



National Institute of
Biomedical Imaging
and Bioengineering

Perspectives on Next Generation Engineering Systems

2024 Symposium on Smart and Autonomous Medical Systems (SaAMS)

Boston, Massachusetts

June 6, 2024

Grace C.Y. Peng, PhD



National Institutes of Health
Office of Data Science Strategy

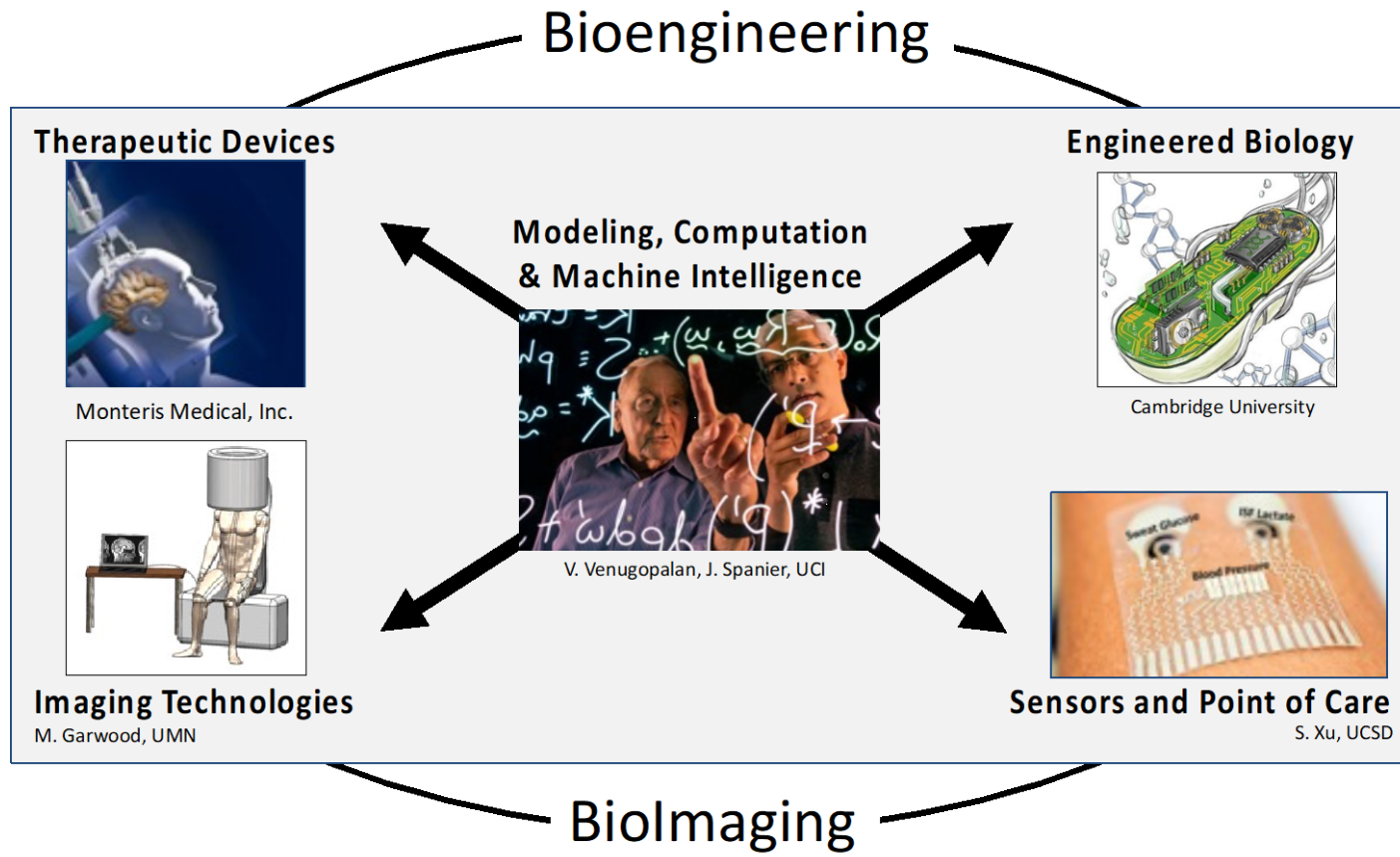


ODSS is addressing:

- findability, interconnectivity, and interoperability of NIH-funded biomedical data sets and resources
- integration of existing data management tools and development of new ones
- universalization of innovative algorithms and tools created by academic scientists into enterprise-ready resources that meet industry standards of ease of use and efficiency of operation
- growing costs of data management.



National Institute of Biomedical Imaging and Bioengineering (NIBIB) Strategic Plan



- **VISION:** Technologies to shape the future of health.
- **MISSION:** Transform, through technology development, our understanding of disease and its prevention, detection, diagnosis, and treatment.

