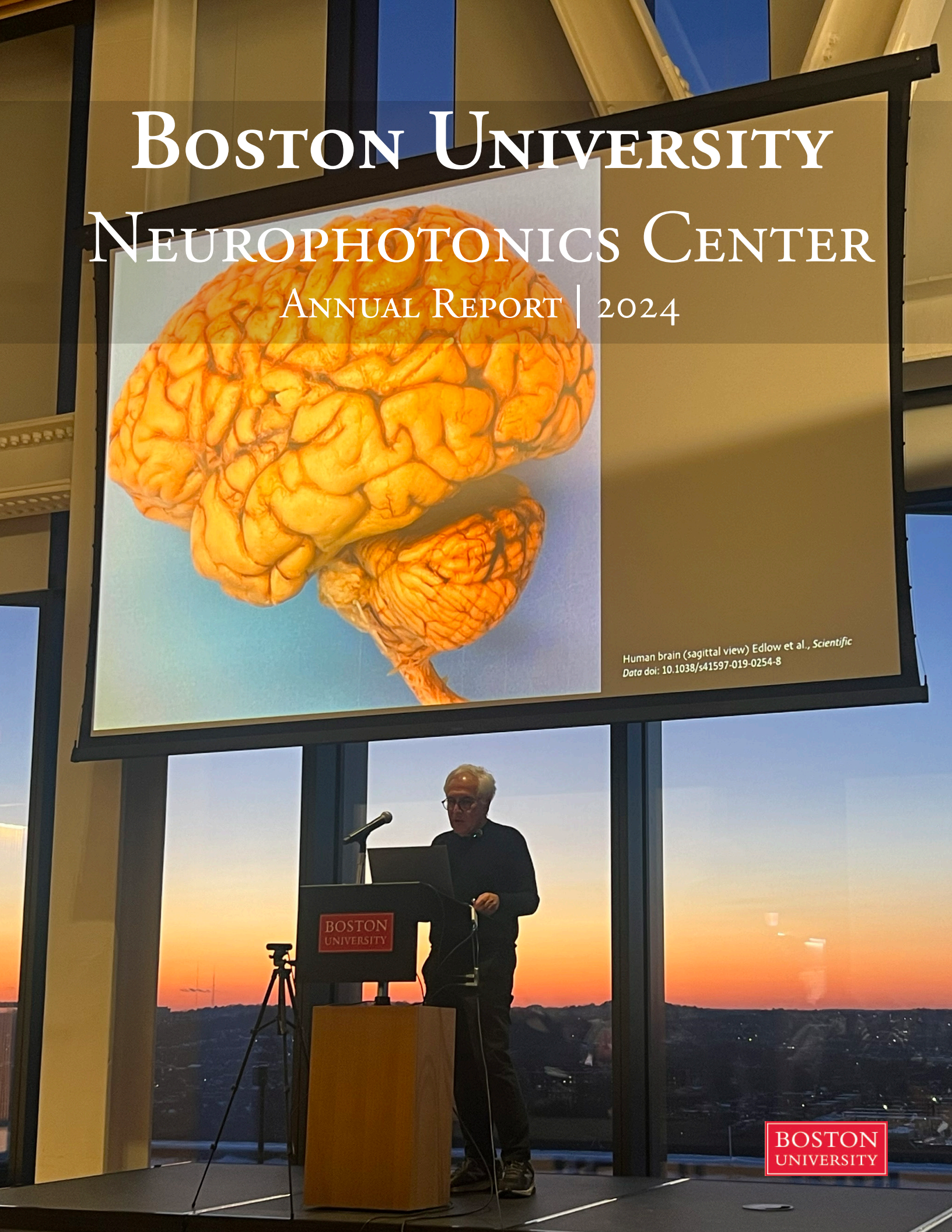
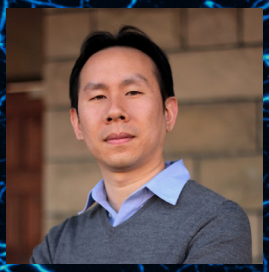
Boston University Neurophotonics Center

Annual Report | 2024



Center Leadership & Staff

David Boas, Ph.D.
Director



Jerry Chen, Ph.D.
Associate Director

Anna Devor, Ph.D.
Associate Director

Christopher Gabel, Ph.D.
Associate Director

Parya Farzam,
fNIRS Specialist and Administrative Director

Danny Giancioppo,
Communications Manager

John Giblin, Ph.D.
Scientist

John Jiang,
Lab Manager

Kıvılcım Kılıç, Ph.D.
Scientist

Martin Thunemann, Ph.D.
Scientist

Meryem Yücel, Ph.D.
Technical Director

Zahid Yaqoob, Ph.D.
Technical Director

Letter from the Director

WE CONTINUE TO SEE TREMENDOUS GROWTH IN NEUROPHOTONICS ACTIVITIES AT BOSTON UNIVERSITY. Our 7th Annual Neurophotonics Symposium, held in January 2024, focused on "Machine Learning and Photonics in the Neurosciences." Organized by Brian Depasquale and Michael Economo, this event had the largest attendance of any of our symposia to date. The symposium was held in Boston University's newest conference space on the 17th floor of the Computing and Data Sciences Building, offering stunning views of Boston, the Charles River, and a winter sunset. A memorable moment from the event was captured on the cover of the 2024 Neurophotonics Center (NPC) Annual Report, showing Jeff Lichtman, the late afternoon symposium speaker, with the sunset in the background. We're excited to announce that the 8th Annual Neurophotonics Symposium will take place January 15, 2025 on "Neurophotonics across the animal kingdom - Imaging neural activity in diverse species."

We've seen a significant increase in the number of new trainees in the Neurophotonics Research Training (NRT) program. In 2024, 29 new trainees joined the program, up from 19 in 2023 and an average of 16 in the previous six years. This growth reflects the rising impact of neurophotonics across many labs on campus and the increasing recognition of the benefits of engaging in multidisciplinary activities facilitated by the NPC. To support our growing trainee cohort, we've secured a new T32 training grant from the NIH National Institute of Neurological Disorders and Stroke for "Graduate Training at the Interface of Neuroscience, Optical Engineering, and Data Science." We owe a big thanks to Principal Investigators Jerry Chen and Michelle Sander for their leadership in securing this grant, as well as to Boston University for its significant support of this training program.

Since the NPC's inception in 2017, our training program has included a neurophotonics bootcamp at the end of the trainees' first year. This bootcamp introduces trainees to the diverse technologies and applications in neurophotonics, as well as to fellow students from eight different graduate programs. With the new T32 grant, we've introduced a second bootcamp on "Data Science and Neurophotonics" for trainees finishing their second year. This bootcamp, led by T32 Faculty Statistician Emily Stephen, was a huge success with the students who were eager to delve into coding best practices, version control, data management and super computing topics, as well as hackathons to reinforce those topics. Emily's dedication and passion were key to its success, and she will continue to work with trainees to expand our monthly tutorial series to include data science topics relevant to neurophotonics. We've also restructured the bootcamps based on feedback from prior years, shifting the focus to more hands-on and collaborative activities. NPC Technical Directors Zahid Yaqoob and Meryem Yücel, along with our senior trainees, played a crucial role in this transformation, and we are deeply grateful for their contributions.

NPC Associate Director Chris Gabel has successfully increased collaborations between BU's Charles River Campus and its Medical School Campus, resulting in several new faculty from the Medical School joining the NPC. He also launched the inaugural Fall NPC Med Symposium, which highlighted new cross-campus collaborations. One rapidly growing area of research is the use of organoids—human cell-based models—to better understand diseases. These organoids offer insights beyond what animal models can provide, especially in the neuroscience field. BU's efforts in organoid research are expanding quickly, as covered in a recent NPC feature and discussed in this year's annual report.

Another area of growth at BU is the field of Neuroscience in the Everyday World (NEW). Since 2019, BU faculty have been working together to integrate multi-modal sensors (such as fNIRS, EEG, inertial monitoring units, eye tracking, and audio recordings) with behavioral assessments to study brain activity in naturalistic settings. This work is supported by an NIH BRAIN Initiative Award U01-EB029856, titled "The Neuroscience of the Everyday World – A Novel Wearable System for Continuous Measurement of Brain Function." Recognizing the importance of this emerging field, the Tianqiao and Chrissy Chen Institute has funded an annual conference on Neuroscience in the Everyday World at BU, first held in August 2023 and again in August 2024. These conferences have brought together faculty and trainees from diverse fields, all eager to collaborate and advance their research. We are also thrilled to welcome new faculty, including Matthias Stangl, who expands our work in this area by studying patients with implanted deep brain electrodes. Matthias' research offers unprecedented insights into neural activity patterns during real-world activities, as detailed in this year's annual report. Looking ahead, we plan to deepen our collaboration with the Computing and Data Science community at BU to tackle the data science challenges in NEW. Stay tuned—excitement continues to grow!

David Boas
Director, Neurophotonics Center

At a Glance

53
Faculty Members

97
Students in NRT

$17m
In Funding

60
Publications from NPC Faculty Collabrations

32
Collaborative Grants Funded

Who We Are

THE MISSION OF THE BU NEUROPHOTONICS CENTER is to build and support an interdisciplinary community that can develop and broadly deploy impactful photonics technologies in the neurosciences to advance our understanding of how the brain works in health and in disease.

Neurophotonics Center Faculty

Lou Awad
Associate Professor
Health & Rehabilitation

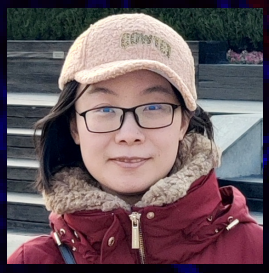
Thomas Bifano
Professor
ME, MSE, BME

Irving Bigio
Professor
BME, ECE

David Boas
Professor, NPC Director
BME, ECE

Jerry Chen
Professor
Biology

Ji-Xin Cheng
Professor
ECE, BME, MSE



Xiaojun Cheng
Research Assistant Professor
BME

David Chung
Assistant Professor
Medicine

Alice Cronin-Golomb
Professor
Psychological & Brain Sciences

Alberto Cruz-Martin
Assistant Professor
Biology

Ian Davison
Associate Professor
Biology

Jeffery Demas
Research Assistant Professor
ECE

Brian DePasquale
Assistant Professor
BME

Anna Devor
Professor
BME

Michael Economo
Assistant Professor
BME

Terry Ellis
Professor
Physical Therapy

Claudio Ferre
Assistant Professor
Health & Rehabilitation

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Physiology & Biophysics

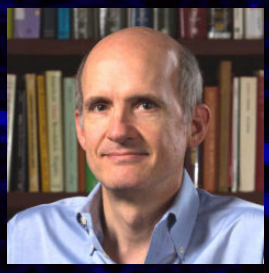
Jefferey Gavornik
Assistant Professor
Biology, BME

Simone Gill
Associate Professor
Medicine

Lee Goldstein
Associate Professor
Neurology, BME, ECE

David Greer
Professor
Medicine

Xue Han
Professor
BME



Michael Hasselmo
Professor
Neuroscience

Mark Howe
Assistant Professor
Psychological & Brain Sciences

Swathi Kiran
Professor
Speech, Language, and Hearing Sciences

Deepak Kumar
Associate Professor
Health & Rehabilitation

Sam Ling
Associate Professor
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Jerome Mertz
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BME, ECE, Physics

Hadi Nia
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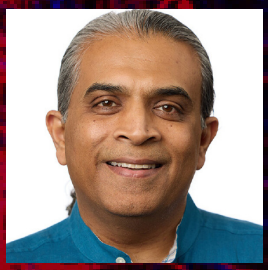
Neurophotonics Center Faculty

Timothy O'Shea
Assistant Professor
BME, MSE



Siddharth Ramachandran
Professor
ECE, MSE, Physics

Steve Ramirez
Associate Professor
Psychological & Brain Sciences

Darren Roblyer
Associate Professor
BME, ECE

Shelly Russek
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Michelle Sander
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Kamal Sen
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Emily Stephen
Assistant Professor
Neuroscience

Chantal Stern
Professor
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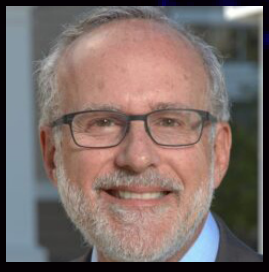
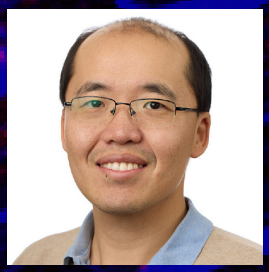


Robert Stern
Professor
Medicine

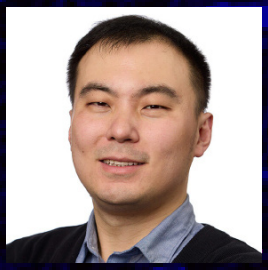
Helen Tager-Flusberg
Professor
Psychological & Brain Sciences

Martin Thunemann
Research Assistant Professor
BME



Lei Tian
Associate Professor
ECE

Michael Wallace
Assistant Professor
Anatomy & Neurobioology



Tianyu Wang
Assistant Professor
ECE

John White
Professor
BME

Ben Wolozin
Professor
Medicine

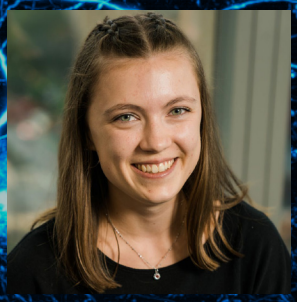
Chen Yang
Professor
Chem, ECE, MSE

Meg Younger
Assistant Professor
Biology

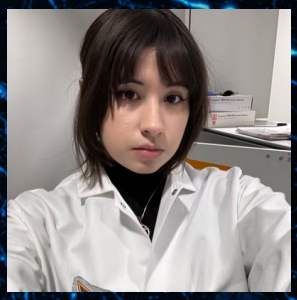
Meryem Yücel
Research Associate Professor
BME

Neurophotonics Center 2024 Fellows

Thanks to the fall 2024 Neurophotonics Center Collaborative Project award, PhD student Regina Slotsky will take part in the "exoWALK" project: EXOsuit-assisted Walking Automaticity and Locomotion Kinetics. Working with Associate Professor Lou Awad and Professor David Boas, Regina will help to advance methodological approaches to measuring the automaticity of walking using fNIRS, as well as multi-objective soft robotic exosuit parameter tuning and single trial real-time applications of fNIRS during post-stroke walking—such as the association between functional connectivity and walking quality. The team has already developed a soft, wearable robotic exosuit that provides external mechanical assistance to the paretic limb, and have produced solid results.



