

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTES OF HEALTH

NATIONAL ADVISORY COUNCIL FOR
BIOMEDICAL IMAGING AND BIOENGINEERING

Summary of Meeting¹
May 21, 2019

The National Advisory Council for Biomedical Imaging and Bioengineering (NACBIB) was convened for its 50th meeting on May 21, 2019, at the Bolger Center in Potomac, Maryland. Dr. Bruce Tromberg, Director of the National Institute of Biomedical Imaging and Bioengineering (NIBIB), presided as Council chairperson. In accordance with Public Law 92-463, the meeting was open to the public from 9:15 a.m. to 12:50 p.m. for review and discussion of program development, needs, and policy. The meeting was closed to the public from 1:55 p.m. to 3:20 p.m. for the consideration of grant applications.

Council members present:

Dr. Richard Buxton, University of California, San Diego, La Jolla, CA
Dr. Maryellen Giger, University of Chicago, Chicago, IL
Dr. David Grainger, University of Utah, Salt Lake City, UT
Dr. Paula Hammond, Massachusetts Institute of Technology, Cambridge, MA
Dr. John H. Linehan, Northwestern University, Evanston, IL
Dr. Robert Nerem, Georgia Tech University, Atlanta, GA
Dr. Gordana Vunjak-Novakovic, Columbia University, New York, NY

Council member absent:

Dr. Sanjiv Gambhir, Stanford University, Stanford, CA
Dr. Carolyn Meltzer, Emory University Hospital, Atlanta, GA

Council member attending by telephone:

Dr. Charles Mistretta, University of Wisconsin, Madison, Madison, WI
Dr. Bruce Rosen, Harvard Medical School, Charlestown, MA

Ex officio members attending:

Dr. Vincent Ho, Uniformed Services University of the Health Sciences, Bethesda, MD
Dr. Sohi Rastegar, National Science Foundation, Arlington, VA

Ex officio members absent:

Mr. Alex M. Azar, National Institutes of Health, Bethesda, MD
Dr. Francis Collins, National Institutes of Health, Bethesda, MD
Dr. Anne Plant, National Institute of Standards and Technology, Gaithersburg, MD

Chairperson:

Dr. Bruce Tromberg

Executive Secretary:

Dr. David T. George

¹ For the record, it is noted that members absent themselves from the meeting when the Council is discussing applications (a) from their respective institutions or (b) in which a conflict of interest may occur. This procedure only applies to applications that are discussed individually, not to "en bloc" actions.

Also present:

NIBIB staff present for portions of the meeting:

Ms. Roberta Albert	Dr. Guoying Liu
Mr. Albricia (Nick) Aldana	Mr. Raymond MacDougal
Dr. Tatjana Atanasijevic	Ms. Jacqueline Martinez
Mr. Angelos Bacas	Dr. Rishi Mathura
Ms. Lily Bisson	Ms. Ruthann McAndrew
Ms. Shirley Coney-Johnson	Ms. Jessica Meade
Ms. Christine Cooper	Mr. Todd Merchak
Dr. Monique Day	Ms. Anna Miglioretti
Mr. Anthony Dorion	Dr. Grace Peng
Dr. Qi Duan	Dr. Carlo Pierpaoli
Ms. Jacklyn Ebiasah	Dr. David Rampulla
Ms. Kate Egan	Ms. Julia Ringel
Ms. Angela Eldridge	Ms. Saltanat Satabayeva
Ms. Katie Ellis	Dr. Seila Selimovic
Dr. Zeynep Erim	Dr. Behrouz Shabestari
Ms. Shirley Finney	Mr. Shaun Sims
Mr. Jason Ford	Ms. Ashley Storm
Ms. Pam Glikman	Dr. Manana Sukhareva
Dr. John Hayes	Ms. Holly Taylor
Dr. Jill Heemskerck	Ms. Florence Turska
Dr. Dennis Hlasta	Dr. Shumin Wang
Ms. Alisha Hopkins	Ms. Jennifer Ward
Mr. James Huff	Dr. Andrew Weitz
Dr. Thomas Johnson	Dr. Patricia Wiley
Dr. Krishna Kandarpa	Dr. Michael Wolfson
Dr. Randy King	Mr. Kwesi Wright
Ms. Truc Le	Dr. Ruixia Zhou
Dr. Richard Leapman	Dr. Steven Zullo

