NATIONAL ACADEMIES Sciences Engineering Medicine

Board on Life Sciences

Biohybrid Materials and Technologies for Today and Tomorrow: A Workshop

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MEETING GOAL AND OBJECTIVES

This workshop will explore emerging trends and frontier opportunities in biohybrid materials and technologies across broad application spaces, including robotics, manufacturing, architecture and agriculture. Speakers will present on cutting-edge biohybrid materials and devices that integrate both biological and engineered components to enhance or add functionality and will highlight efforts toward sustainable designs. By bringing together experts across these multidisciplinary domains, we will identify drivers of innovation arising from the convergence of complementary fields of science and technology, as well as the chokepoints and needs of the communities contributing to this work. In addition, we will identify and discuss educational and workforce challenges and opportunities, and societal impacts including sustainability, ethics, and inclusion of marginalized groups.

THURSDAY, JANUARY 12, 2023

OPEN

8:00-8:30 am EST **Registration**

8:30-8:40 am **Welcome**

Kavita Berger, National Academies – Board on Life Sciences (in person)

Catherine Cabrera, Massachusetts Institute of Technology (in person)

8:40-9:00 am **Opening Remarks from Workshop Planning Group**

Trisha Tucholski, National Academies – Board on Life Sciences (in person)

Megan Valentine, University of California, Santa Barbara (Chair, virtual)

9:00-9:45 am **Keynote Speaker**

Ginger Krieg Dosier, Biomason (in person)

Moderator: Deepti Tanjore, Advanced Biofuels Process Demonstration Unit (virtual)

9:45-10:45 am **Panel: Biomanufacturing for Sustainability**

Moderator: Alshakim Nelson, University of Washington (in person)

Goals:

- Understand the advances in biomanufacturing methods that integrate living microorganisms into their processes to create sustainable materials
- Explore the limitations of natural 'manufacturing' methods as we try to integrate cells into human-made processes for the design and scalable production of materials
- Identify the urgent needs of the field that must be addressed for successful adoption/implementation

Panelists:

Neel Joshi, Northeastern University (in person)
David Breslauer, Bolt Threads (virtual)
Anne Meyer, University of Rochester (virtual)
Ginger Krieg Dosier, Biomason (in person)

10:45-11:00 am **Break**

11:00-12:00 pm **Panel: Frontiers in Bioinspired Materials and Biotechnologies**

Moderator: Robert Full, University of California, Berkeley (virtual)

Goals:

- Understand the approaches to design and implementation for bioinspired materials and technologies that allow programmability, stimuli-responsiveness and other complex functions
- Identify cases where incorporation of biohybrid materials could improve performance, and explore barriers to implementation

Panelists:

Taylor Ware, Texas A&M University (in person)
Muhammad Hussain, Purdue University (virtual)
Abdon Pena-Francesch, University of Michigan (in person)

12:00-1:00 pm **Lunch**

1:00-2:00 pm **Panel: Risks, Roadblocks, and Rewards**

Moderator: Megan Valentine, University of California, Santa Barbara (virtual)

Goals:

- Explore opportunities and roadblocks in the development and use of biohybrid materials and technologies
- Identify conditions and frameworks that enable success, and those that stymie progress
- Identify strategies that enable translation of lab bench breakthroughs into successful products and new markets

Panelists:

Don Ingber, Harvard Wyss Institute (virtual)
Pae Wu, Indie Bio/SOSV (virtual)
David Breslauer, Bolt Threads (virtual)

2:00-2:45 pm **Breakout: Education and Workforce**

Facilitator: Fiorenzo Omenetto, Tufts University (in person)

Goals:

- Consider what expertise and skills are needed to design, develop, analyze and transition research advances
- Identify gaps and needs for education and workforce development
- Explore how to integrate biomaterials and biofabrication into learning curricula
- Explore how to introduce global awareness and sustainability into design thinking

Livestream participants are encouraged to provide written reflections to the Google Jamboard

2:45-3:00 pm **Key Takeaways from Day 1**

Workshop Planning Committee

END OF FIRST DAY

FRIDAY, JANUARY 13, 2023

OPEN

8:00-8:30 am **Registration**

8:30-9:30 am **Panel: Built Environment**

EST

Moderator: Fiorenzo Omenetto, Tufts University (in person)
Goals:

- Understand how to bring large-scale structures to life with biomaterials
- Explore the relationships between form and function when operating at this scale
- Identify challenges in designing at this scale and explore what additional tools/discoveries are needed to make the use of biomaterials for this purpose more commonplace

Panelists:

Laia Mogas-Soldevila, University of Pennsylvania (virtual)
Felecia Davis, Penn State University (virtual)
Tomás Diez, Fab City Foundation (virtual)

9:30-10:15 am **Breakout: Ethics, Risks, and Opportunities for Inclusion**

Facilitator: Deepti Tanjore, Advanced Biofuels Process Demonstration Unit (virtual)

Goals:

- Identify key ethical considerations regarding biohybrid material design and implementation
- Explore the intersection between sustainability and material design, and identify areas of particular need or particular opportunity
- Explore how to incorporate diverse perspectives and communities in disruptive biohybrid material innovation

- Consider how scientific or national cultures may affect research conduct and progress with biohybrid materials

Livestream participants are encouraged to provide written reflections to the Google Jamboard

10:15-10:30 am **Break**

10:30-11:30 am **Panel: Plant-based Technologies and Functional Materials**

Moderator: Megan Valentine, University of California, Santa Barbara (virtual)

Goals:

- Understand state of the art in plant-based materials, devices and electronics, with applications ranging from intelligent agriculture to robotics
- Understand how plants and plant-derived materials can form or be incorporated into functional materials, and the advantages of these approaches.
- Explore limitations of current materials and technologies and identify urgent needs that must be addressed to enable adoption and implementation of plant-based engineering solutions.

Panelists:

Eleni Stravrinidou, Linköping University (virtual)
Chiara Daraio, Caltech (virtual)
Thomas Speck, Universität Freiburg (virtual)
Barbara Mazzolai, Istituto Italiano di Tecnologia (virtual)

11:30-12:30 am **Lunch**

12:30-1:15 pm **Keynote Speaker**

Zhenan Bao, Stanford University (virtual)

Moderator: Robert Full, University of California, Berkeley (virtual)

1:15-2:15 pm **Panel: Biorobotics and Health**

Moderator: Robert Full, University of California Berkeley (virtual)

Goals:

- Understand how biohybrid materials are used in biorobotics and what their use enables in design, manufacturing and applications.
- Explore limitations of current materials and technologies and identify urgent needs that must be addressed to enable adoption and implementation of biorobotic devices.

Panelists:

Ritu Raman, Massachusetts Institute of Technology (virtual)
John Rogers, Northwestern University (virtual)
Victoria Webster-Wood, Carnegie Mellon University (in person)
Zhenan Bao, Stanford University (virtual)

2:15-3:00 pm **Breakout: Innovation Ecosystem and Unmet Needs**

Facilitator: Alshakim Nelson, University of Washington (in person)

Goals:

- Building on the concepts identified in this workshop, identify key needs in biohybrid materials and technologies that are required to advance their adoption and implementation
- Identify areas of underinvestment, and gaps that are hindering progress
- Suggest means by which these needs can be addressed

Livestream participants are encouraged to provide written reflections to the Google Jamboard

3:00 pm **Closing Remarks**

Megan Valentine, University of California, Santa Barbara (virtual)

MEETING ADJOURNS

SPEAKER BIOS

Ginger Krieg Dosier, Biomason (in person)

Title: Revolutionizing the Most Manmade Material on the Planet with Biology

Ginger Krieg Dosier, founder and CEO at Biomason has multi-disciplinary business strategy experience managing a diverse team of scientists, engineers, architects, builders, funding partners, granting agencies, and strategic partners. Her primary background includes sustainable material development from laboratory prototype to commercialization and environmental architecture. Prior to founding Biomason, she worked as an assistant professor of architecture at the American University of Sharjah, in the United Arab Emirates and North Carolina State University. She earned her Masters of Architecture from Cranbrook Academy of Art, and undergraduate degree from Auburn University. In addition, Ginger's professional background encompasses Government Agencies including the US Army Corps of Engineers, currently serving on the State Building Commission, and serving on multiple steering advocacy committees for significantly reducing carbon in the global building industry.

