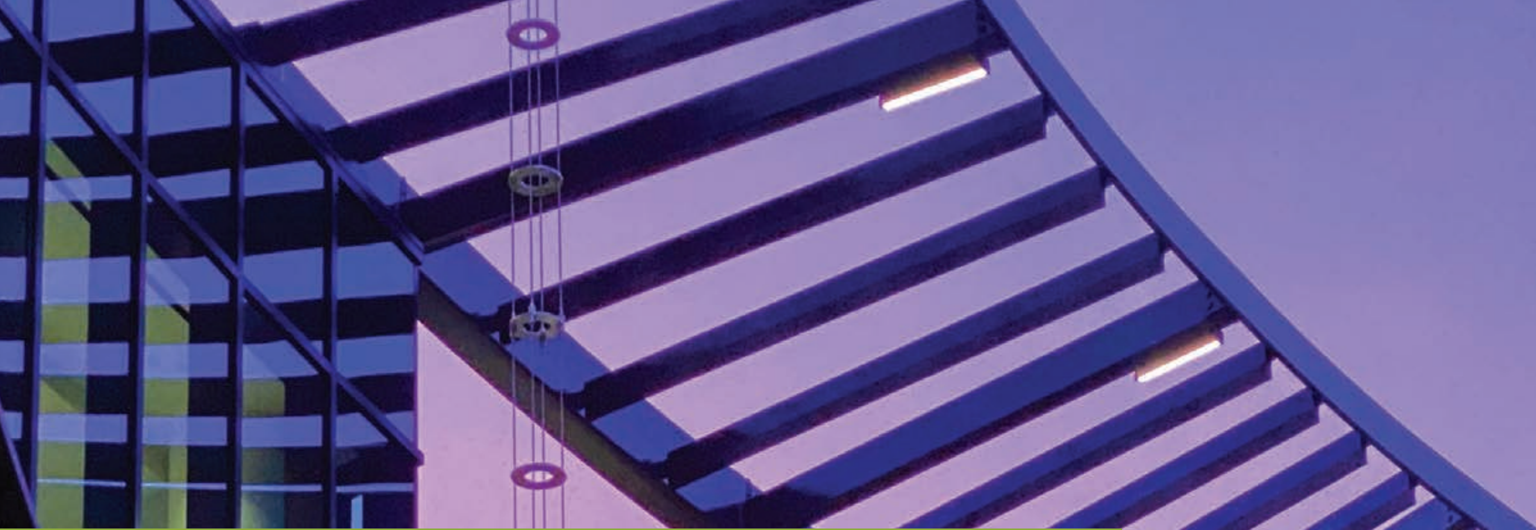


Wu Tsai Neurosciences Institute

AR

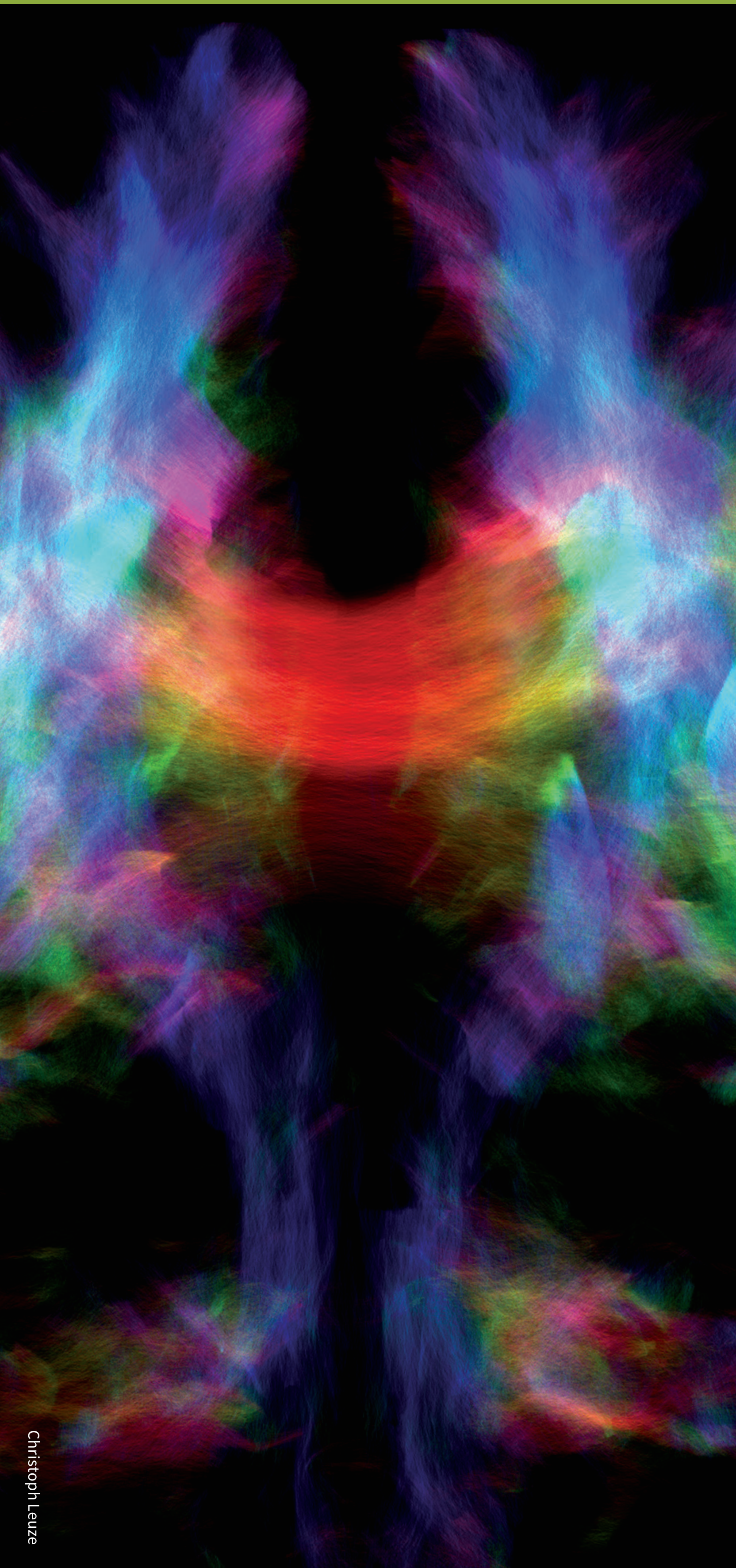
SEPTEMBER 2019
–
AUGUST 2020

A Challenging and Unusual Year

Wu Tsai Neurosciences Institute
Stanford University

“The opening of this complex heralds a new era of scientific collaboration and discovery on campus. The Stanford ChEM-H Building and the Stanford Neurosciences Building will be accessible to the whole university community, allowing experts from different disciplines to work together in advancing human health. We are deeply thankful for the extraordinary generosity of those who are making this visionary complex and these transformative opportunities possible.”

Marc Tessier-Lavigne
President, Stanford University



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< Diffusion MRI of the human brain

Our Mission

The Wu Tsai Neurosciences Institute is dedicated to understanding how the brain gives rise to mental life and behavior, both in health and in disease. Our research community draws from and informs multiple disciplines, including neuroscience, medicine, engineering, psychology, education and law. The discoveries that arise from these collaborations will transform our understanding of the human brain, provide novel treatments for brain disorders and promote brain health throughout the lifespan. Neuroscience is at an inflection point in its history. New technologies are transforming scientists' abilities to explore the brain—yielding more detailed images of its cells, more accurate measurements of its activity, and more precise ability to model its functions than ever before. With these new approaches have come astounding new insights about the exquisite complexity of the brain. The Wu Tsai Neurosciences Institute is at the forefront of this exploration.

Drawing from and Informing Multiple Disciplines

- **Neuroscience**
- **Medicine**
- **Engineering**
- **Psychology**
- **Education**
- **Law**

Collaborative Discoveries Create Positive Change

- **Transforming our understanding of the human brain**
- **Providing novel treatments for brain disorders**
- **Promoting brain health throughout the lifespan**

William Newsome

November 10, 2020

MY PREDOMINANT RETROSPECTIVE THOUGHT ABOUT THE PAST YEAR is obvious: it has been one hell of a year! As 2020 dawned, we looked forward to an unprecedented year of opportunity for neuroscience at Stanford, including dedication of the new Stanford Neurosciences building, moving 18 labs into it, and creating community labs that would serve the entire campus as a hub of creativity and dissemination of cutting edge neuroscience technologies.

Little did we know. In March, only a month after the building dedication, the true magnitude of the COVID crisis crashed upon us, with shelter-in-place orders that emptied our campus! In one of the greatest ironies of my life, my first duty upon moving into the building—which I and so many others had worked on for six years—was to shut it down. Then, beginning in May, with wise guidance from Santa Clara County and Dean Kam Moler's office, we slowly and cautiously reopened, always putting health and safety first. As if the COVID challenge were not enough, we all experienced a clarion call to action on racial justice issues that emerged from tragic events in several of our cities in the spring, reminding us that we as a nation and as a local neuroscience community have unfinished business in this exceedingly important arena. Layered on top of this, our national political situation has been a source of tremendous stress and anxiety for many, to say nothing of the summer's rampant wildfires that provided an urgent reminder of the threat that climate change poses to the entire planet.

As we have ridden this roller coaster of a year, I have witnessed so many concrete instances of fortitude and hope for which I am deeply grateful. The exceedingly long hours of toil by university leadership—notably including the entire staff of the Dean of Research office—in guiding the entire campus through this extraordinary emergency…the gallantry and seriousness of purpose of individual faculty and lab members in shutting down the very scientific activity that we most love…the puckish good humor and faithful cooperation of our front-line scientists (postdocs and students, of course!) as the shutdown turned into months…the determination of each scientist to make the time count by creatively getting on with the work despite the obstacles…the care shown by community members for each other during difficult times… have all impressed me more than I can say. I admire and am deeply grateful for the grace, courage, and tenacity that all of the members of our university research community have shown during this trying time. This has been a testament to our strength and dedication.

