Wu Tsai Neurosciences Institute

Annual Report

September 2017
Through August 2018

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.

Inaugural institute retreat attendees

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Message from the director

Bill Newsome

Vincent V. C. Woo Director
Harman Family Provostial Professor

The 2018 academic year marked an important milestone for the institute: five years of supporting interdisciplinary neurosciences research at Stanford University. On October 11, 2018, at our annual symposium, we announced that we are changing our name to the Wu Tsai Neurosciences Institute in recognition of a generous lead gift from Clara Wu Tsai and Joe Tsai. This inspiring support will enable the institute to intensify and expand our research and programmatic efforts. Our success, both now and in the future, springs from three foundational institute commitments—to outstanding people, to innovative research and to state-of-the-art facilities.

During the past year, our engagement of extraordinary people resulted in the recruitment of Assistant Professor Scott Linderman to the department of statistics. We awarded five postdoctoral Interdisciplinary Scholar Awards and three Stanford Interdisciplinary Graduate Fellowships to promising young neuroscientists who seek to expand their research horizons through interdisciplinary training. We initiated an undergraduate neuroscience interest group. With strong collaboration from faculty leaders, we are also expanding the Mind, Brain, Computation and Technology graduate training program. In May, 185 community members attended our first scientific retreat, and in October, we held our 5th annual symposium, focusing on Natural/Artificial Intelligence.

We continue to support impactful research, granting new Big Ideas in Neuroscience awards to four teams who will receive phase 1 support for novel interdisciplinary research in our broad emphasis areas of NeuroDiscovery, NeuroHealth, and NeuroEngineering. In the 2019 academic year, we are piloting a new Neuroscience:Translate grant program to facilitate the transfer of Wu Tsai Neuro research discoveries into practical benefits for society, and will announce a new round of Seed Grant competition.

Construction is ongoing for the new Wu Tsai Neuro & ChEM-H research complex. Scheduled to open in September 2019, the facility will include a suite of neuroscience community labs that will provide shared instrumentation and expertise to our entire community. Completing construction and fund-raising, and moving faculty research groups into the new building will be our Mount Everest to scale in FY 2019-20.

I am inspired by how far the Institute has come in the past five years, and look forward to a most productive future.

Our benefactors

Clara Wu Tsai and Joe Tsai

Stanford alumna Clara and her husband, Joe, have a longstanding interest in the life sciences. Clara was a member of the presidential task force that helped shape the Stanford Neurosciences Institute and Stanford ChEM-H and (Chemistry, Engineering & Medicine for Human Health). She also served on the advisory council for Stanford Bio-X, an interdisciplinary platform launched in 1998 that has become a model for biosciences programs worldwide. Clara serves as co-chair of the advisory cabinet for the Wu Tsai Neurosciences Institute and is an active member of the advisory council for the interdisciplinary life sciences institutes at Stanford. She also serves on the university's Global Advisory Council.

As a Stanford student, Clara earned a bachelor's in international relations and a master's in international policy studies. She received an MBA at Harvard and then pursued a successful career in business and finance as an executive at American Express and at Taobao, China's largest online shopping site. Beyond Stanford, Clara is an advisory member for the Institute of Protein Design at the University of Washington. She sits on the international council of advisors of the National Geographic Society and was executive producer of "Into the Okavango," a documentary by National Geographic about Botswana's Okavango Delta that premiered at the 2018 Tribeca Film Festival. Clara is also a trustee of Lincoln Center for the Performing Arts in New York City.

Joe Tsai is executive vice chairman and one of the founders of Alibaba Group, a global Internet technology company based in China. Alibaba has businesses in digital commerce, entertainment, cloud computing, logistics and financial technology. Joe is responsible for the company's strategic acquisitions and investments. He attended Yale University, earning a bachelor's in economics and East Asian Studies in 1986 and a law degree in 1990.

Together, Joe and Clara pursue philanthropic investments that advance knowledge, innovation, equality of opportunity, and creativity in the arts. Their work with global partners focuses on the translation of new knowledge into practical applications with human or social impact.