Neel Joshi, Northeastern University (in person)

Title: Biologically Fabricated Materials from Engineered Microbes

Neel Joshi is an Associate Professor in the Department of Chemistry and Chemical Biology at Northeastern University. He completed his PhD at UC Berkeley in the lab of Matt Francis and a postdoc at Boston University in the lab of Mark Grinstaff before starting his independent academic career at Harvard University and then moving to Northeastern in 2020. He is broadly interested in topics related to biologically inspired materials, protein engineering, self-assembly, and biointerfaces. His group works at the intersection of biomaterials science and synthetic biology. Recent projects in the group have focused on repurposing bacterial biofilms and their matrix proteins for biotechnological and biomedical applications.

David Breslauer, Bolt Threads (virtual)

Title: We Are Bolt Threads

David Breslauer is the co-founder and Chief Technology Officer of Bolt Threads. Bolt Threads invents cutting-edge materials for the fashion and beauty industries to put us on a path toward a more sustainable future. There, David leads the research and development teams, focused on Bolt's two breakthrough and commercially available products: Mylo, a mycelium-based leather alternative, and b-silk, a recombinant protein-based silicone elastomer alternative. David obtained his PhD in Bioengineering at UC Berkeley and UCSF, and B.S. in Bioengineering from UC San Diego.

Anne Meyer, University of Rochester (virtual)

Title: 3D Printing of Bacteria into Functional Living Materials

Dr. Anne S. Meyer is an Associate Professor of Biology at the University of Rochester, USA. Dr. Meyer received her Ph.D. in Biological Sciences at Stanford University (USA) in 2005. She was a post-doctoral fellow in the Department of Biology at the Massachusetts Institute of Technology (USA). Dr. Meyer served as an Assistant Professor in the Department of Bionanoscience at TU Delft in The Netherlands, prior to moving her research group to the University of Rochester in 2018. She has served as the lead advisor for eight iGEM (International Genetically Engineered Organisms) teams, which have won numerous awards including the 2015 Grand Prize. Her research focuses on using quantitative techniques in the fields of biochemistry, microbiology, and biophysics to study structural dynamics, macromolecular interactions, and physiological responses of organisms to environmental stressors. She also uses tools of synthetic biology to engineer novel functions into microorganisms, with a particular focus on the production of improved, tunable biomaterials and the development of new tools for 3D patterning of bacteria.

Taylor Ware, Texas A&M University (in person)

Title: Coupling Microorganisms and Synthetic Materials for Dynamic Composites

Taylor Ware is an Associate Professor in Biomedical Engineering and Materials Science and Engineering at Texas A&M University. Prior to joining TAMU in August 2020, he graduated with his B.S. from the Georgia Institute of Technology (2009) and with his Ph.D. from the University of Texas at Dallas (2013) in Materials Science and Engineering. Taylor completed postdoctoral training at the Materials and Manufacturing Directorate at the Air Force Research Laboratory. Dr. Ware was an Assistant Professor from 2015-2020 at the University of Texas at Dallas. His research interests include biomaterials, engineered living materials, liquid crystal materials, flexible electronics, and the interfacing of these technologies in medical devices. Dr. Ware was a recipient of the National Science Foundation Graduate Research Fellowship (2011), the Air Force Young Investigator Award (2017), the NSF CAREER award (2018), and Senior Member status of the National Academy of Inventors (2022).

Muhammad Hussain, Purdue University (virtual)

Title: Semiconductors for Life Sciences

Dr. Muhammad Mustafa Hussain a Professor of Elmore Family Schools of Electrical and Computer Engineering of Purdue University. He is also Co-Director of Purdue SMART and Associate Director of Purdue Semiconductor Education. His research is focused on designing futuristic electronics to realize his vision about empowering humanity through democratized electronics technology. His prior academic experience includes Professorship in UC Berkeley and KAUST. Prior to that he was Program Manager of SEMATECH, Austin, TX and Albany, NY sites and Process Integration Lead for Texas Instruments. He is a Fellow of IEEE, American Physical Society and Institute of Physics (UK). He is the recipient of many awards including the Best Innovation Award in CES 2020.