NIBIB Quantum Projects: Implementation Phase II (U01)

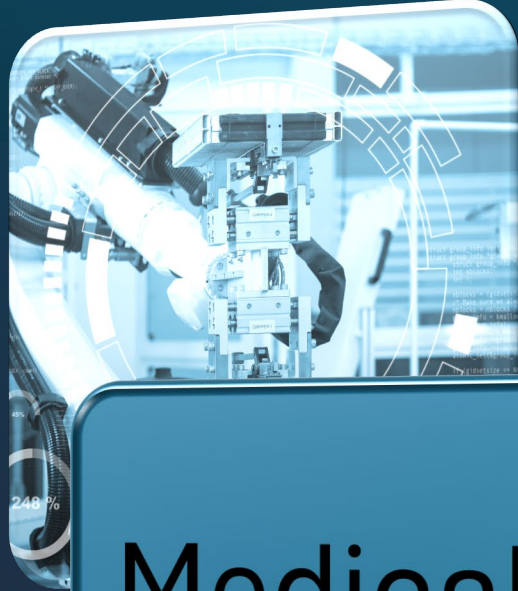
- **RFA-EB-09-003**
- The goal is to achieve a profound (quantum) impact on the prevention, diagnosis, or treatment of a major disease or national public health problem through the development and implementation of biomedical technologies.
- **MD PnP Quantum Award: 9/30/10 – 8/31/15**
- **Program Officers:** Zohara Cohen, Grace Peng, James Luo, Vinay Pai



Centers for Disease Control (CDC)

10 Leading Causes of Death, United States
2020, Both Sexes, All Ages, All Races

	<u><1</u>	<u>1-4</u>	<u>5-9</u>	<u>10-14</u>	<u>15-24</u>	<u>25-34</u>	<u>35-44</u>	<u>45-54</u>	<u>55-64</u>	<u>65+</u>	<u>All Ages</u>
1	Congenital Anomalies 4,043	Unintentional Injury 1,153	Unintentional Injury 685	Unintentional Injury 881	Unintentional Injury 15,117	Unintentional Injury 31,315	Unintentional Injury 31,057	Malignant Neoplasms 34,589	Malignant Neoplasms 110,243	Heart Disease 556,665	Heart Disease 696,962
2	Short Gestation 3,141	Congenital Anomalies 382	Malignant Neoplasms 382	Suicide 581	Homicide 6,466	Suicide 8,454	Heart Disease 12,177	Heart Disease 34,169	Heart Disease 88,551	Malignant Neoplasms 440,753	Malignant Neoplasms 602,350
3	Sids 1,389	Homicide 311	Congenital Anomalies 171	Malignant Neoplasms 410	Suicide 6,062	Homicide 7,125	Malignant Neoplasms 10,730	Unintentional Injury 27,819	Covid-19 42,090	Covid-19 282,836	Covid-19 350,831
4	Unintentional Injury 1,194	Malignant Neoplasms 307	Homicide 169	Homicide 285	Malignant Neoplasms 1,306	Heart Disease 3,984	Suicide 7,314	Covid-19 16,964	Unintentional Injury 28,915	Cerebrovascular 137,392	Unintentional Injury 200,955