NIBIB Staff Attending by Telephone:

Dr. John Holden

Non-NIBIB National Institutes of Health (NIH) employees:

Dr. Ileana Hancu, CSR, NIH, Bethesda, MD
Dr. Leslie Itsara, CSR, NIH, Bethesda, MD
Dr. Peter Kilmarx, FIC, NIH, Bethesda, MD
Dr. Laura Povlich, FIC, NIH, Bethesda, MD
Dr. Paul Sato, OD, NIH, Bethesda, MD

Non-NIH Federal employees:

Dr. Zane Arp, FDA, Silver Spring, MD

Members of the public present for portions of the meeting:

Dr. Richard Baird, Olney, MD
Mr. Milton Berrios, Bolger Center, Potomac, MD
Ms. Casey Cappelletti, The Academy for Radiology & Biomedical Imaging Research, Washington, DC
Ms. Renee L. Cruea, The Academy for Radiology & Biomedical Imaging Research, Washington, DC
Ms. Ilana Goldberg, Potomac, MD
Ms. Martha Nolan, The Academy of Radiology & Biomedical Imaging Research, Washington, DC
Dr. Aydogan Ozcan, University of California at Los Angeles, Los Angeles, CA
Ms. Allison Rafti, The Academy of Radiology & Biomedical Imaging Research, Washington, DC
Ms. Naomi Webber, Lewis Burke Associates, LLC, Washington, DC

I. Call to Order: Dr. David T. George

Dr. David T. George called to order the 50th meeting of the National Advisory Council for Biomedical Imaging and Bioengineering. He reminded attendees that the morning session of the meeting was open to the public and welcomed attendees.

II. Director's Remarks: Dr. Bruce Tromberg

A. Welcome

Dr. Tromberg welcomed a new Council Member, Dr. Bruce Rosen, and announced upcoming Ex Officio Council Member from the Food and Drug Administration, Dr. Jeffrey Shuren. Dr. Tromberg also acknowledged the contributions of the departing Council Members: Dr. John H. Linehan, Dr. Carolyn C. Meltzer, and Dr. Charles A. Mistretta.

B. News

NIBIB Staff Updates: Two new staff, Ms. Beverly Bricker and Ms. Cheryl Shimer, were welcomed to the Office of Science Policy and Communication.

In Memoriam – Dr. Steven H. Krosnick: Dr. Tromberg announced the sad news of the passing of Dr. Steven Krosnick, Program Director for Image-Guided Interventions, and head of the NIBIB Portfolio Evaluation Office, following his courageous battle with cancer. Dr. Tromberg praised Dr. Krosnick's 20-year career as an NIH medical officer and his contributions to the scientific community on behalf of NIBIB. Dr. Tromberg announced that the first prize award in the Design by Biomedical Undergraduate Teams (DEBUT) Challenge will be named the Steven H. Krosnick Prize in recognition of Dr. Krosnick's commitment to the field of biomedical engineering. The Krosnick Prize provides a \$20,000 award in this annual competition recognizing undergraduate excellence in biomedical design and innovation.

Awards: Dr. Tromberg congratulated Dr. Carolyn Meltzer on her Gold Medal Award from the American Society of Neuroradiology for her high-impact research contributions and exceptional leadership throughout her career. He also commended Dr. Paula Hammond who was elected to the National Academy of Sciences for her contributions to self-assembly of polyelectrolytes, colloids, and block copolymers at surfaces and interfaces for energy and healthcare applications.

IMAG Multiscale Modeling (MSM) Consortium: Dr. Grace Peng, NIBIB Program Director for Mathematical Modeling, Simulation, and Analysis, organized a 12th annual consortium meeting on multiscale modeling that focused on translation and dissemination of models. Dr. Tromberg noted that many government agencies attended and elaborated on the importance of modeling to the NIBIB research community. He announced an upcoming Multiscale Modeling (MSM) workshop in October 2019 that will focus on machine learning and artificial intelligence, and that the March 2020 interagency MSM Consortium theme is diversity.