The couple have three children and live in La Jolla, California, and Hong Kong.

Wu Tsai Neurosciences Institute

The Wu Tsai Neuroscience Institute's fifth anniversary and renaming to honor donors Clara Wu Tsai and Joe Tsai has been an opportunity both to celebrate the institute's accomplishments, and to continue to challenge ourselves to build on this strong foundation of achievement and to find new and exciting ways to advance neuroscience research.

Fostering interdisciplinary research, dreaming big and transcending boundaries

Understanding the human brain, the most complex entity in the known universe, is no longer a problem for biology or psychology alone. Since its inception, the institute has fostered a diverse community of scientists and supported cross-disciplinary research with the potential to revolutionize neuroscience research, technologies and treatments. The research emphases of Wu Tsai Neuro fall into three broad categories:

NeuroDiscovery - question-driven discovery about how the brain works

NeuroEngineering - tools for making novel measurements of brain structure and function

NeuroHealth - translating neuroscience discoveries into treatments

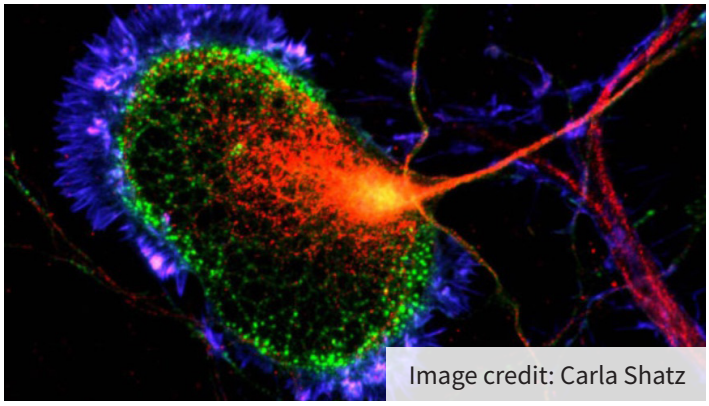


Image credit: Carla Shatz

The institute's flagship research effort is **Big Ideas in Neuroscience**; in addition to the seven Big Ideas projects previously supported by the institute (three of which have progressed to Phase 2 and are ongoing), this year four new Phase 1 Big Ideas projects were awarded. The institute also funded one new **Research Accelerator** award for a project with substantial potential for high impact, and continued to support six ongoing **Seed Grant** teams piloting novel ideas that could develop into significant advances in the future.

Retreat attendees are encouraged to engage and connect

Building community and training the next generation

None of the important neuroscience research being supported by the institute would be possible without its community of remarkable researchers. Wu Tsai Neuro is proud to count faculty from all seven Stanford schools among its members, and to have recruited Dr. Scott Linderman to Stanford as one of our institute **Faculty Scholars**, each of whom drive research programs that span traditional disciplinary boundaries. Through our seminar series, annual symposium, and inaugural institute retreat, we have created opportunities to discuss new ideas and spark future collaborations, and with our **Community Labs**, to provide the tools our researchers need. Next year, the new **research complex** for our institute and ChEM-H will open, becoming a physical hub for our community. And, Wu Tsai Neuro has also continued its dedication to training the next generation of neuroscientists, awarding five **Interdisciplinary Scholar Awards** to outstanding postdoctoral scientists and three **Stanford Interdisciplinary Graduate Fellowships** to remarkable graduate students in the past year. For the first time, the Institute has engaged with the undergraduate community through its sponsorship of the **Stanford Undergraduate Neuroscience Society**.

We invite you to learn more about each of these accomplishments in the coming pages.