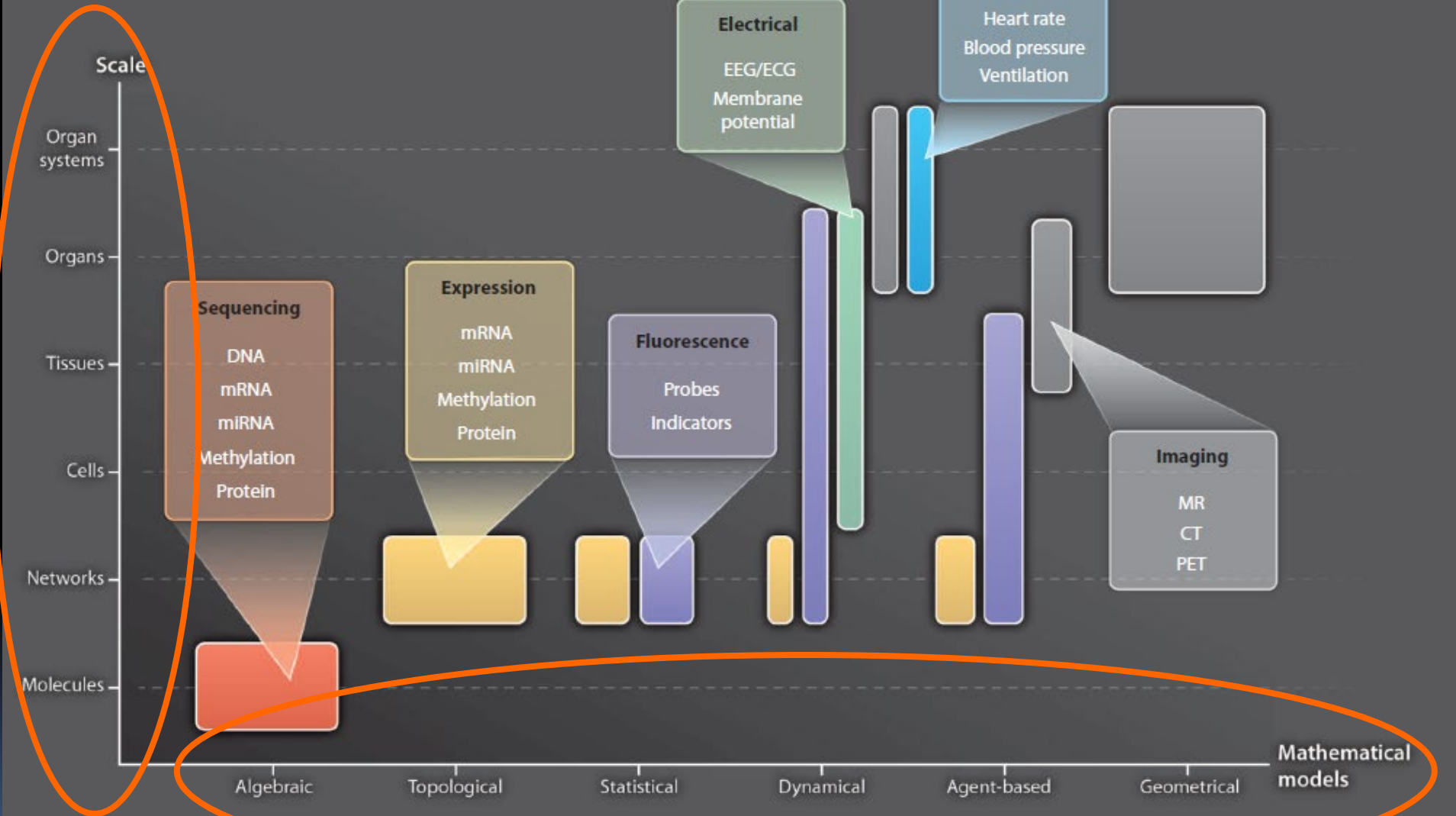


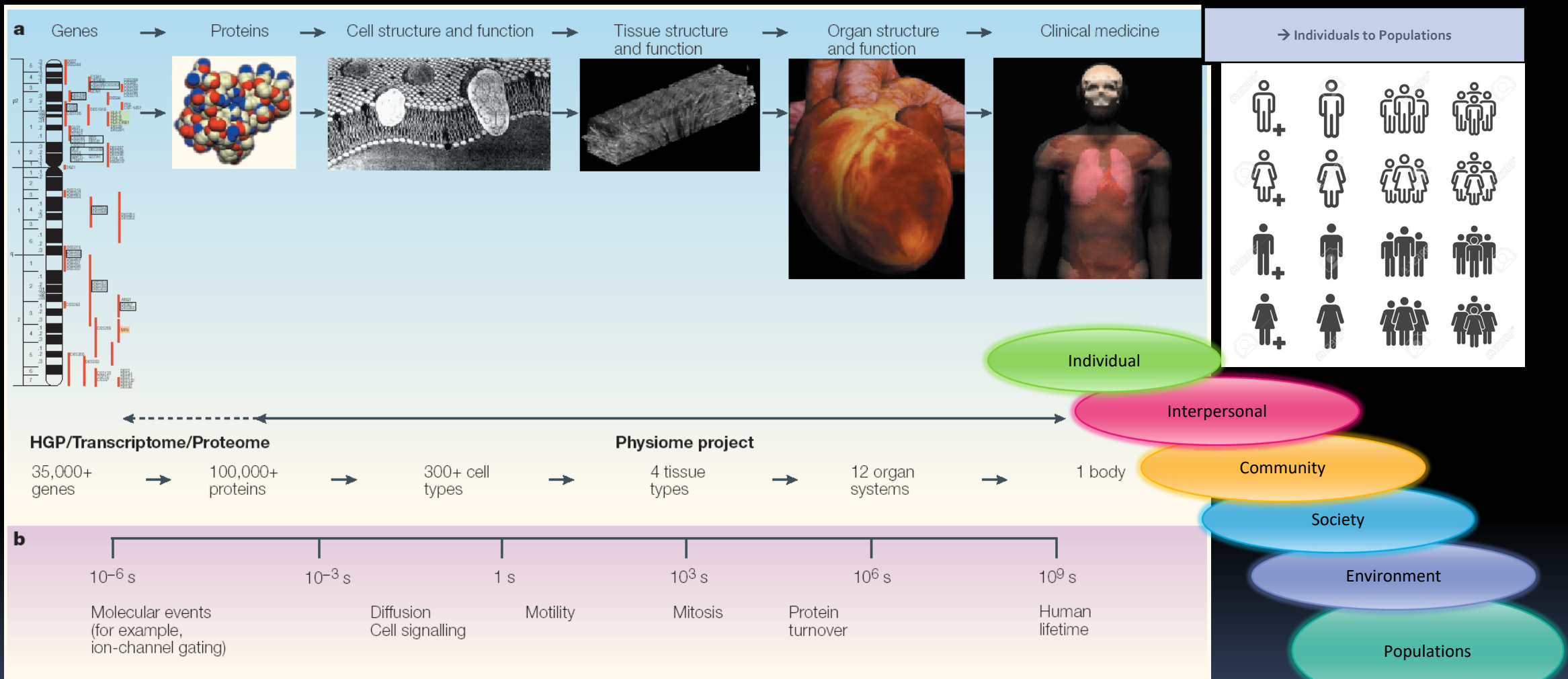
Medical
Devices



Medical
Data

Winslow et al., 2012

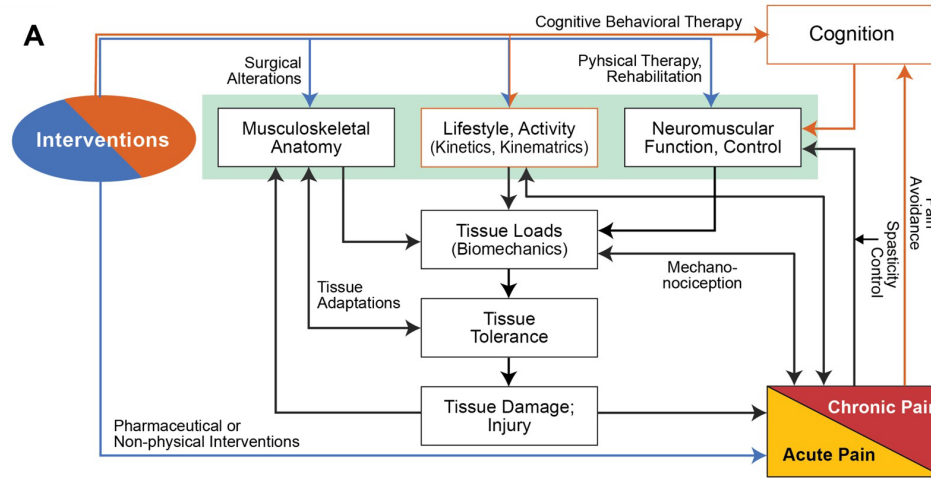




Hunter and Borg, Nature 2003

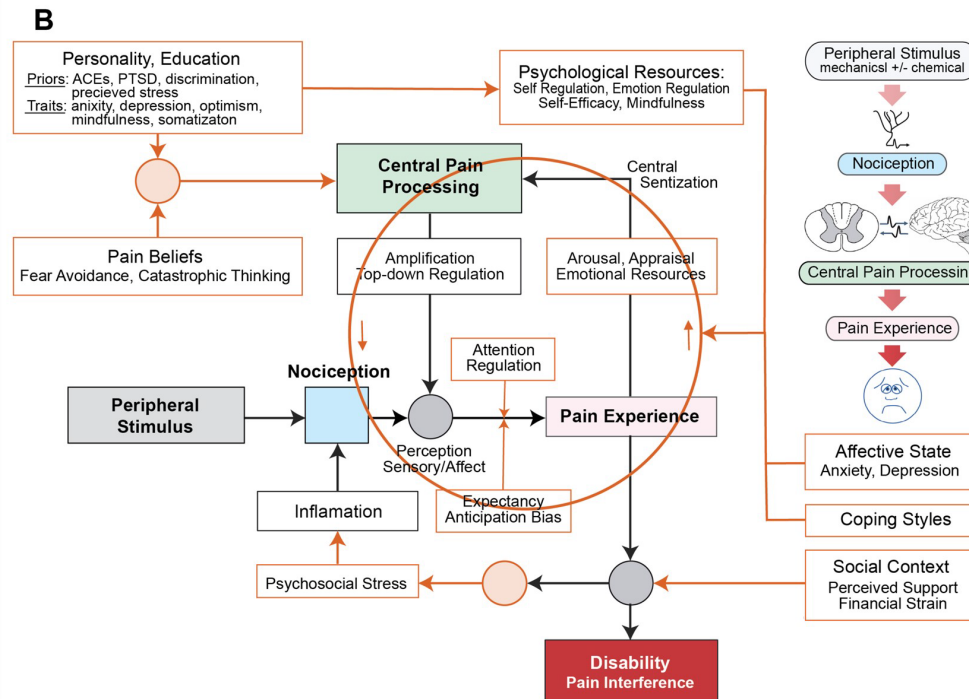
Theoretical Schemas to Guide NIH Back Pain Consortium (BACPAC) Chronic Low Back Pain Clinical Research

A) This scheme illustrates features and activities contributing to loads generated in the spine during daily-living activities. Tissue stresses triggering nociception can exceed tissue tolerances, cause damage, and thus facilitate the development of neuropathic pain. Concurrent feedback phenomena can affect neuromuscular control and function.

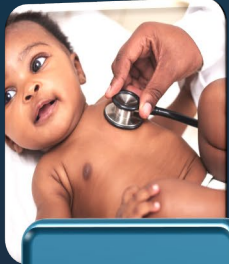


More mechanistic insight creates a higher value product → less propagation of uncertainty

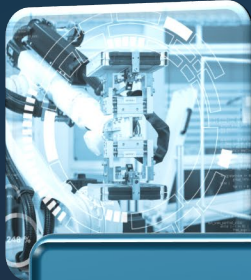
(B) This scheme illustrates how social, biobehavioral, psychological, and patient-specific features and phenomena can influence central pain processing, pain experience, and ultimately disability. The circle highlights features and phenomena that can contribute dynamic bidirectional (“top-down,” “bottom-up”) influences.



Abbreviations: ACE = agreeableness, conscientiousness, extraversion; PTSD = post-traumatic stress disorder.