With funding from the Neurophotonics Center's CAN DO award, graduate student Kate Herrema will advance her thesis project on combining biomaterials, neurorecording devices, stem cell technology and in vivo imaging to guide the development of human cortical organoids transplanted in the mouse brain. Working with faculty from across the Charles River (Tim O'Shea, Martin Thunemann, Anna Devor) and Medical (Ella Zeldich) campuses, this project bridges the two schools in one, convergent project, and will establish new methods and tools for other stem cell investigators within the NPC and beyond.



With funding from NIH's T32 grant, Gabrielle Magalhães Ulloa will continue her work studying affective learning and decision making in adolescent rodents. Working with Assistant Professor Heidi Meyer, Gabrielle will specifically examine the role of the prelimbic region of the prefrontal cortex to better understand age differences in decision making. To do so, Gabrielle will use a fiber photometry technique to look at Parvalbumin-positive neurons, which she believes are key to understanding these age differences. This research fits into Gabrielle's broader interest in understanding human decision making, trauma response, and anxiety.

With funding from the NIH's T32 Program, Matthew Simkulet will continue his work with Assistant Professor Tim O'Shea studying the brain's response to implanted devices. Matthew will investigate microprisms implanted in mouse cortexes using two-photon microscopy in order to examine the brain's natural wound response. In the long term, Matthew's research aims to establish a baseline understanding of how such implants affect the brain on a cellular level. Such an understanding would lay the foundation for therapeutic intervention that could mitigate the side effects of implants.

With funding from NIH's T32 grant, Courtney Aul will continue her work with Professor Alice Cronin-Golomb studying the link between cognition and motor function in Parkinson's patients. To conduct this research, Courtney will integrate neuroimaging, neuropsychological, and behavioral methods. She also plans to use fNRIS to study patients' gaits outside of a controlled lab setting to better understand the influence of the distractions of daily life on gait. If Courtney is able to find a causal link between gait and attention, she hopes future research will be able to create therapeutic interventions for improving the life quality and expectancy for Parkinson's patients.

Neurophotonics Center's 7th Annual Symposium | *"Machine Learning and Photonics in Neuroscience"*

The Neurophotonics Center's 7th annual symposium took place on January 17, 2024, on the Center for Computing and Data Sciences' 17th floor, organized by faculty members Mike Economo and Brian DePasquale. With hundreds of attendees and 11 presenters, the topics were broken down into four sessions under the umbrella of "Machine Learning and Photonics in Neuroscience."

"Our community got to hear about a lot of cutting-edge research that spanned the many ways in which researchers in neuroscience and imaging are interfacing with machine learning to accelerate our understanding of brain function," said DePasquale. "The event was a huge success!"

The first session, entitled "Improving measurements," featured presentations from BU Assistant Professor Lei Tian, Harvard University fellow Dushan Wadduwage, and Harvard professor Adam Cohen. In each presentation, the presenters discussed subject matter ranging from the challenges faced during mesoscale brain-wide imaging at high resolution, to encoding light as a means to improve large-volume imaging of small brains, such as in mice.

Session two, "Improving analyses," featured two Zoom presentations by Kanaka Rajan of Harvard University and Carsen Stringer of the HHMI-Janelia Research campus. With Gal Mishne, of UCSD, finishing the second session with an in-person presentation on the dynamics of functional connectivity, the focus on neuroscience shifted from adeptly capturing data toward understanding what the data can tell researchers within the field.

During lunch, attendees were invited to peruse the many posters presented by student researchers posted along the 17th floor windows, showcasing a wide-range of dedicated study and results.

Session three, "Making sense of behavior," kicked off following lunch, covered by presenters Bob Datta of the Harvard Medical School and Annegret Falkner of the Princeton Neuroscience Institute. Here, the presenters focused on the in vivo study of animals to understand their natural behaviors, as well as the neural dynamics of social dominance and defeat.

"Of course I found all the presentations intriguing, but I have a special spot in my heart for the neural basis of naturalistic and complex behaviors because such behaviors are so integral to our lived experience as animals," shared DePasquale. "The impressive advances that these presenters, such as Bob Datta and Annegret Falkner, discussed, which have been fueled by exciting new developments in machine learning, feel like such a rapid and giant step beyond what our understanding was in the past, that it's hard not to be dazzled by their work. I believe this rapid progress is an excellent example of what cleverly combined approaches from machine learning and imaging can bring to the study of neuroscience, and provides an hopeful picture for future rapid progress in other domains."

In the final session, "Making sense of cells and circuits," BU professor Brian Clearly, alongside Tony Zador of the Cold Spring Harbor Laboratory and Jeff Lichtman of Harvard University, presented on subjects concerning algorithmic tools and technologies, brain wiring, and connectomics. In all three presentations, the subjects well-matched the session topic of "making sense," discussing how to study and understand the inner workings of the brain.

At the conclusion of the four sessions, a reception and subsequent poster session were held, where drinks were had, connections made, and ideas shared among colleagues from all around the education and industry fields.

"The biggest takeaway I had is that we still have a lot of work to do!" said DePasquale. "Our final session was especially filled with examples of the tidal waves of data our field is about to become overwhelmed by, and it is only through new and well-designed machine learning approaches do we have a hope to make sense of these data. A related point is the continuing importance of collaboration, which the symposium itself was undoubtedly an act of: investigators working in different domains — imaging, behavior, machine learning, etc. — need to continue to come together and discuss challenges and progress, because it's 100-percent clear to me that substantive progress in understanding the brain will only come from the combined expertise of many, many individuals with complementary specialties."

"I lost track of the number of 'ah-ha!' moments I had during the symposium when a speaker would discuss a machine learning approach they were applying to say, imaging, that could have profound impact on the study of behavior, and vice versa. I hope the attendees had those ah-ha moments as well!"

MED Symposium Begins Collaboration Between CRC and MED Campuses

October 30, 2023, marked the first in what hopes to be several major collaborations between the Boston University Medical School Campus and the Charles River Campus. With a symposium featuring student and faculty presenters from both campuses, the Neurophotonics Center and Chobanian & Avedisian School of Medicine hosted the event which shared current research efforts by both sides of campus.

Running from 3:00 to 5:30 p.m., the symposium featured 12 speakers from across the two campuses, discussing research on subjects such as:

- "Simultaneous Imaging of Neural Activity and Neurotransmitter Release During Freely Moving Behavior," Mike Wallace and Joseph Martinez
- "Deciphering Functional Mechanisms of Alzheimer's Disease Genetic Risk Using iPSC Models," Julia TCW and Lu Qian
- Quantifying Myelin Degradation in Late-Stage Alzheimer's and CTE Using Polarized Light Imaging," Irving Bigio, David Boas and Anna Novoseltseva

Each talk highlighted the collaborations already taking place between the two campuses to further the understanding of the brain and brain disease, with the aim of nurturing more collaborations to come.

"It was fun to catch up with our colleagues on the MED campus that we don't often see," Professor Boas, director of the Neurophotonics Center, said, "and in particular the event did a great job of showcasing the active collaborations happening between MED and CRC. I am sure that this will be the first of many annual events to showcase the cross-campus neuroscience and neurophotonics activities."

First Neuroscience of the Everyday World Conference Draws 300+ Attendants from Around the World

August 29–30, 2023 marked the inaugural Neuroscience of the Everyday World Conference, hosted by the Boston University Neurophotonics Center and Center for Brain Recovery in collaboration with the Tianqiao and Chrissy Chen Institute. Located on the first floor of the Rajen Kilachand Center for Integrated Life Sciences and Engineering, over 300 guests were registered to attend. Guests not only included BU's own NRTs, graduate students, faculty, and staff, but renowned neuroscience scholars from around the world. Some represented countries included Germany and the Netherlands, with speakers and learners alike coming to the see the advancing utility of neuroscientific research being done outside of a laboratory setting.

Presentations covered topics such as: "Neuropsychiatric and Cognitive Neuroscience Applications of NIRS" (Allan L. Reiss, Stanford University), "Imaging Natural Cognition in the Real World" (Klaus Gramann, TU Berlin), "Brain-in-the-loop control of soft robotic exosuits for gait assistance in the everyday world" (Lou Awad, Boston University), and more over the course of three symposiums, with a total of nine presentations.

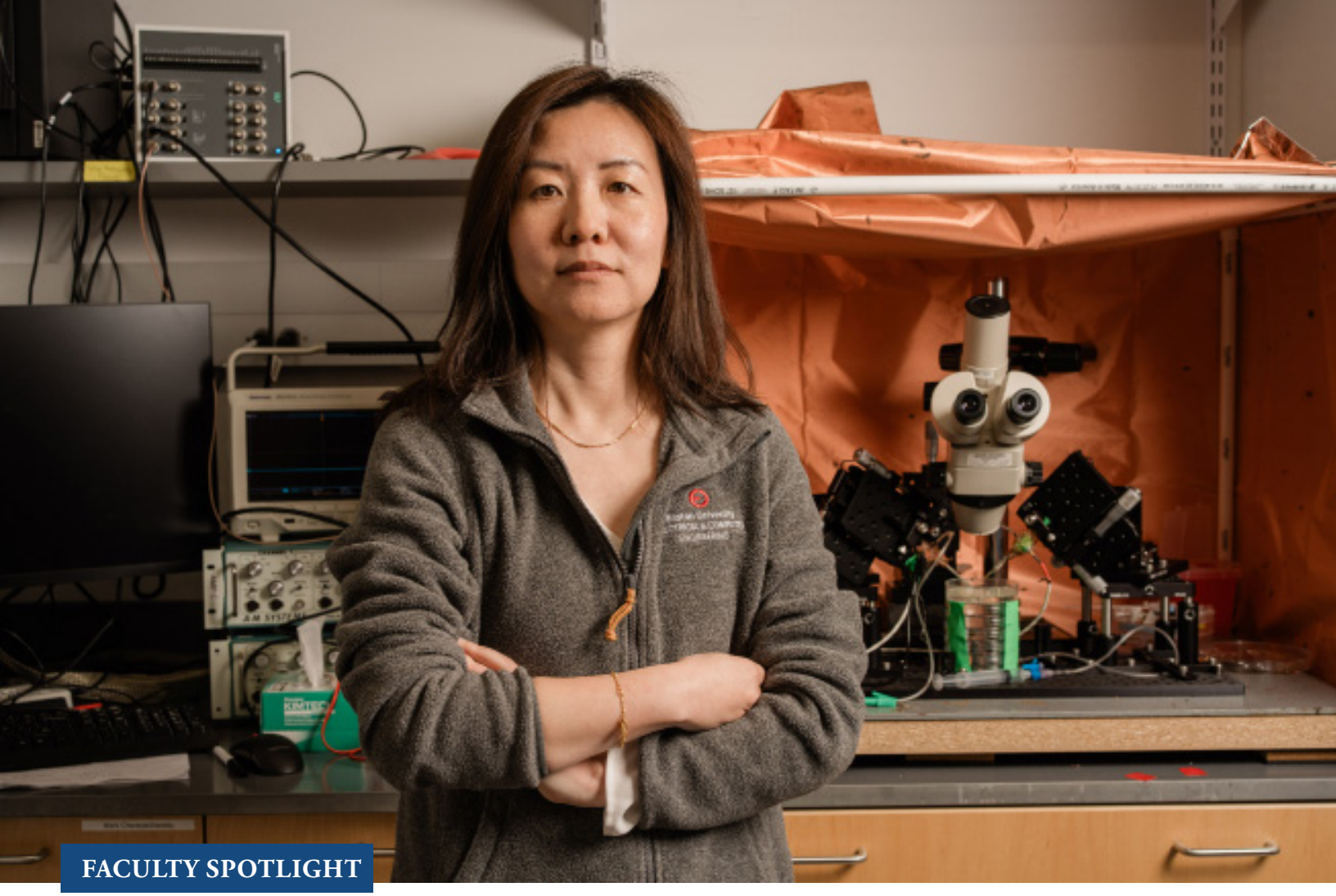
In between these symposiums, other researchers were given the chance to showcase their strengths in the field of neuroscience. With a total of 24 posters, student researchers and professionals in the field shared their dedicated work toward better understanding the brain through fNIRS, referential processing, multimodal techniques, and a variety of subjects.

From preschool children's neurological development during shared book readings, augmented reality for real-time neuro-imaging guidance, to patients of brain injury, researchers showcased the wide-ranging utility of neuroscience study in the real world.

Included among the poster presenters was incoming faculty member Matthias Stangl, previously of UCLA as a postdoctoral scholar. Professor Stangl presented a poster on the neural mechanisms that allow us to keep track of where we are, and where other individuals are, while we navigate through the environment. He expressed that the Neuroscience of the Everyday World Conference was "an amazing conference that brought together leaders in the field as well as students interested in this exciting new research area."

"It was very inspiring to see so many members of the neuroscience community come together at BU, to exchange ideas, discuss promises and challenges of this young research field, and establish collaborations that will hopefully lead to many exciting future projects," Stangl continued. "This conference showed that we are at the beginning of a new era of neuroscience, where we now have the methods and tools to study the human brain under ecologically-valid conditions during natural movement and behavior in our everyday world." (Be sure to also check out the NPC's recent profile on Professor Stangl).

Professor Swathi Kiran of the Neurophotonics Center and Center for Systems Neuroscience, as well as director of the Center for Brain Recovery, shared her thoughts on the impact of this week's conference. "It is truly a defining moment of neuroscience research at Boston University. Not only did the meeting bring leaders in the field of the study of neuroscience of the everyday world. It also put Boston University, the Neurophotonics Center and the Center for Brian Recovery on the map for research groups at the forefront of this work."



FACULTY SPOTLIGHT

DESIGNING A BETTER WORLD FOR THE PEOPLE SAT BESIDE YOU – PROFESSOR CHEN YANG'S LAB WORKS TO ENHANCE RETINAL AND BRAIN IMPLANTS

by Danny Giancioppo, Photos by Christopher McIntosh

Nanomaterials & Interdisciplinary Research

For recently promoted Professor Chen Yang, ECE, Chem, MSE making a societal impact through her work—utilizing nanotechnology to research, understand, and develop retinal and neurostimulative devices—is everything. The interdisciplinary nature of her research, meanwhile, is a natural part of the process.

"It's interdisciplinary because the goal, interest, and mission that we're pursuing is really focused on developing novel materials and making innovative devices as a neural interface, in particular for neurostimulation," Professor Yang says. "We like to not only record the neuroactivity—for example, you record brain waves to understand how the brain responds to different stimuli: light, language, behavior—but develop technology using those devices to control brain activity. To stimulate it or to inhibit it."

This multitude of goals allows Professor Yang and her team of graduate researchers to bring significant developments to the field of neurostimulation. Taking advantage of carbon- and polymer-based nanomaterials brings

forth not only an enhanced understanding of stimulation in brains and eyes with damaged or suboptimal function, for example, but new and non-invasive means of studying, perhaps even improving said functionality.

