OUTLINE OF A NEW NIH-FUNDED TRAINING PROGRAM ON ARTIFICIAL INTELLIGENCE AND PRECISION NUTRITION

Saurabh Mehta, M.B.B.S., Sc.D.
Janet and Gordon Lankton Professor and Director, Program in International Nutrition
Founding Co-Director, Center for Precision Nutrition and Health
Co-Director, NIH Center for Point-of-Care Diagnostics for Nutrition, Infection, and Cancer
Division of Nutritional Sciences, Cornell University, Ithaca, New York, US

CPNH Center for Precision Nutrition and Health

PORTENT Point of care diagnostics for nutrition, infection, and cancer for global health

PIN

Nutritional Sciences
Cornell Human Ecology
Cornell CALS College of Agriculture and Life Sciences

DISCLOSURE

AFFILIATION/FINANCIAL INTERESTS (prior 12 months)	ENTITIES
Grants/Research Support	National Institutes of Health (NICHD, NIBIB, OD, FIC, NCCIH) National Science Foundation Global Alliance for Improved Nutrition United States Department of Agriculture United States Agency for International Development HarvestPlus/International Food Policy Research Institute Department of Defense Centers for Disease Control and Prevention World Health Organization
Scientific Advisory Board/Consultant/Board of Directors (unpaid)	VitaScan World Economic Forum EAG on Frontiers of Nutrition
Speakers Bureau	None
Stock Shareholder	VitaScan
Employer	Cornell University
Other	N/A

OUTLINE

1. Precision Nutrition: What?
2. Why AI?
3. How do we build capacity?
   Example of our program
4. What are trainees going to do?
5. Challenges and the road ahead....

PRECISION NUTRITION: WHAT?

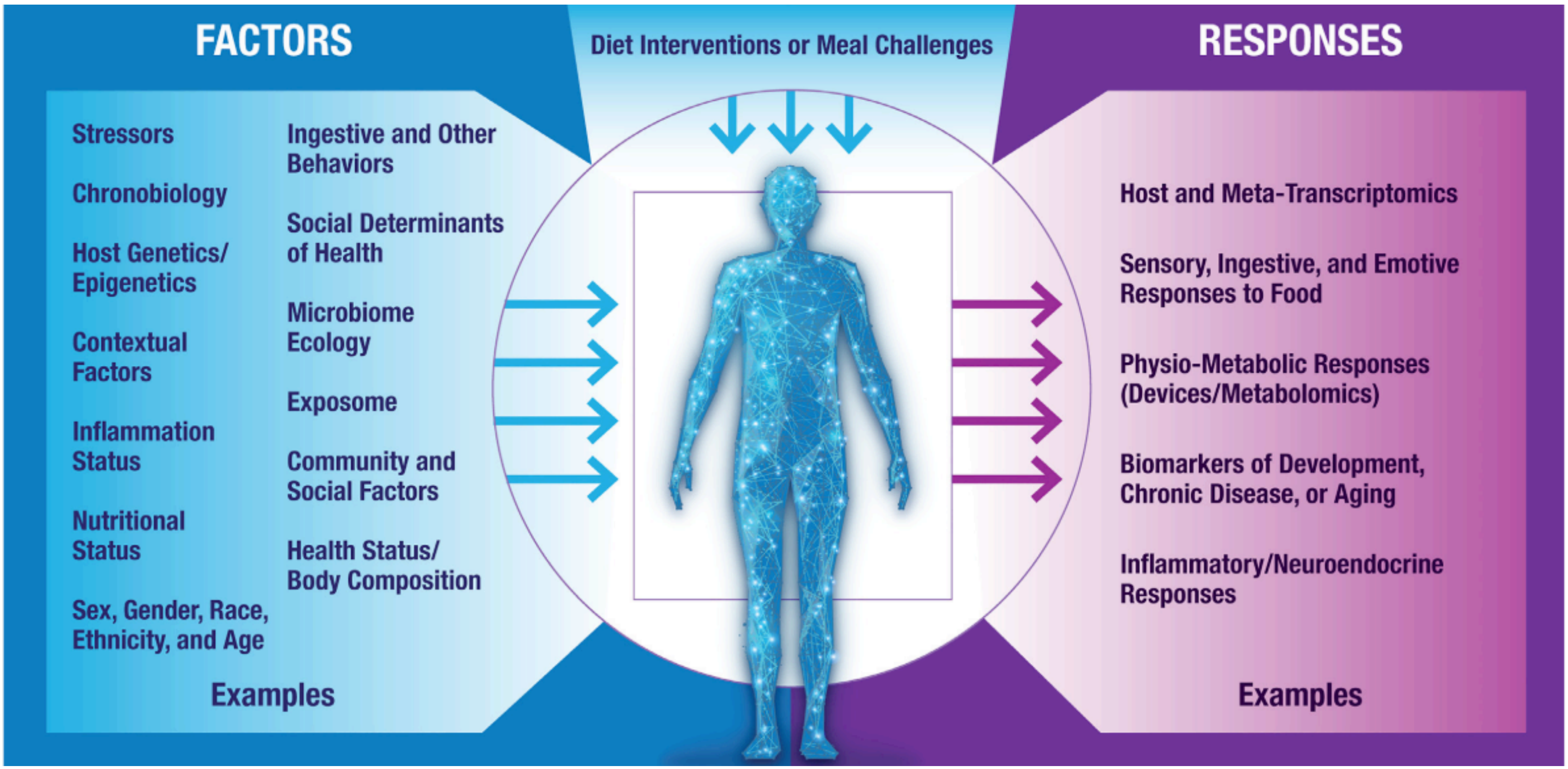
PRECISION NUTRITION: WHAT?

- The **2020-30 NIH Strategic Plan for Nutrition Research** states that precision nutrition is a unifying and holistic approach to developing comprehensive and dynamic nutritional recommendations relevant to both individual and population health.

- Additionally, it is a framework to incorporate **genetics, dietary habits** and **eating patterns, circadian rhythms, health status, socioeconomic and psychosocial characteristics, food environments, physical activity, and the microbiome** in assessing nutrition status and developing interventions.

PRECISION NUTRITION: WHAT?

Lee BY, et al. Am J Clin Nutr. 2022 Dec 2;0:1–24



WHY AI?

WHY DO WE NEED AI?

- Complex diet-disease relationships
  - Further complicated by time lag and relevant biological period particularly for chronic disease
  - Feedback loops in our biological systems
- Opportunity to integrate data from multiple disciplines relevant to nutrition questions
- Availability of large complex datasets in both US and internationally
  - NIH's *AllofUs* and *Nutrition for Precision Health*
  - Common Fund Data Ecosystem
  - Global Burden of Disease

WHAT IS AI AND WHAT CAN IT DO?

- Lee et al note that "AI is a very broad umbrella term encompassing any use of computers or computer-driven technology to perform tasks that intelligent beings would typically perform"
- Machine learning, on the other hand, is defined as creating algorithms to identify data patterns and simulate human 'learning'
    - supervised, as in the case of use of training datasets where the input and outputs are prespecified, or
    - unsupervised, where the inputs and outputs are not prespecified
- AI and ML can offer advantages over traditional analytical methods particularly for large multimodal data

HOW DO WE BUILD CAPACITY IN AI?

