

Center for Nutrition Research @ Illinois Tech

Nutrition and AI

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JIFSAN
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Outline

- Introduction: Center for Nutrition Research (CNR) at Illinois Tech
- Research broadly
- Human variability → Precision Nutrition for Health

Center for Nutrition Research

Provide a research platform to support scientific inquiry of food and nutrition related issues impacting public health

- Supports foundational discovery research lead by faculty
- Supports academic-industry innovation in food and health
- Works closely with government on nutrition priorities
- Works with HPOs to modernize approaches in medicine and disease management (Food is Medicine)

Center for Nutrition Research

Core Capabilities / Facilities

Human Clinical Research Center

Clinical chemistry and Biochemistry lab

Analytical Chemistry

Ultrasound imaging

Cognitive & Behaviors lab

Cell culture

Gut microbiome, metagenomics

Precision Metabolic & Production Kitchen



NIH National Institutes of Health

Nutrition for Precision Health

Powered by the All of Us Research Program, part of the National Institutes of Health

ILLINOIS TECH

CNR

IFSH INSTITUTE FOR FOOD SAFETY AND HEALTH

Center for Nutrition Research

Core Capabilities / Facilities

Clinical chemistry and Analytical Chemistry

- Metabolic panels
  - glucose, insulin, triglycerides, cholesterol
- Gut peptides and hormone panels
  - GLP-1, GIP, PYY, CCK, Leptin
- Inflammatory markers
  - cytokines, chemokines, adipokines
- Oxidative stress markers
- Micronutrients, Phenolic compounds
  - Metabolites (pharmacokinetics)





Center for Nutrition Research

Team

- Faculty Scientists/Physiological Chemistry
- Faculty Biostatistics, ML/AI specialists
- Operations Managers: Clinical, Kitchen, Lab
- Clinical research coordinators
- Diet technicians
- Culinary specialists
- Lab technicians
- Medical staff
- Sonographer
- PhD and MS students
- OPT Trainees
- IIT and visiting Undergraduates

Collaborators/ions

- Northwestern
- Univ Chicago
- Rush
- Roselyn Franklin
- Illinois College of Optometry
- UC Davis
- Tufts - USDA Aging
- Univ Cincinnati

Center for Nutrition Research

What We Do

Discover and Validate through Human Research: Design, Conduct, Analyze, Report

Clinical trials

- Interventional
  - efficacy, safety, characterize human response variability to diets, specific foods, dietary components

Generate Data, Characterize and Predict outcomes

- Chemical, Biological and Behavioral Signatures → personalization
  - Foodomics → Metabolomics → Health outcomes
- Mechanisms of action - Cell signaling