The use of nanomaterials in optical and photonic devices helps to develop brain and retinal implants, taking advantage of the materials to contain strong absorption within optimal wavelengths, thereby producing clearer readouts of data, and offering solutions by way of improved visual and neural stimulation. And it's not only research like this that's so interdisciplinary in the Yang group.

"Our group members are actually very interdisciplinary," Yang says. "I have students from Chemistry, from Mechanical Engineering s, from ECE (Electrical and Computer Engineering), from MSE (Materials Science & Engineering). And we also collaborate with groups and students with BME (Biomedical Engineering)."

Graduate students in Professor Yang's laboratory share a collaborative and varying list of responsibilities, from developing injectable solutions—that is, non-surgical implants—which can still be used as means to help restore vision, to developing electronic and photonics-based devices for capturing neurostimulation data, to performing applications for non-drug pain reduction strategies via neural inhibitors. To be a successful student in Professor Yang's lab, she explains, a researcher must value teamwork, shared responsibility, and a willingness to share in both triumphs and defeats.

Professor Yang explains what successful students are to her: "Number one: they're not afraid of learning new things, taking new projects that they never touched on. In fact, all my students, when they joined my group—nobody knew how to culture neurons. They all learned from that first step […] When you are in research, every project you're solving is a new project. So you must be fearlessly interested in doing that."

"My students are brave. They are fearless. They believe 'as long as I learn, I'll be able to solve this problem.'"

Photoacoustics & Societal Impact

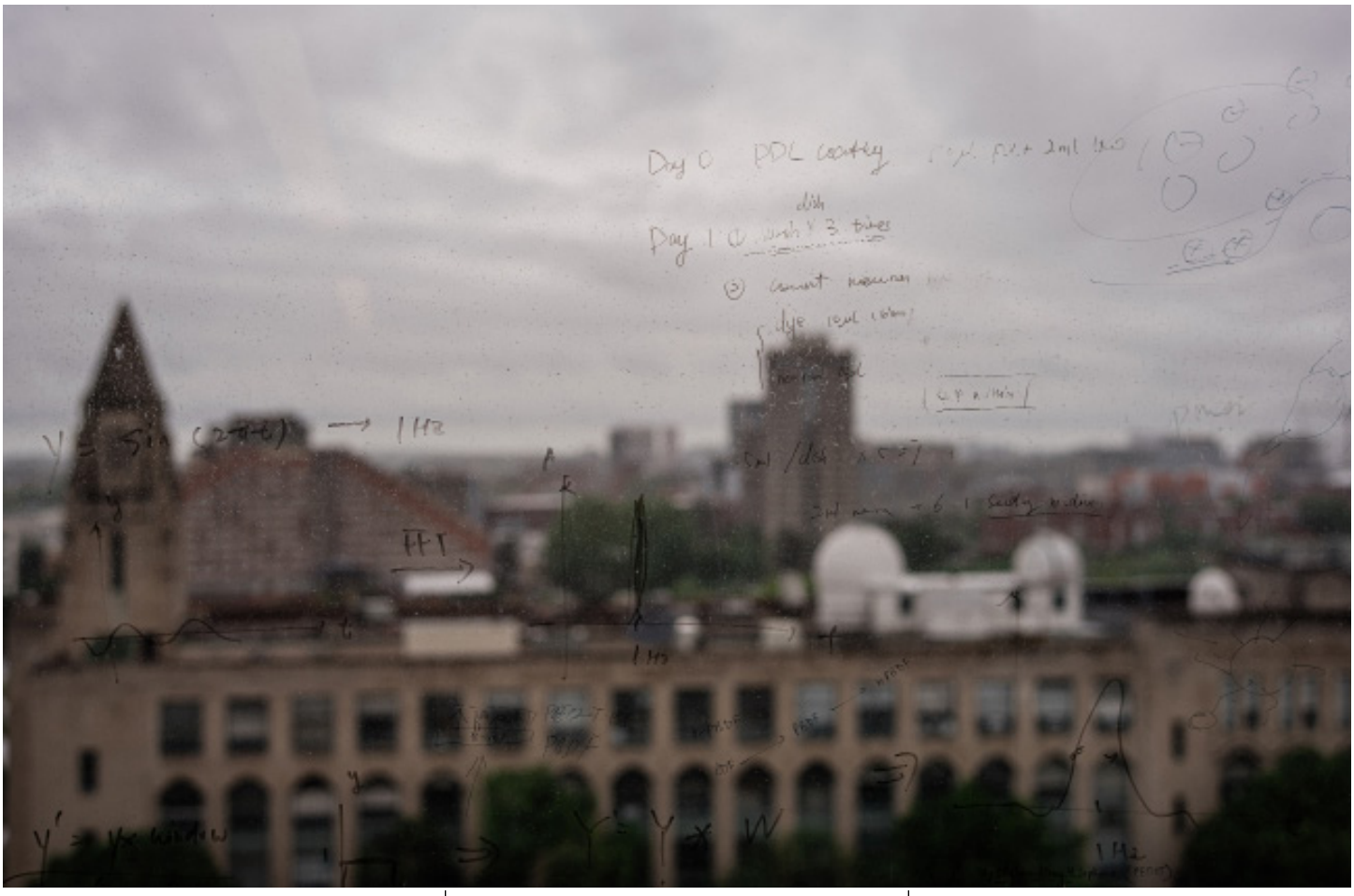
For anyone who hasn't heard of photoacoustics, it's as cool as it sounds, but perhaps simpler than you'd think. Described by Professor Yang as a "physics" or "energy-conversion process," photoacoustics is similar to wearing a black article of clothing in the summer; that black clothing soaks in a high amount of light and converts the energy into heat. In photoacoustics, the captured light is instead transferred into sound waves (ultrasound) to elicit a neuronal response. In other words, turning light into sound to study and improve brain and retinal function.

Professor Yang explains, "What's happening is, we deliver light to the device, the device will convert the light energy into mechanical waves, and those produced mechanical waves will actually activate the neurons in the brain or in the retina."

Where this research method has a wide breadth of application, including treating disease models where drugs aren't helping. To elaborate, by using mechanical waves, neurons can be activated, meaning they will respond to the mechanical waves, to trigger neuronal activity in the brain. In some cases, this can be used to control the neuronal activity of a subject, thereby mitigating deviation or improper function, such as with epilepsy. It has even been shown to improve vision for the seeing-impaired.

"In retina application where photoreceptor cells are damaged, those generated mechanical waves can actually activate the healthy part of the retina and generate vision perception in the patient's brain," Professor Yang says.

If it seems like this particular research has the potential to change lives, that's because it has been precisely what Professor Yang has kept in mind since working at Boston University. While she hadn't begun as a researcher focusing on societal impact, "it's [been] a journey," for



her.

"When I was a graduate student, or junior faculty, I worked on different types of projects," Yang says. "Some of them were more focused on science. Trying to discover new findings, to understand what exists and how it works. But I think BU is a great place that's allowed me to think that, when we work as engineers, it is possible to develop technology that can eventually become a product."

These products are eventually disseminated among other research labs worldwide—with such collaborators in California, Paris, and beyond. The ultimate goal being to not only enhance the understanding of brain and retina stimulation, but put it into practice as a commercialized product. Namely, practices like their high-precision, non-genetic stimulation project.

On a pixel level, using high-precision stimulation within the retina can aid blindness with non-invasive technology, offering a potential two- to three-times larger retinal implant than what's currently offered. By using a thin film to generate mechanical waves which stimulate the retina—with materials developed by her students—the healthy sections of otherwise damaged retina are effectively perceiving restored vision. Her team of graduate researchers has even been looking at injectable solutions as an alternative to surgical implants. With all these advancements, Yang is hopeful that in five to ten years, the technology may be ready for human trials. And not a moment too soon, at that.

"The reason why I'm inspired to do this is because I know that it's needed," Yang says.

She and her graduate researchers closely collaborate with Professor Serge Picaud at the Institut de la Vision in Paris. When Yang was visiting with a graduate researcher, she says it was outside the lab that they shared a moment which emphasized the importance of their work.

"[Picaud's group] is in a building next to a hospital that specializes in treating blind patients. I saw more blind patients [there] than in the rest of my life." In a nearby café when the team went for a lunch, Yang explains, she and her colleagues saw a large group of vision-impaired patients sitting alongside them, eating lunch. "You know those French restaurants—they have very tiny tables, very narrow. [The patients] couldn't use their sticks, they had to put their hands on the [patient] in front of them. They formed one single line to come into the restaurant and sit down."

"That was a really inspiring moment for me. What we're discussing at this table eventually can benefit the people sitting next to us in the same restaurant. That's how close we can

"WHEN YOU ARE IN RESEARCH, EVERY PROJECT YOU'RE SOLVING IS A NEW PROJECT. IT'S A SOLVABLE NEW PROBLEM."

– Chen Yang

be socially impactful, and I think that's really, really exciting."

Promotion to Full Professor & Prospective Students

Throughout her time at BU, Professor Yang has strived to make an impact not only in her university work, but society at large. When she was promoted to a full professor in March of 2024, she considered it recognition for the hard work she and her team started and enabled at BU, and a direct result of the resources and assistance enabled by her colleagues.

Yang describes the support from the Photonics Center community as "immediate" and "the most collaborative environment" she had seen while she and her research group transitioned onto campus in 2017. This included other BU faculty and colleagues teaching her and her students how to perform neuron culture studies, which they had little knowledge of beforehand—and now they're able to perform live animal experiments.

"Everyone is sincerely interested in the problem that we're solving and how we solve it," Yang explains. "They are willing to spend time looking at our work, our results, to help us. I don't have a neuroscience background at all—so we have to learn!"

Looking ahead, Yang wants any and all prospective students to be just as "fearlessly interested" in solving new tasks and learning new solutions. As an interdisciplinary team, she's more interested in a student's drive to advance their group's projects than the particular field of study they may be coming from.

"You really have to be willing to learn," she says. "To me, I feel that's a very general perspective we look for in a successful graduate student. You have to realize, when you are in research, every project you're solving is a new project. It's a solvable new problem." During this process, Yang goes on, students have to pick up new skill sets, and have an excitement for it.

Students, and indeed Professor Yang, herself, are deemed successful due to their confidence, their collaborative studies, and unending hunger to keep learning and adapting to new hurdles along the path to greater and wider-spread solutions.

Bravery, to Professor Yang, drives the confidence that has led to so much success in her research. "They believe, 'as long as I learn, I'll be able to solve this problem.'"

FACULTY SPOTLIGHT

NEUROSCIENCE BEYOND THE LAB

NEUROPHOTONICS CENTER ASSISTANT PROFESSOR MATTHIAS STANGL IS LOOKING INTO THE "HOW" AND "WHY" OF NEURAL MECHANISMS.

by Danny Giancioppo, Photos by Danny Giancioppo

Neuroscientist Matthias Stangl will be joining the Boston University Department of Biomedical Engineering, the Neurophotonics Center (NPC), the Center for Systems Neuroscience, and the Cognitive Neuroimaging Center this January after an already impressive career at UCLA as a postdoctoral scholar aiming to develop a better understanding of the brain's functionality—not only within a laboratory setting, but in the natural world. Some of his research has led to publications documenting the maladaptive neural noise produced in aging brains during ambulatory walking and spatial navigation activities, as well as insights into how our brains are able to keep track of other people. Now, in the ever-advancing field of neuroscience, Stangl hopes to expand the horizon of out-of-laboratory research in his new role at the NPC.

"Thrilled to share that I will be starting my lab at Boston University in January 2024, at the intersection of cognitive neuroscience, neurotechnologies, and data analytics," Stangl tweeted. "We will use invasive electrophysiology and non-invasive neuroimaging to study human cognition & behavior." One such method of study is fMRI, which enables recordings of brain activity in tightly controlled laboratory experiments.

Currently, the use of fMRI and similar neuroimaging technology, while highly generative of new discoveries every day, is nevertheless limited in its capacity for research of brain function in natural everyday life situations, due to the requirement that people remain motionless in rather unnatural environments (e.g., large

"brain scanners") while their brain activity is recorded. Because of these limitations—Stangl explained—fMRI only captures very specific aspects of neural activity that might not necessarily reflect brain activation during everyday life experiences. However, rising technologies in the field have allowed neuroscientists such as Stangl to broaden the environments of study, as well as the means of capturing that information.

Stangl (left) presenting his research to Professor Kamal Sen (right), BME

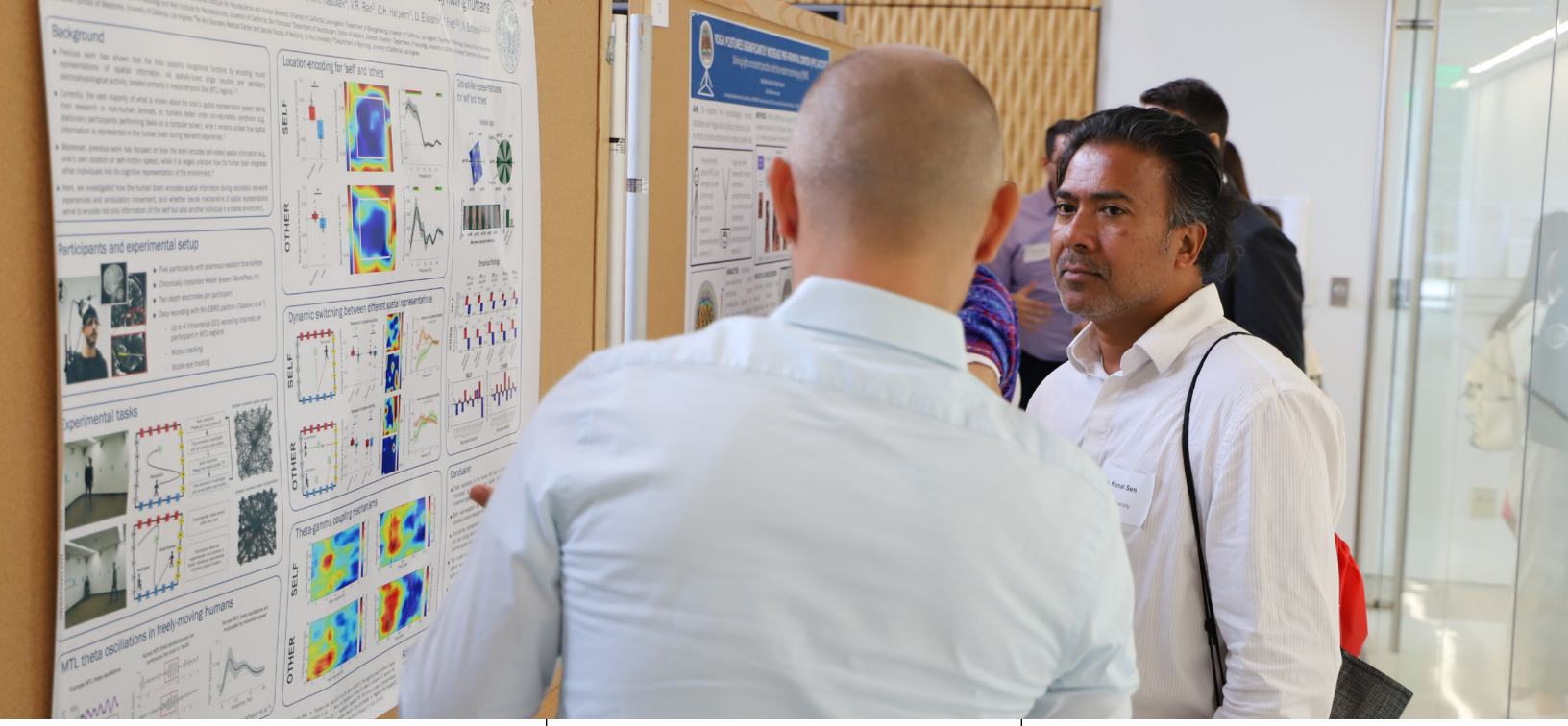
Thus, Stangl's lab work will also use novel mobile neuroimaging techniques, such as recordings of electrophysiological deep brain activity through permanent intracranial implants which allow a "real world" study of what affects the brain on a day-to-day basis. Additionally, special temporary electrode implants allow rare recordings of activation from single neurons in the human brain, thus allowing future Boston University researchers to look at neural mechanisms both within and beyond the laboratory, and across different scales, from single neurons to whole-brain network dynamics.