THE Wu Tsai Neurosciences Institute AT FIVE YEARS

Transforming neuroscience research at Stanford by…

FOSTERING INTERDISCIPLINARY RESEARCH

23 **Grants** awarded for high-risk, high-reward initiatives…

BIG IDEAS

Diverse teams tackling fundamental challenges

SEED GRANTS

New collaborations to pilot novel ideas

RESEARCH ACCELERATORS

Promising projects scaling up for high impact

DREAMING BIG AND TRANSCENDING BOUNDARIES

100% of **Big Ideas teams** have faculty members from **five** or more departments

158 Faculty funded across **six of Stanford's seven** schools

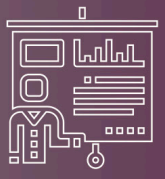
BUILDING COMMUNITY

440 Faculty affiliates representing nearly **3/4** of Stanford's academic departments

200+ **Scientists hosted** from around the world to share their research

TRAINING THE NEXT GENERATION

30 PhD students and postdocs **awarded fellowships**



52 PhD **students supported** in research and technology training programs

Engaging extraordinary people

New faculty

Wu Tsai Neuro successfully recruited **Scott Linderman**, who will be an assistant professor in the department of statistics. Dr. Linderman is developing new statistical models called switching linear dynamical systems to analyze neural data. He is applying those models to complex experimental data sets including cellular and behavioral data, and we expect that he will build strong collaborations with experimental neuroscientists. New statistical analyses will allow us to make sense of large, complex data sets and provide insight into how neural systems function.

Faculty awards and honors

Several faculty affiliates of the Wu Tsai Neurosciences Institute were awarded major prizes or were appointed to preeminent academies.

Ann Arvin, the Lucile Salter Packard Professor of Pediatrics and a professor of microbiology and immunology, is the 2018 winner of the Kenneth M. Cuthberson Award for Exceptional Service to Stanford University.

Helen Blau, the Donald E. and Delia B. Baxter Foundation Professor and a professor of microbiology and immunology, and **H. Tom Soh**, professor of radiology and of electrical engineering, were named fellows of the National Academy of Inventors.

Karl Deisseroth, the D.H. Chen professor and a professor of bioengineering and of psychiatry and behavioral sciences, received the 2018 Kyoto Prize for advanced technology.

Judith Frydman, the Donald Kennedy Chair in the School of Humanities and Sciences and professor of genetics and biology , was elected into the American Academy of Arts and Sciences.

Andrea Goldsmith, the Stephen Harris Professor in the School of Engineering and professor of electrical engineering, received the ACM Athena Lecturer Award.

Oussama Khatib, professor of computer science, was elected into the National Academy of Engineering.

Jin Hyung Lee, associate professor of neurology and neurological sciences, bioengineering, and neurosurgery, is the recipient of the 2018 LINA 50+ Award Grand Prize.

Theo Palmer, professor of neurosurgery, received the Award for Excellence in Mentoring and Service from Stanford Medicine.

Sergiu Pasca, assistant professor of psychiatry and behavioral sciences, received the 2018 ASCB Early Career Life Scientist Award and the 2018 Vilcek Prize for Creative Promise in Biomedical Science.

Anthony Ricci, the Edward C. and Amy H. Sewall Professor in the School of Medicine and a professor of otolaryngology, received the Award for Excellence in Diversity and Inclusion from Stanford Medicine.

Carla Shatz, the Sapp Family Provostial Professor, the David Starr Jordan Director of Stanford Bio-X and a professor of biology and of neurobiology, is the 2018 recipient of the Dean's Medal, for contributions that have significantly advanced the mission of Stanford Medicine.

Daniel Yamins, assistant professor of psychology, was named a 2018 Sloan Research Fellow.

Our team leaders at WEF 2018 conference in Davos (seated R to L) Alia Crum, Beth Darnell and David Spiegel

2018 Interdisciplinary Scholars

We awarded five outstanding post-doctoral scholars with Interdisciplinary Scholar Awards, which include a two-year fellowship and a program for career development and network-building.

Erin Gray (chemistry)

Sponsor: Justin Du Bois, Co-Sponsor: Bradley Zuchero

Dr. Gray aims to develop chemical tools to examine the role of ion channels in neurobiology.

Laura Marquardt (materials science and engineering)

Sponsor: Sarah Heilshorn, Co-Sponsor: Giles Plant

Dr. Marquardt's focus is on improving cell transplantation therapies after spinal cord injury to improve functional regeneration.