Innovations in Technologies to Extend the Golden Hour: Dr. Seila Selimovic, NIBIB Program Director for Technologies for Tissue Chips, Engineered Tissues, and Biosensors and Physiological Detectors, hosted an interagency workshop in March focusing on trauma care. The collaboration, between three NIH institutes (NIBIB, NHLBI, and NINDS), the Food and Drug Administration (FDA), HHS Biomedical Advanced Research and Development Authority (BARDA), and the

Department of Defense's Joint Program Committee-6/Combat Casualty Care Research Program (JPC-6) and Defense Advanced Research Projects Agency (DARPA), discussed bioimaging and bioengineering solutions for military and civilian emergency trauma care. A summary report is forthcoming.

2019 Synthetic Biology Consortium Meeting: Dr. David Rampulla, NIBIB Program Director for Synthetic Biology for Technology Development, will host the first Annual Synthetic Biology Consortium Meeting, on October 28-29th, 2019, on the NIH campus.

C. New Initiatives

FY 19 Initiatives: Dr. Tromberg announced the reissuance of the Team-Based Design in Biomedical Engineering Education R25 Program (PAR-19-215)—a three-year initiative whose next application due date is May 31st. Additionally, two NIBIB-led BRAIN RFAs—Early Stage Next Generation Human Brain Imaging (RFA-EB-17-003) and Development of Next Generation Human Brain Imaging Tools and Technologies (RFA-EB-17-004)—are being reissued with anticipated due dates in September 2019. In encouraging the NIBIB community to submit their innovative ideas for these initiatives, Dr. Tromberg pointed out that about 66% of the \$950 million in BRAIN funding supports bioengineering- and biomedical imaging-related research.

D. Budget and NIBIB Opportunity Impact

The proposed FY2020 budget from the House increased appropriations for NIBIB by 4.8%. There has not been a proposed FY2020 budget from the Senate. The NIBIB FY2019 R01 payline is set at the 19th percentile for established investigators and 24th percentile for new investigators.

Dr. Tromberg highlighted the impact of bioengineering at the NIH. In 2008, about 1% of the total NIH budget went to bioengineering grants, but now nearly 12% of the NIH budget funds bioengineering research. In the past 10 years, NIH-funded bioengineering research has grown about two times faster than the enacted NIH budget.

Regarding the growth of healthcare costs, Dr. Tromberg noted that by 2020, healthcare costs are anticipated to total more than \$4 trillion, which is approximately 20% of GDP and growing five times faster than GDP. In recognition of the challenges associated with the cost of healthcare and to improve outcomes for patients, some broad initiatives have been created, including “All of Us” at NIH and the Biobank Program in the United Kingdom. These programs aim to measure and integrate multiple parameters from a vast number of participants to improve understanding and outcomes. This represents a strategic opportunity for the NIBIB community to expand and achieve a broader impact in healthcare. He highlighted the rapid growth of sensing and imaging technologies, digital health, and cutting-edge biology. NIBIB-supported bioengineers are poised to create new tools and methods to turn modern biology into healthcare solutions.

E. Strategic Planning: Concept and Rationale

Dr. Tromberg announced that the preparations for the 2020 NIBIB Strategic Plan: “Engineering the Future of Health” have commenced. Emerging healthcare technologies allow continuous monitoring of biological measurements to maintain health and prevent disease. The NIBIB vision aims to accelerate the challenge of integrating complex datasets, creating practical knowledge to extend the healthspan.

Dr. Tromberg's vision for the future of NIBIB includes:

1. Develop and disseminate transformational technologies for:
 - a. Data Science, Artificial Intelligence, and Computation
 - b. Engineered Biology
 - c. Sensing and Imaging Health and Disease
 - d. Advanced Therapies/Cures
2. Accelerate Technology Training, Translation, and Commercialization by Expanding:
 - a. Biomedical Imaging and Bioengineering Workforce
 - b. Technology Development Pipelines
 - c. Funding Opportunities for Intra- and Extramural NIBIB Programs
3. Excel as a Federal Science Agency by Developing:
 - a. Internal and External Quality Management Standards and Practices
 - b. Effective Procedures for Implementing and Evaluating Daily Operations, Planning, and Strategic Needs
 - c. Organizational Structures that Enhance Communication, Coordination, Values, and Teamwork
 - d. Mechanisms for Internal Teambuilding, Career Growth, and Shared Commitment to NIBIB Vision/Mission
 - e. Unique Intra- and Extramural Identity, Impact, and Community Commitment

The current timeline aims for completion of the NIBIB Strategic Plan by May 2020. Working groups of NACBIB have been established to provide broad expert input into the scientific aspects of the plan.