"We are able to ask questions we could not ask before," explained Stangl, saying that this rapid evolution of neurotechnology has both literally and figuratively allowed him to access new angles from which to study the brain, including for those with conditions such as epilepsy. "In the past, studying the human brain in the real world and in naturalistic situations has proven to be very difficult, because traditional methods to record brain activity, especially from deep brain regions that are of critical importance for many cognitive functions, are typically limited to recordings in non-natural situations (i.e., in the laboratory) and in immobile participants. But we are now at the beginning of a very exciting new era within the field of cognitive neuroscience, where we have the tools to study the human brain in the real world and during natural everyday-life activities."

To ascertain the best results, numerous technologies that blend both neurophotonics and photonics are needed, such as the use of infrared cameras, eye-tracking cameras, audio/video recording devices, and sensor technology to perform speed and acceleration tracking. This tech helps to capture (and later analyze) data on the environmental influences, transient physical fluctuations, and external stimuli which a patient with a neurological condition might encounter outside of a lab setting. The analysis of these rich and complex datasets will further require advanced data analysis methods, such as multimodal models, machine learning techniques, computer vision, etc., which are not as commonly used in current neurophysiological studies and can be expected in his lab work.

"Importantly, I am convinced that we will get the best possible understanding of the neural mechanisms that we are interested in, and of human brain function more generally, if we use a multi-modal approach by combining the advantages of varying neuroimaging technologies and experimental techniques," Stangl said of his lab expectations. With this approach, he hopes to not only produce new results, but to "bridge the gap" between the long-standing history of rodent research and human research, and varying cognitive neuroscience subdisciplines.

What is so advantageous about these combined methods of research is the expansion of brain activity researchers can begin to understand. For example, how our brains form mental representations of the environment that we are in, and how we integrate other people into this mapping, is of great interest. We do this countless times throughout our day without



knowing it; yet our knowledge of how the brain keeps track of other people in our environment is incredibly limited.

"Until recently, we had literally no idea how the human brain keeps track of another person. Mainly because deep brain recordings in naturalistic settings and during active movements were not possible due to technical limitations," Stangl explained. "My work has shown that we can address these questions now in the real world, in naturalistic scenarios, during active physical movement, social situations, etc. And this gives us many new insights into how the brain works."

The multi-modal neuroimaging approach Stangl bases his research on allows neuroscientists to not only better understand the brain, but what can go wrong in given pathological conditions and why. Understanding these neural mechanisms' functionality, as well as where they falter, provides the capacity to improve treatment for patients diagnosed with a variety of neurological and psychiatric disorders. This sort of work will be the primary focus of his lab, although Stangl does not want students to feel boxed in by his research interests.

Matthias Stangl (second from left) at the first Neuroscience of the Everyday World Conference

"As a teacher and mentor, my goal is to train the next generation of scientists," he said, as well as to learn alongside them. For this reason, one of his major goals is to keep mental health as the most "critical" priority among his researchers, as well as enhancing their professional development. "It is very important for me to focus on all aspects that are relevant for current and future researchers more generally." This includes developing skills in research ethics, paper and grant writing, the publication and peer review process, career development strategies, and more. Additional expectations include regular check-in meetings with team members, conversations on managing the balance between research-related guidance and independence, and clearly aligned expectations between mentor and mentees.

Furthermore, Stangl hopes to create an "interactive program" with students wherein he and they work on a level playing field. He plans to teach his students everything he knows. "But I do not only want to teach my students, but I rather want to work together, and also learn from my students." This is something which Stangl hopes to achieve through a diverse team of researchers. "People with diverse backgrounds and skills often also have different viewpoints, and I am convinced that looking at a question from diverse viewpoints will help in finding the best possible solution for the problem at hand."

Ultimately, Matthias Stangl has high hopes for the future of neuroscience.

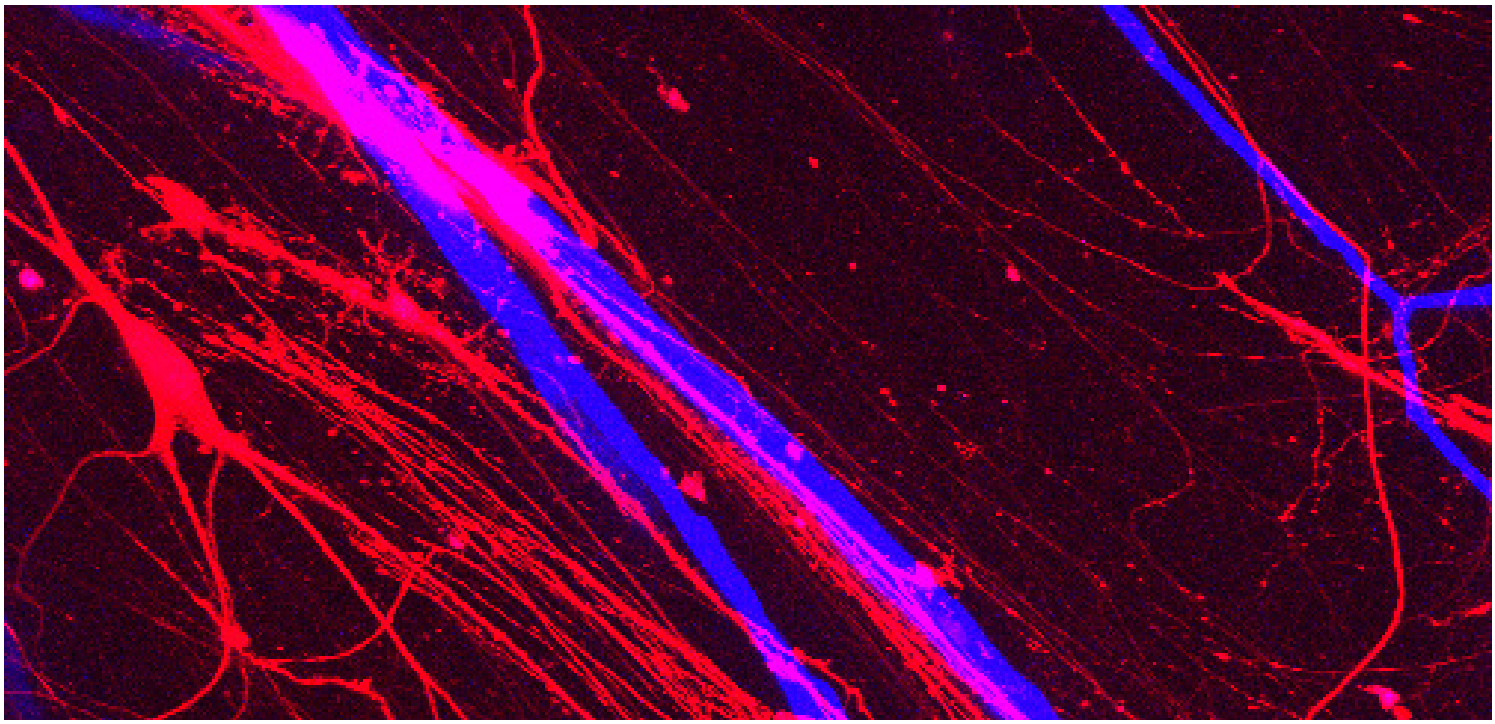
"AS A TEACHER AND MENTOR, MY GOAL IS TO TRAIN THE NEXT GENERATION OF SCIENTISTS, AS WELL AS TO LEARN ALONGSIDE THEM."

– Matthias Stangl

Not only in understanding how the brain works, but when and why it does not, and how to address these issues in a long-lasting manner which can better the lives of those diagnosed with neurological and psychiatric conditions. At Boston University, he feels particularly capable of further achieving his goal to progress the narrative of neuroscience.

"What I find particularly amazing at B.U.," Stangl said, "is that it is an extremely collaborative place, where interdisciplinary work and projects across traditional departmental boundaries are actively encouraged and supported. Also, there are such excellent people with a lot of expertise at BU across many different research areas and disciplines. I am very much looking forward to launching my lab within such an excellent research community, and in such a warm and welcoming environment, where interdisciplinary and collaborative work is not only possible but part of the institution's culture."

Neurophotonics Supported Research



BU'S CORE ORGANOID RESEARCH SPANS CRC & MED CAMPUSES TO RESTORE ORGAN FUNCTION

by Danny Giancioppo and Jack Osmond, Photos Supplied by Martin Thunemann, Ella Zeldich, and Ben Wolozin

Organoids are a growing trend in biomedical research fields internationally—but what are they? As the name suggests, it's a simplified model of an organ made up of cells, studied both in vitro (outside a living organism) and in vivo (inside a living organism) to enhance the understanding and treatment of organ-related diseases and disorders. Their pathology, phenotype, and—in the future—repair, are paths made clearer for researchers by utilizing these human stem cells to recreate miniature brains, pancreases, and other existing organ functionality on a cellular scale.

At Boston University, organoid research extends beyond even a single campus. On the Charles River Campus, faculty members of the Neurophotonics Center have been diligently working with faculty of the Medical Campus to further one another's work, and better the understanding of neurological subjects such as Alzheimer's, Down Syndrome, and Parkinson's, as well as Primary Liver Cancer and Diabetes. The core of organoid-related research at Boston University, then, is one which insists upon cross-campus collaboration to further the application and impact of organ treatment and understanding.

But what does each core facet of organoid research at BU look like, and how do they overlap? To see the convergent work produced across the two campuses, it is imperative to first understand what each core function of organoid research looks like, and the faculty who lead it.

CREATING ORGANOIDS:

Neurodegeneration: Ben Wolozin's Aim to Understand Alzheimer's and ALS

Neurodegenerative disease is a field as complex as the human brain itself. The use of organoids in such research suggests a fervor for not only learning the mechanisms of neurodegeneration, but a willingness to peer further into the brain than we can with the naked eye. You'd have to be pretty dedicated, then, to delve so deep into the why and how of neurodegeneration. Ask Ben Wolozin, MD, PhD, and he'll tell you he's the man for the job.

"I'm a 'neurodegenerate,'" he jokes, explaining that his dedication to the study of neurodegenerative disease leaves him as something of an "intellectual tourist" among other fields and subsections of neuroscience. No matter the source, so long as the research is well-founded, Wolozin follows the work to enhance his studies of what causes brain function to falter and fluctuate.

Ultimately, this work identifies him as a neuronal cell biologist.

Wolozin explains, when asked what use organoids have toward understanding the nature of such diseases: "In the context of neurodegeneration, people in the field of Alzheimer's disease and ALS have had a lot of difficulty developing stem cells to show pathology. You can see disease effects, kind of, but you just don't see the stuff you see in the brain."

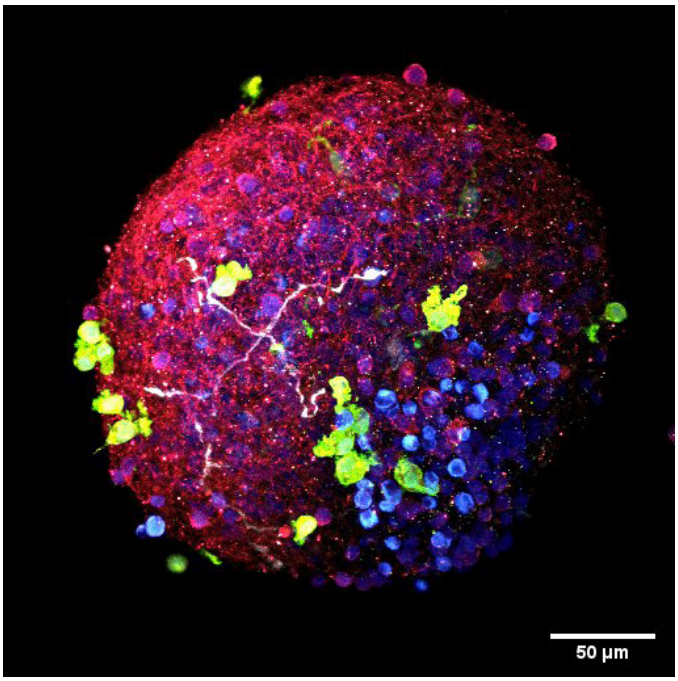
"[With] organoids, you start with some kind of neural precursor cells, and you grow them floating in culture and let them grow up over nine months. And they recapitulate a lot of the cortical structures that you see [in the brain]. They develop some of the types of the excitatory cells, and particularly once they've been in culture for a while, they start to develop astrocytes. In a way, it kind of recapitulates what happens in a fetus, as it takes nine months!"

This comparison to human reproduction is just one of the human elements that makes organoid research so appealing, not only in neurodegenerative research, but beyond. What increasingly drives people toward organoids is their close-knit connection, in fact their origin, from human cells. "If you want to know if it happens in people, you want to be able to look in a human system," Dr. Wolozin says.