NIH AIPRN T32 AS AN EXAMPLE

Funding Opportunity Title	Advanced Training in Artificial Intelligence for Precision Nutrition Science Research (AIPrN) – Institutional Research Training Programs (T32)
Activity Code	T32 Institutional National Research Service Award (NRSA)
Announcement Type	New
Related Notices	NOT-OD-23-012 Reminder: FORMS-H Grant Application Forms and Instructions Must be Used for Due Dates On or After January 25, 2023 - New Grant Application Instructions Now Available NOT-OD-23-020 - Notice of Change: Advanced Training in Artificial Intelligence for Precision Nutrition Science Research (AIPrN) – Institutional Research Training Programs (T32) NOT-OD-22-190 - Adjustments to NIH and AHRQ Grant Application Due Dates Between September 22 and September 30, 2022
Funding Opportunity Announcement (FOA) Number	RFA-OD-22-027

RFA-OD-22-027

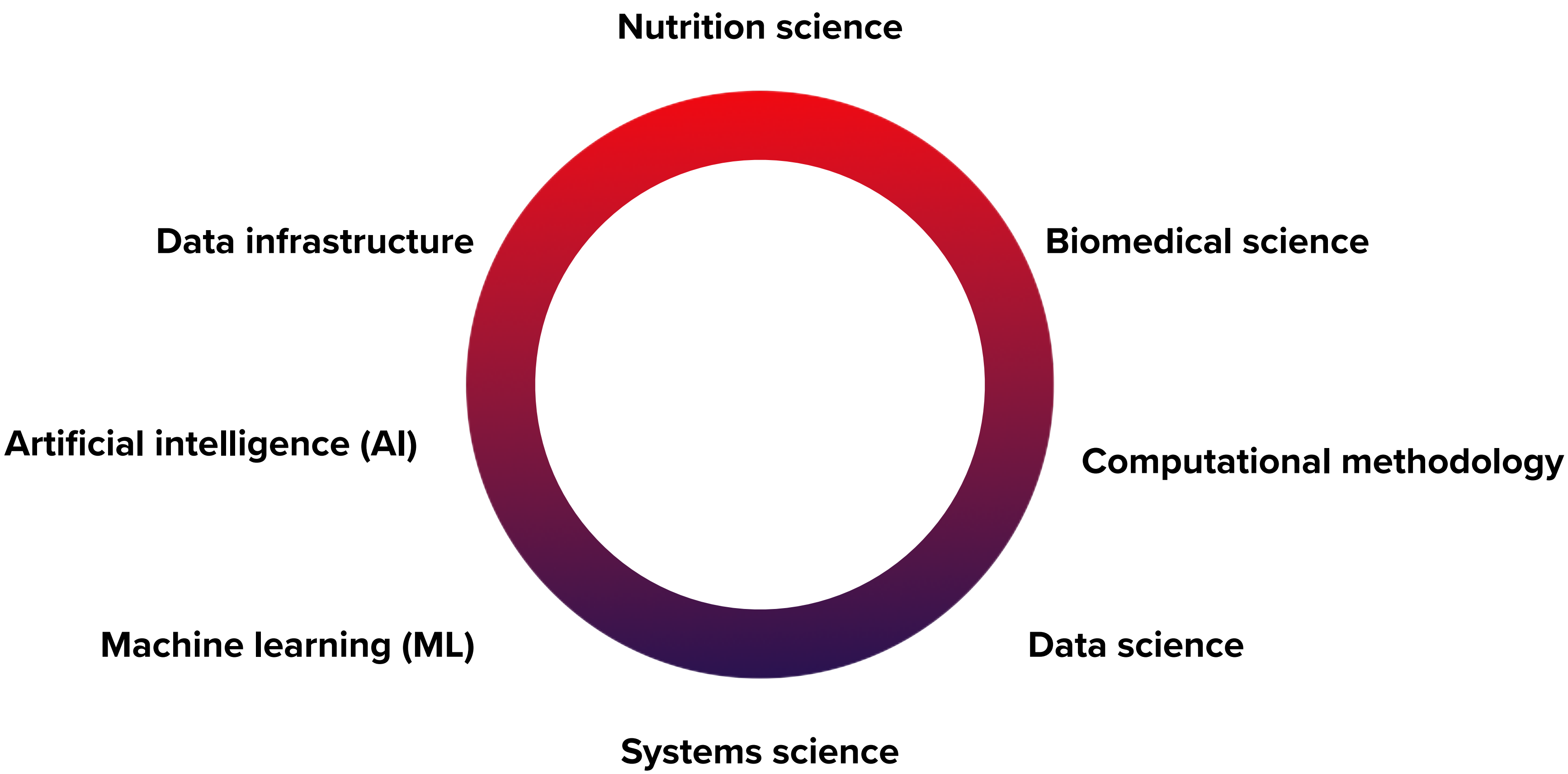
- “A recommended approach to this complexity is assembling teams of interdisciplinary scientists with a wide breadth and depth of expertise spanning across nutrition science, biomedical science, behavioral science, but also core competencies in computational methodology, data science, systems science, machine learning (ML), artificial intelligence (AI), and data infrastructure.”
- “As part of our further consideration, we conducted a portfolio analysis and found that of 1809 NIH T32 training grants, none had a focus on AI or ML. Twenty were focused on some aspect of nutrition, and 28 of the 1809 were bioinformatics/data science related (of which only 2 were nutrition-related).”
- “This program aims to build a future workforce that will be able to make pivotal discoveries using an increasingly complex landscape of Big Data and a wide array of data tools to tackle complex biomedical challenges in nutrition science and diet-related chronic diseases.”

GOAL

Train the **next generation** of **scientists** and build a **workforce** equipped with **expertise in AI and ML** methods to tackle **complex biomedical challenges** in **nutrition** and **health** using **high dimensional data**

supported by the Eunice Kennedy Shriver National Institute of Child Health and Human Development and the Office of the Director, National Institutes of Health

HOW DO WE APPROACH THIS COMPLEXITY?



PARTICIPATING INSTITUTIONS

Cornell University

Division of Nutritional Sciences, College of Human Ecology

HOME INSTITUTION

Cornell University

Ann S. Bowers College of Computing and Information Science

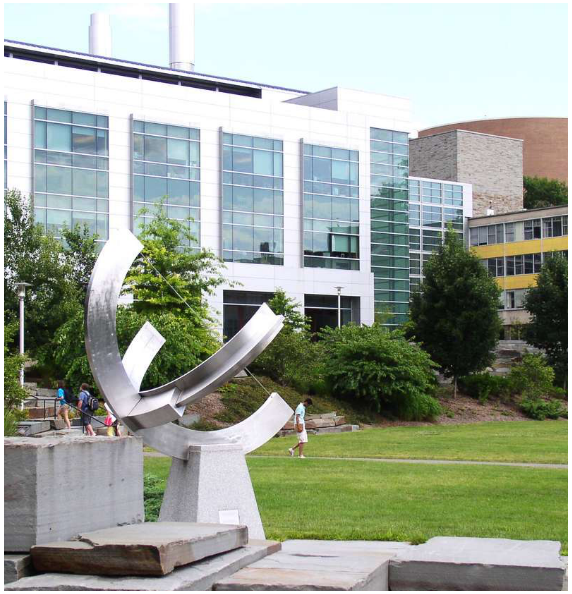
PARTNERING COLLEGE

Cornell Tech

Computer Science

PARTNERING COLLEGE

PARTICIPATING INSTITUTIONS



Cornell University

Cornell Engineering
PARTNERING COLLEGE

Weill Cornell Medicine

Department of Population Health Sciences
PARTNERING COLLEGE

West Point United States Military Academy

Department of Mathematical Sciences
PARTNERING INSTITUTION

T32 DIRECTORS & FACULTY TRAINERS

Director

Saurabh Mehta (Cornell University)

Co-directors

Deborah Estrin (Cornell Tech)

Thorsten Joachims (Bowers CIS)

Martin Wells (Bowers CIS)

David Erickson (Cornell University)

Rulla Tamimi (Weill Cornell Medicine)

Diana Thomas (USMA West Point)