Throughout it all, Wu Tsai Neuro has continued to pursue an ambitious agenda of breaking in a new building, establishing an essential culture of personal and laboratory safety in these extraordinary times, supporting the work of research teams under trying circumstances, administering our vital grant and fellowship programs, moving forward with our community labs (though at a reduced pace), and welcoming and ensuring the safety of new graduate students, postdocs and staff as they arrive on campus. I must recognize the extraordinary effort, grace and good cheer of Dr. Tanya Raschke and her Wu Tsai team during this year…we could not have done it without them!

We all know that there will be additional trying times in the coming year, but I am confident that Wu Tsai Neuro will weather them, and that our scientists will emerge on the other side as stronger, more focused researchers, with greater clarity of purpose for our lives and careers. Other generations of citizens and scientists have faced great challenges; we can rise to the great challenges of our own generation. We will make that journey together.

William T. Newsome, PhD
Vincent V.C. Woo Director
Harman Family Provostial Professor
Professor of Neurobiology

A Challenging and Unusual Year

It felt as though the entire world was turned on its head in 2020, and Stanford University and the Wu Tsai Neurosciences Institute's community of neuroscientists continue to be affected by the reverberations of the SARS-Cov-19 pandemic, catastrophic wildfires intensified by global warming, the renewed and heightened calls for social justice after the tragic deaths of George Floyd and Breonna Taylor, and the increasingly polarized national political arena. Nonetheless, in the 2020 academic year we had some shining moments, including the opening and dedication of the new Stanford Neurosciences Building, recruitment of a new faculty member, the launch of the NeURO undergraduate summer research program, the significant progress on our new neuroscience community labs and the establishment of our committee on diversity, inclusion, belonging, equity and justice.

Some Highlights

- **Dedication of the new Stanford Neurosciences Building**
- **Recruitment of a new faculty member**
- **Launch of the NeURO undergraduate summer research program**
- **Significant progress on our new neuroscience community labs**
- **Establishment of our committee on diversity, inclusion, belonging, equity & justice**

COVID-19 IMPACTS RESEARCH

Though the pace of scientific advances suffered setbacks as we curtailed on-site research activities in response to the Santa Clara County COVID-19 shelter-in-place order, we have gradually recovered most research operations, while maintaining social distancing, wearing masks, heightened cleaning and participating in oh-so-many zoom meetings. We have yet to fully realize the bustling and active community hub that our neurosciences building was purpose-built to be, but our resilient community members have displayed their deep commitment to neuroscience and to each other, going to great lengths to keep the community safe while resuming their experiments.

As the pandemic emerged, Wu Tsai Neuro faculty affiliates joined the research efforts to unravel the mysteries SARS-Cov-19. **Tony Wyss-Coray** (neurology) launched a project to investigate COVID-19 adaptive immune responses and neurotropism. **Anne Brunet** (genetics) began work on two projects. The first is to unravel the role of the immune system in the striking age dependency of severe COVID-19 symptoms. The second project aims to understand how the virus, which infects the lungs, can sometimes cause neurological manifestations, including stroke, headaches, and anosmia (lack of smell). **Michael Lin** tested a battery of existing drugs for activity against an essential SARS-CoV-2 protein, with the goal of identifying existing FDA-approved drugs that could serve as immediate treatments for COVID-19.

We are hopeful that because Stanford's COVID-19 case count remains very low, and to date there has been no transmission of the virus in research labs on campus, our cautious approach will allow our groundbreaking interdisciplinary research to continue. Our community is exploring new ways to connect, collaborate and learn. We are gathering in virtual spaces, holding seminars and symposia online, adapting our training programs and supporting each other in new ways to overcome this collectively challenging time. We look forward to once again hanging out in our building's shared living room space, assembling for conferences in the rotunda, and toasting scientific accomplishments at the pub.

Fontejon Photography

RESEARCH COMPLEX DEDICATION

In 2013, the founding year of the institute, the Wu Tsai Neuro Executive Committee developed their vision for an innovative new building that would encompass and nurture neuroscience research and serve as an intellectual hub for the broad neurosciences community on campus. It was therefore an exciting moment when, after several years of design and construction, the first labs began moving into the Stanford Neurosciences Building in November 2019. The Neurosciences Building is paired with the Stanford ChEM-H Building, forming a research complex located proximally to the School of Medicine, the Science and Engineering Quad, the developing Natural Sciences Quad, and the Clark Center.

The neurosciences building currently houses 19 faculty laboratories. Labs are grouped into neighborhoods of three to five faculty and their teams. Each neighborhood shares an open lab area and student seating, allowing for easy intermixing of teams and their scientific ideas and techniques. In addition, each neighborhood includes specialized lab support rooms designed to facilitate the research underway in the neighborhood.

A key premise for the design of the Neuro and ChEM-H buildings was that the complex would be more than just a collection of lab spaces. A survey of our occupants showed that scientists on average spend one third of their time "at the bench" doing experiments, one third of their time working at their desks, reading papers, documenting experiments and writing manuscripts, and the last third in other locations - predominantly meeting and collaborating. For the new building, Wu Tsai Neuro and ChEM-H wanted to create unique and inspirational spaces to facilitate collaboration. The end results are unique and beautiful living rooms. Light-filled, spacious, with soaring ceilings and furniture to encourage small groups, the living rooms invite researchers from the institute community to seek inspiration and share their ideas.

Another unique space is the Neurosciences Building's Theory Center. Designed as a building-within-a-building, the Theory Center sits in a prominent position in the Neuro living room. The Theory Center will house six faculty, whose labs will focus on developing theories about how the brain computes, applying artificial intelligence to our understanding of the brain, seeking ways for natural intelligence to improve computer models and devising innovative computational and statistical methods for integrating, mining and interpreting the mountain of neuroscience data being generated by researchers. By visibly embedding theorists in the midst of experimentalists, we are creating an environment that encourages collaborations and accelerates our understanding of the brain.

The new research complex also includes meeting spaces for holding small meetings, large seminars and conferences, and informal collaborations. Its courtyard was the location of the building dedication ceremony in February 2020, and will be the site for many future events. We are also looking forward to winter 2021, when the pub will open at the complex. Get tha Fork Outta Here, a Black-owned BBQ business based in Oakland, will serve up hearty soul food for meat-eaters and vegetarians alike. This long-awaited eatery will attract people from across campus, contribute to increased dialog among scientists and hopefully fuel even more neuroscience discoveries.

DEVELOPING NEUROSCIENCE COMMUNITY LABS

The design of the Stanford Neurosciences Building included substantial spaces dedicated to neuroscience community laboratories. In alignment with Stanford's long range vision to enhance shared research platforms, Wu Tsai Neuro is making significant investments in communal spaces and resources to accelerate discovery and foster collaborations amongst researchers. These labs contain cutting-edge scientific equipment for experiments, but more importantly, will be run by highly trained expert staff who will teach, train and collaborate with our researchers. The Community Labs allow faculty and trainees to easily expand their repertoire of knowledge and techniques, widening the scope of scientific questions they can address and better enabling collaborations. Learn more about the Neuro Community Labs on page 26.

DIVERSITY AND SOCIAL JUSTICE

The tragic deaths this summer of George Floyd and Breonna Taylor resulted in protests that filled the streets and a national call to action to reckon with our country's long and ongoing history of racism. Our community of neuroscientists, spearheaded by our graduate students and postdocs, answered this call with new and reinvigorated efforts to address equality and social justice within Stanford. As part of these efforts, Wu Tsai Neuro developed our diversity statement and formed a committee on Diversity, Inclusion, Belonging, Equity and Justice charged with recommending antiracist actions and policies to counter systemic racism that permeates our society, academia and the neurosciences. Committee members—graduate students, postdocs, faculty, staff and an undergraduate student—decided to focus this year on improving equity and belonging for Black, indigenous and other people of color. Their first recommendations were presented to the Wu Tsai Neuro Executive Committee in November 2020, and longer term actions will be presented in April 2021. Early efforts include the inclusion of a diversity statement and evaluation rubric in all future grant and fellowship applications, and the creation of the BIPOC Emerging Leaders Of the Next Generation (BELONG) student association to build community and share the unwritten rules of science. We look forward to implementing these new programs and policies in 2021.

“These facilities provide a blueprint for the future of collaborative team science. Part of that plan is to arm researchers with advances in computing and imaging that will speed up the pace of discovery. Ten years from now, we’ll be able to look back and trace real breakthroughs to what these research buildings, and the Wu Tsai and ChEM-H institutes, made possible.”

Kam Moler, Vice Provost and Dean of Research

William Newsome

The New Stanford Neurosciences and ChEM-H Buildings

18
Undergraduate fellows immersed in the inaugural NeURO research program

31
New graduate students join the NeuroTech and MBCT training programs

5
Interdisciplinary Postdoctoral Scholars receive two-years of fellowship support

Sergiu Pasca

Building Community and Engaging Extraordinary People

NEUROENGINEERING PROFESSOR TODD COLEMAN RECRUITED

This year, Wu Tsai Neuro recruited Todd Coleman, PhD, in partnership with the Department of Bioengineering. Todd is trained in electrical engineering and neuroscience, and is currently a professor of bioengineering at UC San Diego. His lab is exploring ways to better understand and diagnose gastrointestinal (GI) malfunction and disease. His lab developed the high-resolution electrogastrogram (HR-EGG), which is a method of extracting features of gastric wave propagation using a noninvasive multi-electrode array. By non-invasively measuring the electrical signals and mechanical contractions of the stomach and small intestine, Todd's lab will work with clinicians to identify underlying GI problems in patients and improve their therapies. Todd will join Stanford in Fall of 2021, and his lab will be located in the Stanford Neurosciences Building.

FACULTY PROFESSORSHIPS AND SCHOLARS

Wu Tsai Neurosciences Institute has recruited talented interdisciplinary faculty to Stanford University to further broaden our research efforts and build new bridges between the subfields within our neurosciences community. We warmly welcomed their labs into the new Neurosciences Building in winter of 2020.