Such a direct line to the human cellular system can more easily mimic the functionality, or pathology, of not only nominal brain activity and evolution, but malfunctioning cells. You can see the effect in various models as well as in human neurons. This means you can also get diseased cells, or those with genetic variations and mutations to "isogenically" correct said mutations in the organoid. This proves invaluable toward understanding the causes of diseases like Alzheimer's, in that you can test the organoid to see if what is in the gene may be causing the disease.

This sort of mirroring of neurodegenerative pathology is in large part what drives the collaborative nature of Dr. Wolozin's work. "This actually began as a cross-collaborative work that I actually put in with Christine Cheng to get a Kilachand Award." Although Professor Cheng has since left BU's campus, the collaborative nature of Wolozin's work has continued. "I have also interacted with three different groups explicitly about this. I've talked with Anna Devor, and we actually did some experiments looking at these things growing in mouse brains. I didn't have a great question for myself, but Julia TCW is now doing very similar things with good results. I have worked with Ji-Xin Cheng on using optical methods in noninvasive ways to see the pathology, and that's ongoing work that we're doing together."

As for the next stage of organoid research, there are "many, many advancements" to be made, according to Dr. Wolozin. For example, "in Alzheimer's disease, and a lot of diseases of aging, old people have something that you don't have—you young whippersnappers. That is cerebrovascular disease. Their blood vessels are clogged. And it's very clear that diseases of aging are strongly modified by whether or not you get blood to your brain. And so the field is super interested in looking at the interaction between organoids and blood vessels."



Human assembloid containing neurons (neuronal nuclei shown in blue), astrocytes (red) and microglia (green)

His collaborative work with Anna Devor was one such example of pursuing this line of research—and they're not alone. More and more members of the field are following suit in their studies by placing organoids on artificial blood vessels or into the brain with the specific focus of blood vessel interaction. In so doing, researchers are growing the capacity and possibility for a more in-depth understanding of how the brain works, and how it doesn't.

"As we evolve, we're going to make these things more mature," Dr. Wolozin explains. "These things improve dramatically with time."

Neurodevelopment: How Ella Zeldich Studies Neuronal Functionality in Down Syndrome

Ella Zeldich, Assistant Professor at the Chobanian & Avedisian School of Medicine, is using cortical (brain) organoids to research the neurodevelopmental processes associated with Down Syndrome. The genetic condition affects about 1 in 700 babies born, or approximately 200,000 adults in the United States. Also known as trisomy 21, Down Syndrome is caused by a triplication of the 21st chromosome, which leads to pathological changes in the brains of people with the disorder and the development of Alzheimer's disease earlier than in the general population.

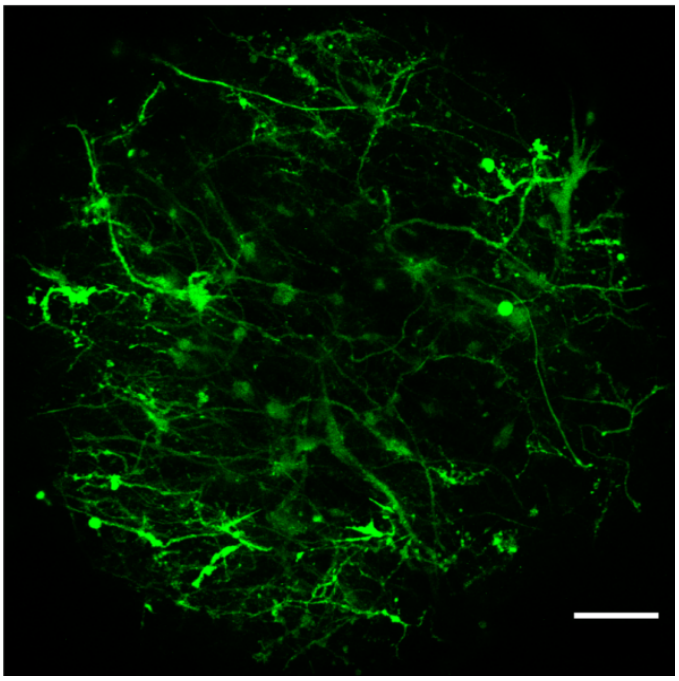


Image of cortical organoid expressing Ca2+ sensor GCaMP7s

According to Zeldich, studying the pathology of Down Syndrome is particularly difficult because it is both a neurodevelopmental and neurodegenerative disorder. It's almost like the question of the chicken and the egg—do neurodevelopmental phenotypes lead to neurodegenerative changes, or vice-versa?

"It is well known that there is an extra dosage of amyloid precursor protein in Down Syndrome, as the gene encoding for this protein is located on chromosome 21. The amyloid precursor protein is a paternal protein for a toxic amyloid beta that accumulates in the brain of patients with Alzheimer's disease. However, we don't know, to what extent early accumulation of amyloid beta due to trisomy, leads to the different neurodevelopmental phenotypes and dysregulation in neuronal functions," Zeldich explains, "or, to what extent abnormal neurodevelopmental processes predispose brain cells in Down Syndrome to neurodegeneration and Alzheimer's related pathology later on.

Zeldich and her research team employ a cortical organoid platform to help answer these questions. The team utilizes induced pluripotent stem cells (iPSCs) to create two types of organoids, one with trisomy 21 and one control to understand the effects of trisomy 21 on the phenotypic and functional properties of certain brain cells. From this, her team has gleaned "some very exciting findings."

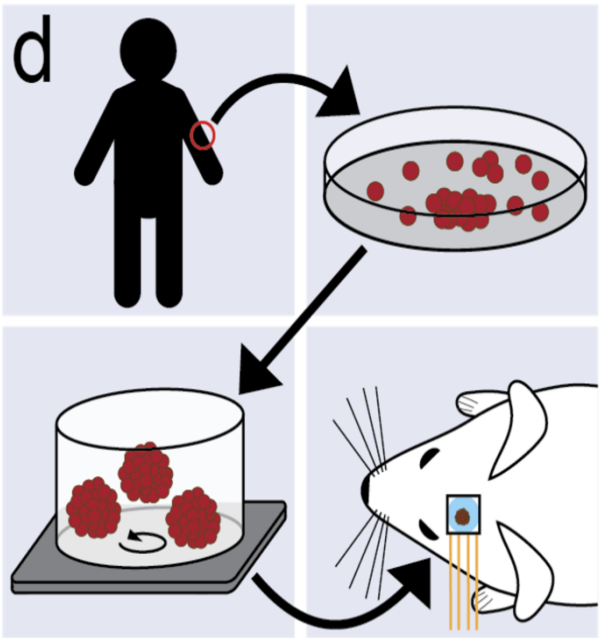
"If we compare the trisomic organoids which have this [extra copy of the] 21st chromosome with the control organoids, we see that the trisomic organoids are smaller, and that there is an underproduction of neurons from deep and superficial cortical layers."

"Our next goal would be to say, okay, we see these structural and phenotypic changes, and now, we are moving further by trying to recapitulate functional changes in the trisomic neurons in our organoid system."

Zeldich strongly believes that collaboration is one of the main keys to scientific advancement. "Our current projects through our collaborations are very exciting." She recently collaborated with Dr. Christopher Gabel, Associate Professor at both the Neurophotonics Center and School of Medicine. The two used calcium imaging to find differences in neuronal activity between trisomic and control organoids. The changes they found correspond to the abnormal neuronal activity observed in the Down Syndrome brain. Zeldich and Gabel plan to expand this collaboration to further their understanding of these variations.

Granted, organoids have their own setbacks. Organoids lack vasculature, limiting their supply of oxygen and nutrients. In addition, the cells within the organoids can only mature to a certain point. To overcome these challenges, Zeldich has recently begun working with Martin Thunemann, Research Assistant Professor of Biomedical Engineering and Anna Devor, Professor of Biomedical Engineering.

Devor and Thunemann have developed an amazing platform where human organoids can be engrafted into mouse brains to overcome some of these "constant challenges." Zeldich and Thunemann are harnessing this system to integrate Down Syndrome organoids into mouse brains in order to investigate the dysregulation in neuronal activity in an environment that promotes the maturation of neurons populating organoids. "This platform is truly remarkable as it enables us to address ques-

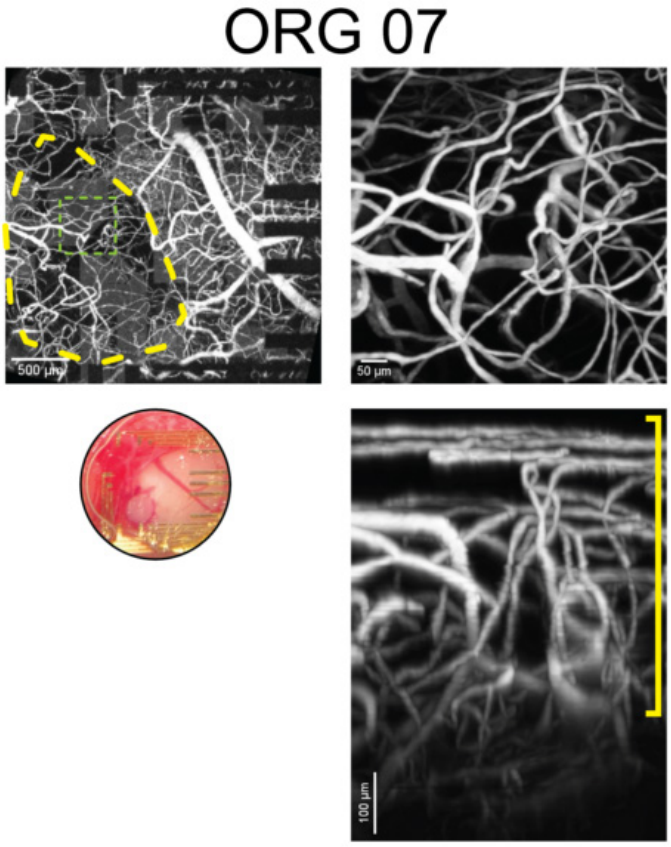


Creating and xenografting an organoid

tions related to human disease modeling in a functionally and physiologically relevant environment," Zeldich says. "The end goal is to understand the mechanisms underlying pathological processes. Once we understand these mechanisms we can come up with therapeutic approaches."

But the research doesn't stop there. Dr. Zeldich is also using organoids to develop therapeutic interventions for Down Syndrome. In one collaborative study with Professor Dr. Tara Moore and Associate Professor Dr. Maria Medalla of the School of Medicine, Zeldich's team was able to harness the beneficial properties of extracellular vesicles (tiny particles responsible for intercellular communication) derived from the bone marrow of a monkey. By exposing the organoids to these vesicles, "we saw that some of the neurodevelopmental changes were resolved, and we detected decreased production of amyloid beta in trisomic organoids," Zeldich explains. In short, organoids may be used to develop therapeutic interventions to alleviate some of the pathological changes related to Down Syndrome.

Ella Zeldich is hopeful for the future of organoids, and doesn't see their great progress slowing down any time soon. "These [organoid] systems can only expand. More diseases will be modeled – we are a long way from the limit."



A vascularized organoid

IMPLEMENTING ORGANOIDS:

Xenografts: Martin Thunemann's Collective Efforts to Understand Disease

"Everybody sees that it works," says Martin Thunemann, PhD, Research Assistant Professor of BME, on the subject of organoids. "You can take brain organoids, implant them into mice, and see that something is happening. I think with our previous work, we are at a stage where we know the right way of doing these implantations, and that it works, and now we want to make it better and more meaningful."

This has driven Professor Thunemann to thoroughly advance the study of organoid research at Boston University. Through the use of xenografts—tissue, or in this case, brain organoids, which are grown from human cells and implanted into mice brains—Dr. Thunemann has been able to pool together the in-house collection of organoids generated at BU (and beyond, through contacts at UC San Diego) from faculty such as Dr. Zeldich, Dr. Wolozin, and Dr. Xue Han. Together, they are greatly enhancing the understanding and potential application of brain organoids in neurodegenerative and developmental disorders.

"I see convergence in enabling disease-relevant models generated and studied at [the] MED campus being investigated with highly sophisticated state-of-the-art methods developed, optimized, and used at [the] CRC."

In the case of on-campus faculty, Dr. Thunemann and his research team work closely with colleagues to further both organoid designers' (Wolozin, Han, Zeldich, etc.) and implanters' (Thunemann and Devor, et al.) understanding of human-based cells. Where other faculty deal more with the curation of organoids and assembloids, Dr. Thunemann implants them into immunodeficient mice brains—therefore assuring the human cells aren't eliminated by the mouse's immune system—and studies how the organoids interact with, and in some cases are integrated with the naturally occurring mouse brain cells and present disease phenotypes in the brain and other tissues. Anna Devor, PhD, Professor of BME, also follows this style of understanding the connectivity between organoids and host brain cells, specifically through blood vessel interactions. Her and Dr. Thunemann's work proves to be therefore symbiotic in advancing the field.

"We are glad to build on Dr. Devor's experience in the field of neurovascular interactions and functional brain imaging to improve our xenograft approach," Dr. Thunemann explains. "One important aspect of our model is that blood vessels from the mouse grow into the organoid and provide it with oxygen and nutrients." Essentially, integrating the organoid into the brain as though

it were a part of it. And when the cells are accepted as a part of the larger organ, Thunemann, Devor, et al. can see how a disease might develop in said organoid, and why. "In the future, we hope that this model can help to investigate disease phenotypes that affect both brain tissue and brain vasculature, including, for example, neurodegenerative disorders such as Alzheimer's."

But that's not all. While in preliminary stages, the opportunity for cell replacement therapy allows not only the chance to understand phenotypes and origins of diseases, but perhaps even means to treat them. "The question is at which point this can move from single first-in-human trials to something which can be done more routinely. I'm hesitant to say for the brain this will be very easy, because it's a very, very complicated organ, which not only requires the cells to be present but [to be] connected the right way, so they can contribute meaningfully. If I had to venture a guess, I think the first in-human studies would be on something like the pancreas. You have Type-1 diabetes patients, and you can give them their own pancreatic beta cells made from their own stem cells back, and hopefully have them not need to take insulin anymore."

Biomaterials: Boosting Organoid Growth

To guide the way these organoids assimilate with other cells, Timothy O'Shea, PhD, has provided developmental boosts to Drs. Thunemann and Devor by way of biomaterials, which are layered above or directly beneath the organoids when placed in mice.

"He uses biomaterials in combination with other types of neurogenic stem cells, or neuron precursors, and is looking into, for example, spinal cord injuries," Dr. Thunemann explains. "Biomaterial can be loaded with molecules acting as developmental cues (or "morphogens") that affect neuronal growth and maturation and are present during normal neurodevelopment."