Rabindra Shivnaraine (molecular & cellular physiology)

Sponsor: Brian Kobilka, Co-Sponsor: Steven Chu

Dr. Shivnaraine's project aims to understand the dynamics of G protein-coupled receptors.

Sergey Stavisky (neurosurgery)

Sponsor: Jaimie Henderson, Co-Sponsor: Krishna Shenoy

Dr. Stavisky aims to develop devices that restore movement to people with paralysis.

Boxuan Zhao (genetics)

Sponsor: Alice Ting, Co-Sponsor: Liqun Luo

Dr. Zhao's research is focused on the development of molecular tools for transcriptome and connectome studies.

2018 Stanford Interdisciplinary Graduate Fellows

Brandon Jay Bhasin (bioengineering)

The 2018 Interdisciplinary Scholars and 2018 Stanford Interdisciplinary Graduate Fellows

Advisor: Jennifer Raymond

Jay is developing mathematical models of learning in the control of eye movement reflexes.

Darian Hadjiabadi (bioengineering)

Advisor: Ivan Soltesz, Co-Advisor: Jure Leskovec

Darian's project aims to apply computational models of the rodent hippocampus to investigate basic science and translational research questions.

Yi Liu (electrical engineering)

Advisor: Ada Poon

Yi is studying the mechanisms of extracellular electrical stimulation and analyzing the effects of different current waveforms applied at the electrode.

Brains behind the institute

Our faculty affiliates are the brains behind the Wu Tsai Neurosciences Institute, advancing our understanding of neuroscience with bold research ideas and interdisciplinary collaborations. In a digital media project during fall quarter, 12 faculty members from across the disciplines shared the stories and experiences that inspired their research—early memories of patients dealing with obsessive-compulsive disorder, catching the "virus of scientific discovery," a fascination with the dance of interactions between different parts of the brain, and more. Each faculty member's story, accompanied by a compelling portrait, was published on Wu Tsai Neuro's social media accounts as well as Stanford's official accounts, increasing the institute's digital media presence and website traffic, and generating positive feedback from Stanford community members.

Read the full profiles on the institute's website at neuroscience.stanford.edu/news/brains-behind-institute.

Nurturing a diverse and vibrant community

Fifth annual symposium

The institute community gathered for our fifth annual symposium on October 11, 2018. In addition to the announcement of our new name and remarks by Clara Wu Tsai, we welcomed top neuroscientists from around the world to share their work on the theme of Natural / Artificial Intelligence: Surya Ganguli (Stanford University), Doina Precup (McGill University and DeepMind Montreal), James DiCarlo (Massachusetts Institute of Technology), Matthew Botvinick (DeepMind and University College London), and Greg Corrado (Google AI).

At the symposium, we also celebrated meritorious research by our postdoctoral scholars and graduate students with the presentation of the 10th annual Sammy Kuo Awards in Neuroscience. This year's first prize postdoctoral award winner was Jessica Walsh (psychiatry and behavioral sciences), and first prize graduate student winner was Lindsey Salay (neurobiology).

Speakers of the 2018 Wu Tsai Neurosciences Institute Annual Symposium with Bill Newsome (right)

Retreat attendees (L to R) Jun Ding and Julia Kaltschmidt

Inaugural institute retreat

The institute's first community retreat took place from May 6-8, 2018 at Pajaro Dunes Resort in Watsonville. We brought together members of our community ranging from full professors to graduate students to share their latest scientific questions and discoveries. The retreat was attended by 185 people representing a wide range of departments and stages in their education and career, with highlights including: a keynote talk by Edward Chang (UCSF) and scientific talk by Stanford President Marc Tessier-Lavigne, a technology session on new tools for neuroscience featuring Katja Brose (Chan Zuckerberg Initiative), Ed Lein and Hongkiu Zeng (Allen Institute) and David Markowitz (Intelligence Advanced Research Projects Activity), a panel discussion about new models for scientific research, and a poster session. Nobel Laureate Steven Chu (physics) presented a poster, and we hope this trend continues in future retreats, which we plan to hold every other year.