Tom Clandinin

Tom Clandinin, a Professor of Neurobiology, is the inaugural Shooter Family Professor and current Chair of the Department of Neurobiology. As Chair, Clandinin is spear-heading key recruitment efforts and supporting junior faculty to cultivate the next generation of faculty leaders. Clandinin's research traverses developmental and visual neuroscience as it seeks to understand how neuronal circuits assemble during development, are maintained during adulthood, and mediate the complex computations essential to animal behavior. His lab uses the fly visual system to model computation and develops new tools to dissect neural circuits at the cellular and molecular level.

Guosong Hong

Assistant Professor Guosong Hong's (materials science) lab leverages the latest materials advances to develop new tools to interface with the brain. The lab uses bio-compatible materials with unique electrical and optical properties to peek into the inner workings of the brain at the single-neuron level with minimum perturbation of the brain's intrinsic function.

Julia Kaltschmidt

Associate Professor Julia Kaltschmidt (neurosurgery) and her lab aim to understand the molecular basis of neuronal circuit formation, particularly those underling locomotion, sexual function and gut motility. They are shedding new light on the fundamental role that local inhibitory microcircuits have in shaping animal behavior, revealing the circuitry of the enteric nervous system in the gut, and are exploring the functional consequences of enteric nervous system abnormalities.

Scott Linderman

Assistant Professor Scott Linderman's (statistics) lab works at the intersection of machine learning and computational neuroscience, developing models and algorithms to better understand complex biological data generated by modern neuroscience tools. Recent work in the Linderman lab includes: state space models for simultaneous recordings of multiple neural populations, development of Neyman-Scott processes—a type of point process model—for discovering sequences in neural spike trains, and probabilistic models of larval zebrafish behavior.

FACULTY PROFESSORSHIPS AND SCHOLARS

Continued

Paul Nuyujukian

Assistant Professor Paul Nuyujukian (bioengineering, neurosurgery) leads the Brain Interfacing Laboratory, and is working to establish brain-machine interfaces as a platform technology for understanding and treatment of neurological disorders. The lab seeks to understand the causal relationships between multidimensional cortical dynamics and behavior. Collaborating with clinicians, Paul is improving the diagnosis and treatment of brain-related disorders such as stroke and epilepsy.

Daniel Yamins

Assistant Professor Dan Yamins's (psychology, computer science) research lies at the intersection of neuroscience, artificial intelligence, psychology and large-scale data analysis. The lab's approaches are unique in that they seek to use biology as inspiration to develop better artificial intelligence algorithms and, in turn, to use improved artificial intelligence algorithms to discover better models of how the brain works.

Fontejon Photography

Panelists Miriam Goodman, Justin Du Bois and Sergiu Pasca presenting at the dedication of the Stanford Neurosciences and ChEM-H Buildings

AWARDS AND HONORS

Wu Tsai Neurosciences Institute faculty are among the brightest leaders in neurosciences. In 2020, our faculty received many awards and honors in recognition of their scientific achievements.

Marc Tessier-Lavigne, Stanford University President, was awarded the 2020 Gruber Neuroscience Prize for his contributions to research on molecular mechanisms that control the growth of axons wiring the nervous system during embryonic development. The award recognizes Tessier-Lavigne's groundbreaking work on axon guidance processes in mammals and their role in spinal cord development. President Tessier-Lavigne used his prize money to establish a fund under Wu Tsai Neuro to provide financial assistance to neuroscience students of diverse backgrounds.

Michael Lim, MD, professor of neurosurgery, oncology, otolaryngology and radiation oncology at the Johns Hopkins University School of Medicine, was appointed chair of the Stanford University School of Medicine's Department of Neurosurgery. Lim assumed the post on Sept. 1, 2020. Lim succeeds **Gary Steinberg**, MD, PhD, who after 25 years as department chair will be stepping down to concentrate on his clinical practice, research and teaching.

In 2020, three Wu Tsai Neuro faculty affiliates were elected to the National Academy of Medicine: **Hongjie Dai**, the J.G. Jackson and C.J. Wood Professor in Chemistry, **Jeffrey Goldberg**, MD, PhD, professor and chair of ophthalmology and the Blumenkranz Smead Professor and **Fei-Fei Li**, PhD, professor of computer science and co-director of the Stanford Institute of Human-Centered Artificial Intelligence.

Fei-Fei Li (computer science) has been elected to the 2020 class of the National Academy of Engineering, She was among the 87 researchers nominated and chosen by their peers to join the academy, which is among the highest professional distinctions accorded any engineer.

Three Wu Tsai Neuro faculty affiliates were among the 120 newly elected members of the National Academy of Sciences. Election to the academy recognizes distinguished and continuing achievements in original research. **Howard Chang** is the Virginia and D. K. Ludwig Professor of Cancer Genomics and of Genetics (dermatology and genetics). **Chaitan Khosla** is the Wells H. Rauser and Harold M. Petiprin Professor in the School of Engineering (chemical engineering and chemistry), and Baker Family Co-Director of Stanford ChEM-H. In 2021, Khosla will become Director of the Innovative Medicines Accelerator initiative. The third inductee is **Richard Lewis** (molecular and cellular physiology).

In 2020, three Wu Tsai Neuro faculty affiliates were elected to the American Academy of Arts and Sciences, which honors exceptional scholars, leaders, artists and innovators engaged in advancing the public good. **Howard Chang** is the Virginia and D.K. Ludwig Professor of Cancer Genomics and of Genetics (dermatology and of genetics). **Thomas Clandinin**, the Shooter Family Professor, is a professor and chair of neurobiology. **Thomas Rando** (neurology and neurological sciences), is the director of the Glenn Center for the Biology of Aging at Stanford and of the Rehabilitation Research and Development Center of Excellence at the Veterans Affairs Palo Alto Health Care System.

The Royal Netherlands Academy of Arts and Sciences has awarded **Karl Deisseroth** (bioengineering and of psychiatry) its 2020 Dr. A.H. Heineken Prize for Medicine. The $200,000 prize is given biennially, in recognition of pioneering work in medicine, to a researcher whose achievements have led or are expected to lead to an important application in medical practice.

Professor **Andrea Goldsmith** (electrical engineering) has been awarded the 2020 Marconi Prize for her pioneering contributions to the theory and practice of adaptive wireless communications. Her intellectual breakthroughs have helped improve the cellular and Wi-Fi services upon which billions of people depend on daily. Goldsmith, the first woman to win the foremost honor in the field of information and communications research, is also honored for her leadership in increasing diversity and inclusion within the engineering profession.

After 21 years as a professor of electrical engineering at Stanford, **Andrea Goldsmith** (electrical engineering) has been named dean of Princeton University's School of Engineering and Applied Science, effective September 1, 2020.

Zhenan Bao, the K.K. Lee professor of chemical engineering at Stanford and chair of chemical engineering, has been named the first winner of the ACS Central Science Disruptors & Innovators Prize for her research into the molecular design of conducting polymers and their applications, including the creation of artificial electronic skin and other wearable medical electronic technologies.

Liqun Luo, the Ann and Bill Swindells Professor in the School of Humanities and Sciences and professor of biology, received an Award for Education in Neuroscience in recognition of his "outstanding contributions" to education and training in the field. Luo shared this year's award, which is presented by the Society for Neuroscience, with Yves De Koninck of Canada's Université Laval.

Guosong Hong, assistant professor of materials science and engineering and Wu Tsai Neuro Faculty Scholar, is the 2020 Science & PINS Prize for Neuromodulation finalist for his essay "Seeing the Sound." The prize, which has one grand prize and one finalist, is administered by Science and Science Translational Medicine.

2020 Interdisciplinary Postdoctoral Scholars

In neuroscience, like most biological disciplines, career training does not end with a PhD—trainees typically continue on to postdoctoral training. This can be a transformative time for young researchers, allowing them to adopt a more interdisciplinary approach to their science by selecting a lab in a new discipline to broaden their expertise or applying PhD knowledge from another field to neuroscience problems. Wu Tsai Neuro helps advance interdisciplinary neuroscience research by supporting these ambitious young scientists who challenge themselves and the traditional boundaries of their field. In 2020, we awarded five new outstanding postdocs our Interdisciplinary Scholar Awards, which include a two-year fellowship, and funds for experiments or travel. Our fellowship program is led by **Miriam Goodman** (Mrs. George A. Winzer Professor in Cell Biology and chair of molecular and cellular physiology). Wu Tsai Neuro's postdoctoral scholars meet regularly for career-building activities, to visit each other's laboratories and explore new areas of neuroscience, and to practice and improve their science communication skills. Thirty promising young neuroscientists have been awarded fellowships in the six years of the program, and our alumni have gone on to careers in academia, industry, nonprofit and government organizations. Wu Tsai Neuro's talented and innovative interdisciplinary scholars are highly sought after among universities recruiting new faculty.

Alex Williams (statistics)
Sponsor: Scott Linderman
Dr. Williams aims to develop statistical methods that identify functional ensembles, or sub-populations, of neurons that work together to encode animal behaviors and sensations.

Claire Bedbrook (bioengineering)
Sponsor: Karl Deisseroth
Co-sponsor: Anne Brunet
Dr. Bedbrook is studying how the brain controls longevity. She hopes to find genes, molecules, and behaviors that extend lifespan and improve health late in life.

Claire McLellan (materials science)
Sponsor: Jennifer Dionne
Co-sponsor: Miriam Goodman
Dr. McLellan's goal is to engineer a new type of mechanical force sensor to probe the sub-nanoNewton forces created and felt by neurons.

Shixuan Liu (chemical and systems biology)
Sponsor: James Ferrell
Co-Sponsor: Mark Krasnow
Dr. Liu aims to identify the molecules that control animal seasonal rhythms such as hibernation and seasonal reproduction cycles.

Sriram Jayabal (neurobiology)
Sponsor: Jennifer Raymond
Co-sponsor: Nicholas Melosh
Dr. Jayabal is exploring the neurobiological underpinnings of meta-learning (the ability to learn to learn) at the molecular, cellular and systems level.

