Spring 2024 Meeting of the Board on Life Sciences

May 30, 2024

THURSDAY, MAY 30, 2024

OPEN SESSION

12:45pm–1:00pm ET

Welcome and Event Introduction

Ann Arvin, Vir Biotechnology

1:00pm–2:30pm ET

Innovations and Implications of Advances in Computational Analyses in Neuroscience Research: Unraveling Insights into Brain Function and Plasticity

Joint Discussion of the Board on Life Sciences and Health Sciences Policy Board

The life sciences have transformed during the past 10-20 years as computing power, data generation and movement, and *in silico* analyses have advanced significantly. These advances enable the study of whole-organism responses, the totality of traits resulting from genetic, molecular, and environmental factors. Fields such as neuroscience simultaneously have led to innovative developments in data analytics, particularly in artificial intelligence models, and gained from these analytic developments. Scientists now are able to study changes within cells, between cells, within whole organisms, and between organisms and other organisms and environmental factors at increasing scale, providing promise toward understanding and addressing critical challenges health. Focusing on brain function and plasticity over lifetimes and in response to various molecular and environmental issues, these analytic capabilities provide opportunities for understanding, measuring, and connecting the complex cellular processes leading to electrophysiological outputs from neurons so critical to thought, learning, memory, behavior, sensations, and many other functions controlled by the brain.

This discussion will highlight forward-leading research and development in neuroscience focusing on advances in understanding the biochemical and electrical signals at scale, and the broader technical, societal, and policy implications associated with this and future research in these fields. Within this context, speakers will discuss current and future research trends transforming our understanding of brain function and plasticity, focusing on various applications including health; the broader policy and societal drivers and concerns associated with this research; and outstanding technical, societal, and policy challenges associated with this research and its possible applications to health and other sectors.

Moderator

Diane DiEuliis, National Defense University

Speakers
Alberto E. Pereda, Albert Einstein College of Medicine
Kafui Dzirasa, Duke University
Sepideh Sadaghiani, University of Illinois Urbana-Champaign
Amina Qutub, University of Texas San Antonio
Gabriel Lázaro-Muñoz, Harvard University
Kari Johnson, National Institute of Neurological Disorders and Stroke

Discussion Questions

- In about 7-10 minutes, please tell us a bit about your research and how it contributes to understanding brain function and plasticity via studies of biochemical and electrical signals and their connections at scale?
- (for Gabe) In about 7-10 minutes, please describe critical ethical and societal considerations associated with this type of research and application of knowledge?
- What are the most promising areas of advancement for studying biochemical and electrical signals at scale to understand brain function and plasticity?
- What are the main technical, policy, and/or societal drivers for this type of research?
- What are critical knowledge gaps that exist? What hurdles contribute to these gaps?
- What are critical ethical, societal, policy, safety, and security considerations associated with studying biochemical and electrical signals at scale to understand brain function and plasticity?
- What opportunities exist to drive forward innovation in this field while also ensuring harms are minimized?
- In your view, what is missing to further advance the science, apply the knowledge gained from the science, and identify and assess the risks associated with the research?

2:30pm–2:45pm ET **Break**

END OF DAY

ADVANCE READING

Cass S and Adee S. The Electrome: The Next Great Frontier For Biomedical Technology. IEEE Podcast. https://spectrum.ieee.org/electrome-new-biomedical-frontier

Coletta L, Avesani P, Zigiotto L, Venturini M, Annicchiarico L, Vavassori L, Ng S, Duffau H, Sarubbo S. Integrating direct electrical brain stimulation with the human connectome. Brain. 2023 Dec 4:awad402. doi: 10.1093/brain/awad402. Epub ahead of print.

De Loof A. The cell's self-generated "electrome": The biophysical essence of the immaterial dimension of Life? Commun Integr Biol. 2016 Jul 1;9(5):e1197446. doi: 10.1080/19420889.2016.1197446.

Eke DO, Bernard A, Bjaalie JG, Chavarriaga R, Hanakawa T, Hannan AJ, Hill SL, Martone ME, McMahon A, Ruebel O, Crook S, Thiels E, Pestilli F. International data governance for neuroscience. Neuron. 2022 Feb 16;110(4):600-612. doi: 10.1016/j.neuron.2021.11.017. Epub 2021 Dec 15.

Kabbara, A., Robert, G., Khalil, M. et al. An electroencephalography connectome predictive model of major depressive disorder severity. Sci Rep 12, 6816 (2022). https://doi.org/10.1038/s41598-022-10949-8

Rodriguez-Cruces R, Royer J, Larivière S, Bassett DS, Caciagli L, Bernhardt BC. Multimodal connectome biomarkers of cognitive and affective dysfunction in the common epilepsies. Netw Neurosci. 2022 Jun 1;6(2):320-338. doi: 10.1162/netn_a_00237.