Abdon Pena-Francesch, University of Michigan (in person)

Title: Bioinspired Dynamic Materials for Adaptation to the Environment

Abdon Pena-Francesch is an Assistant Professor in the Department of Materials Science and Engineering at the University of Michigan. He received his PhD from Penn State University and was a Humboldt Postdoctoral Fellow at the Max Planck Institute for Intelligent Systems (Germany). His research group explores biological and bioinspired functional materials to develop solutions for healthcare, robotics, bioengineering, and environmental applications.

Don Ingber, Harvard Wyss Institute (virtual)

Title: Bridging the Academic-Industrial Interface Through Bioinspired Engineering

Donald Ingber, MD, PhD is the Founding Director of the Wyss Institute for Biologically Inspired Engineering at Harvard University, Judah Folkman Professor of Vascular Biology at Harvard Medical School and Boston Children's Hospital, and Hansjörg Wyss Professor of Bioinspired Engineering at the Harvard John A. Paulson School of Engineering and Applied Sciences. His work spans many disciplines with his most recent advance being the development of human organ-on-a-chip microfluidic culture devices as replacements for animal testing, drug development, and personalized medicine. He is a member of the U.S. National Academies of Medicine, Engineering, and Inventors, as well as the American Institute for Medical and Biological Engineering and American Academy of Arts and Sciences and AIMBE.

Pae Wu, IndieBio/SOSV (virtual)

Pae is a General Partner at SOSV and CTO at IndieBio, where she is responsible for portfolio management and technical oversight. Prior to joining IndieBio, Pae served as the Scientific Director of Telefónica's moonshot factory, Alpha (in Barcelona). She was Science Director at the US Office of Naval Research – Global (out of Singapore), and technical consultant at the Defense Advanced Research Projects Agency (DARPA). Her whole career, Pae has been investing in high-risk solutions to intractable problems for national defense, humanity, and the planet. She is especially passionate about bridging engineered materials and systems to biology. Pae earned her PhD at Duke in Electrical Engineering and her BSE from Princeton.

Laia Mogas-Soldevila, University of Pennsylvania (virtual)

Title: Reviving Matter for Restorative Architecture

Laia Mogas-Soldevila is an Assistant Professor of Graduate Architecture and Director of DumoLab Research at the Stuart Weitzman School of Design, University of Pennsylvania. Laia's research focuses on new sustainable material practices bridging science, engineering and the arts. Her broader pedagogy supports novel theory and applies methods understanding materials and materialization in architecture. She has built scholarship over the past ten years reconsidering matter as a fundamental design driver and partnering with scientists to redesign it towards unprecedented capabilities. Laia holds an interdisciplinary doctorate bridging materials science, biomedical engineering, and design from Tufts University School of Engineering, two master's degrees from the Massachusetts Institute of Technology, and is a licensed architect with a minor in Fine Arts by the Polytechnic University of Catalonia School of Architecture.

Felecia Davis, Penn State University (virtual)

Title: Notes from a Design Research Studio: MycoKnit Thin Shell Structures

Felecia Davis' work in computational textiles questions how we live and she re-imagines how we might use textiles in our daily lives and in architecture. Davis is an Associate Professor at the Stuckeman Center for Design Computing in the School of Architecture at Pennsylvania State University and is the director of SOFTLAB@PSU. She completed her PhD in Design Computation at MIT. Davis' work in architecture connects art, science, engineering and design and was featured by PBS in the Women in Science Profiles series. Davis' designs were part of the MoMA's exhibition Reconstruction: Blackness and Architecture in America. She is a founding member of the Black Reconstruction Collective a not-for-profit group of Black architects, scholars and artists supporting design work about the Black diaspora. Davis' work has been recently recognized by the DigitalFUTURES Group in 2021 for the Black Flower Antenna, the New York Architectural Leagues' 2022 Emerging Voices in Architecture program, ACADIA's 2022 Innovative Research Award of Excellence and the 2022 National Design Award from the Cooper Hewitt Smithsonian Museum for Digital Design.

Tomás Diez, Fab City Foundation (virtual)

Title: Orchestrating Distributed Networks of Production: Building the Fab City Full Stack

Tomas Diez is a Venezuelan Urbanist specialized in digital fabrication and its implications in the future of cities and society. Tomas holds his Bachelor degree in Urban Planning by the Universidad Simon Bolivar (Caracas – Venezuela), Diploma in social work at the University of La Havana (Cuba), Master in Advanced Architecture by UPC (IAAC-Barcelona), and a Diploma in Digital Fabrication from the Fab Academy. Tomas is the founding partner director of the Fab City Foundation, director of the Master in Design for Emergent Futures at Institute for Advanced Architecture of Catalonia (where he sits as a board member), as well the director in the Master in Design for Distributed Innovation. He works as a close collaborator in the development of the Fab Lab Network together with MIT's Center for Bits and Atoms, and the Fab Foundation.