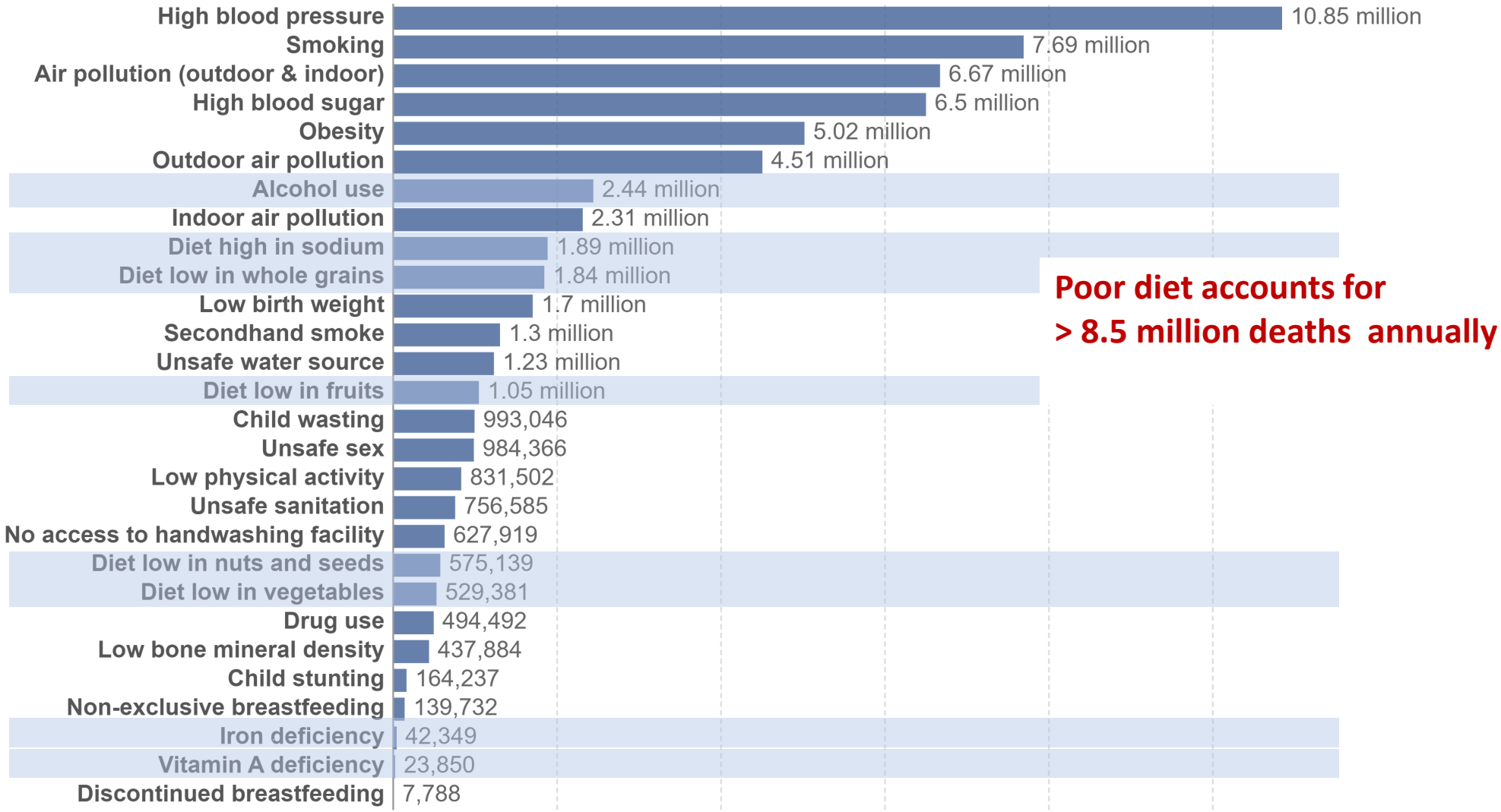
Consumer Behavior

- Food perceptions, beliefs, and attitudes relative to dietary intake patterns

RESEARCH

Annual Deaths by Risk Factor

Poor diet impacts disease and mortality

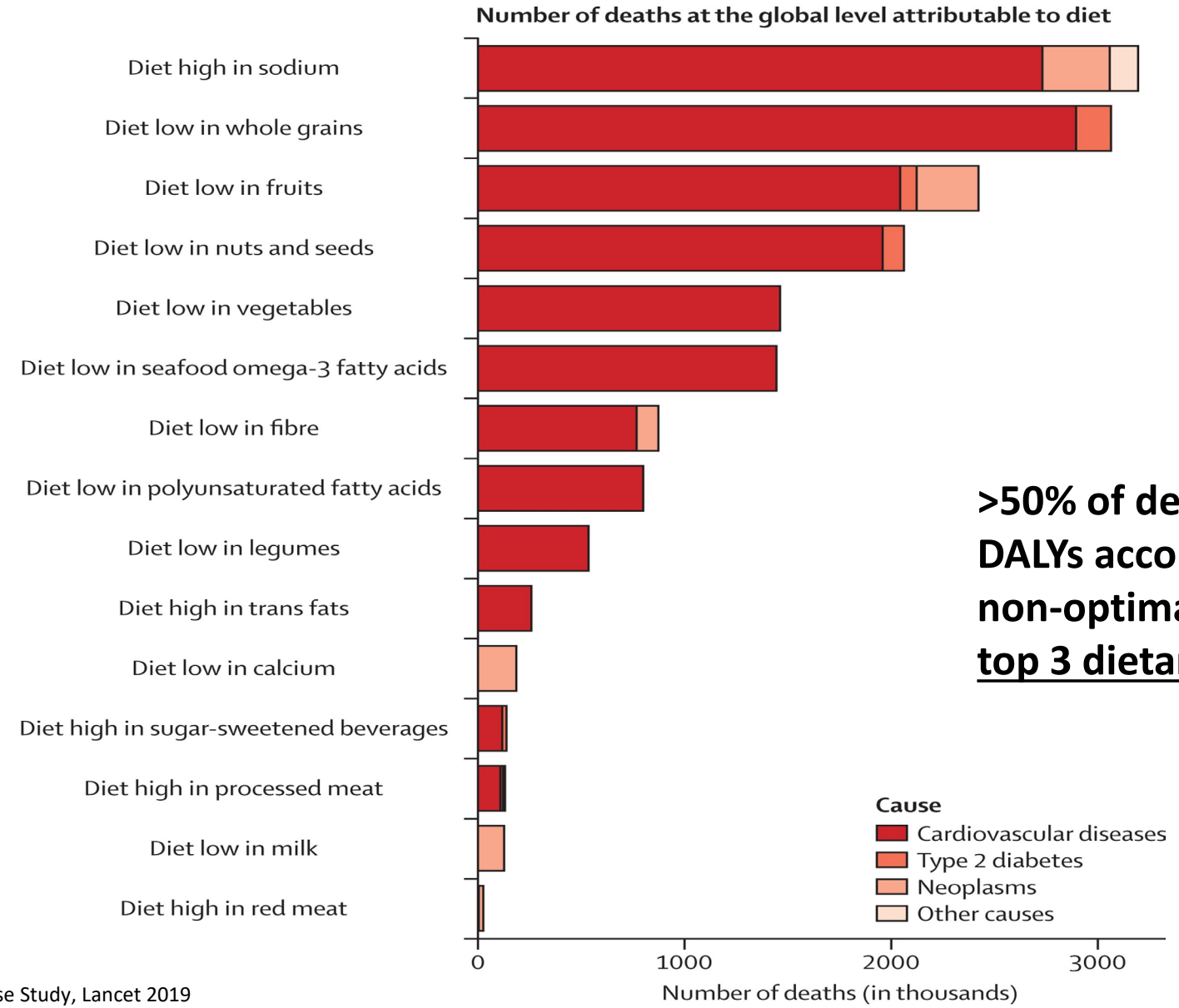


Poor diet accounts for
> 8.5 million deaths annually

Source: The Institute for Health Metrics and Evaluation, Global Burden of Disease (2019)

Number of Deaths Due to Individual Dietary Risks

1. **Diet HIGH in SODIUM**
2. **Diet LOW in WH GRAINS**
3. **Diet LOW in FRUITS**
4. **Diet LOW in NUTS/SEEDS**
5. **Diet LOW in VEGETABLES**



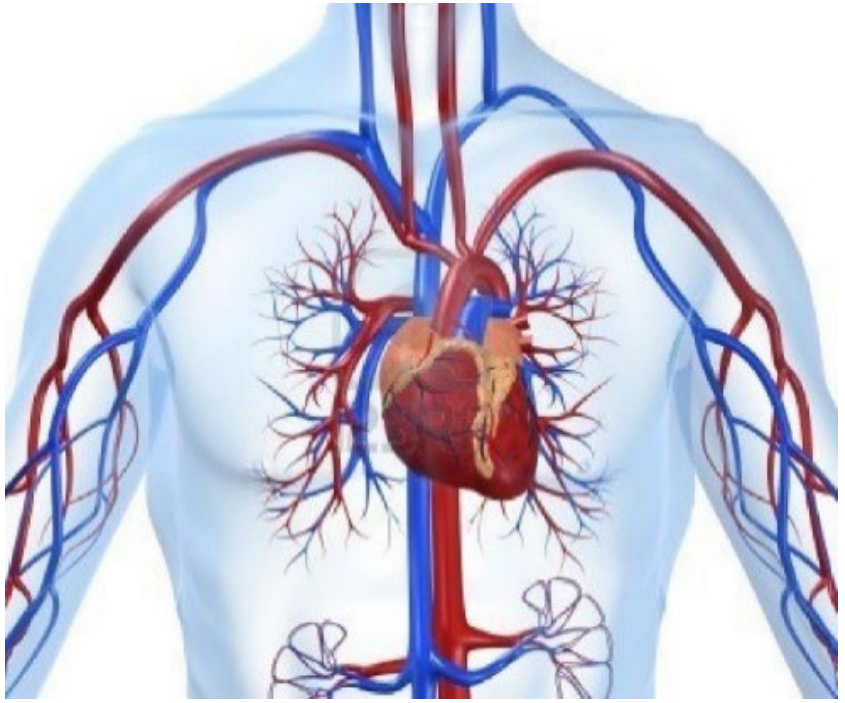
>50% of deaths and 66% DALYs accounted for by non-optimal intake of <u>top 3 dietary factors</u>