NASEM

PROGRAM ORGANIZATION

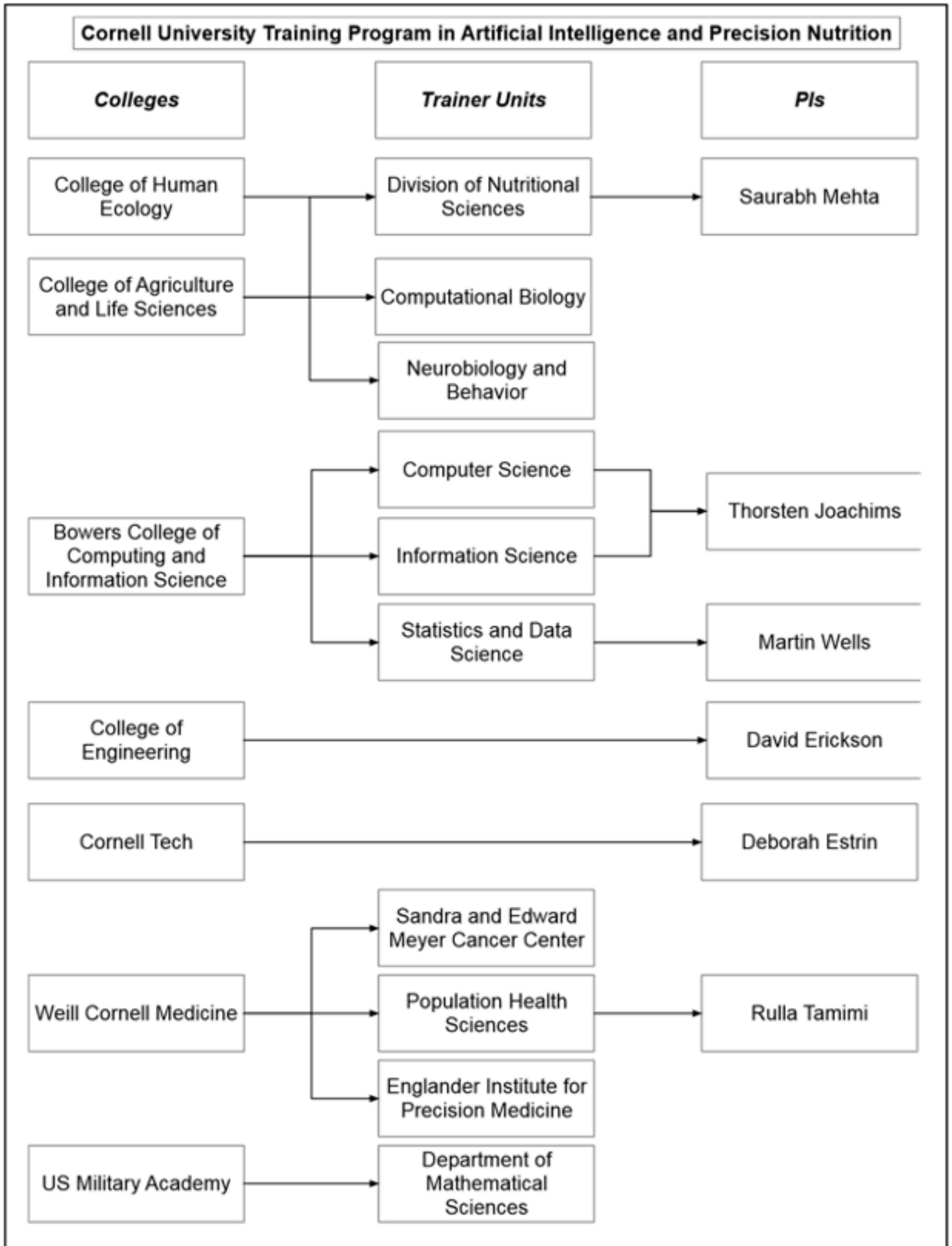


Figure 2.3: Training Program Units

T32 DIRECTORS & FACULTY TRAINERS

Nutrition

Saurabh Mehta, MBBS, ScD - Janet and Gordon Lankton Professor, Director of the T32 Program

Kimberly O. O'Brien, PhD - Professor

Julia L. Finkelstein, MPH, ScD - Associate Professor

Martha Field, PhD - Assistant Professor

Biomedical Disciplines

Rulla Tamimi, ScD - Professor (Epidemiology, Cancer), co-Director of the T32 Program

David Erickson, PhD - Sibley College Professor (Biomedical Engineering), co-Director of the T32 Program

Andrew Clark, PhD - Professor (Computational Biology, Population Genetics)

Jesse Goldberg, MD, PhD - Associate Professor (Neurobiology and Behavior)

Yiwey Shieh, MD - Assistant Professor (Personalized Prevention and Screening, Precision Medicine, Cancer)

T32 DIRECTORS & FACULTY TRAINERS

Computer and Information Science

Deborah Estrin, PhD - Professor (Digital Health Entrepreneurship, Technology Translation), co-Director of the T32 Program

Thorsten Joachims, PhD - Professor (Machine Learning Methods and Theory), co-Director of the T32 Program

Martin Wells, PhD - Professor (ML, Statistics, Data Science, Epidemiology), co-Director of the T32 Program

Diana Thomas, PhD - Professor (USMA West Point), co-Director of the T32 Program (AI, ML, Big Data and Nutrition)

Fei Wang, PhD - Professor (AI, Digital Health)

Carla Gomes, PhD - Professor (AI for Science, Computational Sustainability)

Jyotishman Pathak, PhD - Professor (Bioinformatics, Bioethics, AI, Mental Health, Interoperability of Data)

Haym Hirsh, PhD - Professor (AI, ML)

Sumanta Basu, PhD - Associate Professor (ML, network modeling of high-dimensional time series and nonlinear ensemble learning methods)

Jason Mezey, PhD - Professor (Computational Biology; computational statistics and machine learning methodology to answer questions about complex phenotypes)

Mark Weiner, MD - Professor (ML, Improving data quality in EHRs)

Yiyi Zhang, PhD - Assistant Professor (ML and Data Mining)

Volodymyr Kuleshov, PhD - Assistant Professor (ML and its applications in science, health, and sustainability)

ENVIRONMENT AT CORNELL

Radical collaboration in AI

- **Core AI Capabilities** (i.e. learning, reasoning, perception, language and actuation) to enable new applications and new economic opportunities.
- **Build AI Technology for Human Engagement** at all scales (e.g. individual, groups, society).
  - Requires new criteria like usability, fairness, accountability, transparency, etc.
- **Application Impact Areas** where AI can have impact.
  - Built on Cornell's existing breadth of leadership in impact areas of AI.

Center for Precision Nutrition and Health

- **Home** for a cohort of trainees focused on similar problems
- **Supplemental funding** for trainees particularly postdocs
- **Interdisciplinary faculty expertise**

WHAT ARE TRAINEES GOING TO DO?


https://www.careersevent.com/wp-content/uploads/2021/06/going-to-uni-as-a-mature-student-1.png

4 PREDOCTORAL TRAINEES

1 POSTDOCTORAL TRAINEE

PROGRAM TRACKS

- **Ph.D. in Nutrition or a related biomedical field** with a Computer Science minor
- **Ph.D. in Computer and Information Science** (AI, Tech, Data Science, and Engineering) with a Nutrition Science minor
- **PostDoc** - Ph.D. in one of the computational fields who would like to apply their skillset to problems related to nutrition
- **Dual Mentorship required**
- **Capstone course**

CHALLENGES

...AND THE ROAD AHEAD

CHALLENGES

- Need for Flexibility/Constant Evolution
  - Current data analysis of large data sets relies heavily on bioinformatics - there may be increasing reliance on traditional computer science methods including imaging, natural language processing in the future
- CS courses can represent a steep learning curve for many nutrition PhD students and *vice versa*
  - Initial intake may need to overrepresent those with quantitative/computational backgrounds for example

CHALLENGES

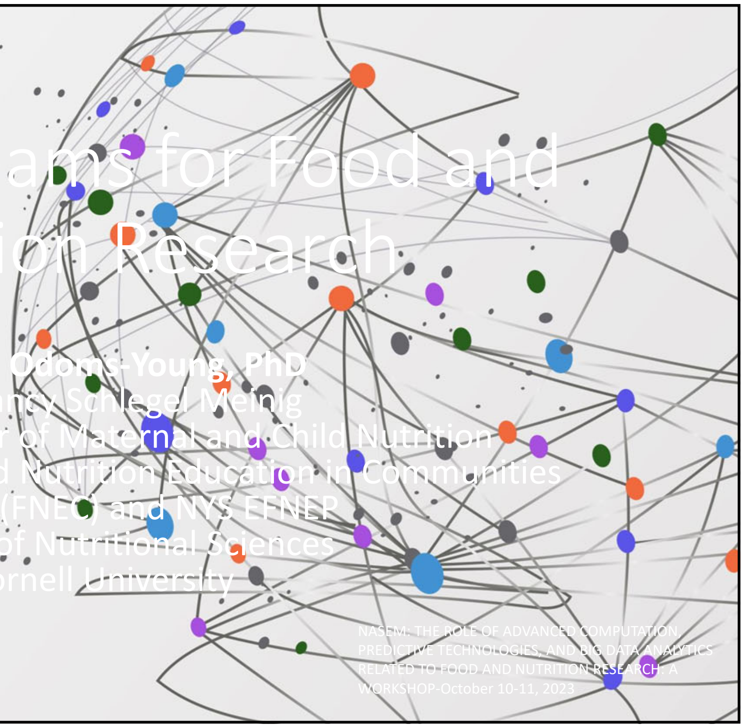
- Taking courses is not enough
    - Co-curricular activities needed to fully develop interdisciplinary scientists
- Dual mentorship
    - Typical T32 trainees are appointed after qualifying exam - which means they already have a dissertation committee chair and a research plan
    - For this T32, appointments may need to happen earlier to allow for full development of a truly co-mentored research and training plan