Eleni Stravrinidou, Linköping University (virtual)

Title: Plant Bioelectronics and Biohybrids

Eleni Stavrinidou is an Associate Professor and leader of the Electronic Plants group at Linköping University. She received a PhD in Microelectronics from EMSE (France) in 2014. She then did her postdoctoral training at Linköping University (Sweden) during which she was awarded a Marie Curie fellowship. In 2017 Eleni Stavrinidou became Assistant Professor in Organic Electronics at Linköping University and established the Electronic Plants group. She received several grants including a Swedish Research Council Starting Grant and a FET-OPEN grant which she was the coordinator. In 2019 she received the L'ORÉAL-UNESCO For Women in Science prize in Sweden. In 2020 she became Associate Professor and Docent in Applied Physics. The same year she was awarded the Future Research Leaders grant of the Swedish Foundation for Strategic Research. In 2021 she was awarded the ERC-Staring Grant. Her research interests focus on plant bioelectronics for real time monitoring and dynamic control of plant physiology and plant-based biohybrid systems for energy and sensing applications.

Chiara Daraio, Caltech (virtual)

Title: Plant Cell and Algae-Based Materials for Engineering Applications

Chiara Daraio is the G. Bradford Jones Professor of Mechanical Engineering and Applied Physics at Caltech. Her work is focused on developing new materials with advanced mechanical and sensing properties, for application in robotics, medical devices, and vibration absorption. She developed new materials and methods for acoustic imaging and thermal sensing in medicine and health monitoring. She received a Presidential Early Career Award (PECASE) from President Obama, was elected as a Sloan Research Fellow, and received a US Office of Naval Research Young Investigator Award. She is also a winner of the National Science Foundation CAREER award. She was selected by Popular Science magazine among the "Brilliant 10." She currently serves as a Board Editor for Science Magazine (AAAS) and as a Senior Research Scientist at Meta.

Thomas Speck, Universität Freiburg (virtual)

Title: What Can Be Learnt from Plant Movements for Motile Systems and Soft Machines

Thomas Speck is Full Professor for 'Botany: Functional Morphology and Biomimetics' in Freiburg and Director of the Botanic Garden of the University of Freiburg. He is spokesperson of the Cluster of Excellence "Living, Adaptive, and Energy-autonomous Materials Systems (livMatS)" and of the Competence Network Biomimetics. He is Deputy Managing Director of the Freiburg Center for Interactive Materials and Bio-Inspired Technologies (FIT), and vice-chair of the Society for Technical Biology and Bionics. His main areas of research are functional morphology and biomechanics of plants, biomimetics, evolutionary biology and palaeobotany.

Barbara Mazzolai, Istituto Italiano di Tecnologia (virtual)

Title: Towards New Adaptive Soft Robots: Lessons from Plants

Barbara Mazzolai is Associate Director for Robotics and Director of the Bioinspired Soft Robotics Laboratory at the Istituto Italiano di Tecnologia (IIT), Genoa. From February 2011 to March 2021, she was the Director of the IIT Center for Micro-BioRobotics (CMBR). She graduated in Biology (with Honours) at the University of Pisa, Italy, and received her Ph.D. in Microsystems Engineering from the University of Rome Tor Vergata. She was Deputy Director for the Supervision and Organization of the IIT Centers Network from July 2012 to 2017. From January to July 2017, she was Visiting Faculty at Aerial Robotics Lab, Department of Aeronautics, of Imperial College of London. She is member of the Scientific Advisory Board (SAB) of the Max Planck Institute for Intelligent Systems (Tübingen and Stuttgart, Germany); member of the SAB of the Max Planck Queensland Centre (MPQC) for the Materials Science of Extracellular Matrices; and member of the Advisory Committee of the Cluster on Living Adaptive and Energy-autonomous Materials Systems - livMatS (Freiburg, Germany). Her research activity is in the field of bioinspired soft robotics, combining biology and engineering for both advancing technological innovation and scientific knowledge. In this field, she has been the Coordinator of several EU-funded projects, such as PLANTOID, GrowBot and I-SEED. In May 2021, she has started the European Research Council (ERC) Consolidator Grant "I-Wood",