GBD 2017 Diet Collaborators, Global Burden of Disease Study, Lancet 2019

Cardio-Metabolic Disease Risk

Obesity

(Pre)Diabetes



Cardiovascular Diseases

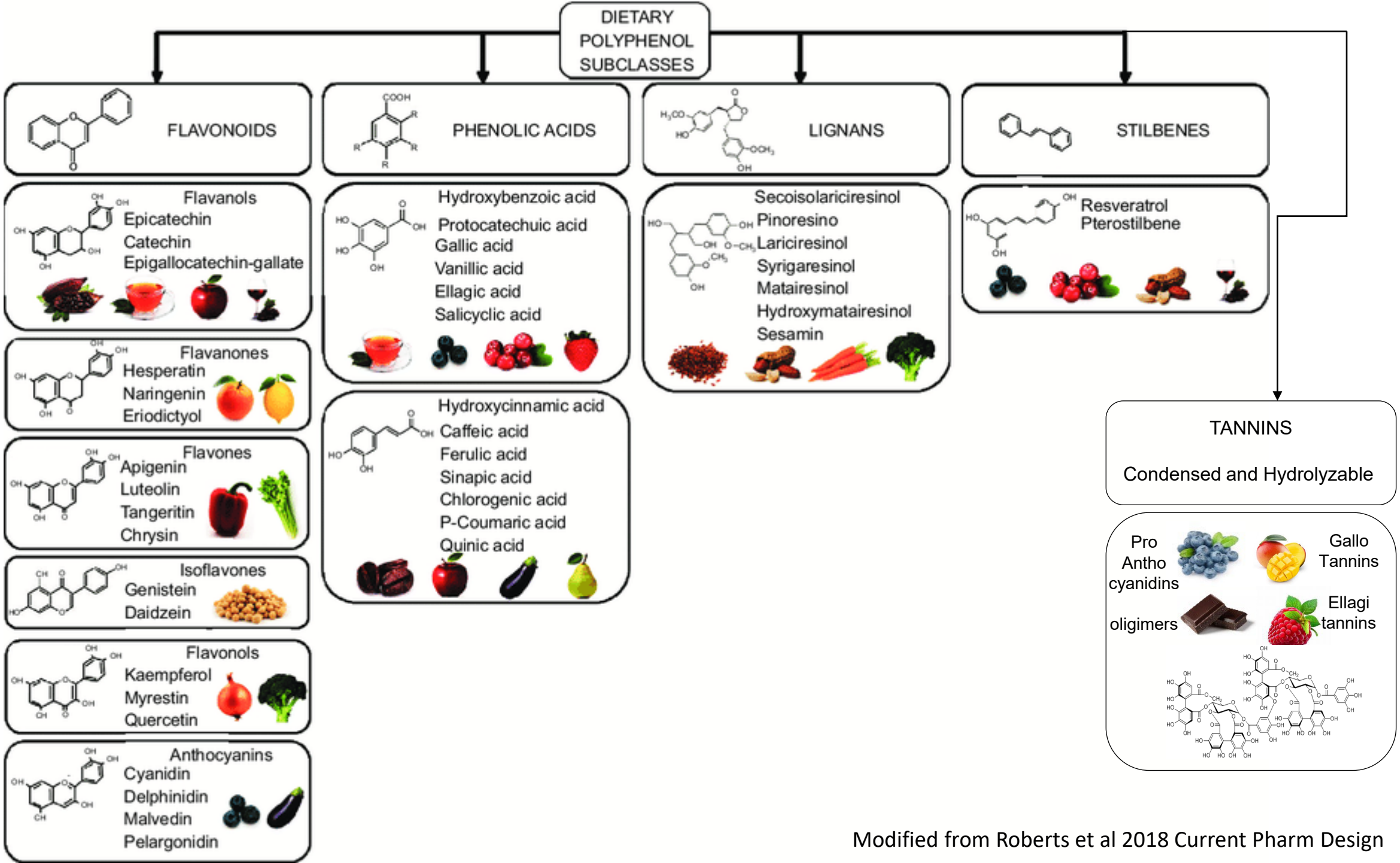
Offenders



Defenders



Defenders



Modified from Roberts et al 2018 Current Pharm Design

Polyphenols and Biological Activity

Benefits to plant:

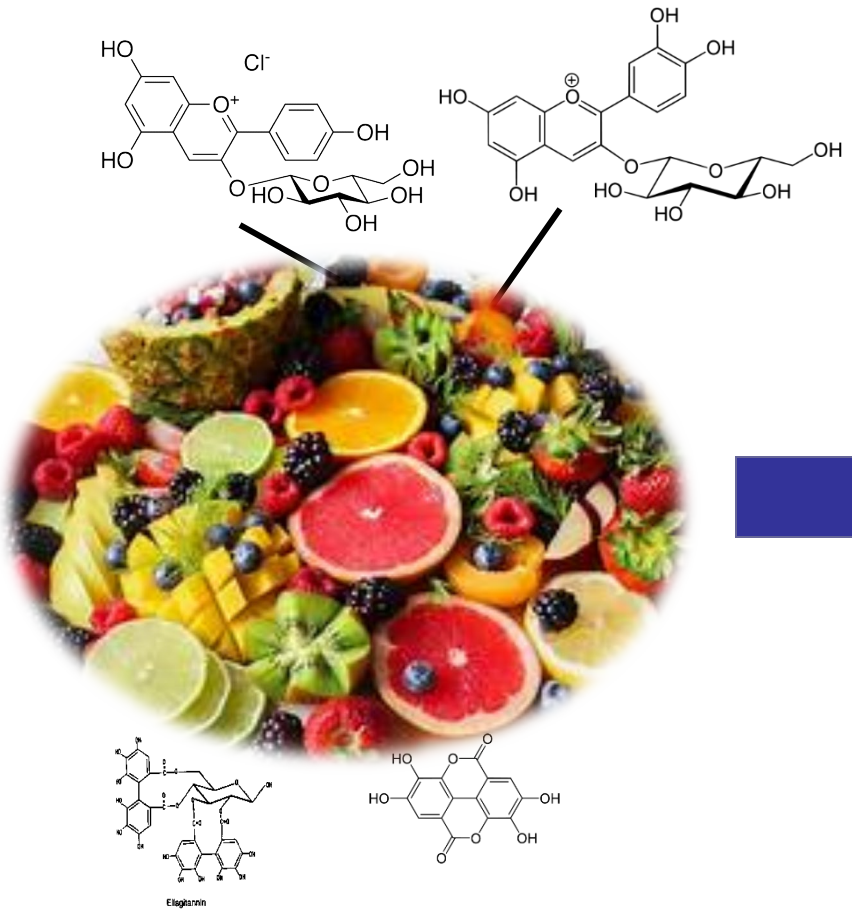
- Anti- bacterial, -fungal, natural pesticide
- Attract pollinating or other seed dispersing insects
- Pigmentation and UV light protection

Benefits to humans:

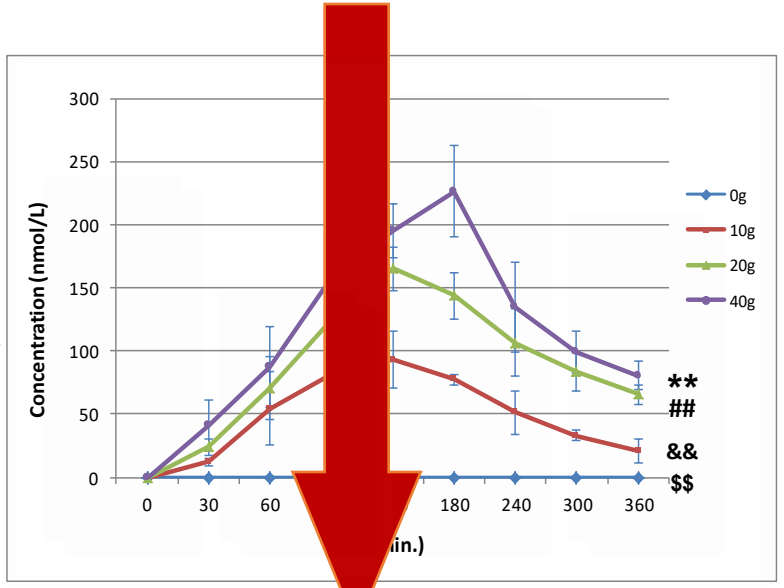
- Immune function / Anti- inflammation
- Alter oxidative production / enhance oxidative defenses
- Alter cell signaling
- Enhance cell-to-cell communication
- Alter estrogen metabolism
- Cause cancer cells to die
- Repair DNA or other tissue damage
- Detoxify carcinogens

Basic Science to Clinical Science

Research Strategy



Blood



HEALTH ENDPOINT



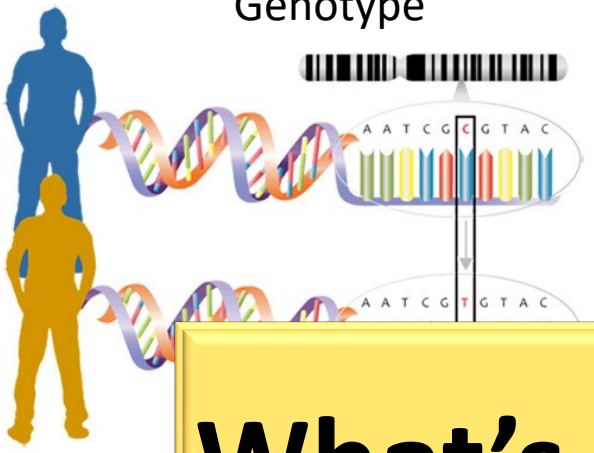
Inter individual variability



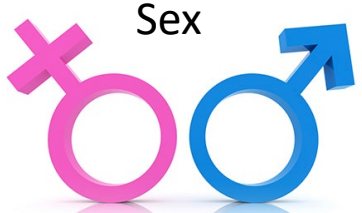
Courtesy of Y. Huang

Factors associated with inter-individual variability in response to diet

Genotype



Sex





Circadian clock

What's the Best DIET for Me?