In other words, they provide direction for cell growth and development in what would naturally occur during prenatal stages of organ growth. Dr. Thunemann and team hope layering the biomaterials with organoids might essentially kickstart a more natural growth of these newly implanted cells (organoids) as though they were part of the initial developmental process and catching up to the rest of the organ. The use of biomaterials furthermore assists in mitigating the variability of organoid development that can otherwise lead to the onset of unguided growth or a general failure to develop.

Assisting in this project is Kate Herrema, who recently won the Neurophotonics Center's CAN DO award for the aim of advancing cortical organoid studies. Specifically, she plans to advance the maturation of organoids, lowering risk of failing or uncontrolled development.

"Kate is very special," Anna Devor explains. "She thinks and writes at the level of an assistant professor if not higher. She is a natural lead investigator. It's not that she is helping us, it's we who assist her!

Working alongside Ella Zeldich, Anna Devor, Martin Thunemann, and Timothy O'Shea—in what Dr. Devor describes as a fully collaborative and equally shared effort—Kate's work is the focal point of BU's convergent organoid studies. Bringing together the collective efforts of the MED and CRC faculty, Kate's efforts leverage the many strengths Boston University has to offer and assures a bright and productive future for organoid studies and utility, not only on campus, but the biomedical field at large.

"Life is short, and the only way to get more done is to team up with colleagues and friends to create something much bigger than the sum of its parts," Dr. Devor says. "We are so fortunate here at BU [in that] we are surrounded by brilliant experts in a wide range of biomedical domains. This is priceless."

KILACHAND FUND AWARDS GO TO CRYSTAL RIB CAGE AND BRAIN CONNECTION PROJECTS

WINNERS OF 2023 INTERDISCIPLINARY RESEARCH FUND GRANTS AIM TO IMPROVE STUDY OF LUNG DISEASE AND BRAIN DEVELOPMENT

by Chuck Leddy, Photos by Cydney Scott

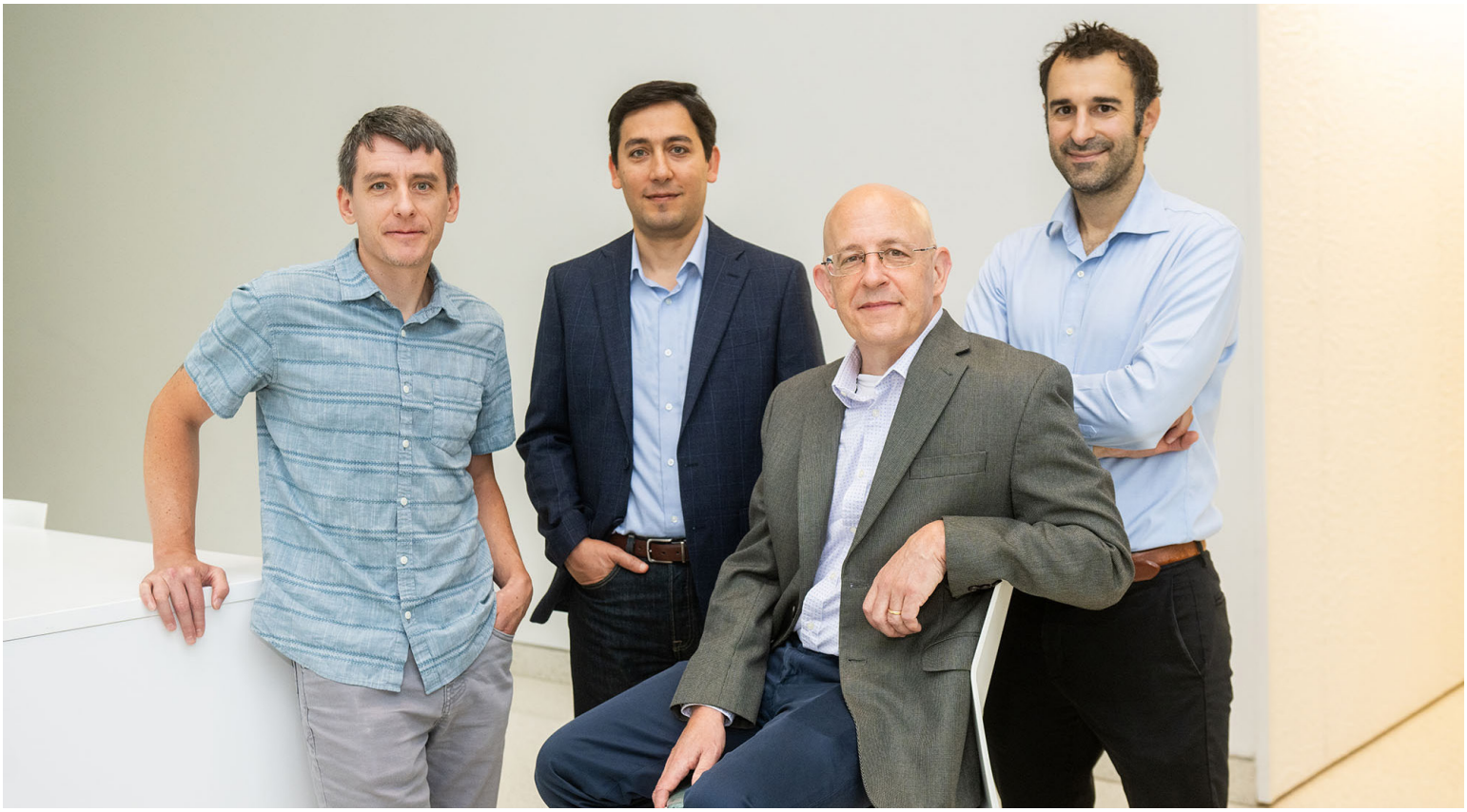
When infection or disease strikes the lung—cancer, pneumonia, COVID-19—it's tough for researchers to see what's going on inside the organ. Even if they simulate in a lab the disease in a lung, they can't recreate the forces the rib cage places on it without blocking their view of what's happening. That's about to change.

A crystal rib cage, developed by a Boston University engineer—and being refined in collaboration with a BU medical researcher specializing in pneumonia—will enable scientists to visualize in real time how the lung develops immunity against infection.

"This innovation will enable us to visualize the entire lung with an optical microscope at different scales, from cell level all the way to the entire organ," says Hadi T. Nia, a BU College of Engineering assistant professor of biomedical engineering.

The crystal rib cage is one of two projects to win a 2023 Rajen Kilachand Fund for Integrated Life Sciences & Engineering award.

Since its launch in 2017, the fund has awarded $14 mil-



lion to support projects that have advanced science, built collaborative structures for interdisciplinary research, and expanded funding opportunities. Past Kilachand award winners have made important scientific breakthroughs, secured patents, founded companies, and sparked important spin-off research.

"Our research is exactly the type of interdisciplinary work the Kilachand Fund was designed to support," says Joseph Mizgerd, a BU Chobanian & Avedisian School of Medicine professor of medicine, who is leading the crystal rib cage project with Nia. "Hadi can engineer systems that allow us to study lungs in ways that nobody else on Earth can. And I have immunological and respiratory infection expertise from decades of work on this topic. Working together, we can potentially transform how pneumonia is treated, and possibly other respiratory diseases and cancer." They were awarded $500,000 per year for up to three years.

BU trustee Rajen Kilachand (Questrom'74, Hon.'14) established the fund with a historic gift of $115 million with the aim of driving solutions to some of the biggest challenges in the life sciences, including heart disease, cancer, and degenerative brain diseases. The second 2023 winning project will investigate genetic and neuronal networks of healthy and diseased brains.

Defending against Pneumonia

A result of respiratory infection, pneumonia is a massive public health concern and more common among the elderly and in children. "Pneumonia is the number one cause of death globally for children under five," says Mizgerd. "In the US, it's the top cause of hospitalization for children under 9, as well as the top cause of death for hospitalized people over 65 years of age." A person's age and history of prior infection are two key factors contributing to the incidence and severity of pneumonia.

But scientists aren't sure why some people have immunity when others don't. Mizgerd says that understanding the impacts of age and prior respiratory infections on someone's immune response to pneumonia has been a long-standing challenge. People can be exposed to the same microbe and have vastly different outcomes—a phenomenon also seen with COVID-19. "There's something different within us that determines the outcome of these respiratory infections," says Mizgerd, "and we're trying to understand exactly what those differences might be."

The crystal rib cage "will allow us to visualize every step of disease progression in real time," says Nia. The researchers will also test how changes in the bloodstream and within the lung itself impact immunity. "In addition, we can evaluate the role of cells that are resident in the lungs and those circulating inside the bloodstream in order to evaluate how differences in age and infection experience affect immunity." That deeper understanding of exactly how immunity against pneumonia works could help inform further studies on prevention and treatment, from improving vaccines to developing new therapeutics.

Nia (left) and Mizgerd won an award to advance research into pneumonia using a crystal rib cage.

Understanding Connections in the Brain

The brain is a complex network made up of thousands of cell types, each expressing a different set of genes. While these patterns of gene expression are associated with cellular connectivity, information processing, and susceptibility to disease, scientists still don't fully understand how they work. This year's other Kilachand Fund award winners intend to change that with a new approach to exploring how genes express themselves in the brain.

The traditional way of defining the impact of genetic expression on brain development and disease involves taking out one gene at a time from an animal and then seeing what happens. Does its brain wire up correctly or does it end up with a disease? "The downside of this classic approach is that it's just very, very slow," says Michael Economo (ENG'12), an ENG assistant professor of biomedical engineering. "And disease states often have multigenic sources, so isolating just one gene is limiting."

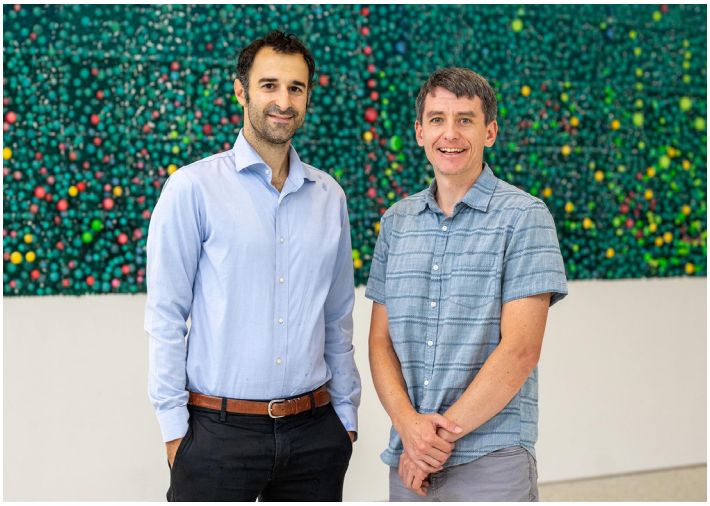
Instead, Economo and his colleagues are trying a novel investigative approach, building upon a technique called Perturb-Seq, which allows researchers to perturb (in other words, to prevent from working) multiple genes at once in a bunch of cells. The team's goal is to pool technologies developed in their respective labs to create a new toolkit—a platform they call Spatial Interrogation of Neurons and Genes, or SING—for better understanding connections in the brain.

The investigators will work to interpret not just how the manipulation of genes changes gene expression, but also how these changes impact cell connection and disease progression. "This is a very enabling technology that builds upon new developments across a number of different domains, including in experimental neuroscience, molecular genetics, virology, and more," says Economo, who is leading the project with Jerry Chen, a BU College of Arts & Sciences associate professor of biology, and Brian Cleary, a Faculty of Computing & Data Sciences assistant professor.

The trio views its work as potentially applicable "for investigating a large number of problems across domains, including the development of the normal functioning of the brain, how the brain wires its connectivity, and what happens in disorders of the nervous system," says Economo. "We're trying to attack those problems in a way that hasn't been possible before."

The research being done by Economo, Chen, and Cleary is high risk, but has the potential for big rewards—it's very new, highly interdisciplinary, and could open up lots of fresh ground for other researchers. The team has been awarded $250,000 per year for up to two years.

"Federal funding agencies are so often hesitant to support this kind of research," says Economo, "but funding from the Kilachand award has been vital for seeding so many new ideas across multidisciplinary interests and expertise. We couldn't do this work without the fund's help."



Economo (left) and Cleary are working with Chen (not pictured) to give researchers a new tool kit for studying connections in the brain.

INNOCENT MOLE OR SKIN CANCER? FDA CLEARS DEVICE WITH BU-DEVELOPED TECHNOLOGY THAT MAKES DETECTION EASIER

DERMASENSOR USES OPTICAL TECHNIQUE PIONEERED BY BU BIOMEDICAL ENGINEER IRVING J. BIGIO AND COULD CUT NUMBER OF MISSED CANCERS BY HALF

by Andrew Thurston for *The Brink*

Maybe it's just a funky-looking, unique-to-you mole. But that irregular patch or evolving mark could signal bad news: skin cancer, the most common form of cancer in the United States. Although spotting skin cancer early could save your life, it can be tough for even some medi-

The DermaSensor uses technology developed by BU's Iriving J. Bigio. Photo courtesy of BU College of Engineering

cal professionals to judge if a mark is benign or potentially harmful. A new noninvasive skin cancer detection device—powered by technology pioneered by a professor at Boston University's College of Engineering—aims to make telling the difference easier and faster.

The US Food & Drug Administration recently cleared for US markets DermaSensor, which uses light and artificial intelligence to examine skin lesions and assess whether a patient should be referred to a specialist. The company bringing the handheld device to market says it has the potential to slash the number of missed skin cancers by half. DermaSensor's underlying sensing technology, elastic scattering spectroscopy (ESS), was developed and refined by Irving J. Bigio, an ENG professor of biomedical engineering and of electrical and computer engineering. He's a scientific advisor to the eponymous company behind the device, which also licensed patents from Bigio and BU.

"The FDA had designated this as a breakthrough technology, which means they gave it higher priority for review because they see it as having a real impact," says Bigio. "And the trials showed that it actually does work."

Bigio says DermaSensor's clearance doesn't just reflect well on his Biomedical Optics Lab, but also on BU's cross-disciplinary approach to fostering new technologies.

The DermaSensor uses technology developed by BU's Irving J. Bigio. Courtesy of BU College of Engineering

"It's a positive statement about BU's commitment to interdisciplinary research that involves the engineering and physical sciences, as well as the medical school," says Bigio, who also holds positions in BU's Chobanian & Avedisian School of Medicine and College of Arts & Sciences physics department. "They are supportive of collaborative research across schools."

According to the American Academy of Dermatology Association, one in five of us will grapple with skin cancer at some point in our lives, which is why it recommends regular skin exams. In its pivotal FDA study—the research that makes or breaks a new clinical technology—DermaSensor says researchers found the device had "a sensitivity of 96 percent across all 224 skin cancers." It can detect the most frequent forms of skin cancer—basal cell carcinoma and squamous cell carcinoma—and the less common, but more deadly, melanoma.