Living
Systems



Medical
Devices



Medical
Data

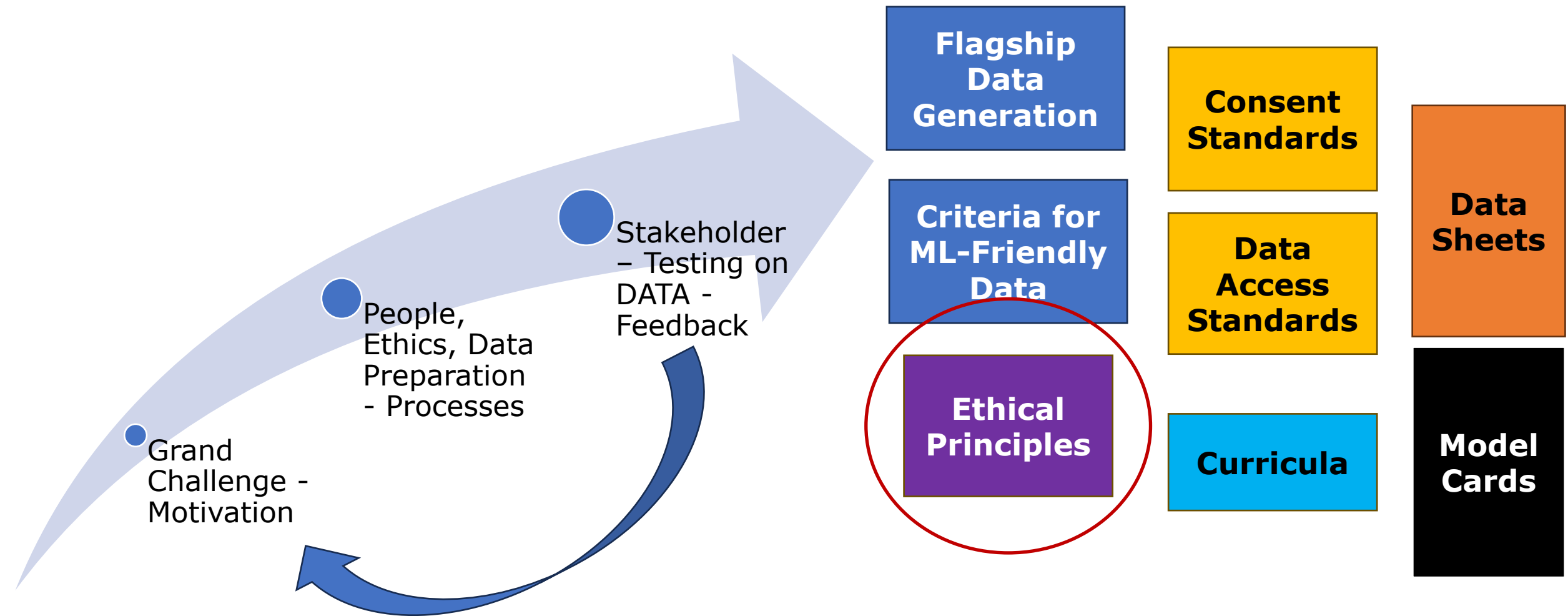


Medical
Care



Health
& Well
Being

NIH Bridge2AI Program



Bridge2AI - Instilling a culture of ethical inquiry

Topol, E.J. High-performance medicine: the convergence of human and artificial intelligence. Nat Med 25, 44–56 (2019). <https://doi.org/10.1038/s41591-018-0300-7>

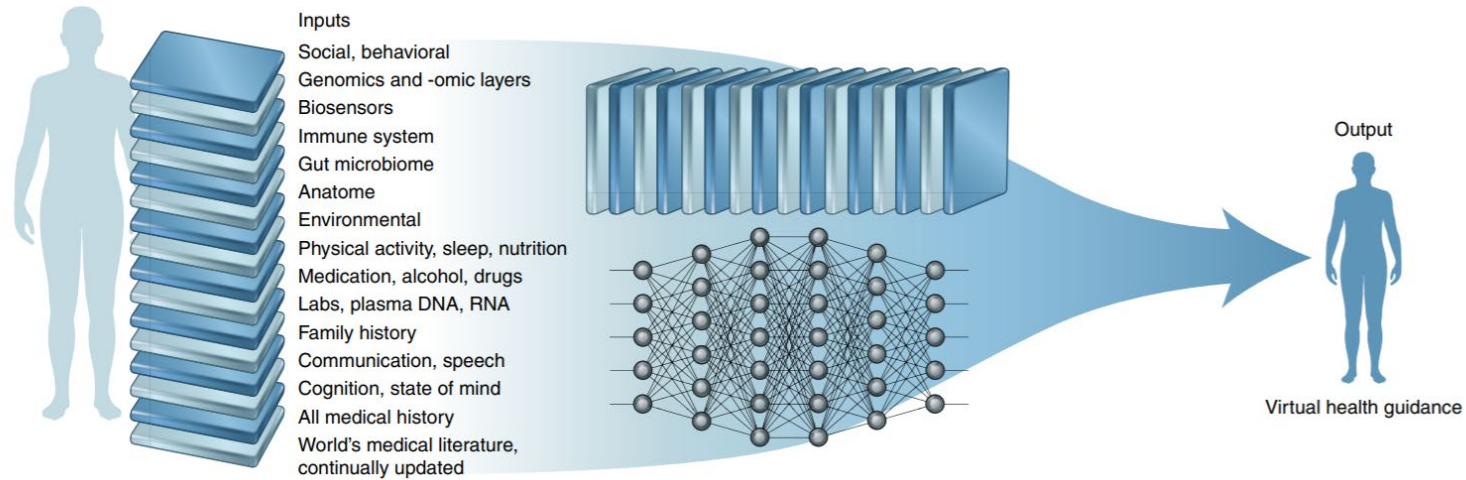
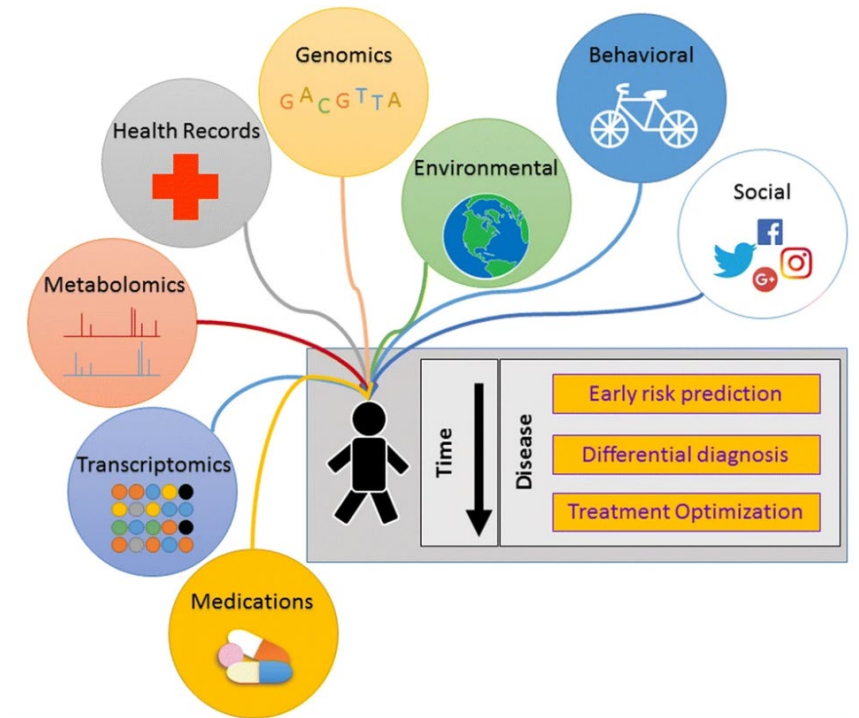