Forest Intelligence: robotic networks inspired by the Wood Wide Web. She has received various awards for her work, including the Marisa Bellisario Award and the Medal of the Italian Senate. She is author and co-author of more than 260 papers appeared in international journals, books, and conference proceedings. In 2019, she published her book “La Natura Geniale” and in 2021 “Il futuro raccontato dalle piante” (ed. Longanesi).

Ritu Raman, Massachusetts Institute of Technology (virtual)

Title: Engineering Biological Motor Control for Applications in Medicine and Machines

Ritu Raman, PhD is the d’Arbeloff Career Development Assistant Professor of Mechanical Engineering at MIT. Her lab is centered on engineering adaptive living materials for applications in medicine and machines. Prof. Raman has received several recognitions for scientific innovation, including being named a Kavli Fellow by the National Academy of Sciences and an Army Young Investigator by the U.S. Department of Defense. She has also been named to the Forbes 30 Under 30 and MIT Technology Review 35 Innovators Under 35 lists and is the author of the MIT Press book *Biofabrication*. She is passionate about increasing diversity in STEM and has championed many initiatives to empower women in science, including being named a AAAS IF/THEN ambassador and founding the Women in Innovation and STEM Database at MIT (WISDM). Prof. Raman received her BS from Cornell University and her PhD as an NSF Graduate Research Fellow at the University of Illinois at Urbana-Champaign. She completed her postdoctoral research with Prof. Robert Langer at MIT, funded by a L’Oréal USA For Women in Science Fellowship and a Ford Foundation Fellowship from the National Academies of Sciences, Engineering, and Medicine. Lab Website | Twitter

John Rogers, Northwestern University (virtual)

Title: Hybrid Materials Constructs for Bio-Interfaced Technologies

Professor John A. Rogers obtained BA and BS degrees in chemistry and in physics from the University of Texas, Austin, in 1989. From MIT, he received SM degrees in physics and in chemistry in 1992 and the PhD degree in physical chemistry in 1995. From 1995 to 1997, Rogers was a Junior Fellow in the Harvard University Society of Fellows. He joined Bell Laboratories as a Member of Technical Staff and then served as Director of the Condensed Matter Physics Research Department from 1997 to 2002. He then spent thirteen years on the faculty at University of Illinois, most recently as the Swanlund Chair Professor and Director of the Seitz Materials Research Laboratory. In the Fall of 2016, he moved to Northwestern University where he is Director of the recently endowed Querrey-Simpson Institute for Bioelectronics. He has co-authored nearly 900 papers and his co-inventor on more than 100 patents. His research has been recognized by many awards, including a MacArthur Fellowship (2009), the Lemelson-MIT Prize (2011), the Smithsonian Award for American Ingenuity in the Physical Sciences (2013), the MRS Medal from the Materials Research Society (2018), the Benjamin Franklin Medal from the Franklin Institute (2019), and a Guggenheim Fellowship (2021). He is a member of the National Academy of Engineering, the National Academy of Sciences, the National Academy of Medicine and the American Academy of Arts and Sciences.

Victoria Webster-Wood, Carnegie Mellon University (in person)

Title: iBio3: Interdisciplinary Biomaterials, Biomanufacturing, and Bioinspiration in Biohybrid Robots

Vickie Webster-Wood is an Assistant Professor in the Department of Mechanical Engineering at Carnegie Mellon University with courtesy appointments in the Department of Biomedical Engineering and the McGowan Institute of Regenerative Medicine. She is the director of the C.M.U. Biohybrid and Organic Robotics Group and has a long-term research goal to develop completely organic, biodegradable, autonomous robots. Research in the C.M.U. B.O.R.G. brings together bio-inspired robotics, tissue engineering, and computational neuroscience to study and model neuromuscular control and translate findings to the creation of renewable robotic devices. Dr. Webster-Wood completed her postdoc at Case Western Reserve University in the Tissue Fabrication and Mechanobiology Lab under the direction of Dr. Ozan Akkus. During her postdoc, Dr. Webster-Wood was supported by the T32 Training Grant in Musculoskeletal Research. She received her Ph.D. in Mechanical Engineering from the same institution as an NSF Graduate Research Fellow in the Biologically Inspired Robotics Lab, during which time she was co-