CHALLENGES

- Stipend
  - Need to be creative with opportunities to complement typical T32 stipends due to differential pay scales
- RCR needs to be strengthened
  - And account for ethics, fairness, and equity in AI
- **Suggestions and input welcome! Thank you.**

Acknowledgments

- NIH - OD, ONR, NICHD, ODS
- Cornell - Samantha Huey, Anna Bennett



Inclusive Teams for Food and Nutrition Research

Angela Odoms-Young, PhD
The Nancy Schlegel Meinig
Associate Professor of Maternal and Child Nutrition
Director of the Food and Nutrition Education in Communities Program (FNEC) and NYS EFNEP
Division of Nutritional Sciences
Cornell University

NASEM: THE ROLE OF ADVANCED COMPUTATION, PREDICTIVE TECHNOLOGIES, AND BIG DATA ANALYTICS RELATED TO FOOD AND NUTRITION RESEARCH: A WORKSHOP-October 10-11, 2023

1

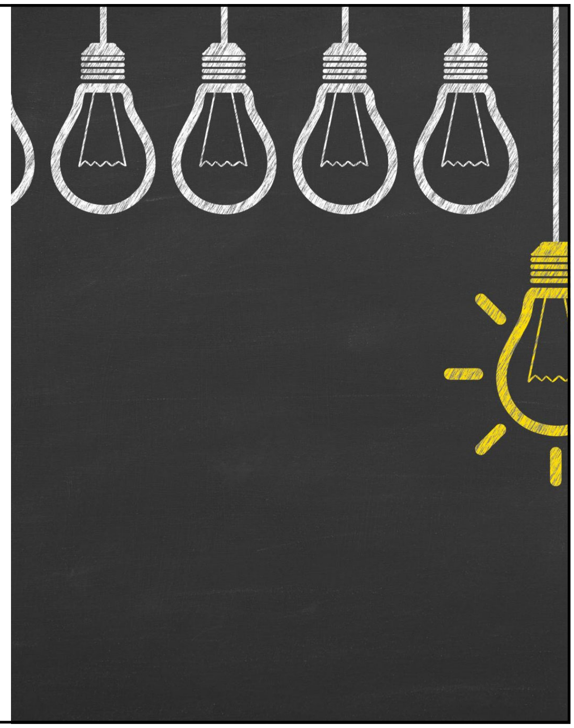
Disclosures

AFFILIATION/FINANCIAL INTERESTS (prior 12 months)	ENTITIES
Grants/Research Support	RWJF, NIH, CDC, Feeding America
Scientific Advisory Board/Consultant/ Board of Directors	DGAC, RWJF-funded Healthy Eating Research (HER), HRSA-funded Healthy Weight Research Network, NASEM Food and Nutrition Board
Owner	Nutrition Equity and Justice Partners Consulting, LLC
Speakers Bureau	N/A
Stock Shareholder	N/A
Employee	Cornell University, University of Illinois at Chicago
Other	N/A

2

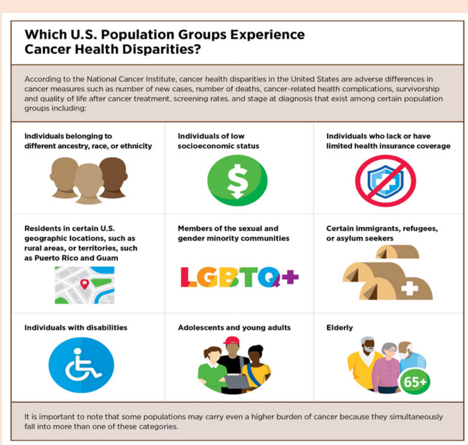
Overview

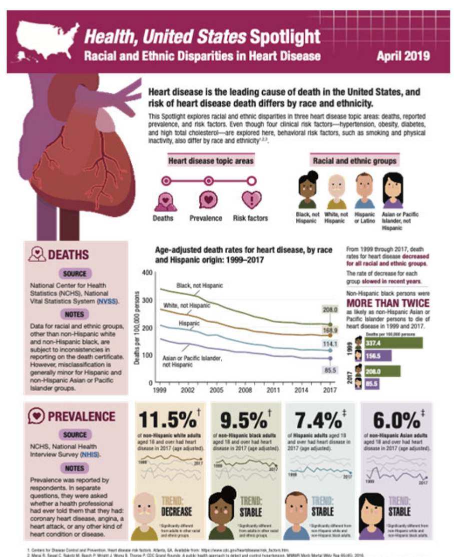
- What is the significance of promoting (justice), diversity, equity, and inclusion, (belonging) (JEDI, DEIB) in the application of advanced computation, big data analytics, and high-performance computing in food systems and nutrition research?
- How do we create a just, diverse, inclusive, and equitable training environment to support robust and ethical application of advanced computation, big data analytics, and high-performance computing in food and nutrition research?



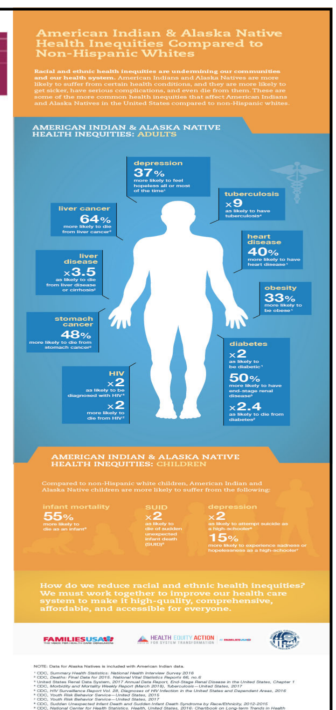
3

Many U.S subgroups experience higher rates of diet-related morbidity and mortality than the general population (e.g., across different socioeconomic, racial, and ethnic subpopulations)



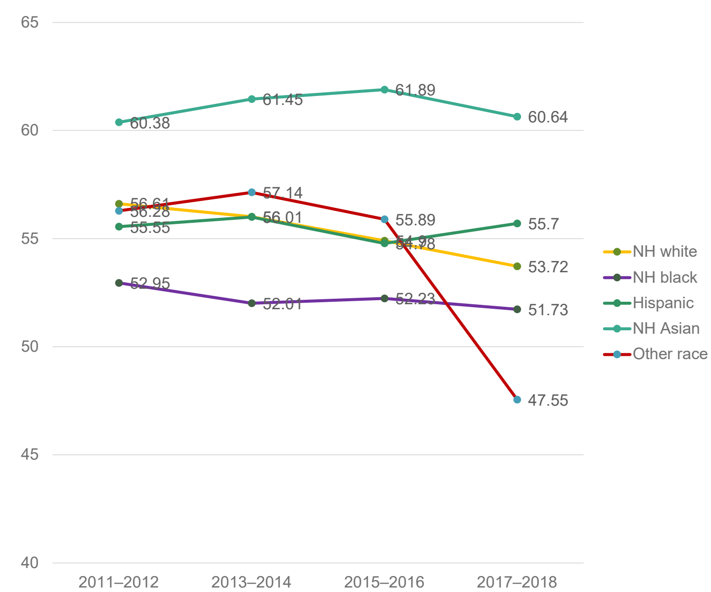


Brown AGM, Shi S, Adas S, et al. A Decade of Nutrition and Health Disparities Research at NIH, 2010-2019. *Am J Prev Med.* 2022;63(2):e49-e57. doi:10.1016/j.amepre.2022.02.012



4

Trends in estimated HEI-2015 score among adult females (binary gender) aged ≥20 years by race/ethnicity, NHANES, 2011–2018



5

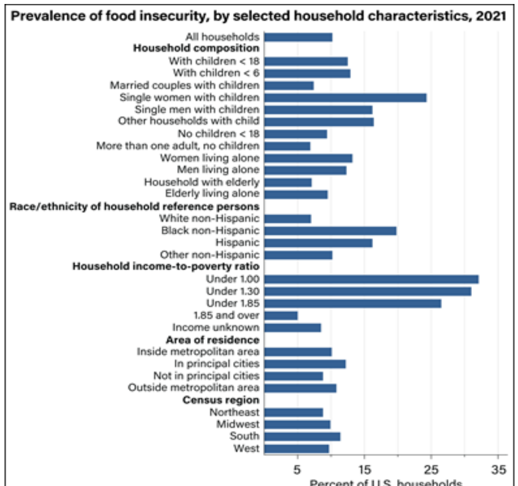
Despite strong efforts at the national, state, and local level, disparities in food insecurity and related outcomes continue to persist

•Households with children headed by a single woman (24.3 percent) or a single man (16.2 percent)

•Households with Black, non-Hispanic (19.8 percent) and Hispanic reference persons (16.2 percent)

•Households with incomes below 185 percent of the poverty threshold (26.5 percent; the Federal poverty line was $27,479 for a family of four in 2021).