Seminar series

In 2018 our weekly seminar series hosted 31 top neuroscientists from around the country and across the globe. Three seminars were hosted in partnership with psychiatry and behavioral sciences. Speakers were nominated by members of our community, and represented a wide diversity of disciplines. Eminent speakers this year included: Xiang Yu (Chinese Academy of Scienes), Hailan Hu (Zhejiang University), Konstantinos Meletis (Karolinska Institute), Sophie Denéve (École Normale Supérieure), Nora Volkow (NIDA) and Marisela Morales (NIDA).

New undergraduate neuroscience program

This year, the institute launched a new undergraduate neuroscience program to bring together a community of students otherwise scattered among Stanford's schools and departments. The Stanford Undergraduate Neuroscience Society (SUNS) was launched in collaboration with an eager group of student leaders and with the guidance of faculty mentors Gregory Scherrer, Mary Hynes and Julia Kaltschmidt, and held two social events and a panel discussion featuring senior students talking about their neuroscience research and extracurricular experiences. Since the society's inception in the spring of 2018, more than 90 undergraduate students have attended one or more SUNS events.

Brains behind the institute

Surya Ganguli

Assistant professor of applied physics

"Accumulating diverse knowledge can lead to the most serendipitous connections."

Lisa Giocomo

Assistant professor of neurobiology

Pursuing questions of "How…?" and having curiosity and the joy of discovery drive your career in science is key.

Fostering interdisciplinary research: NeuroDiscovery

Question-driven investigation of how the brain works

NeuroDiscovery research 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. Over the past year, the institute supported NeuroDiscovery research at Stanford with two ongoing Phase 2 Big Ideas in Neuroscience projects, one newly awarded Phase 1 Big Ideas project, and two ongoing Seed Grants.

Big Ideas in Neuroscience

NeuroPlant: Leveraging a botanical armamentarium to manipulate the brain

Team leaders: Thomas Clandinin (neurobiology), Miriam Goodman (molecular and cellular physiology), Seung Yon Rhee (Carnegie Institute of Biology)

New Phase 1 project

Despite decades of research on mental disorders, understanding of how the central and peripheral nervous systems works remains limited, and tools suitable for manipulating and deciphering the underlying molecular pathways are lacking. To address this gap, this team aims to identify a novel archive of chemicals that act on neuronal receptors, focusing on compounds synthesized by medicinal plants. The team will first test chemical compounds on the roundworm C. elegans, and promising compounds identified in worms will then be tested in human cells. Successful outcomes will include: innovative, scalable platforms for mining a plethora of small molecules, targets of known psychoactive drugs and an initial framework for high-throughput chemical screening using direct behavioral assays in an animal.

Neurodevelopment: Elucidating the development of brain structure, function, and computations

Team leaders: Kalanit Grill-Spector (psychology), Jennifer McNab (radiology), Daniel Yamins (psychology)

New Phase 1 project

Is it largely unknown how brain structure and function develop from infancy to adulthood to enable behavior. This project has the potential to provide a major breakthrough in understanding neurodevelopment by using collaborative research to generate two paradigm shifts. First, the team aims to develop new in vivo imaging technologies that measure specific microstructural changes across development, resulting in a comprehensive understanding of the relation between in vivo measurements and specific biological changes. Second, the team is striving toward a shift from examining isolated aspects of neurodevelopment to an integrated research program elucidating how the interplay among structural development, functional development, and experience together affect brain computations, and ultimately, behavior.

Dan Yamins

NeuroChoice - Understanding and treating addictive behavior, from circuits to policy

Team Leaders: Brian Knutson (psychology), Keith Humphreys (psychiatry), Robert Malenka (psychiatry and behavioral sciences)

Continuing Phase 2 project

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. Addiction (e.g., to substances, gambling, overeating) can be framed as a pathological choice problem ripe for interdisciplinary multilevel solutions. This team continues to deepen interdisciplinary understanding of the neural mechanisms supporting healthy and addictive choices by combining conceptual, experimental, and clinical approaches that bridge historically disparate fields of inquiry. The team 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.