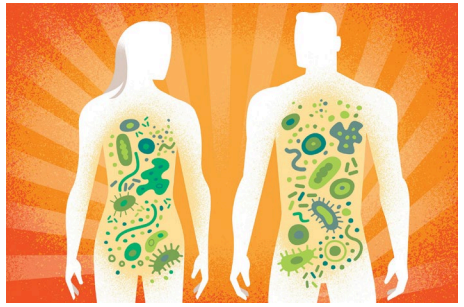


Age

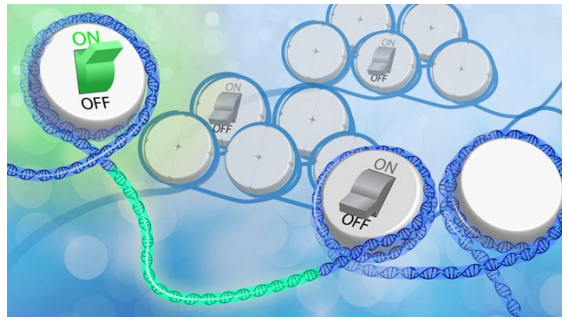
physical activity



Weight



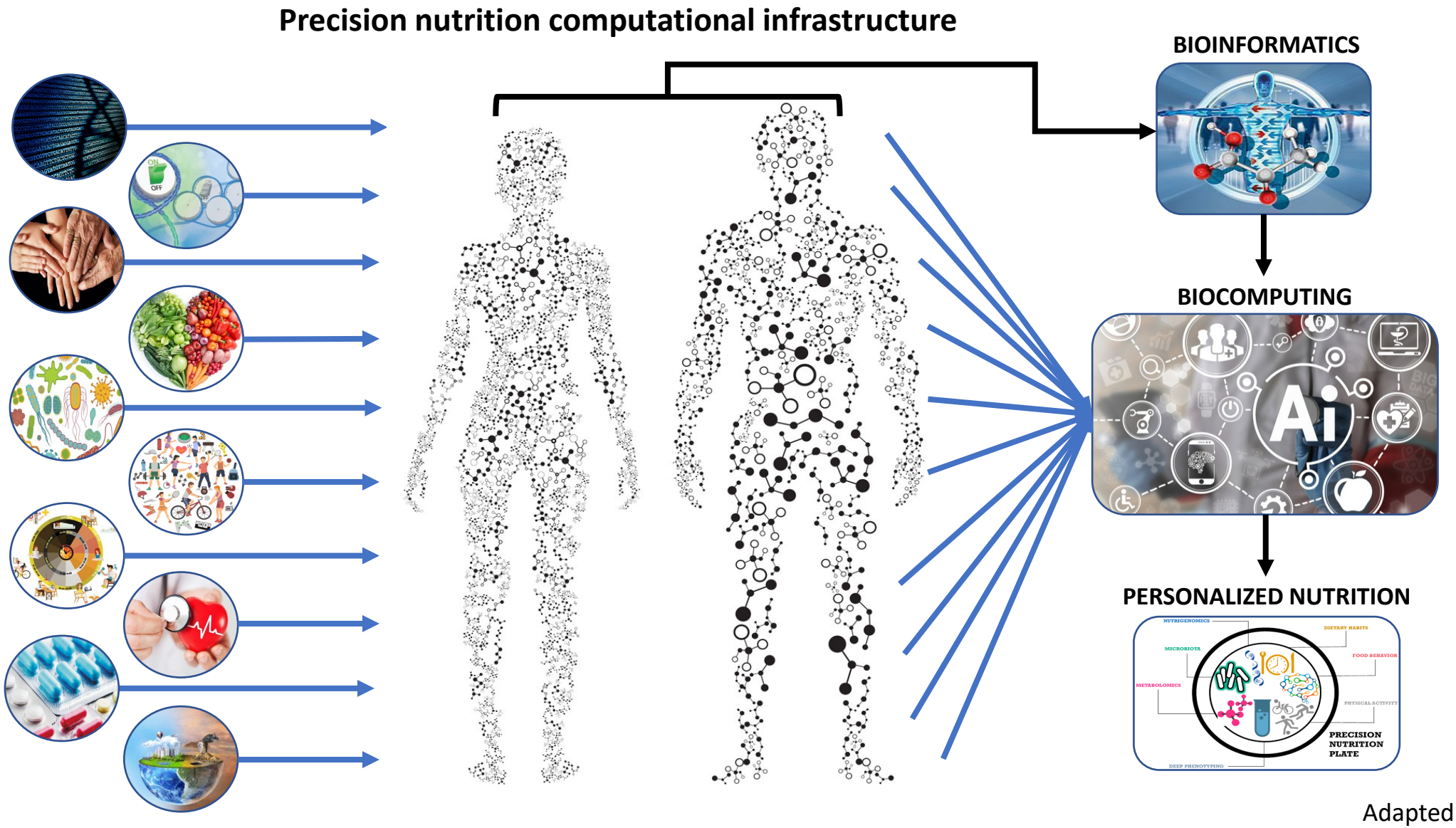
Gut microbes



Gene expression

Adapted from Dr. Das

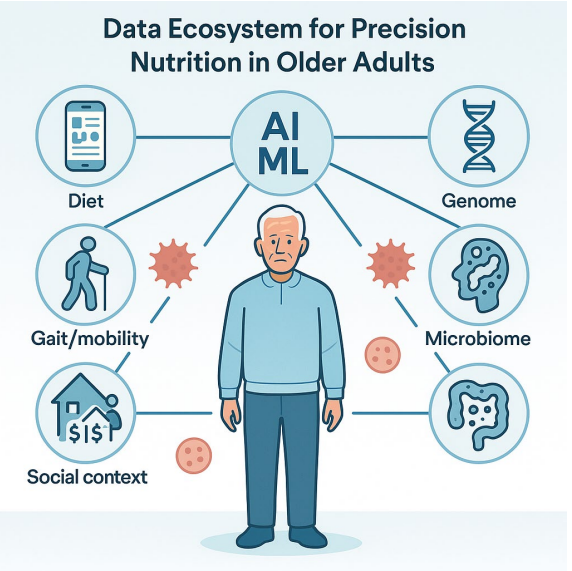
Machine learning and artificial intelligence facilitate the understanding of response variability



Adapted from Dr. Das

We Need a Lot of Data!

- Precision nutrition depends on multi-dimensional, high-resolution data
  - Dietary data: repeated 24-hour recalls, food timing, meal composition
  - Body composition: DXA, BIA, MRI for muscle/fat distribution
  - Clinical data: Labs, CGM, other wearables
  - Genomic and epigenomic profiles to identify at-risk individuals
  - Microbiome and metabolome: Chemical, Biological and Behavioral signatures
  - Functional data including cognition
  - Social factors: built and food environment



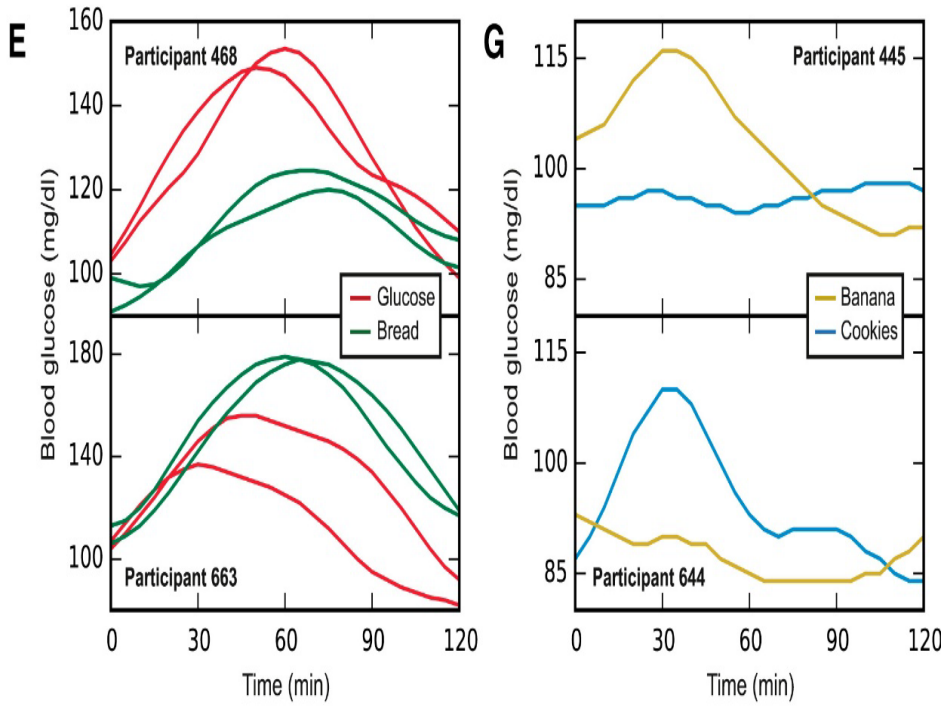
- AI/ML models are only as powerful as the diversity and quality of training data
- Without granular, serial data, true personalization is impossible.

Adapted from Dr. Das

Precision nutrition studies: Early work

Personalized Nutrition by Prediction of Glycemic Responses