Prevalence of food insecurity, by selected household characteristics, 2021



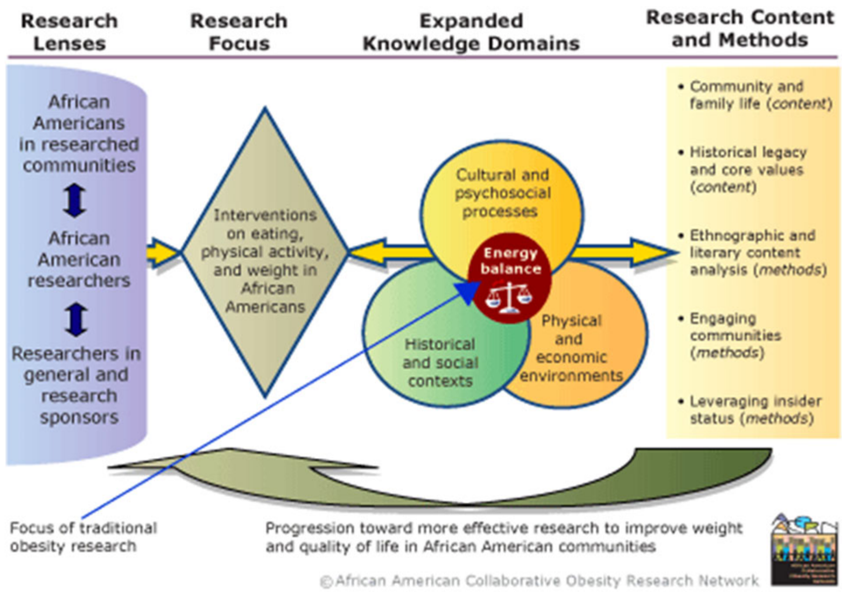
Source: USDA, Economic Research Service using data from U.S. Department of Commerce, Bureau of the Census, 2021 Current Population Survey Food Security Supplement.

Coleman-Jensen, Alisha, Matthew P. Rabbitt, Christian A. Gregory, Anita Singh, September 2022. Household Food Security in the United States in 2021, ERR-309, U.S. Department of Agriculture, Economic Research Service.

#Nutrition2023 • July 22 - 25, 2023 • Boston, MA

NUTRITION 2023

6



7

There is a bias to what kinds of problems we think are important, what kinds of research we think are important, and where we think AI should go. If we don't have diversity in our set of researchers, we are not going to address problems that are faced by the majority of people in the world. When problems don't affect us, we don't think they're that important, and we might not even know what these problems are, because we're not interacting with the people who are experiencing them.

~Timnit Gebru,
Co-founder, Black in AI
Member, Microsoft's Fairness, Accountability, Transparency, and Ethics in AI group

8

Why Diverse Teams in AI Research?

- Evidence indicates that diverse teams can result in more inclusive and relevant research questions, which is particularly important when examining social and structural drivers.
- Diverse perspectives can enhance problem identification, decision-making, and problem-solving, which can lead to new discoveries and novel solutions.
- Diverse research teams can alter the behavior of a group's social majority in ways that lead to improved and more accurate group thinking.
- Team members bring unique knowledge, skill sets, and subject matter expertise, which can enrich the research process and result in a more comprehensive understanding of the subject matter.
- A diverse research team is less likely to be influenced by unconscious biases and stereotyping, leading to more objective and unbiased research findings.
- Research conducted by diverse teams is more likely to reach and resonate with a broader audience based on its relevance to various communities and stakeholders.

•Lorenzo, R., Yoigt, N., Schetelig, K., Zawadzki, A., Welpe, I., & Brosi, P. (2017). The mix that matters: Innovation through diversity. Boston Consulting Group. https://www.bcg.com/publications/2017/people-organization-leadership-talent-innovation-through-diversity-mix-that-matters.aspx

•Rock, D., & Grant, H. (2016, November 4). Why diverse teams are smarter. *Harvard Business Review*. https://hbr.org/2016/11/why-diverse-teams-are-smarter

•Yang, Y., Tian, T. Y., Woodruff, T. K., Jones, B. F., & Uzzi, B. (2022). Gender-diverse teams produce more novel and higher-impact scientific ideas. *Proceedings of the National Academy of Sciences*, *119*(36), e2200841119.

•Wegge, J., Jungmann, F., Liebermann, S., Shemla, M., Ries, B. C., Diestel, S., & Schmidt, K. H. (2012). What makes age diverse teams effective? Results from a six-year research program. Work, 41(Supplement 1), 5145-5151.

9

Algorithmic Bias

"*Knowledge without wisdom is a load of books on the back of an ass*" (Japanese proverb).

- Algorithmic bias occurs when an algorithmic decision creates unfair outcomes that unjustifiably and arbitrarily privilege certain groups over others.
- This matters because algorithms act as gatekeepers to economic and health opportunity.
- The Black Intelligence Test of Cultural Homogeneity (Williams, 1972)

10

Community/Stakeholder Engagement

- Ensure the diversity and representativeness of datasets used for training AI algorithms (Ferrara, 2023).
- Diverse data from different populations and demographics, the risk of bias can be reduced.
- Allow users to understand how algorithms make decisions and identify potential biases ("Addressing Algorithm Bias in AI-Driven Customer Management", 2021)

11

Artificial Intelligence and Wisdom

- AI encompasses a variety of technologies which model human learning and decision-making behaviors.
- Notions of wisdom are also products of worldviews, and even less work has been done to examine AW from the perspective of alternative worldviews, such as the metaphysically inclusive Indigenous worldview.
- The current "narrow" or "weak" AI is, by itself, fundamentally a data analysis tool (i.e., a means to an end) that does nothing more or less than its programming instructs it to do. It has no values or goals of its own, it simply follows the values and pursues the goals provided to it by its programmers.
- We have only begun to consider artificial wisdom (AW) as an essential complement with the potential to make AI a better tool and eventually perhaps more than a tool (i.e., an end in itself). At least for now, however, AW must also be programmed and therefore similarly reflects only the wisdom of its programmers.

Williams, D. and Shipley, G. (2021) Enhancing Artificial Intelligence with Indigenous Wisdom. *Open Journal of Philosophy*, **11**, 43-58. doi: 10.4236/ojpp.2021.111005.

12

Barriers to Diversity, Equity, Inclusion, and Belonging

Implicit Bias: Researchers and team leaders may have unconscious biases that influence their decision-making regarding team composition. These biases can lead to the underrepresentation of diversity in research teams, even when qualified candidates are available.

Limited Networking Opportunities: Access to professional networks and mentorship is crucial for career advancement in research. People of color specifically may have fewer opportunities to network within research contexts, making it more challenging to find collaborators and mentors.

Lack of Inclusive Hiring Practices: Inadequate efforts to promote diversity and inclusion in hiring practices can perpetuate a lack of representation on research teams. Traditional hiring methods may favor candidates from majority groups.

Tokenism: In some cases, people of color, women, LGBTQ+ individuals, or individuals with disabilities may be included on research teams as tokens, rather than for their expertise and contributions. Tokenism can lead to feelings of isolation and marginalization and limit the potential impact of diverse perspectives.