2020 Stanford Interdisciplinary Graduate Fellows

Two SIGFs affiliated with Wu Tsai Neuro were awarded in 2020 to talented young neuroscientists.

Gustavo Chau (bioengineering)
Advisor: Jennifer McNab
Co-Advisor: Michelle Monje
Gustavo uses quantitative MRI to non-invasively probe white matter microstructural changes during epileptogenesis.

Katheryn Wu (neurosciences)
Advisor: Brad Zuchero
Co-Advisor: Wah Chiu
Kathryn uses advanced imaging techniques to probe mechanisms underlying the motility of Schwann cell protrusions during both sorting and myelination.

Sammy Kuo Awards

The Sammy Kuo Awards in Neuroscience honor the memory of Sammy Kuo, who died of a rare, progressive encephalitis in 2006, and recognize meritorious neuroscience research by postdoctoral and graduate student scientists at Stanford. Professor **Corinna Darian-Smith** (comparative medicine) announced the 2020 awardees at the Pioneering NeuroHealth Symposium in October 2020.

Sayaka Inoue (first prize for postdoctoral scholars)
Paper: *Periodic remodeling in a neural circuit governs timing of female sexual behavior*
(Cell, Volume 179, Issue 6)

Jiefu Li and Shuo Han (joint co-authors; first prize for graduate students)
Paper: *Cell-surface proteomic profiling in the fly brain uncovers wiring regulators*
(Cell, Volume 180, Issue 2)

Center for Mind, Brain, Computation and Technology

The Center for Mind, Brain, Computation and Technology (MBCT), founded in 2007 by professor **Jay McClelland** (psychology), continues to engage the community in a multitude of ways and to advance research at the intersection of neuroscience (including cognitive science and psychology), applied sciences and engineering.

This year the MBCT training program welcomed 23 new graduate students, for a total of 60 in the program, and the MBCT seminar series invited seven guest faculty, four Stanford faculty and four MBCT graduate student trainees to speak about their research. Additionally, the center's annual symposium was a community highlight, and included four esteemed neuroscientists from institutions around North America who presented their work on the theme "Learning: Cognitive, Neural and Computational Perspectives."

This year also saw the selection of our second cohort of graduate students for the NeuroTech training program, led by professors. **E.J. Chichilnisky** (neurosurgery), **Ivan Soltesz** (neurosurgery) and McClelland. This five-year, $3M research training grant from the National Science Foundation aims to propel neuroscience research by helping Stanford graduate students from the technical disciplines of engineering, physics, statistics and computer science become leaders in the emerging field of neurotechnology. The NeuroTech program encompasses a popular new neuroscience immersion course and graduate training seminar, and supports its partner departments in the effort to recruit and support promising students from underrepresented groups in STEM. The program's newest cohort of eight students is 75% female and 25% Latinx.

Stanford Undergraduate Neuroscience Society

Since its launch in the spring of 2018 by a small handful of enthusiastic undergraduates, our institute has supported the growth of the Stanford Undergraduate Neuroscience Society, which aims to bring together a community of students with a shared passion for understanding the mysteries of the brain and nervous system. In the two and a half years since it was founded, this group has expanded to become a university-recognized club of more than 600 students. Their professional development, social and research-related events, which are held throughout the year, regularly draw crowds of between 50 and 80 students. This past year the society also launched a popular Brain Buddies membership program, which allowed undergraduates without research experience to shadow researchers in neuroscience labs on campus.

TRAINEES AND TRAINING PROGRAMS
Continued

Neuroscience Undergraduate Research Opportunity

This year the institute launched a new program to support undergraduate research—the Neuroscience Undergraduate Research Opportunity (NeURO) fellowship. Designed particularly to meet the needs of students without previous access to research opportunities and those from underrepresented groups in STEM, the program includes a research fundamentals course, a neuroscience foundations course, and 10 weeks of full-time lab immersion. Despite the upheaval of Covid-19, the program was able to continue successfully by moving its courses and research opportunities entirely online, and supported an initial cohort of 18 fellows, 60% of whom were from underrepresented groups in STEM.

> "I am so proud to be part of this program and to call myself a NeURO fellow. I struggled all throughout undergrad to feel a sense of belonging within the research field, and at one point stopped considering it as a career option. The NeURO program allowed me the opportunity to dream of being a neuroscientist once again, and have the confidence to see myself as a scientist in the future. No other program has given me the support and confidence, both financial and professional, to pursue my love for neuroscience."
>
> **Anonymous NeURO Fellow**

Undergraduate Honors

Stanford student **Mustafa Fattah** '20 received the 2020 Marshall Scholarship.

After completing his Stanford studies in human biology and bioengineering, Fattah will pursue a master's degree in neuroscience at Cambridge University. "My focus has been on neuroscience, specifically on imaging neurodevelopmental disorders, and I can't wait to expand the scope of my neuroscience knowledge through the Marshall Scholarship," Fattah said. The California native applied for the Marshall Scholarship to engage with scholars in the U.K. and broaden his worldview.

COMMUNITY PROGRAMS

CONNECT Symposium with ChEM-H

On February 11, 2020, Stanford ChEM-H and Wu Tsai Neurosciences Institute jointly hosted a scientific symposium on the occasion of the official dedication of the new Stanford ChEM-H and Neurosciences Buildings. Over 300 attendees from both institutes met to hear from outstanding speakers in both neuroscience and chemistry. It was a wonderful opportunity for scientific interaction between the communities of both institutes prior to the dedication of the Stanford ChEM-H and Neurosciences Buildings, later that day.

Kevan Shokat (UCSF) spoke about strategies for drugging undruggable targets in oncology. Nobel laureate **May-Britt Moser** (Norwegian University of Science and Technology) spoke about the role of the entorhinal cortex in navigation and episodic memory. Stanford's **Alice Ting** (chemistry, biology and genetics) described molecular technologies for temporally-resolved calcium integration for tagging and manipulation of activated cellular ensembles. **Steve Ramirez** (Boston University) shared his work on artificially manipulating positive and negative memory engrams in healthy and psychiatric disease-like states. Finally, **Tony Wyss-Coray** (D.H. Chen Professor II, neurology) spoke about systemic regulation of brain aging and function.

Pioneering NeuroHealth Symposium

Despite not being able to gather in person, our community came together virtually on October 8, 2020 for our Seventh Annual Symposium, which was organized by **Marion Buckwalter** (neurology). We welcomed top neuroscientists to share their work on the theme of Pioneering NeuroHealth: **Michelle Monje** (Stanford), **Michael Kahana** (University of Pennsylvania), **Amy Bastian** (Johns Hopkins), **Walter Koroshetz** (National Institute of Neurological Disorders and Stroke), **Karen Parker** (Stanford), and **Todd Coleman** (University of California, San Diego). Following these presentations, we enjoyed watching a conversation between Stanford's President **Marc Tessier-Lavigne** and **Dr. Jim Simons** about effective philanthropy for promoting innovative translational research. At the symposium, we also celebrated outstanding research by our postdoctoral scholars and graduate students with the presentation of the Sammy Kuo Awards in Neuroscience (see page 15) by **Corinna Darian-Smith** (comparative medicine).

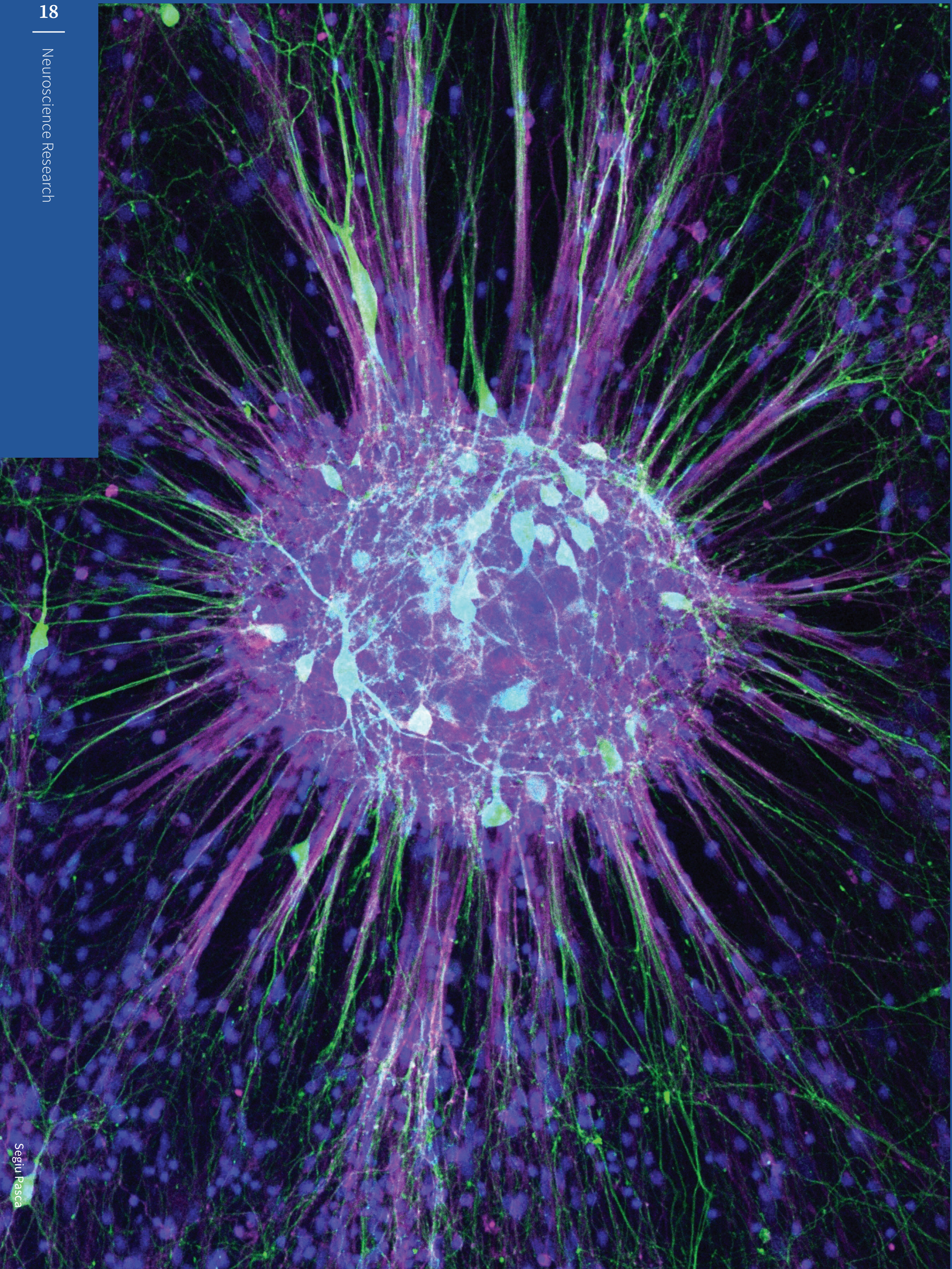
EPFL-Stanford Symposium on Neurotechnology