Fig. 3 | The virtual medical coach model with multi-modal data inputs and algorithms to provide individualized guidance. A virtual medical coach that uses comprehensive input from an individual that is deep learned to provide recommendations for preserving the person's health. Credit: Debbie Maizels/ Springer Nature

To integrate all types of ethically sourced biomedical and behavioral data to predict health outcomes



From: [Big data hurdles in precision medicine and precision public health](#), Proserpi et al. BMC Medical Informatics and Decision Making (2018)

DATA COLLECTION

- Data Acquisition & Aggregation Bias
- Biased Synthetic Data

- Population Bias
- Popularity/Patient-based Bias
- Temporal Bias
- Sampling/Representation/Selection Bias
- Detection Bias
- Amplification Bias
- Training Data Bias
- Cognitive Bias

MODEL DEVELOPMENT

- Inherited/Error Propagation Bias

MODEL EVALUATION

- Statistical Bias

- Institutional/Systemic Bias
- Activity Bias

- Presentation Bias

DATA PREPARATION

- Content Production Bias

- Exclusion Bias

- Membership Bias
- Historical Bias
- Behavioral Bias

- Automation Complacency/Loss of Situational Awareness Bias

- Annotator Bias

MODEL DEPLOYMENT

- Deployment Bias
- Concept Drift/Emergent Bias
- User Interaction Bias

- Uncertainty Bias/Epistemic Uncertainty

- Evaluation Bias

- Funding/Publication Bias

Major Bias Sources

- **Data Collection**
- **Data Preparation**
- **Model Development**
- **Model Evaluation**
- **Model Deployment**

Bias Awareness Tool:
<https://www.midrc.org>

Community Partnerships to Advance Science for Society (ComPASS)

To advance the science of health disparities and health equity research, the National Institutes of Health (NIH) Common Fund launched the ComPASS Program.

The goals of ComPASS are to:

1. Study ways to reduce health disparities by addressing underlying structural factors within communities.
2. Develop a new research model for NIH where the projects are led by community organizations in collaboration with research partners.

ComPASS has three initiatives:



Community-Led, Health Equity Structural Interventions (CHESIs)



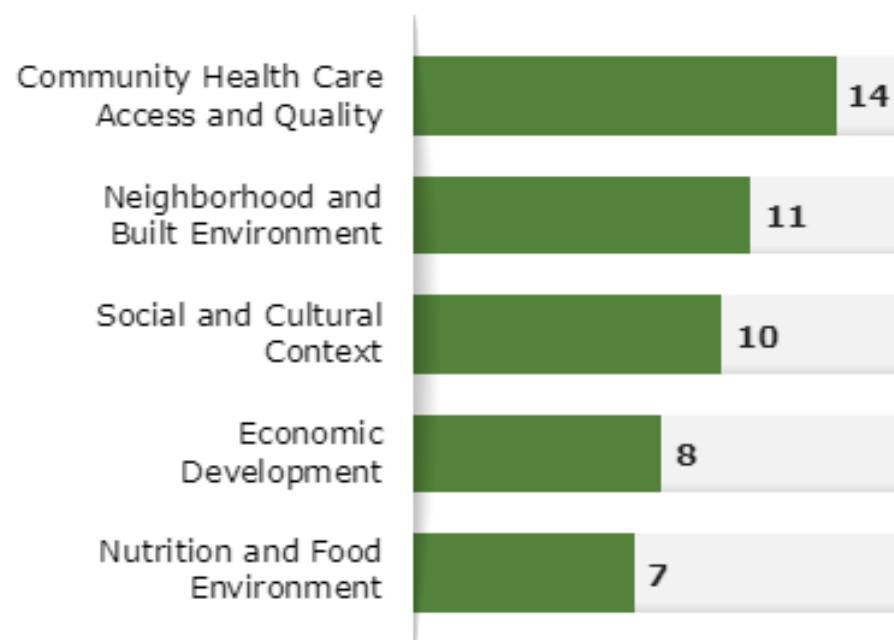
ComPASS Coordination Center (CCC)