Microaggressions and Discrimination: Experiences of microaggressions and discrimination within research teams can create hostile work environments affecting members well-being and professional development.

13

Barriers to Diversity, Equity, Inclusion, and Belonging

Inequitable Allocation of Resources: Individuals may face disparities in access to funding, equipment, and other resources necessary for their research. This can hinder their ability to conduct research and publish their findings.

Lack of Representation in Leadership Roles: A lack of diversity among research team leaders and principal investigators can limit opportunities for career advancement and an inclusive voice.

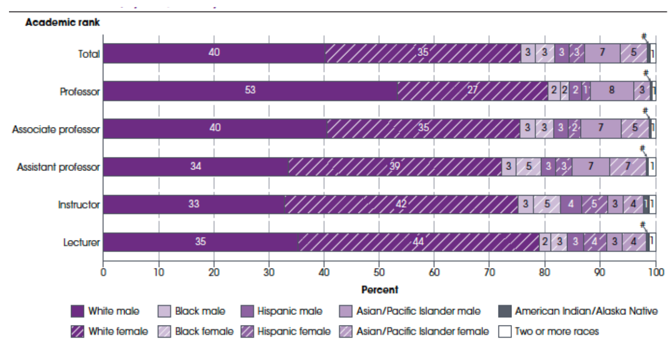
Culturally Insensitive Environments: Research teams that do not take into account the cultural backgrounds and needs of individual members may inadvertently create environments that are less welcoming and inclusive.

Limited Role Models: A lack of visible role models from various backgrounds in research can make it harder for aspiring researchers to envision successful career paths in academia or the scientific community.

Stereotypes and Preconceptions: Stereotypes about the abilities and interests of researchers can influence team dynamics and opportunities for advancement. Preconceived notions about researchers' areas of expertise may limit their involvement in certain projects.

14

For each academic rank, percentage distribution of full-time faculty in degree-granting postsecondary institutions, by race/ethnicity and sex: Fall 2018

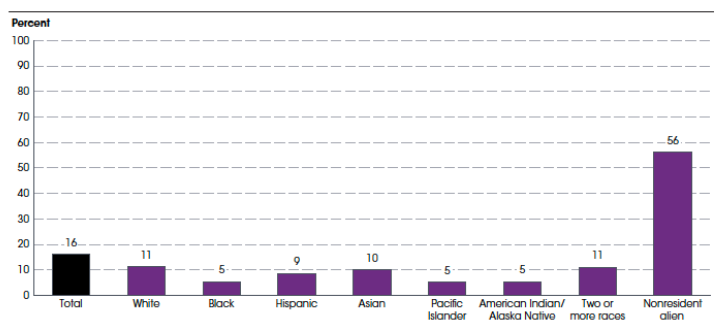


Rounds to zero.
NOTE: Sex breakouts excluded for faculty who were American Indian/Alaska Native and of Two or more races because the percentages were 1 percent or less. Degree-granting institutions grant associate's or higher degrees and participate in Title IV federal financial aid programs. Race categories exclude persons of Hispanic ethnicity. Percentages are based on full-time faculty whose race/ethnicity was known. Detail may not sum to 100 percent due to rounding. Although rounded numbers are displayed, the figures are based on unrounded data.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), IPEDS Spring 2019, Human Resources component. See *Digest of Education Statistics 2019*, table 315.20.

- Hussar, B., Zhang, J., Hein, S., Wang, K., Roberts, A., Cui, J., Smith, M., Bullock Mann, F., Barmer, A., and Dilig, R. (2020). *The Condition of Education 2020* (NCES 2020-144). U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved [date] from https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2020144.

15

Percentage of doctor's degrees conferred in science, technology, engineering, and mathematics (STEM) fields, by race/ethnicity and nonresident status: Academic year 2017–18



NOTE: STEM fields include biological and biomedical sciences, computer and information sciences, engineering, engineering technologies, mathematics and statistics, and physical sciences and science technologies. Data are for postsecondary institutions participating in Title IV federal financial aid programs. Race categories exclude persons of Hispanic ethnicity. Race/ethnicity categories exclude nonresident aliens. Although rounded numbers are displayed, the figures are based on unrounded data.
SOURCE: U.S. Department of Education, National Center for Education Statistics, IPEDS, Fall 2018, Completions component. See *Digest of Education Statistics 2019*, tables 318.45 and 324.25.

Hussar, B., Zhang, J., Hein, S., Wang, K., Roberts, A., Cui, J., Smith, M., Bullock Mann, F., Barmer, A., and Dilig, R. (2020). *The Condition of Education 2020* (NCES 2020-144). U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved [date] from https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2020144.

16

SCIENCE ADVANCES | RESEARCH ARTICLE

SCIENTIFIC COMMUNITY

Topic choice contributes to the lower rate of NIH awards to African-American/black scientists

Travis A. Hoppe[1,2], Aviva Litovitz[1,2], Kristine A. Willis[3]*, Rebecca A. Meseroll[1,2], Matthew J. Perkins[1,2], B. Ian Hutchins[1,2], Alison F. Davis[4], Michael S. Lauer[5], Hannah A. Valantine[4], James M. Anderson[2], George M. Santangelo[1,2]†

Despite efforts to promote diversity in the biomedical workforce, there remains a lower rate of funding of National Institutes of Health R01 applications submitted by African-American/black (AA/B) scientists relative to white scientists. To identify underlying causes of this funding gap, we analyzed six stages of the application process from 2011 to 2015 and found that disparate outcomes arise at three of the six: decision to discuss, impact score assignment, and a previously unstudied stage, topic choice. Notably, AA/B applicants tend to propose research on topics with lower award rates. These topics include research at the community and population level, as opposed to more fundamental and mechanistic investigations; the latter tend to have higher award rates. Topic choice alone accounts for over 20% of the funding gap after controlling for multiple variables, including the applicant's prior achievements. Our findings can be used to inform interventions designed to close the funding gap.

INTRODUCTION

Despite ongoing efforts at the National Institutes of Health (NIH) to promote a diverse biomedical workforce (*1*, *2*), a 2011 study showed that applications from African-American/black (AA/B) scientists were significantly less likely to receive an R01 award than those submitted by white (WH) scientists, even after controlling for educational background, country of origin, training, previous research awards, and employer characteristics (*3*). Especially concerning was the finding that typical measures of scientific achievement (e.g., NIH-funded training, previous grants, publications, and citations) did not translate into an equal probability of funding across racial/ethnic groups, highlighting the need for further study to guide interventions aimed at closing the funding gap. No significant funding gap for applications from Hispanic scientists or women was identified by the 2011 study; however, a more recent study disaggregating race and gender showed that applications from African-American and Asian-American women were less likely to receive R01 awards, underscoring the possibility of an additive effect for women of color (*4*). These studies raised important questions about fairness in peer review because most of the funding gap for AA/B applicants remained unexplained. Here, we seek to answer those questions by examining the characteristics of applications submitted by AA/B and WH scientists.

The underlying causes of the funding gap have been difficult to identify, in large part because of the complex and multifaceted nature of the application and review process. To address this challenge, we identified six decision points at which differential outcomes might contribute to an overall difference in funding: how frequently applicants submit, whether an application was chosen for discussion by a study section, reviewer-assigned impact scores of discussed applications, final funding decisions made by NIH institutes and centers (ICs), resubmission if the application was not funded, and a previously unstudied factor—choice of topic. An analysis of both new (Type 1) and renewal (Type 2) R01 applications ($N = 157{,}549$; attributes summarized in table S1) shows that, although the award rate has dropped for all applicants over the past decade, the funding rate for WH scientists remains approximately 1.7-fold higher than for AA/B scientists [16.1% AA/B versus 29.3% WH in fiscal year (FY) 2000–2006 (*3*) and 10.7% AA/B versus 17.7% WH in FY 2011–2015; Fig. 1].

Complex problems such as this are frequently studied with multivariate regression analysis, which can account for the effect of many independent variables on a single dependent variable. However, interpreting multivariate regression data can be challenging. When one independent variable acts both directly on the outcome and indirectly on another variable, when variables presumed to be independent are highly correlated, or when two or more variables interact with each other in a feedback loop, it can be difficult to decipher which factors make the most significant contributions to an outcome. In addition, real-world data may not provide sufficient power to calculate statistical interactions when a large number of variables act on a relatively small population. For these reasons, we first did simple descriptive analyses to characterize each of our six decision points independently before using multivariate regression analysis to determine how the relevant variables might be interrelated.