David Zeevi,[1,2,8] Tal Korem,[1,2,8] Niv Zmora,[3,4,5,8] David Israeli,[6,8] Daphna Rothschild,[1,2] Adina Weinberger,[1,2] Orly Ben-Yacov,[1,2] Dar Lador,[1,2] Tali Avnit-Sagi,[1,2] Maya Lotan-Pompan,[1,2] Jotham Suez,[3] Jemal Ali Mahdi,[3] Elad Matot,[1,2] Gal Malka,[1,2] Noa Kosower,[1,2] Michal Rein,[1,2] Gili Zilberman-Schapira,[3] Lenka Dohnalová,[3] Meirav Pevsner-Fischer,[3] Rony Bikovsky,[1,2] Zamir Halpern,[5,7] Eran Elinav,[3,9,*] and Eran Segal[1,2,9,*]



Cell 2015

nature medicine

Article | Published: 11 June 2020

Human postprandial responses to food and potential for precision nutrition

Sarah E. Berry, Ana M. Valdes , David A. Drew, Francesco Asnicar, Mohsen Mazidi, Jonathan Wolf, Joan Capdevila, George Hadjigeorgiou, Richard Davies, Haya Al Khatib, Christopher Bonnett, Sajaysurya Ganesh, Elco Bakker, Deborah Hart, Massimo Mangino, Jordi Merino, Inbar Linenberg, Patrick Wyatt, Jose M. Ordovas, Christopher D. Gardner, Linda M. Delahanty, Andrew T. Chan, Nicola Segata, Paul W. Franks & Tim D. Spector

Nature Medicine **26**, 964–973 (2020) | Cite this article

TODAY - Nutrition for Precision Health

National Institutes of Health Common Fund invests $200 MM in Nutrition for Precision Health (NPH)

Develop **algorithms to predict individual responses** to foods and dietary patterns that inform personal plans for optimal health

What's the Best DIET for Me?