III. Global Health: Dr. Peter H. Kilmarx and Dr. Laura Povlich

Peter H. Kilmarx, MD, Deputy Director of the Fogarty International Center and Laura Povlich, PhD, Program Officer in the Division of International Training and Research, addressed the Council on "NIH Opportunities for Global Health Research and the Fogarty International Center."

Dr. Kilmarx described multiple compelling reasons for pursuing research in global health. These include populations with unique genetics; novel exposures of patients to varied diets and environmental factors; the innovative technologies such as mobile health used in many worldwide health projects; and the increasing interest of students in becoming involved in global health care.

Kilmarx highlighted several innovative technologies that have had a significant impact on improving health in low- and middle-income countries (LMICs). For example, the Pumani bubble is a Continuous Positive Airway Pressure device developed by Rebecca Richards-Kortum, PhD, for Malawian newborns with severe respiratory illness. The \$400 device has improved survival rates of neonates by nearly 30% compared with the previous standard of care. The Cardio-Pad is an iPad-based system that can remotely send EKG readings to in-country cardiologists and be interpreted within 20 minutes. Cardio-pad was launched in Cameroon and is now in use in Gabon, Kenya, India, and Nepal.

Dr. Kilmarx presented an overview of NIH foreign investment. From 2011 to 2017, NIH grants to countries outside the U.S. or to U.S. investigators conducting research outside the U.S. increased in the range of 60% - 160% across world regions, with an approximate 100% increase in projects in Low and Middle Income Countries (LMIC) in Africa, Asia and the Middle East. An analysis conducted in 2017 revealed that 35% of NIH-funded publications included a foreign co-author, with 5% of those involving only international investigators.

Dr. Povlich joined Fogarty seven years ago with the aim of using her engineering expertise to incorporate more engineering into Fogarty-supported technology development. She described a grant program involving NIBIB and several other ICs, called “Mobile Health: Technology and Outcomes for Low- and Middle-Income Countries.” The program aims to contribute to the evidence base for the use of mobile technology to improve clinical outcomes and public health, while building research capacity and expertise in mobile health technologies in LMICs.

Dr. Povlich highlighted that Fogarty partners with NIBIB on the NIBIB-led NIH Point-of-Care Technology Research Network (POCTRN), by helping to support one of the four POCTRN Centers—the Center for Innovation in Point of Care Technologies for HIV/AIDS at Northwestern University (C-THAN). The center goals include developing a sustained pipeline of POC technologies that meet the needs of people with HIV/AIDS in LMICs. The center is also focusing on building in-country capacity for local development and manufacturing of POC technologies.

Dr. Povlich described the Fogarty Fellows and Scholars Program, which has supported 93 medical students, fellows, and post-docs who have had mentored research training in LMICs. The goal of the program, which includes 17 NIH IC partners, is to provide a one-year training experience for individuals interested in pursuing a research career in global health.

Dr. Kilmarx concluded that interest in global health research is benefitting from a convergence of strong support from NIH leadership and deep interest from students and faculty. This is coupled with the opportunities presented by global research, which include working with unique populations, developing novel approaches to biomedical imaging and bioengineering, and the overseas relationships that Fogarty has forged, which NIBIB and other ICs can leverage to more fully engage in global health research.