RESULTS

Career stage and institutional resources influence the gap in the number of submissions by AA/B and WH scientists

One factor that might be expected to influence whether a scientist receives funding is how many applications he or she submits. From FY 2011–2015, AA/B scientists submitted R01 applications at 83.7% the frequency of WH applicants (Fig. 1 and fig. S1). However, AA/B applicants are unevenly distributed across institutional funding quintiles; 33.9% of all AA/B investigators are from institutions in the lowest quintile, compared with only

[1]Office of Portfolio Analysis, National Institutes of Health, Bethesda, MD, USA. [2]Division of Program Coordination, Planning, and Strategic Initiatives, National Institutes of Health, Bethesda, MD, USA. [3]National Institute of General Medical Sciences, National Institutes of Health, Bethesda, MD, USA. [4]Scientific Workforce Diversity, National Institutes of Health, Bethesda, MD, USA. [5]Office of Extramural Research, National Institutes of Health, Bethesda, MD, USA.
*Present address: National Cancer Institutes, National Institutes of Health, Rockville, Maryland, USA.
†Corresponding author. Email: george.santangelo@nih.gov

"Despite efforts to promote diversity in the biomedical workforce, there remains a lower rate of funding of National Institutes of Health R01 applications submitted by African-American/black (AA/B) scientists relative to white scientists.

To identify the underlying causes of this funding gap, we analyzed six stages of the application process from 2011 to 2015 and found that disparate outcomes arise at three of the six: the decision to discuss, impact score assignment, and a previously unstudied stage, topic choice.

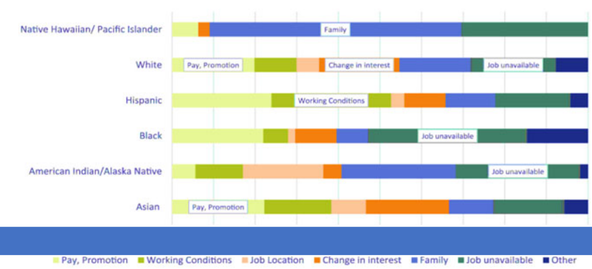
Notably, AA/B applicants tend to propose research on topics with lower award rates. These topics include research at the community and population level, as opposed to more fundamental and mechanistic investigations; the latter tend to have higher award rates. Topic choice alone accounts for over 20% of the funding gap after controlling for multiple variables, including the applicant's prior achievements. Our findings can be used to inform interventions designed to close the funding gap."

•Travis A. Hoppe et al. Topic choice contributes to the lower rate of NIH awards to African-American/black scientists.*Sci. Adv.***5**,eaaw7238(2019).DOI:10.1126/sciadv.aaw7238

17

- Primary reason why women with STEM (science, technology, engineering, and mathematics) degrees take jobs outside field by race.

Original analysis. *Note*. National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System, 2015. Retrieved from http://www.nsf.gov/statistics/sestat/

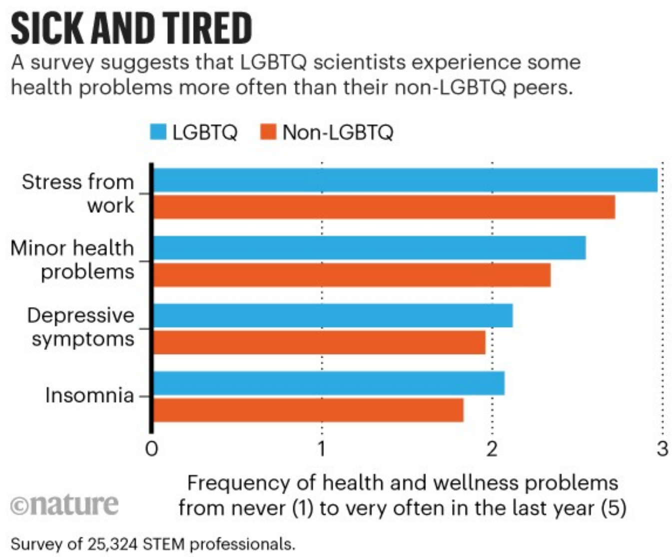


Metcalf, H., Russell, D., & Hill, C. (2018). Broadening the Science of Broadening Participation in STEM Through Critical Mixed Methodologies and Intersectionality Frameworks. *American Behavioral Scientist*, *62*(5), 580–599

18

The survey found that LGBTQ scientists were less likely to report opportunities to develop their skills and access to the resources required to do their jobs well than were their colleagues. They were also 20% more likely than non-LGBTQ scientists to have experienced some kind of professional devaluation, such as being treated as less skilled than their colleagues, and were 30% more likely to have experienced harassment at work in the past year.

- E. A. Cech, T. J. Waidzunas. Systemic inequalities for LGBTQ professionals in STEM.*Sci. Adv.***7**,eabe0933(2021).



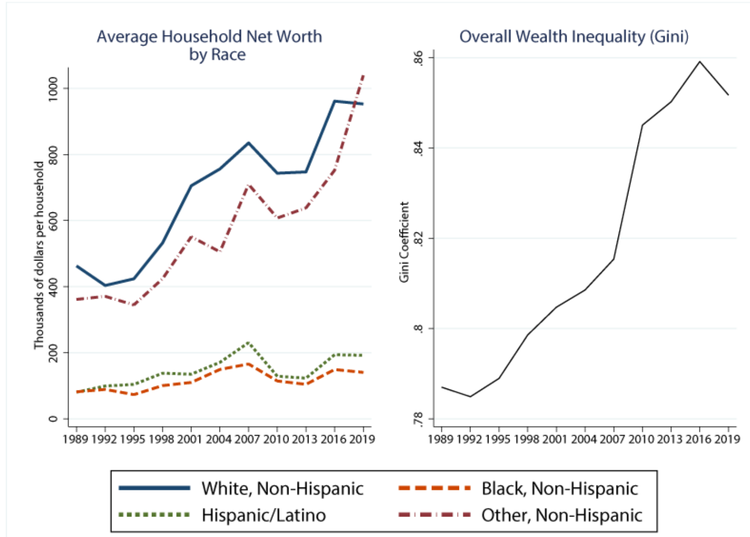
19

Other Factors

- Wealth/Income gaps
- Disparities in Educational Attainment

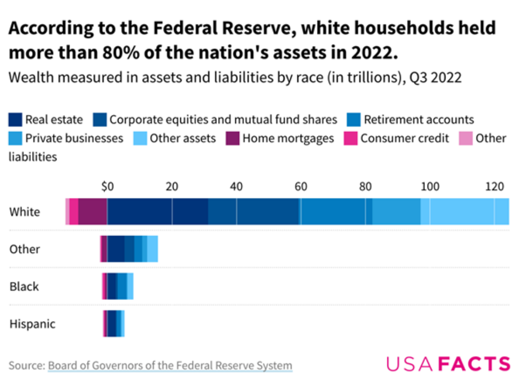
20

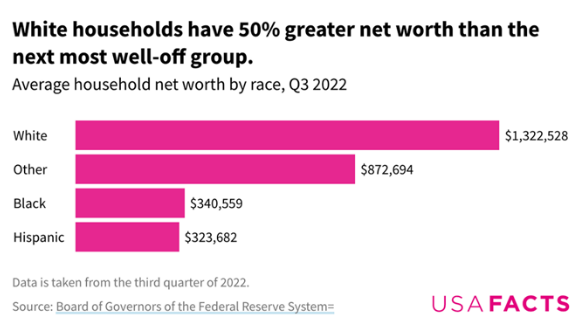
Racial Gaps in Net Worth Continues to Persist



21

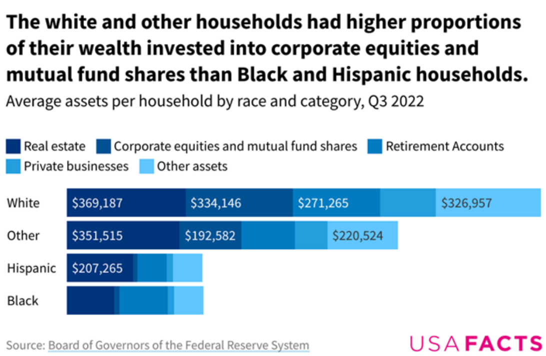
Racial Gaps in Net Worth Continues to Persist