One of the silver linings of the COVID pandemic has been the new forms of interaction it has inspired among members of the scientific community. Though plans for an in-person EPFL-Stanford symposium had to be abandoned with the onset of the pandemic, we quickly pivoted to create an online symposium that was proudly "not another online webinar." Organizers **E.J. Chichilnisky** (John R. Adler Professor, neurosurgery and ophthalmology) and **Krisha Shenoy** (Hong Seh And Vivian W. M. Lim Professor, electrical engineering) cultivated a genuinely interactive experience and exploited the unique features of the videochat medium to encourage interaction and collaboration between Stanford and École Polytechnique Fédérale de Lausanne (EPFL) researchers. Sessions included thought-provoking talks by our EPFL colleagues **Mackenzie Mathis**, **Grégoire Courtine**, **Stéphanie Lacour** and **Alexandre Alahi**, interactive lab tours, student-guided discussions and curated conversations about the future of neurotechnology.

Seminars

Our weekly seminar series hosted 15 top scientists from across the country before the COVID-19 pandemic turned the world upside down. With national and international travel curtailed, Wu Tsai Neuro suspended our seminars in the Winter and Spring quarters. Our speakers' seminars will be rescheduled for the 2020-2021 academic year. This year's eminent speakers included: **Yukiko Goda** (RIKEN Center for Brain Science), **Bryan Roth** (University of North Carolina at Chapel Hill), **Patricia Janak** (Johns Hopkins University), **Vivek Jayaraman** (Janelia Research Campus - HHMI) and **Sophia Vinogradov** (University of Minnesota). Wu Tsai Neuro thanks **Jun Ding** (neurosurgery) for his leadership as chair of the seminar committee.

Fontejon Photography

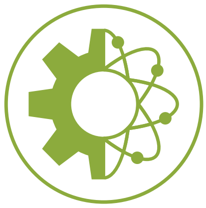

Segiu Pasca

Neuroscience Research

The research emphases of Wu Tsai Neurosciences Institute fall into three areas, encompassing our objective of fostering interdisciplinary research in the neurosciences broadly defined.

NeuroDiscovery

NeuroDiscovery applies cutting-edge techniques to make fundamental discoveries in brain science — discoveries that could unlock new medical treatments, transform education, inform public policy, and help us understand who we are.



NeuroEngineering

Understanding the complexity and dynamics of the human brain requires new tools and technologies. New tools will enable as yet unimagined discoveries and will allow us to repair and augment the human brain.

NeuroHealth

Our clinical scientists combine patient care with basic science research to pioneer novel treatments for psychiatric and neurological disease. Understanding the brain in health and disease will benefit individuals, families, and society.

Big Ideas in Neuroscience

Big Ideas are the Wu Tsai Neurosciences Institute's flagship research projects. Each initiative represents a big idea that could have a large impact on how we understand the brain. Our goal is to incentivize cross-disciplinary teams working on important neuroscience and to keep the Big Ideas program alive and evolving.

HUMAN BRAIN ORGANOGENESIS

Team Leaders: **Sergiu Pasca** (psychiatry) and **Karl Deisseroth** (D.H. Chen Professor, bioengineering)
NeuroHealth

The development of a bony skull to protect the fragile human brain was important for our survival as a species, but it creates a major challenge for neuroscience: we lack direct access to functioning human brain tissue for detailed investigation. Bridging campus-wide expertise in neurosciences, stem cell biology, engineering, chemistry, medicine and law/ethics, and leveraging unique technology developed at Stanford, this team aims to overcome this challenge by using stem cells to recapitulate neural development in a dish. These 'brain-in-a-dish' models are a non-invasive method to understand how human neurons communicate and identify what goes wrong when mental disorders develop. This team is committed to maximizing their impact by sharing their technology widely, which they did this year through an international hands-on course in January 2020, a seminar series, and a virtual symposium in September 2020. The team also endeavors to develop ethical guidelines, including the ethical, social and legal implications for this emerging field.

NEURODEVELOPMENT: ELUCIDATING THE DEVELOPMENT OF BRAIN STRUCTURE, FUNCTION AND COMPUTATIONS

Team Leaders: **Kalanit Grill-Spector** (psychology), **Jennifer McNab** (radiology), and **Daniel Yamins** (psychology)
NeuroDiscovery

Any parent knows that the first year of life is a time of unprecedented neurological development, however, the structural and functional brain

development that enables massive postnatal behavioral changes to happen is not well understood. This team of cellular and computational neuroscientists, bioengineers, and MRI experts, aims to address that gap in knowledge by focusing on development of the visual system from birth to one year. By combining their newly developed non-invasive imaging technology with traditional brain scans (electroencephalogram or EEG), the team can correlate anatomical measurements with visual function in the same infants. The team's novel techniques have already generated unexpected results suggesting that the level of myelination (thought to be an indicator of neuronal maturity) does not predict how fast a cluster of neurons will develop. The team is also using cutting-edge deep neural networks to model brain development, which they have shown can accurately predict neural responses seen in infants.

NEURO-OMICS

Team leaders: **Alice Ting** (genetics), **Liqun Luo** (Ann and Bill Swindells Professor, biology), and **Stephen Quake** (Lee Otterson Professor, bioengineering)
NeuroEngineering

This team of bioengineers, neurobiologists and molecular tool builders imagines a world where availability of tools isn't a limiting factor in how we ask questions about the brain. The "omics" revolution has allowed scientists to study many biological questions at the scale of all genes (genomics) and all their protein products (proteomics). This team aims to bring the omics revolution to the brain in hopes of bridging the molecular understanding of neurons with systems neuroscience, whose focus is on cellular ensembles that give rise to behavior. The suite of new tools and analysis methods that this team is developing will allow neuroscientists to interrogate what genes and proteins are produced in their favorite neuronal types, and what other neuronal types their favorite neurons connect with. The success of these efforts will help fill the chasm between our understanding of the brain at the level of genes and proteins on one hand, and circuits and systems on the other hand, with important clinical applications.

NEUROPLANT: LEVERAGING A BOTANICAL ARMAMENTARIUM TO MANIPULATE THE BRAIN

Team Leaders: **Thomas Clandinin** (Shooter Family Professor, neurobiology), **Miriam Goodman** (Mrs. George A. Winzer Professor in Cell Biology, molecular & cellular physiology), and **Seung Yon Rhee** (Carnegie Institute of Biology)
NeuroDiscovery

This team of neuroscientists, plant biologists, computational scientists, and chemical engineers aims to identify plant-derived chemicals that can be used to study the nervous system and treat disease. The team leveraged decades of knowledge about the genetics and neurobiology of the roundworm, C. elegans, to develop a high-throughput screening method and identify promising plant compounds. The team is now working to understand how identified compounds affect roundworm and human cells, by looking for the receptors that these plant-derived compounds act on. Understanding the lock and key style interaction of chemicals and receptors is a crucial step in harnessing these novel compounds for treating psychiatric disease. This team is driven by the potential of their novel screen to identify new psychiatric drug treatments - all current drugs were discovered or developed prior to or during the 1950's and 1960's.

BRAIN REJUVENATION

Team Leaders: **Tony Wyss-Coray** (D.H. Chen Professor II, neurology) and **Aaron Gitler** (genetics)
NeuroHealth

Aging leads to a precipitous loss of cognitive faculties and is the key risk factor for dementia and neurodegenerative diseases. Many new genetic factors causing neurodegeneration have been identified, but how they cause disease and how aging modulates disease is unknown. This highly collaborative team of engineers, neurologists, neuroscientists, chemists, geneticists, and stem cell biologists will tackle this problem by creating a campus-wide infrastructure to facilitate the study of brain aging and neurodegeneration. Current projects include: using a short-lived vertebrate model system (African killifish) to study aging and neurodegeneration, performing genome wide screens in human cells and neurons to define neurodegenerative disease mechanisms, and studying important modifications in human blood during aging. Together, the team aims to slow or reverse aging to maintain brain function and extend health span, to rejuvenate brains for the treatment of neurodegenerative and other neurological diseases, and to elucidate novel mechanisms of human neurodegenerative diseases.

NEUROCHOICE (OPTIMIZING CHOICE: FROM NEUROSCIENCE TO POLICY)

Team Leaders: **Brian Knutson** (psychology), **Keith Humphreys** (Esther Ting Memorial Professor, psychiatry), and **Robert Malenka** (Nancy Friend Pritzker Professor, psychiatry)
NeuroDiscovery

Our decisions define the quality of our lives as well as those of future generations. Understanding the links from neural circuits to individual choice to group choices could spark major advances both in basic neuroscience research as well as the application of neuroscience findings to enduring societal problems. This team of neuroscientists, clinicians, engineers, and public policy experts is examining addiction to deepen interdisciplinary understanding of the neural mechanisms supporting healthy and addictive choices. This team is combining conceptual, experimental, and clinical approaches to bridge historically disparate fields of inquiry. The team also engages with policymakers whose work on addiction might be informed by neuroscience evidence, and who might reciprocally help identify promising new issues poised to benefit from transformative research advances.

