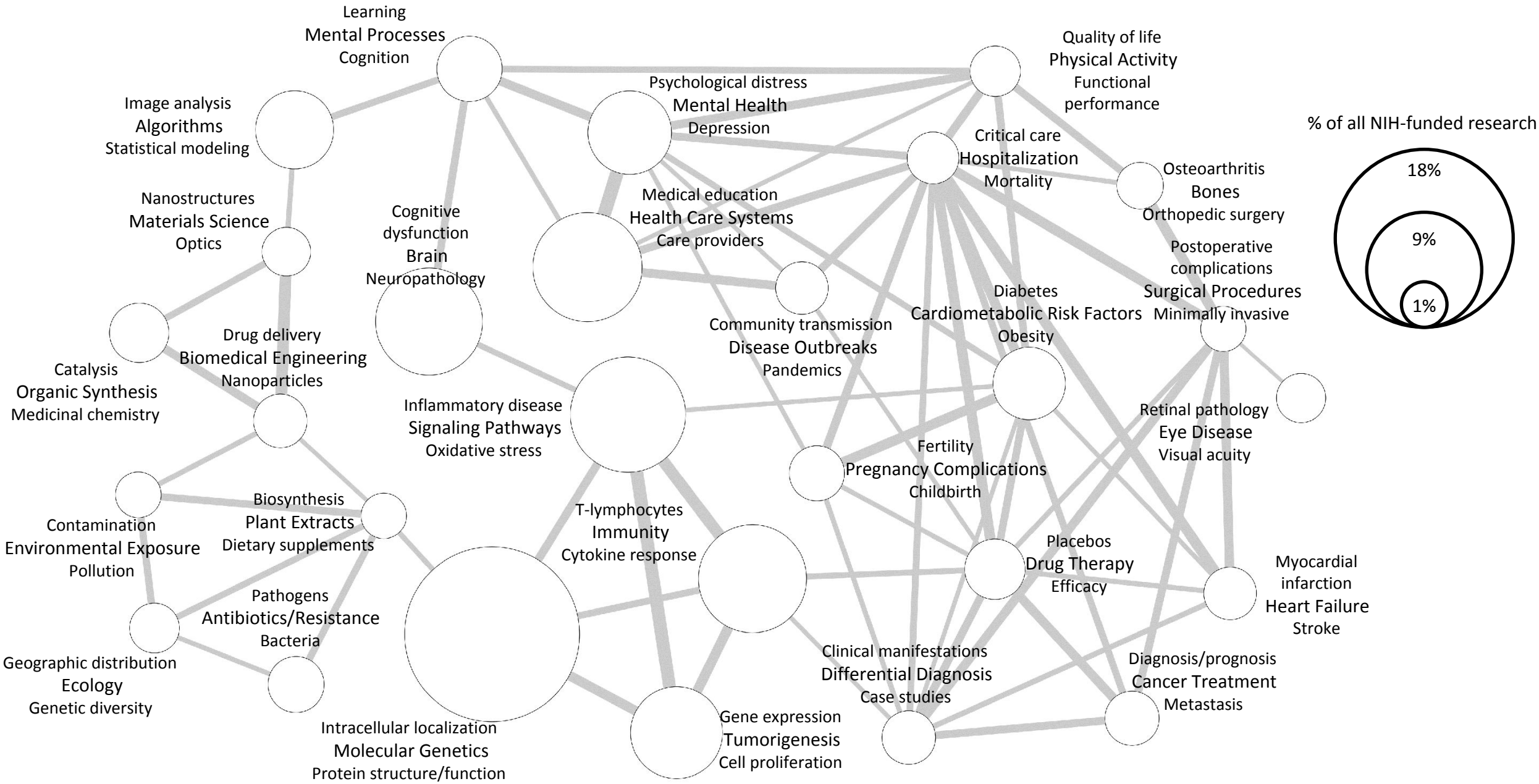
NIH Director's Vision
Expand biomedical research data use to inform new research and improve health outcomes