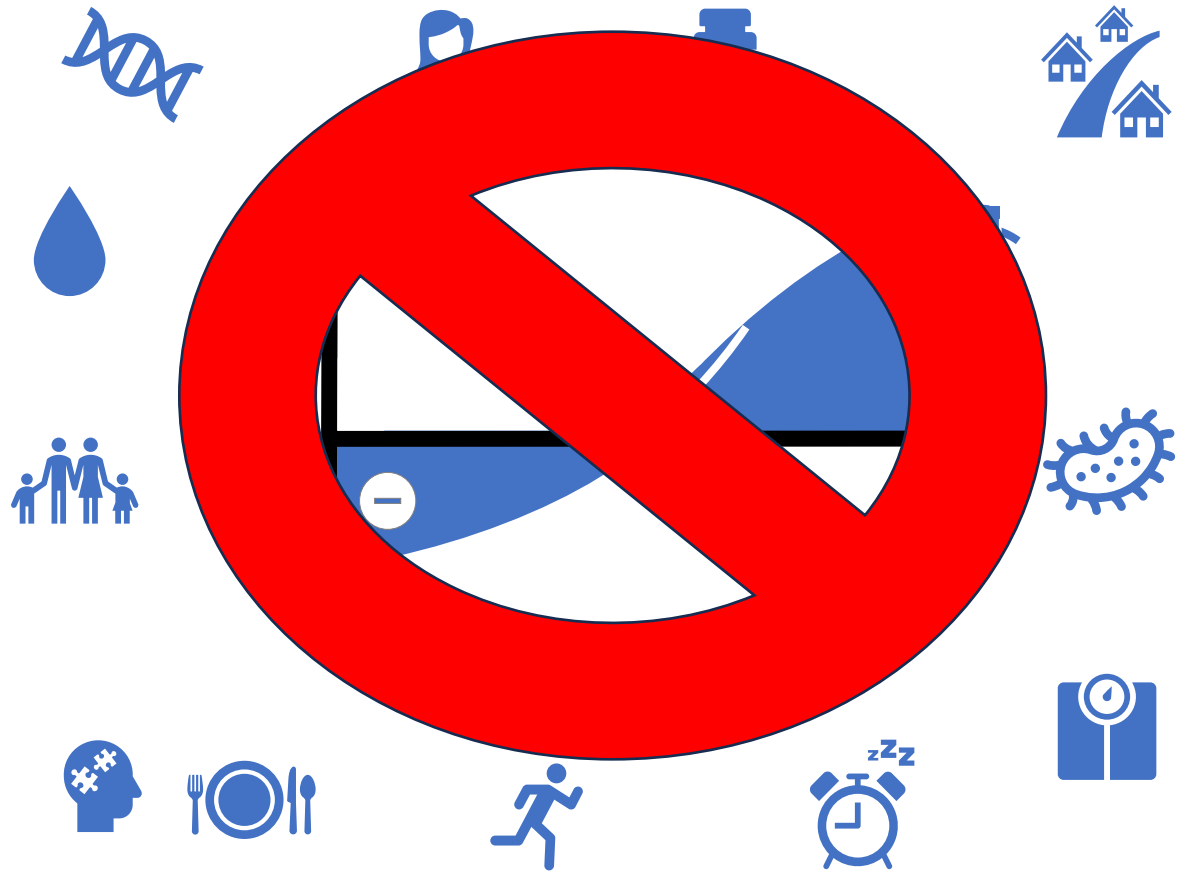
Nutrition for Precision Health

Dump the "One-SIZE-Fits-all" approach to nutrition and health

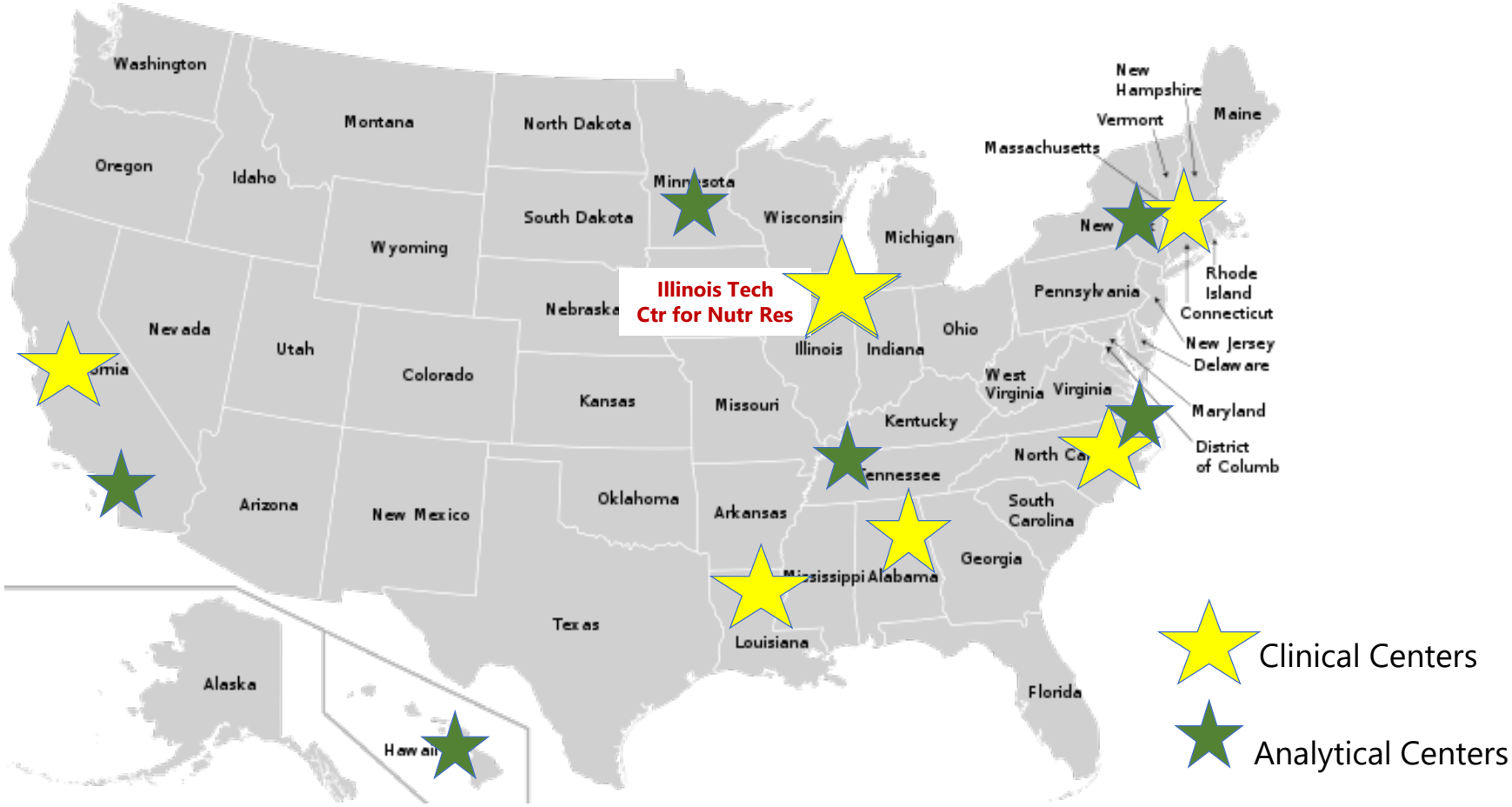
And

Focus on discovery research that empowers the individual

RIGHT FOODS for the RIGHT PERSON at the RIGHT TIME



NIH
Nutrition for Precision Health Research Sites



Powered by All of Us

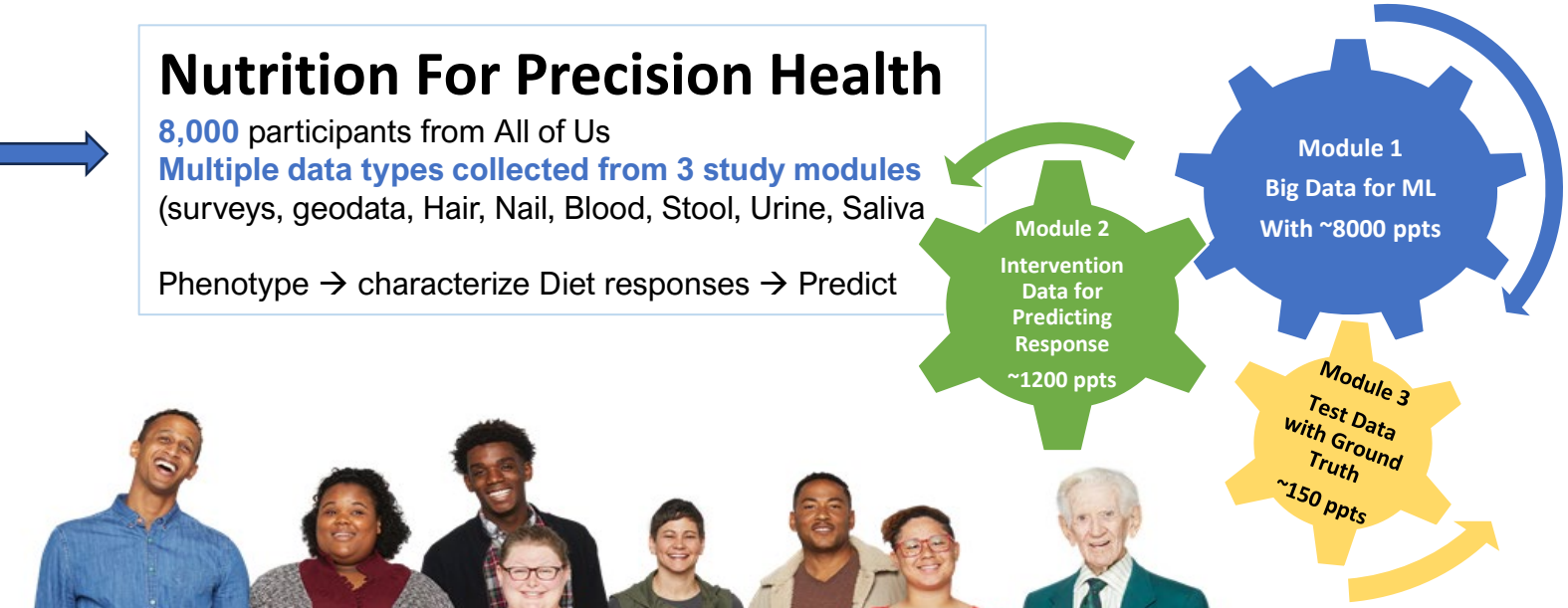
All of Us

Precision Medicine
1M+ diverse participant partners
Multiple data types
(EHR, surveys, genotype, biospecimens)

Nutrition For Precision Health

8,000 participants from All of Us
Multiple data types collected from 3 study modules
(surveys, geodata, Hair, Nail, Blood, Stool, Urine, Saliva