NEUROTECHNOLOGY INITIATIVE

Team Leaders: **Nicholas Melosh** (materials science) and **E.J. Chichilnisky** (John R. Adler Professor, neurosurgery, ophthalmology)
NeuroEngineering

Neural interfaces of the future will be used to treat a wide range of diseases for which there is yet no cure, ranging from sensory and motor degeneration to psychiatric disorders. However, present-day neural interfaces remain crude compared to the neural circuits in which they


L.A. Cicero

are embedded. This team is leveraging expertise in neuroscience, biomaterials engineering, nanofabrication, and integrated circuit design to develop the next generation of neural interfaces that match the resolution and performance of the biological circuitry. The team is focused on two signature efforts to spearhead the necessary advances: high-density wire bundles for electrical recording and stimulation, and analog and digital bi-directional retinal prostheses for restoration of vision.

Neuroscience:Translate Awards

The Wu Tsai Neurosciences Institute Neuroscience:Translate grant program supports translational neuroscience research. The goal is to encourage teams of researchers—typically clinicians paired with engineers—to address unmet needs in any area of neuroscience. The goal is to rapidly facilitate moving promising basic or clinical science discoveries into treatments, devices or software to improve people's lives.

DEEP LEARNING FOR AUTOMATED SEIZURE LOCALIZATION

Christopher Lee-Messer (neurology and pediatrics), **Daniel Rubin** (biomedical data science, radiology and medicine), and **Emel Alkim** (biomedical data science)
NeuroHealth

Current automated seizure detection software is slow, inaccurate and rarely precise enough for clinicians to rely upon. This team aims to use cutting-edge artificial intelligence methods to develop a powerful new algorithm that will enable better seizure diagnosis and treatment plan formation.

CPSTIM: OPTIMIZED NON-INVASIVE BRAIN STIMULATION FOR CHRONIC PAIN

Sean Mackey (Redlich Professor, anesthesiology), **Mark Schnitzer** (biology and applied physics), **Danielle DeSouza** (neurology), **Thomas Baer** (Ginzton Laboratory), **Simon Haziza** (biology), **Gregory Scherrer** (cell biology, University of North Carolina), and **Nicole Mercer Lindsay** (biology)
NeuroHealth

In light of the dual public health crises of chronic pain and opioids, there is an urgent need to develop non-addictive alternative therapies for chronic pain. This team's goal is to develop a new protocol for transcranial magnetic stimulation—a non-invasive method of neuromodulation—that is optimized for chronic pain treatment.

PTS GLOVE PASSIVE TACTILE STIMULATION FOR STROKE REHAB

Allison Okamura (mechanical engineering), **Maarten Lansberg** (neurology), **Caitlyn Seim** (mechanical engineering), and **Brandon Ritter** (mechanical engineering)
NeuroHealth

This team is developing wearable stimulation devices to improve limb function after stroke. The technology includes a tactile stimulation method, and the wireless, lightweight, and low-cost wearable computing devices to apply this stimulation. *This award is a renewal of a 2019 Neuroscience:Translate grant.*

TARGETING DNA REPAIR FOR NEUROINFLAMMATION IN STROKE

Eric Kool (George A. and Hilda M. Daubert Professor, chemistry) and **Katrin Andreasson** (neurology)
NeuroHealth

Acute brain inflammation after stroke and head trauma causes adverse health outcomes affecting millions of patients each year in the U.S., and current treatments are insufficient. This team will test a promising new therapy to reduce inflammation by targeting the enzyme OGG1, a potentially important controller of acute inflammatory responses. *This project is jointly supported by Wu Tsai Neurosciences Institute and SPARK.*

THE WEARABLE ENG: A DIZZY ATTACK EVENT MONITOR

Kristen Steenerson (otolaryngology and neurology), **Peter Santa Maria** (otolaryngology), and **Ada Poon** (electrical engineering)
NeuroHealth

Recurrent dizziness attacks are a debilitating condition for 10% of the population during their lifetime, and can lead to a complete inability to function, multiple hospital admissions and investigations chasing many potential diagnoses. This team aims to address the unmet need for means of tracking patients' specific symptoms, so that correct treatments can be identified that will improve patients' function and quality of life.

Seed Grants

In 2020, teams awarded the third round of Wu Tsai Neuro Seed Grants continued work on their projects. Seed Grants are 2-year awards, and our fourth round of funding will begin in early 2021. Despite setbacks in the spring due to COVID-19, research activity bounced back in Summer and Fall, and progress continues on these high-risk but high-reward interdisciplinary efforts.

GENETIC TOOLS TO DETERMINE CIRCUIT-SPECIFIC ROLES OF MYELINATION

Bradley Zuchero (neurosurgery), **Polly Fordyce** (bioengineering, genetics), and **Ivan Soltesz** (James R. Doty Professor of Neurosurgery and Neurosciences, neurosurgery)
NeuroDiscovery

This team aims to determine how myelin—the electrical insulator around neuronal axons that speeds nerve signaling—contributes to the plasticity of neuronal circuits. The team is developing the world's first-ever genetic tools for selectively perturbing myelin in the mammalian brain, which they call "IMAGeNs" (Inhibitors of Myelination Around Genetically- defined Neurons). Promising preliminary results suggest that they can achieve high expression of candidate IMAGeNs throughout the brain. The team will use IMAGeNs to dissect how myelin contributes to specific brain circuits and types of neurons.

INJECTABLE PHOTOVOLTAICS FOR A WIRELESS, GLIOSIS-FREE NEURAL STIMULATION INTERFACE

Guosong Hong (materials science),
Marion Buckwalter (neurology),
and **Alberto Salleo** (materials science)
NeuroEngineering

Therapeutic neural implants have shown promise in alleviating the symptoms of a wide range of neurological diseases, from Parkinson's disease to obsessive compulsive disorder. A major obstacle of this technology is chronic gliosis - the brain's scarring response - that occurs at the implant/tissue interface over time. This project launched a new collaboration between materials scientists and neurologists to develop tiny, ultraflexible, wirelessly powered, microdevices that can be delivered into the brain via syringe injection. The team's initial results have already demonstrated successful fabrication of these microdevices and brain implantation. Critically, the molecular indicators of scar formation are lacking in the mouse brain after device injection, suggesting that these microdevices could overcome the challenges associated with an otherwise promising treatment.

INVESTIGATING THE ROLE OF A HUMAN-SPECIFIC REPEAT ELEMENT IN NEUROPSYCHIATRIC DISEASE RISK AND CEREBELLAR FUNCTION

David Kingsley (Rudy J. and Daphne Donohue Munzer Professor, developmental biology) and **Jennifer Raymond** (Berthold and Belle N. Guggenheim Professor, neurobiology)
NeuroHealth

Schizophrenia and bipolar disorder are devastating neuropsychiatric diseases that tend to run in families, suggesting that a genetic mutation plays a role in these diseases. David Kingsley, who studies evolutionary differences between humans and other primates, may have uncovered one reason why, when he discovered mutations in a calcium channel gene called CACNA1C. These mutations, which affect a person's risk for neuropsychiatric disease, lead Kingsley to seek out Jennifer Raymond. Raymond, whose focus is on neural learning algorithms, is an expert in the cerebellum, the part of the brain where CACNA1C produces it's insidious (or advantageous) proteins.


Tanya Raschke

Together, this unlikely team is undertaking an interdisciplinary approach to characterize the changes in behavior, neural function, and gene expression in the cerebellum of newly engineered mouse models that carry either the risk or protective versions of CACNA1C. Understanding these mutations could be a key for early identification and possibly treatment of bipolar disorder, schizophrenia, and other psychiatric diseases.

QUANTIFYING AUDITORY-VOCAL AFFECT IN HUMAN SOCIAL COMMUNICATION

Karen Parker (psychiatry), **Jonathan Berger** (Denning Family Provostial Professor, music), and **Michael Frank** (David and Lucile Packard Foundation Professor in Human Biology, psychology)
NeuroHealth

Our ability to understand another person's emotions from the sound of their voice is fundamental to meaningful social connection. Impairment of this ability features prominently in multiple psychiatric disorders, including most significantly, autism. This team combines expertise in psychiatry, psychology, neuroscience, speech, and music to rigorously define impairments in auditory-vocal aspects of psychiatric social deficits. The results of this research will advance characterization of a key component of social function in autism and beyond, providing a foothold for neurobiological investigations of dysfunction in human auditory-vocal processing across a variety of psychiatric disorders.

SENSORY PROCESSING IN A PRE-SEIZURE STATE

John Huguenard (neurology, neurosurgery), **Anthony Norcia** (psychology), and **Brenda Porter** (neurology, pediatrics)
NeuroHealth

This team brings together expertise in human sensory perception, animal models of epilepsy, and child neurology/epileptology clinicians to identify and capitalize on pre-seizure signals that can be used to predict, and ultimately to prevent, seizures. The team has shown that seizures are preceded by a period of altered sensation that can be observed in the brain's electrical activity (EEG). They are now leveraging the power of silicon probes to record from hundreds of neurons in mouse epilepsy models to understand neural correlates of the pre-seizure EEG. These results will be used to optimize a real-time seizure prediction algorithm that will be tested in human patients.

ULTRASONIC NEURAL CONTROL AND NEUROIMAGING IN THE AWAKE, MOBILE AND BEHAVING SMALL RODENT

Raag Airan (radiology), **Jeremy Dahl** (radiology), and **Butrus Khuri-Yakub** (electrical engineering)
NeuroEngineering

The mainstay of many psychiatric treatments and neuroscientific investigations is pharmacology: antidepressants are prescribed to treat major depression and stimulants are used in scientific studies of attention and decision making. In each case, we have an incomplete understanding of how these drugs act on the brain to mediate their physiologic or behavioral effects. To address this long standing knowledge gap, this team of electrical engineers and radiologists has developed an ultrasound-based tool, called ultrasonic drug uncaging, to noninvasively deposit a defined amount of a drug into a specific brain region. They are now designing ultrasound hardware and software that will allow them to apply both ultrasonic drug uncaging and functional ultrasound concurrently in awake and behaving small rodents so they can track whole-brain changes in neural activity in response to drug delivery.