- **Integrate** data from basic and social science research, public health, and clinical care
- Increase capacity for data hosting
- Enable low-cost **access** to data using open-industry data standards
- Support broad access to advanced analytics and computational power
- Employ a **federated architecture** for data sharing and use
- Provide **education** and workforce development

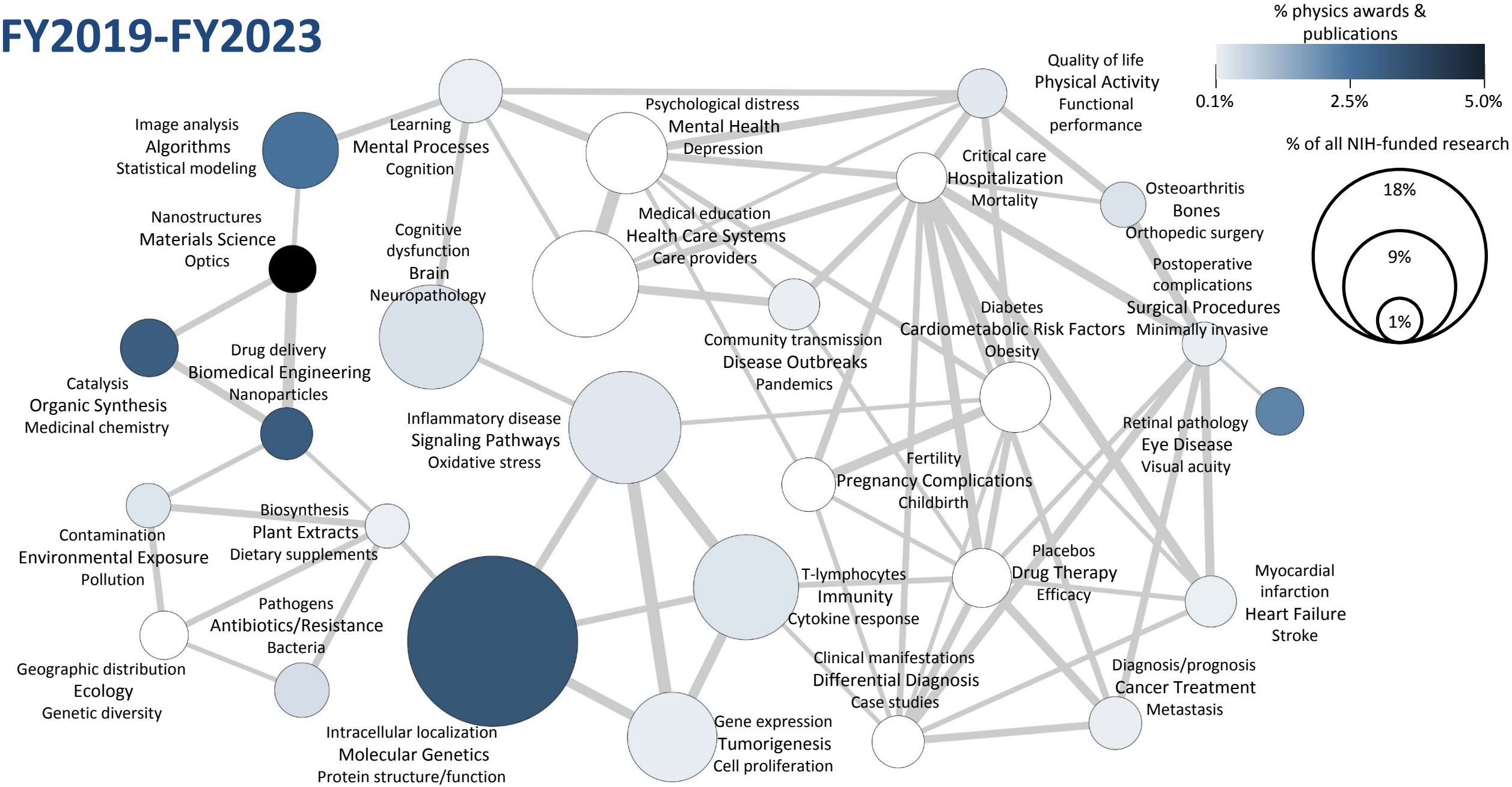
Physics Research at NIH

- Overview of NIH and its Priorities
- **Portfolio of NIH-Funded Physics Research**
- NCATS Collaboration with NASA
- Q&A