Seed Grants

Identification of sex hormone interacting proteins

Nirao Shah (psychiatry and behavioral sciences, neurobiology) and Justin Du Bois (chemistry)

Continuing project

These collaborators aim to elucidate the multiple roles that sex hormones play in development of the nervous system and in regulating brain functions that influence gender identity, puberty, and reproduction. There is a common misperception that the action of sex hormones, namely estrogen and testosterone, is well established, when in fact quite the opposite is true. Answers to questions regarding how these molecules traffic into and within cells and regulate cellular functions remain largely unknown. To gain deeper insight into the pharmacology of sex hormones, the team is developing selective chemical probes that mimic sex hormones to enable labeling and identification of proteins that interact with these molecules. Subsequent studies will determine the consequences of these molecular interactions for physiology and behavior.

TrkA-ing the chronic pain

Bianxiao Cui (chemistry) and Gregory Scherrer (anesthesia)

Continuing project

Although acute pain serves an essential protective function, many types of chronic pain including inflammatory, neuropathic and cancer pain cause disabilities and significantly impact life quality. Nerve growth factor (NGF) and its membrane receptor, TrkA, are potent mediators of chronic pain. Despite their vast potential as therapeutic targets, the question of how NGF/TrkA plays a role in pain remains unanswered. In particular, how NGF differentially sensitizes pain in sensory neurons versus in the central nervous system (CNS) is unknown. To fill this gap in knowledge, this team is developing a novel approach that activates TrkA directly with light, in the absence of NGF. This light-inducible approach allows high spatial and temporal control of TrkA activation. These new light-inducible TrkA systems will permit analysis of how TrkA activation influences the excitability of sensory neurons detecting painful stimuli, on neurotransmission between these sensory neurons and CNS pain circuits, and on acute and chronic pain perception with in vivo behavioral pain tests.

Image credit: Amanda Janesick

Brains behind the institute

Kalanit Grill-Spector

Professor of psychology

"About half of your brain will respond to visual stimuli—faces of family members, the sun reflecting off the Golden Gate Bridge, words on a screen"

Fostering interdisciplinary research: NeuroEngineering

Tools for making novel measurements of brain structure and function

The human brain has 100 billion nerve cells and trillions of connections between them. Understanding the workings of such a complex and dynamic organ requires new tools and technologies that will enable yet unimagined discoveries and will allow us to repair and even to augment the human brain. Over the past year, the institute supported NeuroEngineering research at Stanford with one newly awarded Phase 1 Big Ideas project, one ongoing Phase 2 Big Ideas in Neuroscience project, two ongoing Seed Grants and one newly awarded Research Accelerator award.

Big Ideas in Neuroscience

Neuro-omics

Team leaders: Alice Ting (genetics), Liqun Luo (biology, biology), Stephen Quake (bioengineering, applied science)

New Phase 1 project

New technologies in the past two decades have enabled scientists to study many biological questions at the scale of all genes (genomics) and all protein products (proteomics). This team aims to bring the omics revolution to the brain, the most complex organ with the largest number of cell types, by creating a suite of new tools and analysis methods that 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. These neuronal types include not only those traditionally defined by where they are and what type of neurotransmitters they produce, but also how they are activated by any stimulus or behavioral episode. 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.

Stanford neurotechnology initiative

Team Leaders: Nicholas Melosh (materials science and engineering) and E.J. Chichilnisky (neurosurgery, ophthalmology)

Continuing Phase 2 project

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 are embedded. This project's goal is to develop the next generation of neural interfaces that match the resolution and performance of the biological circuitry. This 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. In the process, the initiative will develop an interdisciplinary research and training environment to place Stanford as a global leader in neurotechnology.