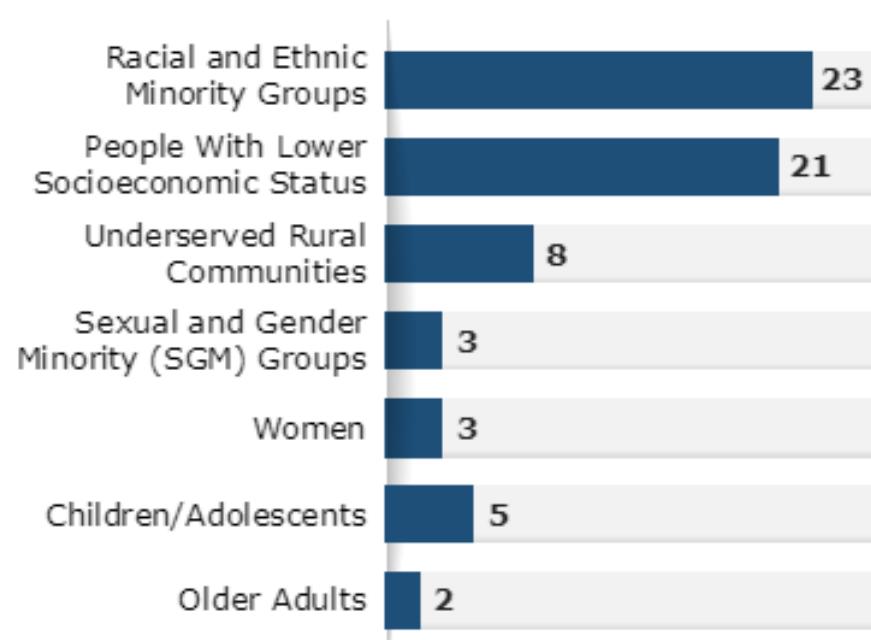
Health Equity Research Hubs (Hubs)

The 25 CHESI Structural Factors and Participant Populations

Social Determinants of Health and Structural Factors of the Projects



Populations That Experience Health Disparities and Other Participant Populations*



*Note that CHESI projects that focus on more than one social determinants of health and/or population experiencing health disparities are counted more than once.

Connect With Us!



For more information, visit the NIH Common Fund ComPASS website at commonfund.nih.gov/compass.



Learn more by viewing the [ComPASS Video Overview](#).



To receive ComPASS program announcements and information about funding opportunities, join the [ComPASS listserv](#).

Foundational Research Gaps and Future Directions for Digital Twins

*Karen Willcox (chair), Caroline Chung, Jim Kinter,
Irene Qualters, Brittany Segundo*

December 15, 2023

[https://www.nationalacademies.org/
digital-twins](https://www.nationalacademies.org/digital-twins)