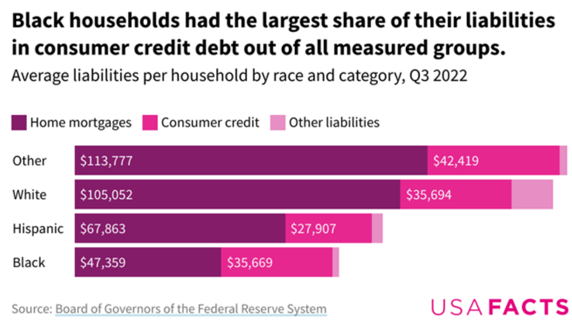




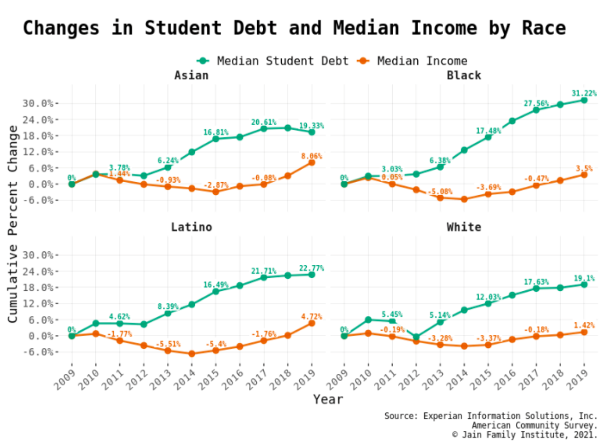
22

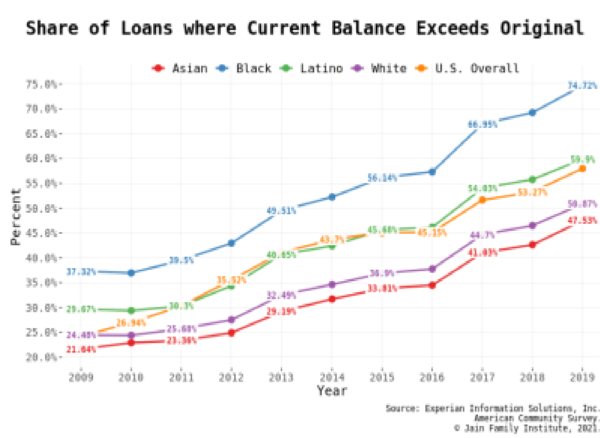
Racial Gaps in Net Worth Continues to Persist





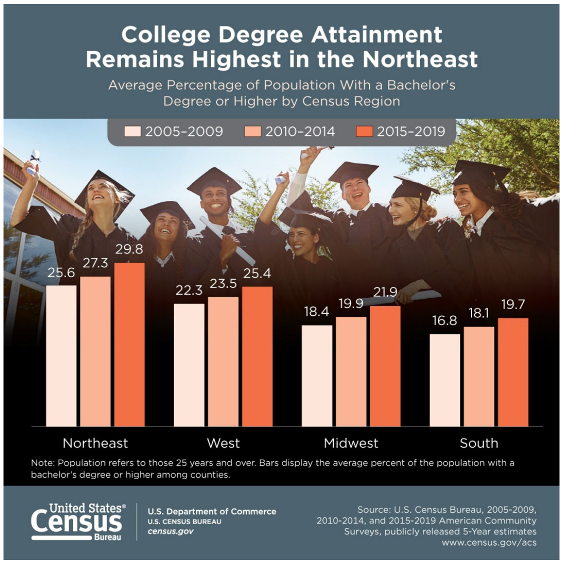
23

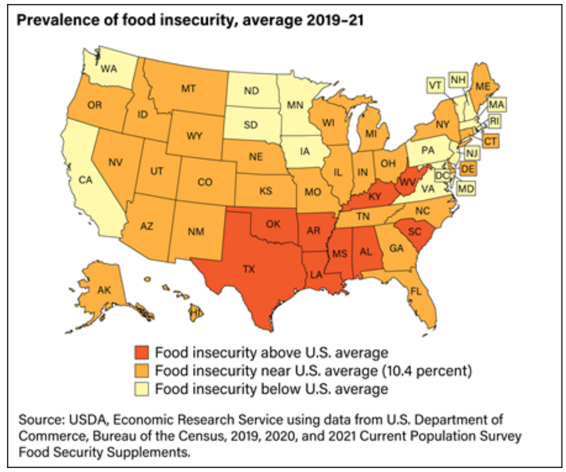




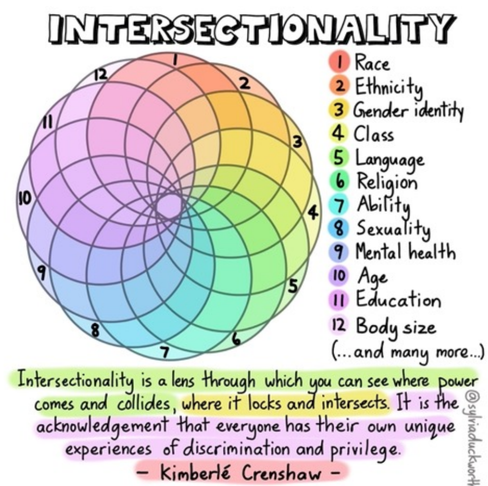
Perry, A. M., Steinbaum, M., & Romer, C. (2021). Student loans, the racial wealth divide, and why we need full student debt cancellation.

24





25



Definition of Diversity, Equity, Inclusion, and Belonging

26

Recommendations for Increasing JEDI, DEIB

- Themes identified by Martin et al., 2023
  - Recruitment
  - Retention
  - Advancement
  - Intersectionality of multiple challenges (e.g., being Black and a woman)
  - Funding agencies
  - Implementation of strategies to address problems related to DEI.

- Source: Martin SL, Cardel MI, Carson TL, Hill JO, Stanley T, Grinspoon S, Steger F, Blackman Carr LT, Ashby-Thompson M, Stewart D, Ard J; Nutrition Obesity Research Center Taskforce to Advance the Careers of Researchers from Groups Underrepresented in Academia; Stanford FC. Increasing diversity, equity, and inclusion in the fields of nutrition and obesity: A roadmap to equity in academia. Am J Clin Nutr. 2023 Apr;117(4):659-671.

27

Strategies

- Outreach and Recruitment (e.g., partnering with HBCUs, HSI, tribal colleges, Develop position descriptions that communicate an institutional commitment to DEI.
- Focus on Policies, Procedures, and People (e.g., Guide committee members on how to evaluate DEI in candidates. track data on recruitment and retention of URA scientist and evaluate to identify points of attrition contributing factors.
- Create an Inclusive Environment (e.g., institution wide cultural safety training, Cultural/Structural Competence and Implicit bias Training)
- Assemble Diverse Research Teams
- Identify and Remove Institutional or Systemic Barriers (e.g., pilot funding, equitable workloads)
- Support Community Engagement
- Foster Representation in Leadership
- Allow for Diverse Research Topics
- Evaluate Progress

28

Ten Hagen, K.G., Wolinetz, C., Clayton, J.A. *et al.* Community voices: NIH working toward inclusive excellence by promoting and supporting women in science. *Nat Commun* **13**, 1682 (2022). https://doi.org/10.1038/s41467-022-28665-2

29

Justice Ketanji Brown Jackson on the Recent Affirmative Action Ruling

"Gulf-sized race-based gaps exist with respect to the health, wealth, and well-being of American citizens. They were created in the distant past, but have indisputably been passed down to the present day through the generations. Every moment these gaps persist is a moment in which this great country falls short of actualizing one of its foundational principles — the 'self-evident' truth that all of us are created equal."

"Our country has never been colorblind. Given the lengthy history of state-sponsored race-based preferences in America, to say that anyone is now victimized if a college considers whether that legacy of discrimination has unequally advantaged its applicants fail to acknowledge the well-documented 'intergenerational transmission of inequality' that still plagues our citizenry."

30