advised by Drs. Roger Quinn, Ozan Akkus, and Hillel Chiel. She received the NSF CAREER Award in 2021, is a co-PI of the N.S.F. NeuroNex Network on Communication, Coordination, and Control in Neuromechanical Systems (C3NS), and has received additional funding from the NSF Foundational Research in Robotics Program, a PITA grant from the Commonwealth of Pennsylvania, Department of Community and Economic Development, as well as funding from the PA Manufacturing Fellows Initiative, and the Manufacturing Futures Initiative.

Zhenan Bao, Stanford University (virtual)

Title: Building Soft Neuromorphic E-skin

Zhenan Bao is K.K. Lee Professor of Chemical Engineering, and by courtesy, a Professor of Chemistry and a Professor of Material Science and Engineering at Stanford University. She was Department Chair of Chemical Engineering from 2018-2022. Bao founded the Stanford Wearable Electronics Initiate (eWEAR) in 2016 and serves as the faculty director. She is a CZ Biohub investigator since 2022. Prior to joining Stanford in 2004, she was a Distinguished Member of Technical Staff in Bell Labs, Lucent Technologies from 1995-2004. She received her Ph.D in Chemistry from the University of Chicago in 1995. She has over 700 refereed publications and over 100 US patents with a Google Scholar H-Index 197. She is one of the Clarivate Citation Laureates. Bao is a member of the National Academy of Engineering, the American Academy of Arts and Sciences and the National Academy of Inventors. She a foreign member of the Chinese Academy of Science. She serves on the Board of Directors of the Camille and Henry Dreyfus Foundation and is a member of its scientific affair committee. Bao was the inaugural recipient of the VinFuture Prize Female Innovator 2022, the ACS Chemistry of Materials Award 2022, MRS Mid-Career Award in 2021, AICHE Alpha Chi Sigma Award 2021, ACS Central Science Disruptor and Innovator Prize in 2020, Gibbs Medal by the Chicago session of ACS in 2020, Wilhelm Exner Medal by Austrian Federal Minister of Science 2018, ACS Award on Applied Polymer Science 2017, L'Oréal-UNESCO For Women in Science Award in the Physical Sciences 2017. Bao is a co-founder and on the Board of Directors for C3 Nano and PyrAmes, both are silicon-valley venture funded start-ups. She serves as an advising Partner for Fusion Venture Capital.

WORKSHOP PLANNING COMMITTEE

Megan Valentine, University of California, Santa Barbara (Chair, virtual)

Megan T. Valentine is a Professor of Mechanical Engineering and Co-Director of the California NanoSystems Institute at the University of California, Santa Barbara. Her research group investigates biological and bioinspired materials, with an emphasis on understanding how forces are generated and transmitted in living materials, how these forces control cellular outcomes, and how the extraordinary features of living systems can be captured in manmade materials. This highly interdisciplinary experimental work lies at the intersection of engineering, physics, biology and chemistry, and advances diverse application areas, ranging from marine-inspired materials to mechanobiology to soft robotics. Professor Valentine's work has been recognized with numerous awards including a NSF CAREER Award for her work on neuron mechanics, and a Fulbright CORE scholar award to study adhesion mechanics in Paris, France. She is a Fellow of the American Physical Society and American Institute for Medical and Biological Engineering. She received her Ph.D. in Physics from Harvard University, and completed a postdoctoral fellowship at Stanford University in the Department of Biological Sciences, where she was the recipient of a Damon Runyon Cancer Research Postdoctoral Fellowship, and a Burroughs Wellcome Career Award at the Scientific Interface.