Research Accelerators

Our research accelerator program supports interdisciplinary projects with promising results and the potential for high impact in understanding the brain and improving mental health. Research accelerators are projects that do not fit neatly into the big idea or seed grant framework, yet Wu Tsai Neuro is able to fund them through philanthropic gifts to the institute.

BRAIN REJUVENATION SEQUENCING CLUSTER

Tony Wyss-Coray
(D.H. Chen Professor II, neurology)
NeuroHealth

Sequencing the human genome revolutionized genetics by giving scientists access to the entire code for the human body. However, the value of the human genome lies not only in having the code, but in understanding where and when genes do their work (called gene expression). The shared resource established by this team will allow the Stanford community to perform high throughput RNA sequencing to detail gene expression. The power of this bulk processing means that scientists can study gene expression in thousands of single-cells that work together in the nervous system: a critical advance in neuroscience. The core has been up and running for just under a year and has already resulted in powerful discoveries for over six research groups. The scope of these discoveries ranges from detailing the molecular mechanics that underlie aging and neurodegenerative diseases, to uncovering the biology that explains why autism is more prevalent in boys.

DEVELOPING AN EARLY ENTERIC MARKER OF PARKINSON'S DISEASE

Julia Kaltschmidt (neurosurgery)
NeuroHealth

A major challenge for the treatment of neurodegenerative diseases, like Parkinson's Disease (PD), is the lack of early detection methods. Up to 80% of PD patients report experiencing constipation before the emergence of disease-defining motor symptoms, which lead Julia Kaltschmidt to consider if there might be a link between what's happening in the brain and what's happening in the gut. It turns out that aggregations of α-synuclein protein, the hallmark sign of PD in the brain, also occur in the enteric nervous system, the network of neurons and glia that control function of the gastrointestinal tract. This team has developed novel mouse models to determine if constipation reflects the impact of α-synuclein protein aggregations on gut cells. The success of this project could result in an early detection method for PD, which is critical to further our understanding of this devastating disease and to develop effective treatments.

THE NEURAL PROSTHETICS TRANSLATIONAL LABORATORY

Krishna Shenoy (Hong Seh and Vivian W. M. Lim Professor, electrical engineering) and **Jaimie Henderson** (John and Jene Blume - Robert and Ruth Halperin Professor, neurosurgery)
NeuroEngineering

This team is investigating fundamental principles of human neuroscience and translating those laboratory insights into clinically viable assistive devices for people with paralysis. The overarching goal is to design and demonstrate high-performance and highly robust brain-computer interfaces (BCIs) to help restore lost motor function. Using small, surgically implantable sensors, this group decodes nerve cell activity from the areas of the brain that control movement, allowing their research participants with paralysis to move computer cursors, robotic limbs, and other assistive devices. They recently demonstrated the highest typing performance ever reported using a brain-computer interface, allowing a person with paralysis to type up to eight words per minute using an on-screen computer keyboard.

REAL-TIME BIOSENSORS FOR MEASURING MULTIPLE NEUROMODULATORS

Hyongsok Tom Soh (radiology, electrical engineering) and **Karen Parker** (psychiatry)
NeuroEngineering

Decades of neuroscience research has been devoted to understanding the neural circuitry and communication that underlies brain function in health and breakdown in disease. Understanding the dynamics of neurotransmitters, the chemicals that neurons use to communicate, is critical for unlocking mysteries of the brain and for designing effective therapeutics to treat disease. Despite the success of compounds like selective serotonin reuptake inhibitors (SSRIs) in treating depression, it is still unknown exactly how they work because we lack effective methods for probing neurotransmitter levels in the brain before, during and after these treatments. This team of chemists, engineers, neuroscientists, and clinicians hopes to develop novel biosensor technology to enable continuous measurement of multiple neurotransmitters in the brain—in real time. The successful development of the proposed technology will transform our understanding of how the brain works and will form the basis of the first laboratory-based diagnostic tests to detect brain diseases as well as to monitor investigational drug efficacy and safety in real time.

STROKECOG

Marion Buckwalter (neurology, neurosurgery) and **Maarten Lansberg** (neurology)
NeuroHealth

This team has a multipronged approach to address the common, but poorly understood, problem of cognitive decline following stroke. Molecular imaging specialists are developing new tools to detect brain inflammation, engineers are designing new devices for stroke recovery, and clinicians run a large prospective cohort study investigating the links between neuroinflammation and post-stroke cognitive decline. StrokeCog sprung from a previously funded Big Idea project, the Stroke Collaborative Action Network (SCAN), and is a key component of the Stanford Stroke Recovery Program. Wu Tsai Neuro funding continues to support SCAN investigators with their clinical pilot studies via a clinical core. The core helps investigators with study design, stroke subject recruitments, and regulatory requirements for human research such as institutional review board applications and compliance. This team has secured $9.6 million in external funding to support the future of this project.

Neuroscience Community Labs

The opening of the new Stanford Neurosciences Building was a huge step forward in the realization of vital shared research platforms—the Neuroscience Community Laboratories. The Institute created specialized spaces within the building for five new laboratories as well as new homes for two of our three existing labs. In 2020, our existing labs quickly adapted to and then recovered from research restrictions due to COVID-19. Despite COVID-19, we were able to construct facilities and recruit talented scientists to lead the new labs.

Javier Alcudia

The development of our community labs converges with Stanford's long range vision for shared research platforms. "State-of-the-art resources for research are becoming more impactful, yet too complex and expensive for individual use," said Vice Provost and Dean of Research **Kam Moler** (Marvin Chodorow Professor, applied physics, physics). "Researchers in science, engineering, medicine, the arts, and the humanities cannot afford to acquire every advanced tool or dataset for the exclusive use of their own research groups. We must think in terms of shared resources—those that not only drive our own research but that also establish a scientific "watering hole" where scholars of different types can congregate and collaborate. Think of the traditional library. Since the beginning of human scholarship, libraries have brought scholars together to benefit all who teach and learn. We can create modern communal resources for data collection, imaging, making, and modeling."

New Community Labs

HUMAN BRAIN ORGANOGENESIS LAB

Professor **Sergiu Pasca** (psychiatry) leads the Human Brain Organogenesis Lab. In 2020, the lab moved into its new space and smoothly continued its work on long-term human-derived neural tissue cultures. These differentiated cellular spheroids mirror the early developmental processes of mammalian brain and neural tissue. Because they are derived from human cells, these cultures can recapitulate complex neural diseases, unlike simple tissue culture techniques routinely used in research labs. In January, Pasca led a highly successful workshop to disseminate his ground-breaking techniques to scientists from around the world.

KORET HUMAN NEUROSCIENCE LAB

Cutting-edge human neuroscience and clinical research will be facilitated by the Human Neuroscience Lab under the direction of Professors **Anthony Norcia** (psychology) and **Nolan Williams** (psychiatry). The lab provides state-of-the-art transcranial magnetic stimulation (TMS) and 128-channel electroencephalogram (EEG) equipment. TMS is a non-invasive brain stimulation technique that shows promise in treatment of psychiatric disorders. Our system includes a computer-controlled robot arm that accurately and reproducibly positions the device to deliver magnetic stimulation to the desired target region. The EEG equipment has generated great interest across campus for experiments on human perception and behavior because our setup allows subject isolation for precise visual or audible stimulation to monitor brain activity.

NEUROSCIENCE PRECLINICAL IMAGING LAB

The Neurosciences Preclinical Imaging Laboratory was designed specifically to house a new 7T magnetic resonance imaging (MRI) instrument for small animal imaging, that was purchased, in part, with funds provided by the NIH from a grant written by Professor **Jin Hyung Lee** (neurology). Further funds for the purchase of the instrument and lab construction were provided by Wu Tsai Neuro and several other Stanford departmental partners. With lab construction complete, we are preparing for delivery of the MRI instrument in early 2021 and launching a national search to recruit a staff scientist director for the facility. The new MRI will be optimally configured for neuroscience-focused experiments using a broad range of animal species, such as non-human primates and large rodents.

VINCENT V.C. WOO SANDBOX LAB

In software development terms, a sandbox is a separate environment where research and code development can be done without affecting production systems. Part biological wet lab, part engineering workshop and part maker space, the Sandbox Lab will be a hub of novel collaborative research and cross-training between neuroscientists and engineers with a deep interest in neuroscience applications. The lab programs are directed by professors **John Huguenard** (neurology), **Nicholas Melosh** (materials science), **Sergiu Pasca** (psychiatry) and **Ada Poon** (electrical engineering). The tissue culture room was furnished in time to support the Brain Organoid workshop offered by Prof. Sergiu Pasca in January 2020. We look forward to hosting future short courses, workshops and the annual Stanford Intensive Neuroscience Bootcamp in the Sandbox.

VISUALIZATION LAB

The Visualization Lab is a collaborative space focused on human perception, and is spearheaded by two research projects that informed the design of the lab: a virtual reality/augmented reality (VR/AR) project led by Professor **Jennifer McNab** (radiology) and Dr **Christoph Leuze** (radiology), and an adaptive optics (AO) project led by Professor **Alfred Dubra** (ophthalmology). The VR/AR project envisions displaying virtual representations of clinically obtained 3D data, such as MRI scans of the brain, through virtual reality headsets worn by a physician/research scientist onto real human subjects. The AO project will allow Prof. Dubra to custom build an adaptive optics scanning light ophthalmoscope (AOSLO) in the Neurosciences Building, bringing this powerful technology to the Wu Tsai Neuro community. The AOSLO will allow non-invasive visualization and stimulation of single retinal cells of human subjects. The finalized space (completion in early 2021) will include specialized rooms for each of these projects, in addition to a collaborative workspace.