Sadaghiani S, Brookes MJ, Baillet S. Connectomics of human electrophysiology. Neuroimage. 2022 Feb 15;247:118788. doi: 10.1016/j.neuroimage.2021.118788. Epub 2021 Dec 12.

Schöttner, M., Bolton, T.A.W., Patel, J. et al. Exploring the latent structure of behavior using the Human Connectome Project's data. Sci Rep 13, 713 (2023). https://doi.org/10.1038/s41598-022-27101-1

Shen X, Finn ES, Scheinost D, Rosenberg MD, Chun MM, Papademetris X, Constable RT. Using connectome-based predictive modeling to predict individual behavior from brain connectivity. Nat Protoc. 2017 Mar;12(3):506-518. doi: 10.1038/nprot.2016.178. Epub 2017 Feb 9.

Walder-Christensen K, Abdelaal K, Klein H, Thomas GE, Gallagher NM, Talbot A, Adamson E, Rawls A, Hughes D, Mague SD, Dzirasa K, Carlson DE. Electome network factors: Capturing emotional brain networks related to health and disease. Cell Rep Methods. 2024 Jan 22;4(1):100691. doi: 10.1016/j.crmeth.2023.100691. Epub 2024 Jan 11.

Wisedchaisri G, Tonggu L, McCord E, Gamal El-Din TM, Wang L, Zheng N, Catterall WA. Resting-State Structure and Gating Mechanism of a Voltage-Gated Sodium Channel. Cell. 2019 Aug 8;178(4):993-1003.e12. doi: 10.1016/j.cell.2019.06.031. Epub 2019 Jul 25.

SPEAKER BIOGRAPHIES

Dr. Diane DiEuliis is a Distinguished Research fellow at National Defense University, where she researches the impacts of emerging technologies on biodefense, biosecurity and national defense. Her expertise covers biotechnology, the US bioeconomy, dual use life sciences research, neurotechnology, and behavioral, cognitive, and social issues (including ELSI). Dr. DiEuliis teaches in biotechnology and biodefense, and lectures in foundational professional military education. Prior to joining NDU, Dr. DiEuliis was the Deputy Director for Policy and Planning, in the Office of the Administration for Strategic Preparedness and Response (ASPR), U.S. Department of Health and Human Services. Dr. DiEuliis was the Assistant Director for Life Sciences and Behavioral and Social Sciences in the Office of Science and Technology Policy (OSTP) in the Executive Office of the President across two presidencies. During her tenure at the White House, she created policy in biosecurity, synthetic biology, biotechnology, behavioral science, scientific collections, and human subjects' research. Prior to working at OSTP, Dr. DiEuliis was a program director at the National Institutes of Health (NIH), where she managed a diverse portfolio of neuroscience research in neurodegenerative diseases. She is the author of over 80 publications.

Dr. Kafui Dzirasa is the first African American to complete a PhD in Neurobiology at Duke University. His research interests focus on understanding how changes in the brain produce neurological and mental illness. Kafui obtained an MD from the Duke University School of Medicine in 2009 and completed residency training in General Psychiatry in 2016. Kafui was featured on CBS 60 Minutes and has been awarded the One Mind Rising Star Award and the Sydney Baer Prize for Schizophrenia Research. In 2017, he was recognized as 40 under 40 in Health by the National Minority Quality Forum, and the Engineering Alumni of the Year from the University of Maryland Baltimore County.

Kafui was awarded the Presidential Early Career Award for Scientists and Engineers (PECASE): the nation's highest award for scientists and engineers in the early stages of their independent research careers. He has also been recognized with the Alan Leshner Public Engagement Fellowship from the American Association for the Advancement of Science and the Society for Neuroscience Young Investigator Award. He has served on the Editorial Advisory Board for TEDMED and currently serves on the Advisory Committee for the National Institutes of Health (NIH) Director. Kafui is a member of the National Academy of Medicine and is a Howard Hughes Medical Institute (HHMI) Investigator.

Dr. Kari Johnson is a Program Director at the National Institute of Neurological Disorders and Stroke. Her portfolio includes BRAIN Connectivity across Scales (CONNECTS) projects that are aimed at large-scale mapping of local and long-range neural connectivity. Prior to joining NINDS in 2023, Kari was on the faculty of Uniformed Services University of the Health Sciences (Bethesda, MD), where her lab studied basal ganglia circuits involved in reinforcement learning and behavioral flexibility. She received her PhD in Pharmacology at Vanderbilt University and completed a postdoctoral fellowship at the National Institute on Alcohol Abuse and Alcoholism.

Dr. Gabriel Lázaro-Muñoz is Assistant Professor of Psychiatry and Global Health and Social Medicine in the Center for Bioethics and the Department of Global Health and Social Medicine at Harvard Medical School, and the Department of Psychiatry at Massachusetts General Hospital. Dr. Lázaro-Muñoz combines his background in neuroscience, law, and bioethics to examine the implications of emerging biomedical technologies in neuroscience and genomics. He is principal investigator of studies funded by the BRAIN Initiative-National Institutes of Health, National Institute of Mental Health, and the National Human Genome Research Institute.