Bigio first began working on ESS as a senior research scientist in New Mexico at Los Alamos National Laboratory, and continued to advance it when he joined BU in 2001. An optical technique, ESS involves directing pulses of light at tissue, then scrutinizing which colors of light bounce back to reveal important information about cellular and subcellular structures. In the case of DermaSensor, the light can reveal whether tissue is potentially cancerous, as malignant and benign lesions scatter light differently. Bigio says it works equally well on different skin tones.

"The word elastic means that the light scatters but doesn't change its wavelength; on the other hand, how efficiently it scatters and in what direction it scatters does depend on the wavelength," says Bigio. "And that wavelength dependence is informative about the size and density of the microscopic structures in the tissue."

In the clinic, a physician or nurse puts the tip of the DermaSensor on a lesion. The device then fires off a pulse of light and analyzes the spectral information of the backscattered light using an AI-powered algorithm. Eladio Rodriguez-Diaz (ENG'09), a former PhD student in Bigio's lab, developed much of the sensor's machine learning and data analysis technology; he's a coinventor on some of the patents.

"It's incredibly gratifying to see Dr. Bigio's innovative research incorporated into an FDA-cleared medical device, especially one with the potential to noninvasively detect skin cancer," says Frances Forrester, director of business development in BU Technology Development. "Early detection is known to save lives, and now a new tool is available to US-based primary care providers and their patients through BU research."

According to Bigio, many potentially cancerous lesions are currently missed in primary care clinics—something DermaSensor could help change. He gives the scenario of a patient who spots a concerning mark on their body

The DermaSensor was given a priority review by the FDA, because "they see it as having a real impact," says BU's Irving J. Bigio. Photo courtesy of DermaSensor/Business Wire

and asks their doctor to take a look.

"If it looks suspicious, they'll send the patient to the dermatologist, but of patients who are referred to the dermatologist, only one out of 18 to 20 actually have cancer, or precancer," says Bigio. "But of the patients who present in the primary care setting who actually have skin cancer, only half are currently being referred."

Bigio says the device is the first consumer-facing medical product using ESS to hit the market, but that he and his clinical collaborators have spent decades testing the technology's potential in other fields. In multiple National Institutes of Health–funded studies, they've shown it could help pinpoint the locations of tumors, measure the effectiveness of cancer medications, detect malignant thyroid nodules, and differentiate normal from abnormal polyps during a colonoscopy. In some cases, he says, that research is ready to make the jump from the bench to the bedside—they just need to find the right commercial partners to take things to the next level, as DermaSensor has done.

"I think the DermaSensor success in getting FDA clearance, and some initial commercial success that I'm quite confident is going to come now, will be the rising tide that floats other boats," says Bigio. "Once investors or med tech companies see this, they're going to take a stronger interest. And we're already starting to see that in what we've been doing for interventional radiology and intravital measurements in various organs."

WHEN CUTTING-EDGE MICROSCOPES MEET DEEP LEARNING ALGORITHMS

LEI TIAN'S COMPUTATIONAL IMAGING SYSTEMS GROUP IS CALCULATING NEW WAYS TO SEE MOLECULES, CELLS, AND LIFE IN ACTION

by Kat McAlpine, Research images provided by Lei Tian, Photos by Kelly Peña

Lei Tian – a faculty member at BU's Photonics Center and a BU College of Engineering (ENG) assistant professor of electrical and computer engineering – has spent his career harnessing physics, electronics, and optics to create new imaging systems capable of applications ranging from the enormous (illuminating the flow of massive oil spills within oceanwater) to the minute (detecting precise cellular activity within biological tissues).

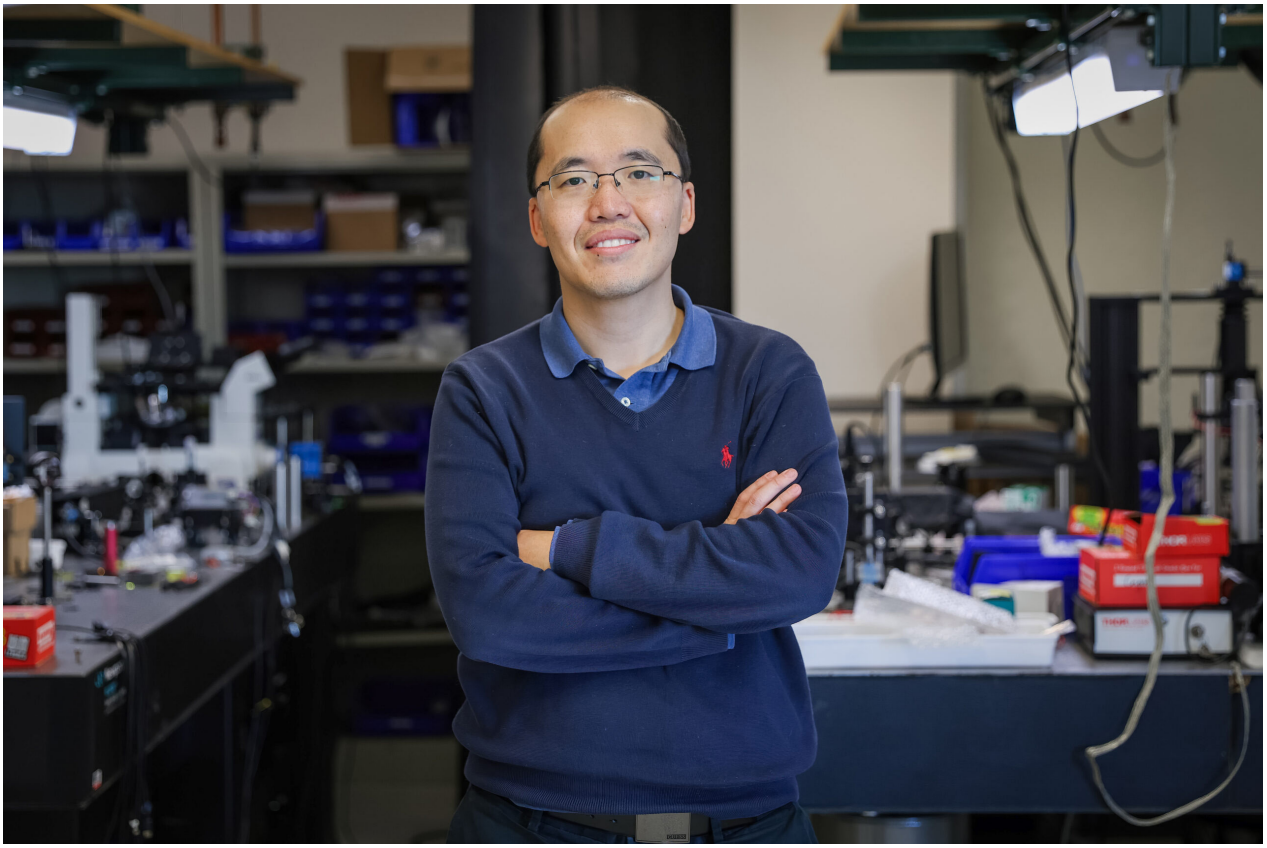
He credits holography – which manipulates laser light to display 3D images – as his entry point into the field of computational imaging at a time when it was still a nascent idea, while he was earning his PhD at Massachusetts Institute of Technology (MIT). There, he was focused on digital holography, employing sensors to capture real 3D information and then reconstructing objects computationally by modeling the way light diffracts through space.

Using that approach to develop holography systems for submersible vehicles, Tian recalls that the 2010 Deepwater Horizon oil spill added a new layer of interest and urgency to his work. "We wanted to design better 3D cameras for large-scale applications" like detecting where the oil had spread throughout ocean columns and currents, he says.

Working on the macroscale, however, led to a new inspiration. "We also realized these techniques would be good for looking at very, very small things on the microscopic scale."

After completing his PhD, he pursued postdoctoral work at University of California, Berkeley, where he developed computational microscopy techniques for imaging cells, leveraging tiny distortions of light that happen as it travels through cells.

Since then, Tian's passion for inventing novel computational microscopy tools has been ablaze. Upon arriving at BU in 2016 to start his own lab, "all my projects, both large and small, focused on microscopy." Now, leading BU's Computational Imaging Systems Lab (CISL), Tian is making incredibly powerful and extremely small new types of microscopes possible – with the goal of visualizing how cells and the brain's neurons communicate and behave with higher resolution and clarity.



"Through computational imaging, we are augmenting imaging hardware with advanced algorithms to increase what microscopes are capable of capturing," Tian says. "Harnessing deep learning to understand the way light travels through space, the way light travels through tissue… that's the special sauce of what we're doing."

And it's taking a village of research partners. "It's a nexus of research that's bringing together many different people – to solve big problems like this, understand and construct the hardware, and computationally extract and analyze gigantic amounts of information, we need people from all these different backgrounds."

Tian received a Dean's Catalyst Award from ENG, which promotes such cross-disciplinary research, that helped him launch a hub of collaborations. CISL has stretched its tendrils into a network of collaborations across BU's Charles River and Medical campuses. Tian is affiliated with BU's Department of Biomedical Engineering, the Neurophotonics Center, the Center for Information and Systems Engineering (CISE), the Hariri Institute for Computing and Computational Science and Engineering, and the Nanotechnology Innovation Center.

The lab's goals have evolved to be "about 80 percent focused on neuroscience applications," Tian says, crediting the support of David A. Boas, director of BU's Neurophotonics Center, and research partnerships with BU Neurophotonics faculty members Jerry L. Chen and Ian G. Davison as essential to his team gaining momentum in brain science applications, which Tian had no prior experience in.

These days, CISL's work is getting noticed near and far.

In January 2023, Tian's Computational Imaging Systems Lab was awarded more than $1.3 million over two and a half years in funding from the Chan Zuckerberg Initiative (CZI), part of a grant program that backs advancements in monitoring biological processes in motion and across time and space. With the CZI support, the team is designing miniaturized microscopes that can image whole mouse brains at single-cell resolution, seeking to visualize molecular and cellular activity like never before.

Their petite, lightweight microscope designs are empowered by special miniaturized lenses to enable powerful imaging despite their compact size. Aboard each 'scope, the team typically employs an array of several microlenses to peer into samples from multiple angles, combining those readouts computationally to build 3D images of the brain.

They call their devices mesoscopes because they can achieve both single-cell imaging of neurons and a large field of view across brain tissue; the prefix "meso-" originates from the Greek word for middle, and used here it describes a mesoscope's ability to image both individual cells and whole tissues.

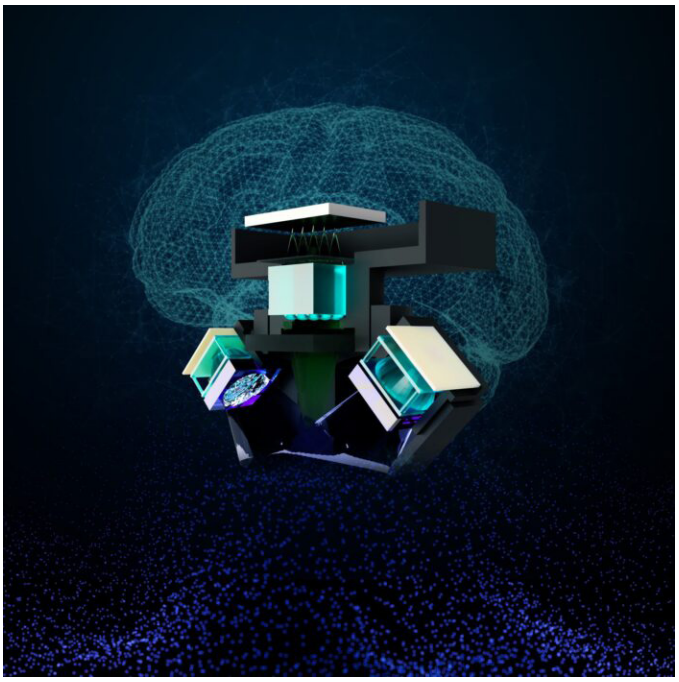
"We're building these as wearable devices for fundamental research in mice, with the goal that we can mount one of our mesoscopes on a mouse's head, allowing us to image neural activity across its entire brain as the mouse moves around and performs various behaviors," Tian

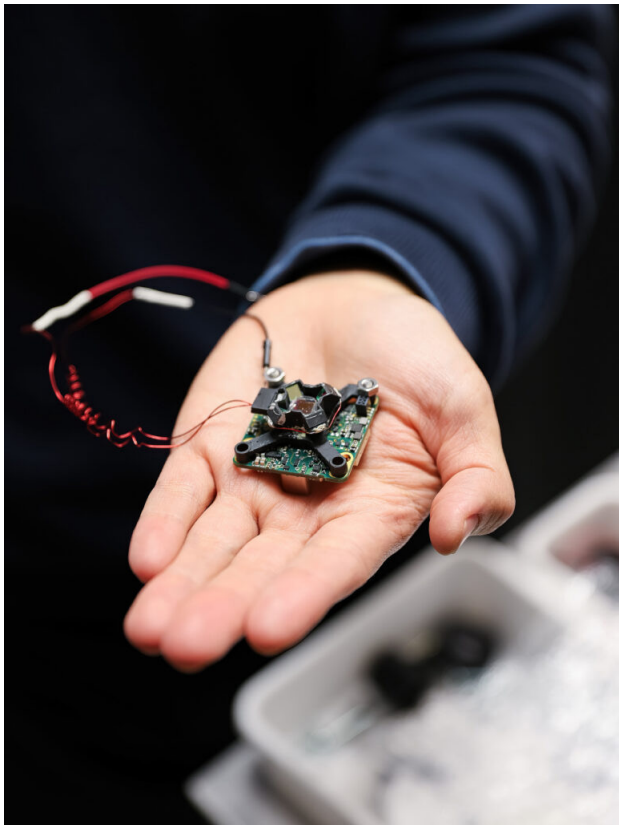
says.

Within his lab, teammates are working on several approaches to creating their miniaturized wearable microscopes. PhD student Joseph Greene is experimenting with different architectural designs of non-conventional optics and also investigating which algorithms best enhance their imaging capabilities. In May 2023, Tian and Greene were authors of a paper published in Neurophotonics describing a new low-cost, head-mounted miniscope that can capture images from deeper within mouse brain tissue using miniature diffractive optics and an algorithm that compensates for the effect of light scattering through tissue.

Meanwhile, Yujia Xue, a former Tian lab member (who earned his PhD and is now developing new cameras at Apple, Inc.), and Qianwan Yang, a current PhD student, have been dedicated to the algorithm and deep-learning aspect of microlens arrays, seeking to computationally extract the most 3D information from each sample as accurately as possible. In August 2023, Xue, Yang and Tian published a study in Optica describing a computational miniature mesoscope design that utilizes deep learning image reconstruction to achieve high resolution, wide-field microscopy.