Established Community Labs

GENE VECTOR AND VIRUS CORE

Molecular tools are a cornerstone of current cellular and circuit-based neuroscience experiments. Optogenetics, calcium imaging and CRISPR-Cas9 all rely on novel genetic constructs. These tools can change the biochemistry of cells which may mimic a disease, permit specific imaging of cells or allow researchers to control cellular events. The Gene Vector and Virus Core (GVVC), led by Dr **Javier Alcudia**, provides scale-up production of genetic constructs (either in the form of “plasmids” or “viral vectors”) to neuroscientists at Stanford and around the globe. Packaging genetic constructs within specially designed viruses allows the tools to be deployed with cell-specific accuracy. GVVC provides an important service by centralizing the production of genetic constructs, delivering high quality products widely, and improving experimental reproducibility. In 2020, the GVVC operations were successfully moved from an off-campus facility to the new Neurosciences Building, With appropriate safety measures, GVVC staff continued operations throughout the COVID-19 pandemic to meet researchers’ experimental needs.

NEUROSCIENCES MICROSCOPY SERVICE

The Neurosciences Microscopy Service (NMS) offers access to cutting-edge microscope technologies to the Stanford neurosciences community, with a collection of high-end microscopes not typically available in individual laboratories. Late in 2020, after many years directing NMS, Dr **Andrew Olson** announced his retirement. As founding director, Olson was known for his technical expertise and beloved by the Wu Tsai Community for his outstanding teaching and collaborative partnerships. A national search for a new director has been launched, and a replacement is anticipated to take over operations in early 2021. NMS was relocated to the new Stanford Neurosciences Building in 2020. Wu Tsai Neuro made a significant investment in a new Zeiss LSM-980 microscope, which is now the most advanced confocal microscope available to the Stanford community in a shared facility.

BEHAVIORAL AND FUNCTIONAL NEUROSCIENCE LABORATORY

The Behavioral and Functional Neuroscience Laboratory (BFNL) directed by professor **Mehrdad Shamloo** (neurosurgery) provides a range of research services to enable functional and behavioural studies on rodent models. The lab provides rodent models of neurological and psychiatric disease and facilitates investigation of drug-related impact on rodent behavior — important experimental steps in the translational pipeline of basic scientific discovery to clinical treatment. Industry-standard behavioral equipment is available to Stanford researchers to conduct their own research, or staff can be contracted to perform these studies directly. The lab also provides services to non-academic customers. While BFNL is the only community lab located outside the Stanford Neurosciences Building, renovations will soon be underway at its labs in the Arastradero facility and in the Lorry I. Lokey Stem Cell Research Building. Shamloo recently received an NIH grant to install fully automated and remote monitored enclosures to meet increasing experimental demands and improve research reproducibility.

Development

Wu Tsai Neuro faculty and students across Stanford appreciate close friends and supporters who recognize the importance of basic and translational neuroscience research. We are grateful for the thought leadership, time, dedication, and philanthropic partnership from these committed families—which include Stanford alumni, parents, friends, and key volunteers like members of the Stanford Interdisciplinary Life Sciences Council. Their involvement truly advances innovative brain science that makes a major difference in the lives of people worldwide.

A major highlight of the 2020 fiscal year was the celebratory dedication of the state-of-the-art Stanford Neurosciences Building and Stanford ChEM-H Building. We were thrilled that many close friends of Wu Tsai Neuro attended in person to honor this major milestone. The new interdisciplinary research complex marks a watershed moment for team science at Stanford. Thanks to significant gifts from key donors, this unique collaborative research facility has become a reality. Fundraising efforts continue in support of Wu Tsai Neuro and ChEM-H programs, people and shared research platforms such Wu Tsai Neuro Community Labs (and ChEM-H Knowledge Centers)—all of which are vital to advancing groundbreaking, high-impact research.

Wu Tsai Neuro leaders capitalized on the energy and momentum generated by the dedication. In adherence with shelter-in-place protocols, virtual stewardship and creative online programming enabled Wu Tsai Neuro to steward existing donors while also engaging broader audiences in meaningful conversations about the important work of the institutes. These efforts centered around a highly successful *Science in Motion* Zoom series, which offered in-depth conversations with faculty and leaders. Topics included how the pandemic has rewired collaboration at Stanford and shaped research and fundraising priorities, as well as how Stanford's Long-Range Vision is creating new opportunities for interdisciplinary hubs like Wu Tsai Neuro. The institute also provided high-touch stewardship for key donors such as custom written updates from faculty and virtual faculty panels.

Over the past year, Wu Tsai Neuro sought to meet present needs by providing emergency funding for graduate students and postdocs who were affected by the pandemic, and creating an engaging online community for its undergraduates through its inaugural NeURO fellowship program. With an eye on the long-term goal of building a foundation for collaborative, interdisciplinary research, the institute continues to seek much needed support for key priorities. These include the Wu Tsai Neuro Community Labs, innovative research programs like *Big Ideas in Neuroscience* and *Neuroscience:Translate*, as well as securing gifts to endow professorships for faculty retention and recruitment, and fellowships for interdisciplinary PhD and postdoctoral scientists. Moving forward, Wu Tsai Neuro also will continue to serve as a fundamental partner collaborating with leaders across Stanford's seven schools to help advance Stanford Long-Range Initiatives including Strategic Platforms (Shared Research Platforms), Human-Centered Artificial Intelligence (HAI), Transforming Learning Accelerator (TLA), and the Data Science Initiative (DSI).

Leadership and Staff

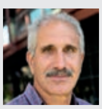
Executive Committee

Marion Buckwalter, MD, PhD
Professor of Neurology and of Neurosurgery

Bill Newsome, PhD
Vincent V.C. Woo Director, Harman Family Provostial Professor, Professor of Neurobiology

Scott Delp, PhD
James H. Clark Professor in the School of Engineering, Professor of Bioengineering and of Mechanical Engineering

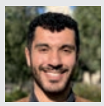
Tanya Raschke, PhD
Director for Planning and Operations



Rob Malenka, MD, PhD
Nancy Friend Pritzker Professor of Psychiatry and Behavioral Sciences

Brian Wandell, PhD
Isaac and Madeline Stein Family Professor, Professor of Psychology

Administrative Team



Ramy Abbady, MA
Academic and Student Services Coordinator

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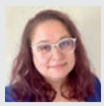
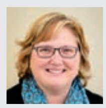
Financial Analyst



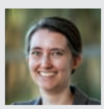
Sarah Dondysh
Administrative Associate

Janice Lee
Project Manager for Development

Tim Doyle, DPhil
Assistant Director for Neuroscience Community Labs



Maura McGinnity
Senior Director of Development



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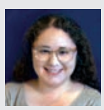
Director for Planning and Operations



Melissa Landeros, MA
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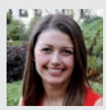

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Neuroscience Community Labs Accountant


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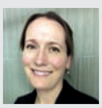
Administrative Associate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Midori Yoshimura
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Community Labs Staff


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Denise Briggs, PhD
Postdoc
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Shravanti Kulkarni
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Lab Manager
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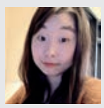
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Gaku Ogawa
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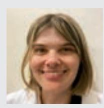
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Andrew Olson, PhD
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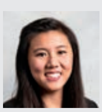
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Subba Dhulipala
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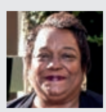
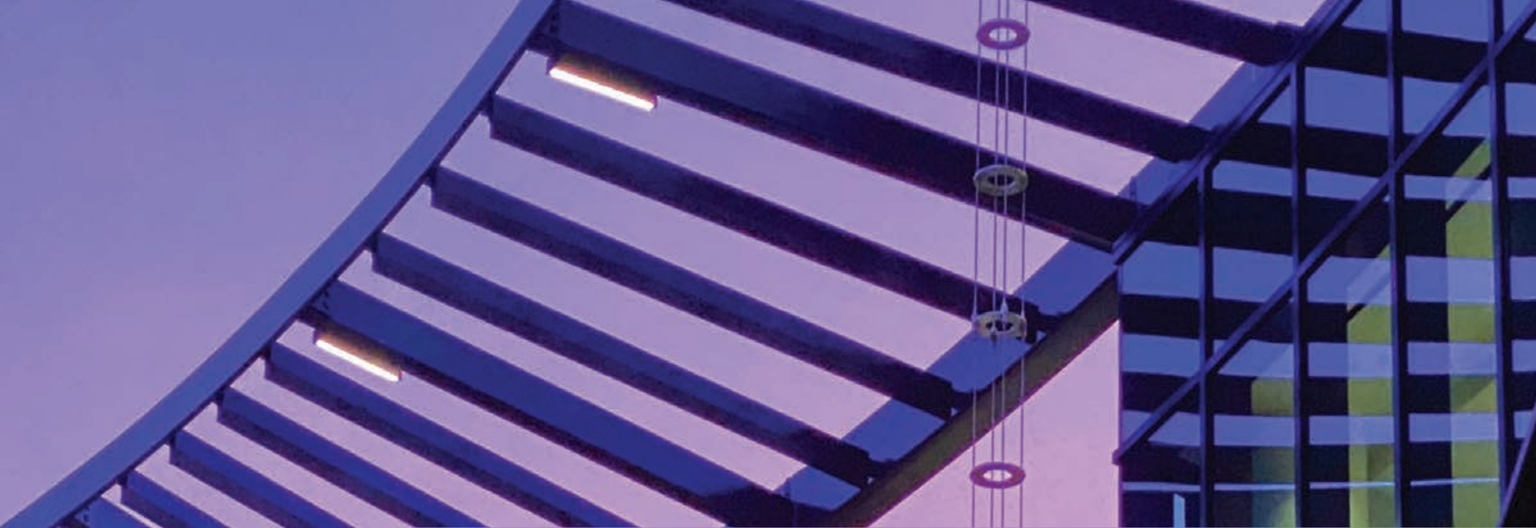
GVVC


Tammie Forbes
Administrative Associate
BFNL, GVVC, NMS

William Newsome

“We all know that there will be additional trying times in the coming year, but I am confident that Wu Tsai Neuro will weather them, and that our scientists will emerge on the other side as stronger, more focused researchers, with greater clarity of purpose for our lives and careers. Other generations of citizens and scientists have faced great challenges; we can rise to the great challenges of our own generation. We will make that journey together.”

William T. Newsome, PhD
Vincent V.C. Woo Director
Harman Family Provostial Professor
Professor of Neurobiology

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