Dr. Lázaro-Muñoz's current studies examine ethical and social implications of the integration of psychiatric genomics into clinical care, polygenic embryo screening, the development of neurotechnologies such as adaptive deep brain stimulation systems, and the use of deep brain stimulation in children. He is a member of the Genomics & Society Working Group of the National Human Genome Research Institute, and the International Society of Psychiatric Genetics (ISPG) Ethics, Position, and Policy Committee. Dr. Lázaro-Muñoz is developing the Latin American Bioethics Consortium (LABC) to strengthen bioethics infrastructure across Latin America, and is a co-founder of the Harvard Neurethics Hub. Dr. Lázaro-Muñoz is also adjunct professor at the University of Puerto Rico School of Medicine, and Baylor College of Medicine. He has been quoted in the LA Times, Scientific American, STAT News, National Public Radio, and MIT Technology Review, among other media outlets. Dr. Lázaro-Muñoz received his Ph.D. in Neuroscience from New York University; his J.D. and Master of Bioethics from the University of Pennsylvania; and his BA in Psychology from the University of Puerto Rico.

Dr. Alberto E. Pereda is a Professor in the Dominick P. Purpura Department of Neuroscience at of the Albert Einstein College of Medicine. His laboratory is interested in the properties and dynamics of gap junction-mediated electrical transmission in the vertebrate brain. The approach involves investigating electrical transmission at identifiable auditory mixed (electrical and chemical) synapses on the fish Mauthner cells, as well mammalian brain structures. While the study

of plasticity of chemical synapses has long been an area of primary interest to neuroscientists, less is known about the modifiability of electrical synapses. Alberto's laboratory investigates mechanisms underlying changes in synaptic strength at electrical synapses, which ultimately requires determining their full molecular and structural complexity. Alberto has served as faculty in the Neurobiology course from 1996-2000 and 2004-2007, and directed the Grass Laboratory in 2012-2014. He began co-directing NS&B in 2020.

Dr. Amina Qutub is an Associate Professor at the University of Texas, San Antonio (UTSA), and research thrust lead of the Artificial Intelligence MATRIX Consortium. She is also Director of the UTSA – UT Health Joint Graduate Group in Biomedical Engineering. Bridging basic science to translational impact, she directs the Quantu Project, a nationwide study to optimize brain health over a lifespan using an integration of biosensing technology, modeling and functional neurogenesis bioassays. Dr. Qutub also serves as the computational lead for the international Leukemia Protein Atlases, a clinical and engineering collaboration to identify new therapeutic targets for pediatric and adult leukemias. Dr. Qutub completed her postdoc as a National Institute of Health NRSA fellow in Biomedical Engineering at The Johns Hopkins University, School of Medicine. She is an American Institute for Medical and Biological Engineering Fellow, National Academies' Keck Future Initiatives Awardee, and National Science Foundation CAREER Awardee. Dr. Qutub has served as Conference Chair and Co-Organizer for two National Academies of Sciences, Engineering & Medicine Arab-America Frontiers Symposia, and participated as an invited speaker or participant at four other Frontiers of Engineering Symposia (Indo-American, China-America, and two additional Arab-America meetings). She was a National Academy of Engineering nominated participant in the Royal Academy of Engineering Global Grand Challenges (London, 2019), and she was nominated this year by the National Academy of Sciences as a participant in the World Laureates Symposium (Shanghai, 2021). She also is leading a project started under the auspices of the National Academy of Engineering COVID-19 Call-for-Engineering Action on studying neurovascular effects of viral infection. Dr. Qutub received her B.S. in chemical engineering at Rice University in 1999, and Ph.D. in Bioengineering from Berkeley and UCSF in 2004 with a major in mathematical modeling and minor in neurology.

Dr. Sepideh Sadaghiani is Associate Professor of Psychology (Cognitive Neuroscience program area) and Bioengineering, and faculty of the Neuroscience Graduate Program at the University of Illinois, Urbana-Champaign. She directs the CONNECTlab at the Beckman Institute for Advanced Science and Technology where she is full-time faculty. Sadaghiani received a Ph.D. in Neural and Behavioral Sciences from the Max Planck Graduate School and postdoctoral training at Berkeley and Stanford. She investigates the role of neural connectivity and spontaneous brain activity in cognitive control and behavior through a multi-modal lens. Sadaghiani serves as handling editor at Imaging Neuroscience (formerly NeuroImage), Brain Topography, and Network Neuroscience. She has been recognized as National Science Foundation (NSF) CAREER Awardee, Lincoln Excellence for Assistant Professors (LEAP) Scholar and Helen Corley Petit Scholar. Her work has been funded by the National Institutes of Mental Health (NIMH), Neurological Disorders and Stroke (NINDS), and the NSF.