IV. Deep Learning-Enabled Computational Imaging and Sensing: *Dr. Aydogan Ozcan*

Dr. Aydogan Ozcan, Chancellor’s Professor at UCLA, HHMI Professor with the Howard Hughes Medical Institute, and leader of the Bio- and Nano-Photonics Laboratory at UCLA Electrical Engineering and Bioengineering Departments, spoke to the Council on “Deep Learning-Enabled Computational Imaging and Sensing.” He explained the development of lensless microscopy which uses CMOS (complementary metal oxide semiconductor) sensors to create images in devices such as digital cameras and smartphones by converting photons into electrical signals that are then processed to produce an image. Using advanced computational methods to develop, for example, small, inexpensive smartphone-based microscopes that can be employed to build low-cost diagnostic tools for use in low- and middle-income countries, he characterized his work as the “democratization of measurement tools”.

Dr. Ozcan described the construction of a lensless microscope, a device just five inches tall and costing about \$500, that uses a CMOS sensor with output modified through computational

algorithms to provide one billion pixels per image. The lensless microscope uses holographic reconstruction and can process large areas on tissue samples or pathology slides, similar to the 40x field of view light microscope. He presented example imaging images showing identification of malaria-infected cells in a blood smear and H and E stained pneumonia-infected lung slices. He explained that charge-coupled devices (CCDs) are found in advanced digital camera systems and are being used in these lensless microscopes to obtain images that are 1000-fold higher resolution. With digital imaging, there is no loss of resolution when the field of view is increased, which is a significant problem with lens-based light microscopes. In addition to microscopy, smartphone technologies are also being used as sensors, including pathogen detector tools and fluorescent test readers. For example, a smartphone using fiber-optic technology and machine learning was developed to quantify colorimetric tests for Herpes Simplex Virus, measles, and mumps. Dr. Ozcan stressed that the hands-on approach needed to build and operate these devices has been instrumental in engaging students. More than 200 undergraduate authors of publications have come from his laboratory over the last several years.

Turning to machine learning and deep neural networks, Dr. Ozcan explained that physics-based algorithms used with light microscopy estimate and correct iteratively to create the best image. Deep neural networks allow image reconstruction by using data obtained from the CMOS or CCD sensor. Instead of estimating and correcting, the deep neural network is collecting data from all the phases of a holograph simultaneously. This enormous amount of data is then compared to the physics-based best image, and through this process, the neural network is trained to identify which segments of the vast amount of data it has collected are the segments needed to construct an accurate image.

This technology promises to be extremely useful, for example, during surgery, where the technology can detect tumor margins quickly, inexpensively, and accurately without the need for the lengthy staining process currently conducted by pathologists.

He concluded by explaining that his team is now in the process of comparing diagnoses made by pathologists to results from images created by artificial intelligence. So far, the precision of the neural networks has been impressive. Ultimately, Dr. Ozcan believes that we are approaching a symbiotic relationship between professionals and machine learning, with deep learning providing high-quality information at the front end for use by diagnosticians and other professionals.

V. Adjournment

The open session of the NACBIB meeting was adjourned at 12:50 p.m.

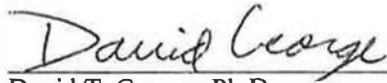
VI. Closed Session

Review of Council Procedures and Regulations: Dr. David T. George

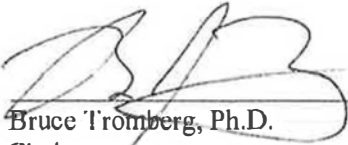
The grant application review portion of the meeting was closed to the public in accordance with provisions set forth in Section 552b(c)(4) and 552b(c)(6), Title 5, U.S. Code, and 10(d) of the Federal Advisory Committee Act, as amended (5 U.S.C. appendix 2). The closed session was adjourned at 3:20 p.m.

Certification:

We certify that, to the best of our knowledge, the foregoing minutes are accurate and complete.²



David T. George, Ph.D.
Executive Secretary
National Advisory Council for Biomedical Imaging and Bioengineering
Associate Director for Research Administration
National Institute of Biomedical Imaging and Bioengineering



Bruce Tromberg, Ph.D.
Chairperson
National Advisory Council for Biomedical Imaging and Bioengineering
Director
National Institute of Biomedical Imaging and Bioengineering

² These minutes will be approved formally by the Council at the next meeting on September 11, 2019, and corrections or notations will be stated in the minutes of that meeting.