Phenotype → characterize Diet responses → Predict



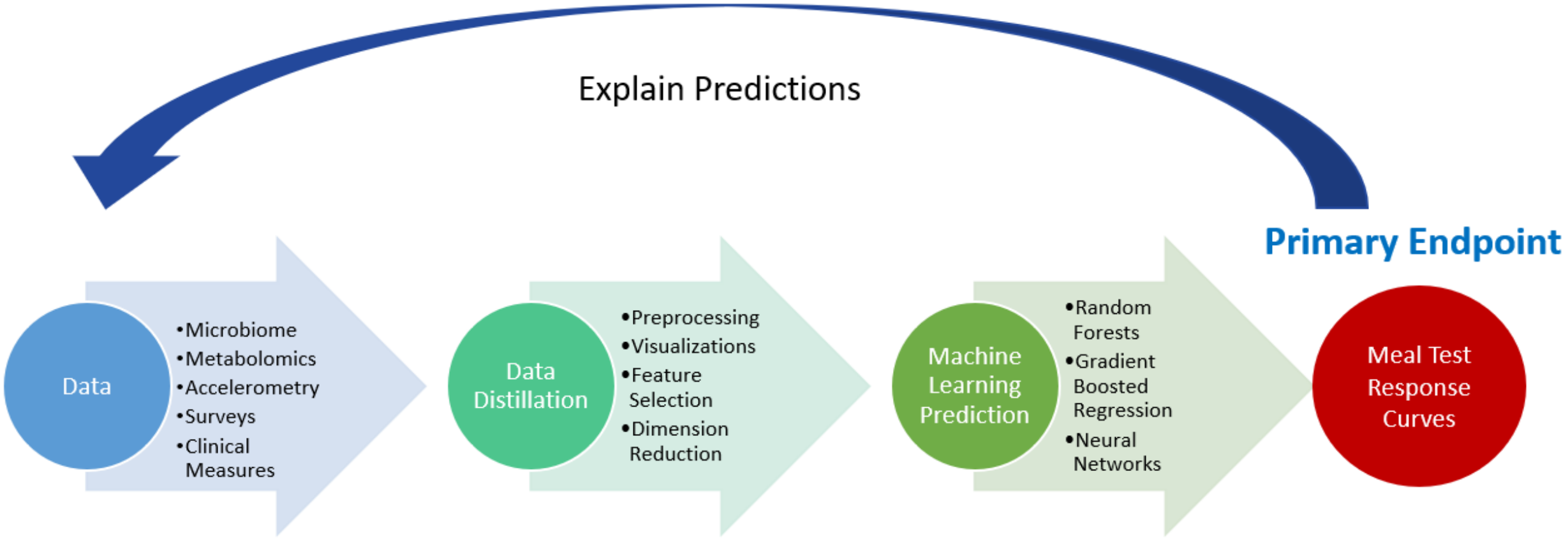
Nutrition for Precision Health



Nutrition for Precision Health
Powered by the *All of Us* Research Program



Parent model: a discovery science algorithm



All data will be available in a researcher workbench via NIH with varying public restrictions

Databases rich for discovery

Case Study:
Develop novel predictive framework using AI/ML and retrospective clinical trial data to predict clinical responses to a polyphenol rich diet

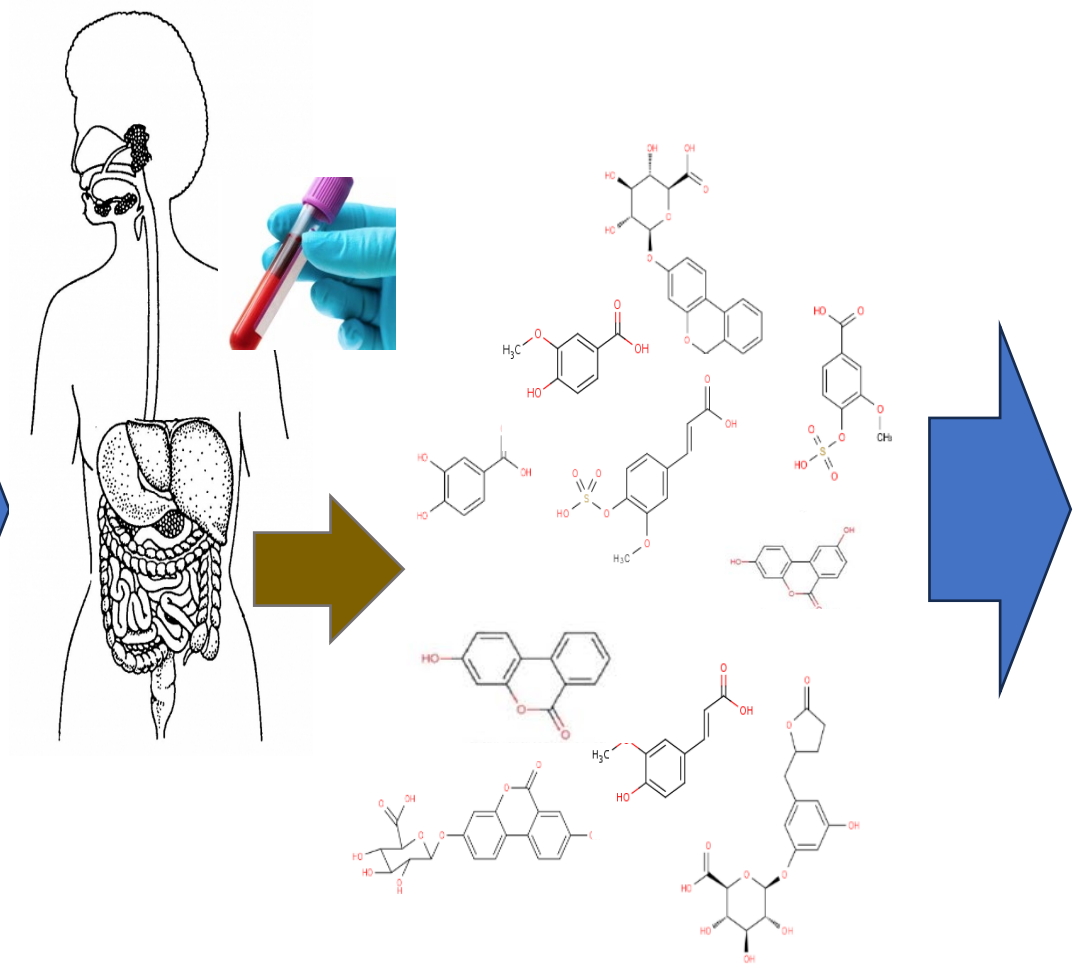
2 clinical trials



RCT1, n=34, 2Tx, crossover



RCT2, n=68, 3Tx, parallel



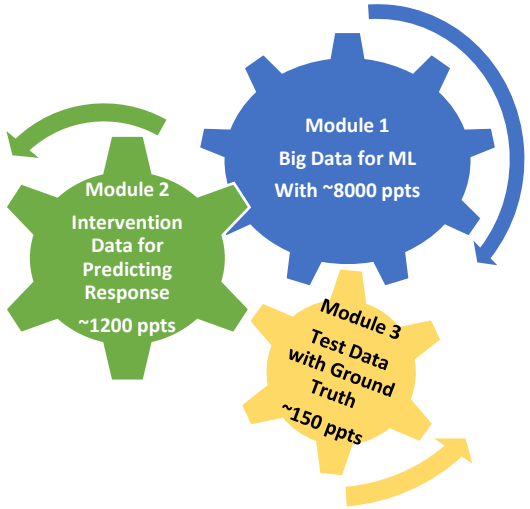
Predict clinical response to polyphenol rich diet



Total Cholesterol
LDL cholesterol
Glucose
FMD, blood vessel flexibility

Ajayi et al, submitted

Database is rich for discovery and testing models for prediction



NEXT:
Apply Framework to NPH DATABASE for advanced prediction



The Future is Here



Acknowledgements



Yudai Huang, PhD cand.
Polyphenol metabolites



Oluwaseun Ajayi, PhD
Predictive modeling







Our Team

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Current and Past
Undergraduate and Graduate Students

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CFSAN colleagues

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Food Science and Nutrition

Thank you

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