In October 2023, Tian's team reported in arXiv an ultrafast imaging technique using single-shot, wide-field 3D imaging augmented with a sensor that detects changes in neural activity, or "events". It gives its readout in response to these events, rather than frame by frame like more conventional 'scopes. They further enhanced the information of the event-based readout by designing an algorithm to accurately interpret imaging data both spatially and in the context of time. In the lab, they demonstrated how this technique can capture clear and contextually rich images of freely moving C. elegans





worms. Tian and his co-authors say the method could have wide-ranging applications across biological and biomedical research.

Beyond fundamental research, Tian's lab is also closely collaborating with researchers at BU's Chobanian & Avedisian School of Medicine (MED), including faculty members Ann McKee, B. Russell Huber, and Jonathan Cherry, leaders at BU's dedicated research centers focused on Chronic traumatic encephalopathy (CTE), Alzheimer's, and other neurodegenerative diseases. Together, they're working to advance computational imaging systems and deep learning algorithms to image and interpret human brain data.

"We're building multi-scale datasets and looking to cover the entire human brain so that we can gain more insights into disease development and progression in people," Tian says. The collaborators envision that computational imaging could help pinpoint the exact location of molecules like tau proteins, the spread of which is a key catalyst in both Alzheimer's and CTE.

Undergraduate researcher Sunni Lin, who was mentored by former Tian lab member Shiyi Cheng, is using deep learning to extract new information from human brain images, essentially looking to map out structural data using digital – rather than traditional chemical – staining. (Cheng defended his thesis this year and is now at Apple, prototyping camera features and video algorithms.) Digital staining could simplify sample preparation, making neural imaging more broadly accessible to researchers with diverse training. It could also create more bandwidth within tissue samples for prioritizing other types

of labels and markers attached to molecules of interest.

"The focus on deep learning algorithms continues to grow within my group," Tian says. "We're not just using off-the-shelf datasets or general-purpose neural networks for training our [microscopy] algorithms. We're really trying to integrate as much physical knowledge as we can through experimental data – and that's the core philosophy of computational imaging, to synergistically combine algorithms with imaging methods."

Within the last year, Tian's team has also received funding support from the National Institute of Neurological Disease and Stroke at the National Institutes of Health, National Institute of Biomedical Imaging and Bioengineering, and Samsung.

BU'S INNOVATOR OF THE YEAR HAS PIONEERED DEVICES TO ADVANCE ASTRONOMY, MICROSCOPY, EYE EXAMS

PHOTONICS CENTER DIRECTOR THOMAS BIFANO RECOGNIZES FOR HELPING OTHERS NURTURE THEIR IDEAS AND FOR "ALWAYS TRYING TO SOLVE PROBLEMS"

by Andrew Thurston for *The Brink*, Photos by Jackie Ricciardi

The light from the stars filling the sky travels mind-boggling distances to reach us: the nearest star, beyond our own, is about 25 trillion miles from Earth. For most of its journey to our planet, that light is undisturbed, flying parallel and unimpeded through the vacuum of space. But then, in the very last microseconds, our atmosphere gets in the way, and the light bends.

If you're looking through a telescope, "the result is that the image is blurry, because not all of the light is getting to the right focus," says Boston University mechanical engineer Thomas Bifano.

For astronomers studying distant stars, blurry just won't cut it.

But Bifano created a solution: a mirror that can shift its surface as quickly as every millisecond to compensate for the atmosphere's fluctuating effect, pulling the image into focus. It's a technology, called MEMS (micro-electro-mechanical systems) deformable mirrors, that he's also used to improve eye exams, satellite communications, and imaging research—and that has now helped earn Bifano BU's Innovator of the Year award.

The director of the University's cross-disciplinary Photonics Center, Bifano is the 14th winner of the award, given to an "outstanding faculty member who has translated world-class research into an invention or innovation that benefits humankind." A holder of 10 patents, he's also chief technology officer of Boston Micromachines Corporation, a company he cofounded to develop and market deformable mirrors and other optics products.

Thomas Bifano, an ENG professor of mechanical engineering, is the cofounder of Boston Micromachines Corporation, a company specializing in deformable mirrors that he spun out of his BU lab 25 years ago.

"I'm deeply, deeply honored by the award," says Bifano, a BU College of Engineering professor of mechanical engineering. "But I'm also aware that my advocacy for others is partly responsible for why I've been chosen."

As head of the Photonics Center—which is a hub for the study of light and development of technologies utilizing it—Bifano has helped many others nurture their own innovations. The center is home to 70 faculty research labs and the Business Innovation Center, which hosts tech, biotech, manufacturing, and medical devices start-ups and corporations.

"Tom's leadership at Boston Micromachines, where he solves real optics problems, and his role in connecting innovative research groups across the University via the Photonics Center, demonstrate his ability to think creatively and foster interdisciplinary collaboration," says biotech entrepreneur David Freedman (ENG'10), whose first company, NanoView Biosciences, was incubated and funded through the Photonics Center. Freedman is now back on campus, using the Business Innovation Center to cultivate his latest start-up, Everest Biolabs.

"Tom's ability to balance risk-taking with practicality and his commitment to fostering innovation make him a role model for success," he says. "He has his own innovative track record, but also creates an ecosystem of innovation."

Playing, Discovering, Failing, Solving

Before Bifano's MEMS deformable mirrors, existing peer technologies for bending light were big, expensive, and drained lots of power. That meant they were mostly only viable in large instruments—think a hulking telescope in a desert rather than a small microscope in a lab. His innovation was leveraging microfabrication techniques used for making microscopic objects—like inkjet printer nozzles—to develop tiny mirrors moved by electrostatic actuators. By creating deformable mirrors that were smaller, faster, cheaper, and more efficient, Bifano vastly opened up their range of applications.

He spun Boston Micromachines out of his lab in 1999 and says the company hitting its quarter of a century mark is gratifying—and not just because of the impact its technologies have had on astronomy, healthcare, and more.

"I've watched the employees there grow and raise their children, put them through college," says Bifano. "And the reason they've been able to do all those things, to have lives that are meaningful and useful, is a direct result of the innovations that we made here at BU."

One of those who has been at Boston Micromachines from the start is Paul Bierden, its president and CEO. A former student in Bifano's lab, Bierden (ENG'92,'94) helped him found the company.

"I have known Tom since I was 18 years old. He has been a teacher, a mentor, a business partner, and a friend," says Bierden. "He is a true engineer, which in my opinion, is that he is always trying to solve problems.

"Tom has always instilled in me to not be afraid to try something new. Dive into a problem, break things, flip switches, turn knobs, learn from your mistakes, and try again."

Those lessons in innovation are ones Bifano continues to share today, encouraging students to roll with the failures, to keep playing and discovering—but to also focus on the end goal.

"I tell my students early on—and the ones who grasp it do much better than the ones who don't—that you need to own the problems you're working on," he says. "You're not working on it because somebody assigned it to you, you own it, it's yours. The motivation is not to satisfy me or your doctoral committee, it's to knock down the problem. "You're not really a good engineer unless the things you do turn into helpful benefits for society."

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NPC Faculty Collaborative Publications

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NPC Faculty Collaborative Grants

The table below summarizes the NPC Center, New Collaborative, and Ongoing Collaborative grants. Additional grants to NPC Director Boas are included as well as they contribute to the resources of the Center that are made available to NPC members through the 2023 and 2024 academic years.

PI	Award Title	Sponsor	Funds Awarded FY24
BIGIO, IRVING; Rosene, Doug	OPTIMIZATION AND VALIDATION OF QUANTITATIVE BI-REFRINGENCE MICROSCOPY FOR ASSESSMENT OF MYELIN PATHOLOGIES ASSOCIATED WITH COGNITIVE IMPAIR-MENTS AND MOTOR DEFICITS IN YOUNG AND OLD AGING MONKEY BRAIN	NIH	$559,055
BOAS , DA-VID	TIME-GATED DIFFUSE CORRELATION SPECTROSCOPY FOR FUNCTIONAL IMAGING OF THE HUMAN BRAIN	NIH	$102,424
BOAS , DA-VID	THE NEUROSCIENCE OF EVERYDAY WORLD- A NOVEL WEARABLE SYSTEM FOR CONTINUOUS MEASUREMENT OF BRAIN FUNCTION	NIH	$2,577,580
BOAS , DA-VID	NEUROPHOTONIC ADVANCES FOR MECHANISTIC INVES-TIGATION OF THE ROLE OF CAPILLARY DYSFUNCTION IN STROKE RECOVERY	NIH	$662,228
BOAS , DA-VID	BRAIN CONNECTS: MAPPING CONNECTIVITY OF THE HU-MAN BRAINSTEM IN A NUCLEAR COORDINATE SYSTEM	NIH	$105,255
BOAS , DA-VID	BRAIN CONNECTS: THE CENTER FOR LARGE-SCALE IMAG-ING OF NEURAL CIRCUITS (LINC)	NIH	$17,929
BOAS , DA-VID	LOW-COST HIGH-PERFORMANCE NIRS-SCOS DEVICE FOR NON-INVASIVE MONITORING OF CEREBRAL BLOOD FLOW AND INTRACRANIAL PRESSURE IN TRAUMATIC BRAIN INJURY	NIH	$114,927
CHEN, JERRY	BRIDGING FUNCTION, CONNECTIVITY, AND TRANSCRIP-TOMICS OF MOUSE CORTICAL NEURONS	Allen Institute, d/b/a Allen Institute for Cell Science	$278,884
CHENG, JI-XIN	SUB-MILLIMETER PRECISION WIRELESS NEUROMODULA-TION USING A MICROWAVE SPLIT RING RESONATOR	NIH	$206,250

NPC Faculty Collaborative Grants

PI	Award Title	Sponsor	Funds Awarded FY24
CHENG, XIAOJUN; Boas, David	A TRANSFORMATIVE METHOD FOR FUNCTIONAL BRAIN IMAGING WITH SPECKLE CONTRAST OPTICAL SPECTROSCOPY	NIH	$417,289
DEVOR, ANNA	EFFECTS OF INTRINSIC AND DRUG-INDUCED NEUROMODULATION ON FUNCTIONAL BRAIN IMAGING	NIH	$370,026
DEVOR, ANNA	LOCAL NEURONAL DRIVE AND NEUROMODULATORY CONTROL OF ACTIVITY IN THE PIAL NEUROVASCULAR CIRCUIT	NIH	$2,520,076
DEVOR, ANNA	METABOLIC AND NEURAL ACTIVITY NORMALIZATION BY CEREBRAL BLOOD FLOW INCREASE IN AD/ADRD MODELS	NIH	$475,500
ECONOMO, NICHOLAS MICHAEL	REVERSE ENGINEERING THE BRAIN STEM CIRCUITS THAT GOVERN EXPLORATORY BEHAVIOR	NIH	$86,613
ECONOMO, NICHOLAS MICHAEL	ILLUMINATING THE MOLECULAR MECHANISMS OF MEMORY FORMATION DURING BEHAVIOR	The Kavli Foundation	$55,000
FERRE, CLAUDIO	CODEVELOPMENT OF SENSORY AND MOTOR FUNCTION IN INFANTS AT RISK FOR CEREBRAL PALSY	NIH	$210,600
HOWE, MARK	STRIATUM WIDE DYNAMICS AND NEUROMODULATION OF CELL-TYPE SPECIFIC STRIATUM POPULATIONS DURING LEARNING	NIH	$608,771
HOWE, MARK	MAPPING THE MODULATORY LANDSCAPE GOVERNING STRIATAL DOPAMINE SIGNALING AND ITS DYSREGULATION IN PARKINSON'S DISEASE	University of Oxford	$578,852
MERTZ, JEROME	MULTI-LAYER NEURONAL IMAGING WITH REVERBERATION MULTIPHOTON MICROSCOPY	NIH	$388,501

NPC Faculty Collaborative Grants

PI	Award Title	Sponsor	Funds Awarded FY24
NIA, HADI	UNCOVERING CELL INTRINSIC AND EXTRINSIC FACTORS GOVERNING MELANOMA DORMANCY AT SINGLE-CELL RESOLUTION	DOD	$646,252
NIA, HADI	DEVELOPMENT OF CRYSTAL RIBCAGE FOR IMAGING OF FUNCTIONING LUNG AT HIGH SPATIOTEMPORAL RESOLUTION	The Arnold and Mabel Beckman Foundation	$150,000
O'SHEA, MARK	INTRAVITAL IMAGING OF TRANSPLANT EVOKED GLIA REPAIR IN STROKE	NIH	$206,250
O'SHEA, MARK	NANOTHERAPEUTICS FOR TARGETED GLIAL CELL DRUG DELIVERY	NIH	$247,500
O'SHEA, MARK	REGULATING PARENCHYMAL REPAIR IN WOUND HEALING	NIH	$412,500
O'SHEA, MARK	GLIA REPAIR OF CHRONIC SCI LESION CORES BY A SEQUENTIAL ENZYMATIC DEBRIDEMENT AND CELL GRAFTING STRATEGY	Wings for Life	$108,400
RAMIREZ, STEVE	THE EFFECT OF ADOLESCENT DRUG-INDUCED NEUROIMMUNE SIGNALING IN SEX-SPECIFIC SOCIAL DEVELOPMENT AND REWARD LEARNING	Albany Medical College	$12,198
RAMIREZ, STEVE	DISCOVERING PRINCIPLES OF MEMORY STORAGE, RETRIEVAL, AND RESTORATION	DOD	$1,378,172
SCOTT, BENJAMIN	THE ROLE OF THE LOCUS COERULEUS-NOREPINEPHRINE SYSTEM IN FLEXIBLE DECISION-MAKING	NIH	$371,250

NPC Faculty Collaborative Grants

PI	Award Title	Sponsor	Funds Awarded FY24
SCOTT, BENJAMIN	UNDERSTANDING THE MULTIPLE TIMESCALES OF NEUROMODULATION USING THREE PHOTON INSTANT FILM	Research Corporation for Science Advancement	$55,000
SEN, KAMAL	NCS-FR: ENGINEERING BRAIN CIRCUITS FOR COMPLEX SCENE ANALYSIS	NSF	$2,961,895
TIAN, LEI	COMPUTATIONAL MINIATURE MESOSCOPE FOR CORTEX-WIDE, CELLULAR RESOLUTION CA2+ IMAGING IN FREELY BEHAVING MICE	NIH	$400,125
YOUNGER, MEG	NON-CANONICAL ODOR CODING IN MOSQUITOES	The Smith Family Foundation	$133,000

TOTAL: $17,418,302

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