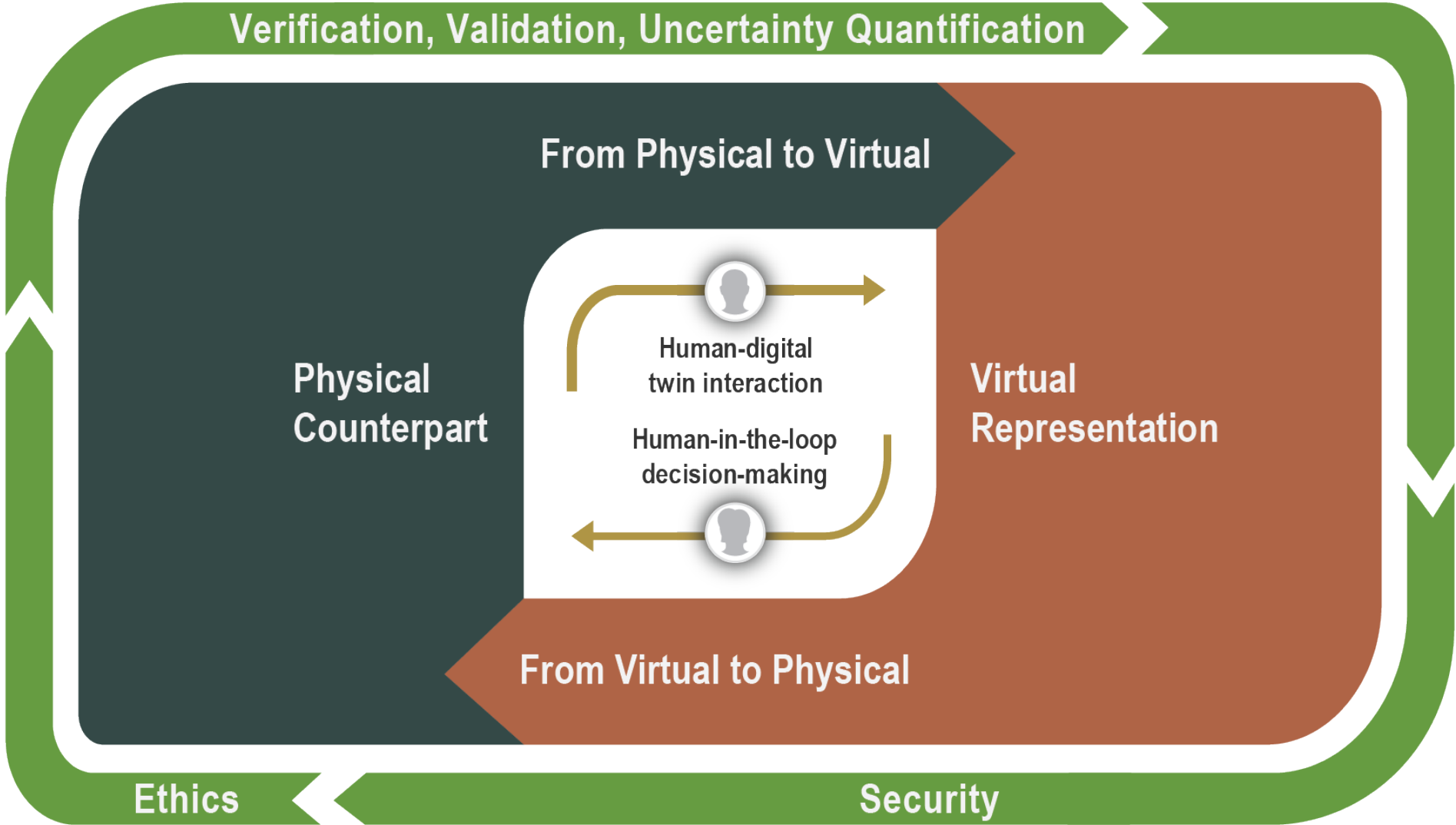


Definition of a Digital Twin

“ *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.*

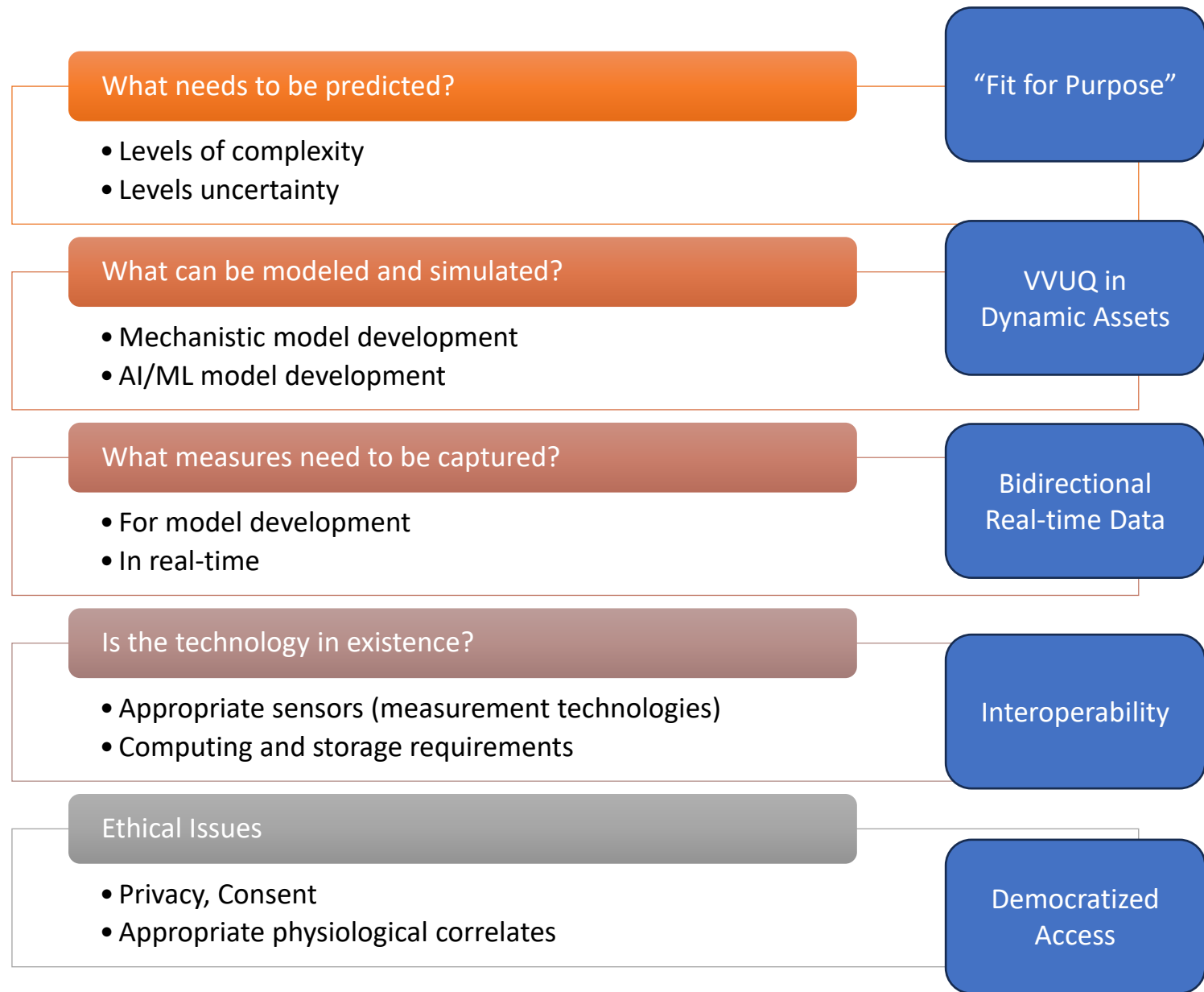
Committee’s definition builds on a definition from an AIAA and AIA Position Paper (2020)

A Digital Twin is More Than Just Simulation and Modeling





Digital Twin Challenges



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What you can do

Think beyond devices and data

Understand mechanisms of health

Instill a culture of ethical inquiry

Seek diverse perspectives

Disseminate your principles

Develop the workforce

Participate in NIH grants & Review

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