Topic map of the NIH portfolio



NIH-funded physics research (awards and linked publications) FY2019-FY2023



NIH-funded physics research: FY2019-FY2023

- Physics research accounted for 3% of NIH research awards (FY2019 to FY2023)
  - Other than studies on astronaut health, NIH did not support astronomy-related research over that time frame

- NIH-funded physics research is primarily focused on six research topics
  - Imaging is a cross-cutting area of NIH-funded physics research focused on improving a wide range of visualization methodologies that span different types of molecular and medical imaging

	Intracellular localization Molecular Genetics Protein structure/function	Image analysis Algorithms Statistical modeling	Nanostructures Materials Science Optics	Catalysis Organic Synthesis Medicinal chemistry	Drug delivery Biomedical Engineering Nanoparticles	Retinal pathology Eye Disease Visual acuity
Number of NIH-funded physics awards (FY19-FY23)	1183	822	116	92	64	48

Examples of NIH-funded physics research

Structure, function, and regulation of the proteome

"… drawing on concepts from astrophysics already resonant with [mass spectrometry], we anticipate that our highly creative method will overcome pervasive bottlenecks in cryo-electron microscopy sample preparation …."

R35GM118110

Image analysis
Algorithms
Statistical modeling

Cryo-ET guided single particle reconstruction of HIV

"Thus, using cryo-electron tomography, we are able to identify the location of "crowded" [HIV] Gag hexamers in the cryo-EM image, and using [single particle reconstruction], we are able to limit the electron radiation damages to the specimen and better correct the microscope contrast transfer function."

R21AI148328

Intracellular localization
Molecular Genetics
Protein structure/function

Examples of NIH-funded physics research

Biophysical models and mechanisms for cellular adaptation to environmental stress

"The goal of the proposed research is to develop quantitative theory and data-driven computational models to uncover the biophysical feedback mechanisms underlying cellular adaptive response to environmental stresses."

R35GM143042

Image analysis
Algorithms
Statistical modeling

Functional imaging of retinal photoreceptors

"We propose here to characterize the biophysical mechanism of the fast photoreceptor-[intrinsic optical signal]; and validate fast photoreceptor-IOS imaging for objective [optoretinography] of photoreceptor function in human subjects. "

R01EY023522

Retinal pathology
Eye Disease
Visual acuity

Emerging areas

Quantum Sensing Technologies opportunities:

Novel quantum sensing technologies could drastically enhance current biological imaging and sensing measurements

Quantum Computing opportunities:

Development of quantum competencies, experience with utilizing prototype quantum computing systems, and identification of relevant quantum applications and algorithms

Emerging areas

Digital twins

A digital twin is a set of virtual information constructs that mimics the structure, context, and behavior of a natural, engineered, or social system (or system-of-systems), is dynamically updated with data from its physical twin, has a predictive capability, and informs decisions that realize value. The bidirectional interaction between the virtual and the physical is central to the digital twin.

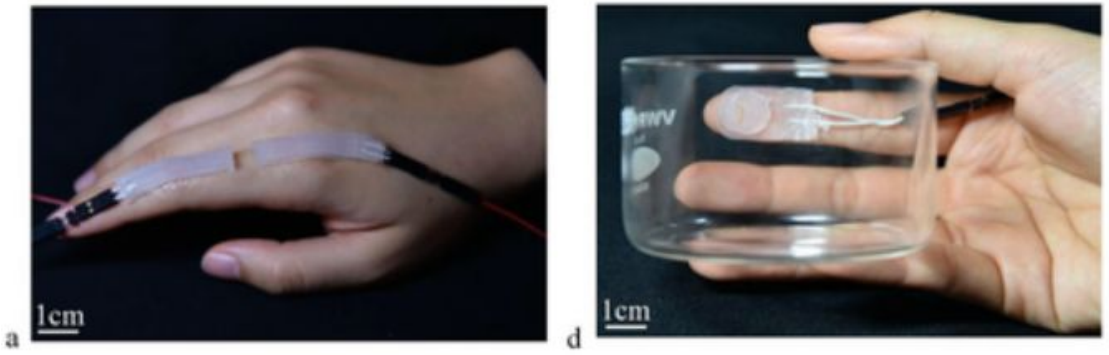
Two real world example of digital twins:

1. The Automated Insulin Pump, also known as the artificial pancreas, functions as a digital twin capable of detecting human blood sugar levels, monitoring recent physical activities, and factoring in other physiological variables. It uses this information to predict the body's insulin requirements and administer the necessary insulin into the human body. Continuously receiving new data from its sensors, it adjusts its responses accordingly.
2. The self-driving car is another real-world example of digital twins. The sensors of the car collect vehicle and environmental information, make predictions regarding potential accidents, and adjust driving speed and direction accordingly.

Emerging areas

Smart Health and Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science

Biocompatible Soft Fluidic Strain and Force Sensors for Wearable Devices



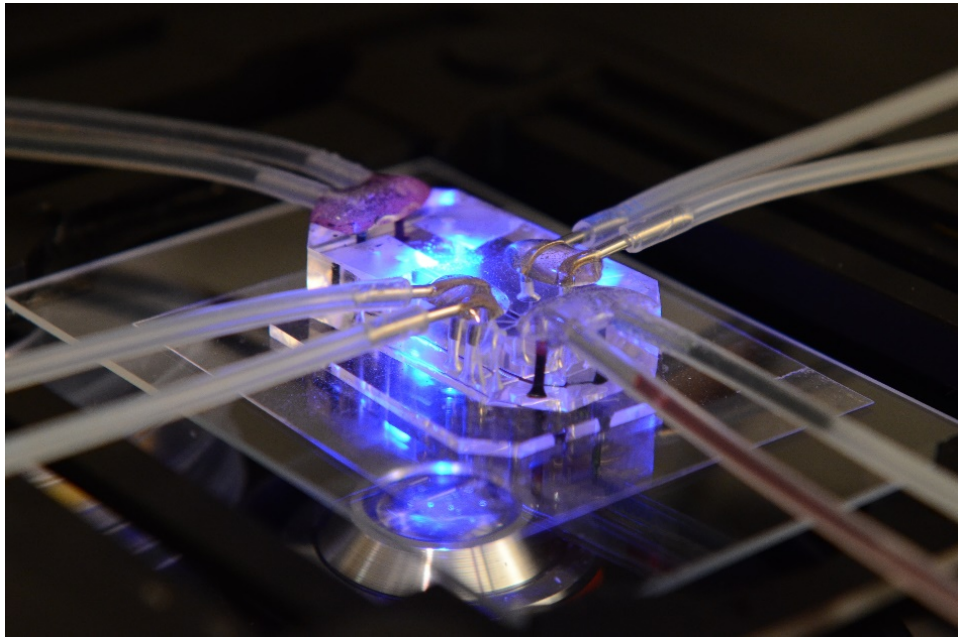
Demonstration of the functionalities of the strain and force sensors as wearable devices for human motion detection

NIH-NSF interagency program to advance the science in mathematics, statistics, engineering, computer science, and their application in biomedical areas.