Robert Full, University of California, Berkeley (virtual)

Robert J. Full is a Howard Hughes Medical Institute Professor of Integrative Biology at the University of California at Berkeley where he holds a joint appointment in Electrical Engineering and Computer Science. Professor Full directs the Poly-PEDAL Laboratory investigating the Performance, Energetics and Dynamics of Animal Locomotion. He has authored over two hundred research contributions in animal motion science using diverse biological designs as natural experiments. He has collaborated closely with engineers, applied mathematicians, material scientists, and industry by providing biological principles to inspire the design of search-and-rescue and hazard detection robots, artificial muscles, novel control algorithms, and self-cleaning, dry adhesives. Professor Full has created a new Howard Hughes Medical Institute-supported education program on Bioinspired Design. He is the founder and director of the Center of Interdisciplinary Bio-inspiration in Education and Research (CiBER) and served as the Editor-in-Chief of the journal Bioinspiration & Biomimetics from 2013-2021. He received his undergraduate, masters, and doctoral degrees at SUNY Buffalo and then held a postdoctoral position at The University of Chicago. He has served on the NAS's Board of Life Sciences since 2017 and is an elected Fellow of the American Association for the Advancement of Science and the American Academy of Arts and Sciences. Professor Full currently serves on the Scientific Advisory Boards for the Wyss Institute at Harvard University and the Swiss National Science Foundation National Centre of Competence in Research Robotics.

Alshakim Nelson, University of Washington (in person)

Alshakim Nelson is a Professor Chemistry and the Molecular Engineering and Sciences Institute Director of Education at the University of Washington. Professor Nelson's laboratory develops stimuli-responsive and biohybrid materials for additive manufacturing. Prior to his current position, he was a Research Staff Member at IBM Almaden Research Center for 10 years, where he developed polymeric materials for microelectronics applications. Since his move to the University of Washington in 2015, his laboratory has pioneered protein-based resins that can be 3D printed into degradable hydrogels and shape-memory bioplastics. Professor Nelson has over 70 publications and 30 issued patents. His awards and recognition include IBM Master Inventor, ACS PMSE Young Investigator, Kavli Fellow, NSF CAREER Award, and Washington State Academy of Sciences Fellow. He received his B.A. in chemistry from Pomona College, his Ph.D. from UCLA in 2004, and was an NIH Postdoctoral Fellow at Caltech before starting his independent career at IBM in 2005.

Fiorenzo Omenetto, Tufts University (in person)

Fiorenzo G. Omenetto is the Frank C. Doble Professor of Engineering, and a Professor of Biomedical Engineering at Tufts University. He also holds appointments in the Department of Physics and the Department of Electrical Engineering. His research interests are in the convergence of technology, biologically inspired materials, and the natural sciences with an emphasis on new, transformative approaches for sustainable materials for high-technology applications and solutions for global health and sustainability. He has proposed and pioneered the use of silk as a material platform for advanced technology with uses in photonics, optoelectronics, and nanotechnology applications, and is co-inventor on several disclosures on the subject. Professor Omenetto was formerly a J. Robert Oppenheimer Fellow at Los Alamos National Laboratories, a Guggenheim Fellow, and is a Fellow of the Optical Society of America, the National Academy of Inventors, and of the American Physical Society and a recipient of the Tällberg global leadership prize. He received his Ph.D. in Electrical Engineering and Applied Physics at the University of Pavia. Professor Omenetto's technologies are licensed by major corporations, and he has co-founded multiple companies such as Vaxess LLC, Mori LLC, and Sofregen, LLC.

Deepti Tanjore, Advanced Biofuels Process Demonstration Unit (virtual)

Deepti Tanjore is Director of the Advanced Biofuels Process Demonstration Unit (ABPDU) at Lawrence Berkeley National Laboratory and interfaces with several scientists from industry, academia, and start-ups that are each individually trying to resolve scale-up challenges for their synthetic biology–based technologies. Deepti's interests lie in articulating industry-wide issues and developing technologies that no single company is incentivized to pursue. Her research at ABPDU focuses on modeling the impact of bioprocess conditions on microbial heterogeneity and developing in-line analytical tools for real-time adaptation of process development in bioreactors. Dr. Tanjore holds a B.Tech. degree in Chemical Engineering from Andhra University, an M.S. in Biological Engineering from North Carolina State University, and a Ph.D. in Biological Engineering from Pennsylvania State University and is currently enrolled for an MBA from University of California - Berkeley. She is currently a member of the Standing Committee on Biotechnology Capabilities and National Security Needs and was also a member of the workshop planning committee for Successes and Challenges in Biomanufacturing – A Workshop.