Emerging areas

Micro-physiological systems

Advanced and scalable manufacturing methods for micro-physiological systems; understanding the relationship of mechanical signals to cellular activity



Organ-on-a-chip technologies offer more lifelike platforms to study therapies for disease

Photo: flickr.com/photos/nihgov/27195794031/in/album-72157659401055954

Physics Research at NIH

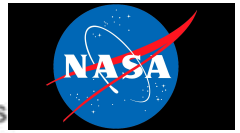
- Overview of NIH and its Priorities
- Portfolio of NIH-Funded Physics Research
- **NCATS Collaboration with NASA**
- Q&A

NASA and NIH Share Interests: Exploring Health Hazards of Human Spaceflight

- Space radiation
- Microgravity
- Isolation and confinement
- Healthcare delivery in remote and resource-limited environments

NCATS aims to translate research findings from biomedical experiments in Low-Earth Orbit (LOE) and space towards real world applications that can benefit the health and wellbeing of life on Earth.

CHIPS IN SPACE

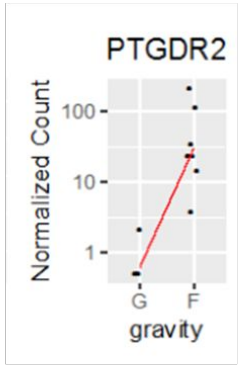


- Partnership through a memorandum of understanding (MOU) between **NCATS and International Space Station-National Laboratory (ISS-NL)** to:
  - **Collaborate and coordinate efforts for biomedical research** at the ISS-NL
  - **Develop tissue chips that model human diseases and conditions mimicking the pathology of major organs and tissues in the human body when exposed to the extreme environments of space** upon the deployment of these models to the ISS-NL

NCATS Tissue Chips in Space Program

Preliminary Results from Tissue Chips in Space

UCSF

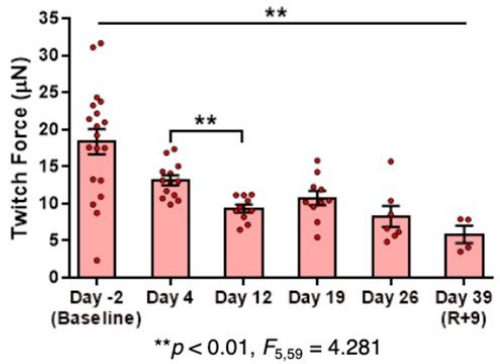


- Microgravity mimics immune cell aging in just 15 days (instead of years on Earth)
- Microgravity causes changes in cell markers of senescence (aging), proliferation and wound healing

UNIVERSITY of WASHINGTON

JOHNS HOPKINS UNIVERSITY

THE OHIO STATE UNIVERSITY



- Microgravity causes functional deficits in heart tissues which increase over time

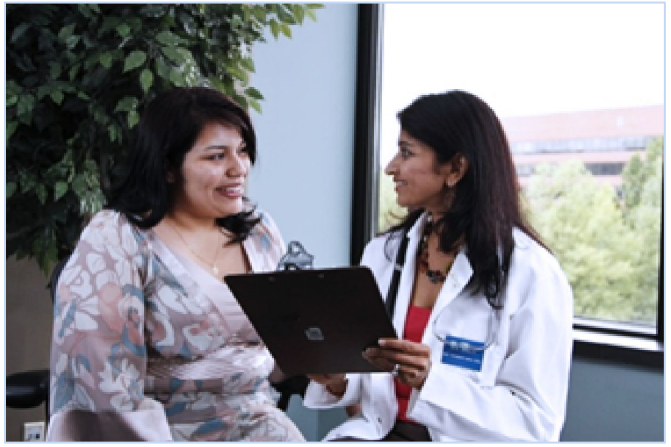
- Microgravity provide environment to model aging-related disorders in a shorter time frame

Summary

- Physics research is an essential component of the NIH research portfolio – advancements and findings impact outcomes across NIH's many research areas.
- NIH supports physics research through several funding avenues and programs, creating opportunities for discovery in many topic areas.
- NIH collaborates with other agencies and entities to conduct novel and advanced physics research.
- There are exciting opportunities for future physics research to create and improve tools and methodologies that will affect human health.

Physics Research at NIH

- Overview of NIH and its Priorities
- Portfolio of NIH-Funded Physics Research
- NCATS Collaboration with NASA
- **Q&A**

NIH...

Lawrence.Tabak@nih.gov

Turning Discovery Into Health