Amin Arbabian (right)

Seed Grants

Enabling faster and more responsive voltage imaging through computational biophysics

Ron Dror (computer science) and Michael Lin (neurobiology, bioengineering)

Ongoing project

Our brains process information and make decisions by means of electrical and chemical interactions between many millions of neurons. Being able to measure when neurons fire electrical impulses (at scale, from many thousands of neurons simultaneously) would allow us to better understand how the brain carries out critical functions, such as encoding sensations, recalling thoughts, or making decisions. In this project, a computational biophysicist (Dror) and a protein engineer (Lin) are teaming up to improve voltage-sensing fluorescent proteins —

proteins that can report electrical activity by changing their production of light. By identifying what parts of the protein limit speed and responsiveness, new ideas for improving their responses will be generated that can be tested immediately. If successful, this collaborative interdisciplinary work can lead to dramatic improvements in voltage sensor performance, enabling the detection of faster or smaller electrical impulses than previously possible.

Remote and localized neural activation using sonomagnetic stimulation

Amin Arbabian (electrical engineering) and Stephen Baccus (neurobiology)

Ongoing project

Brain stimulation therapies now treat Parkinson's disease, depression, dystonia and epilepsy and hold promise for Alzheimer's, anxiety, schizophrenia and stroke. However, neurostimulation methods that generate electrical currents, such as transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS), can only reach shallow brain structures or large target volumes. An alternative approach, ultrasonic neurostimulation, is a promising technology that can reach deep into the brain, but has shown much weaker effects than those from TMS. This team is developing a new modality of noninvasive neural stimulation, sonomagnetic stimulation (SMS), that can generate an electrical current focused in a small volume deep in neural tissue. Their method combines ultrasonic and magnetic field interactions to enable remote neural activation and, if successful, will introduce a fundamentally new tool for the study of neural function and treatment of neural disease.

Research Accelerators

Real-time biosensors for measuring multiple neuromodulators

Team leaders: H. Tom Soh (electrical engineering and radiology), Karen Parker (psychiatry and behavioral sciences)

New project

Neural circuit activity is dependent on the simultaneous actions of a bewildering array of chemical signaling molecules, often termed neuromodulators, yet the existing tools to measure these substances are primitive in that they lack chemical specificity, detection sensitivity, spatial resolution, and temporal resolution. This award will support work to develop a real-time neurochemical sensor that can simultaneously and precisely measure multiple signaling chemicals in specific brain targets in freely behaving animals. The successful development of the proposed technology would be transformative, enabling creation of multidimensional maps of neuromodulator action in the brain and multidimensional biomarker algorithms that can form the basis of diagnostic tests to detect brain diseases and monitor investigational drug efficacy and safety in real time.

Brains behind the institute

Karen Parker

Associate professor of psychiatry and behavioral sciences

"The magic in science happens at the interdisciplinary boundaries of a field."

Fostering interdisciplinary research: NeuroHealth

Translating neuroscience discoveries into treatments

Understanding the brain in health and disease will improve treatments for ourselves and our loved ones, benefiting not just individuals, but society as a whole. Our clinical scientists not only treat patients, but are also working with basic scientists to pioneer novel treatments for psychiatric and neurological disease. Over the past year, the institute supported NeuroHealth research at Stanford with one newly awarded Phase 1 Big Ideas project, one ongoing Phase 2 Big Ideas in Neuroscience project, two ongoing Seed Grants and two ongoing Research Accelerator awards.

Big Idea in Neuroscience

Human brain organogenesis

Team leaders: Sergiu Pasca (psychiatry and behavioral sciences) and Karl Deisseroth (bioengineering)

New Phase 1 project

A challenge in understanding the intricate programs underlying the development, assembly, function and dysfunction of the human brain is the lack of direct access to functioning human brain tissue. The Human Brain Organogenesis Project aims to recapitulate neural development in a dish by building next-generation technologies for deriving functioning human brain tissue non-invasively from stem cells. The research team will use these 'brain-in-a-dish' models to understand how human neurons talk to each other, and identify what goes wrong when mental disorders develop. The team will maximize the impact of their research by broadly sharing their technology and developing ethical guidelines for this emerging field.

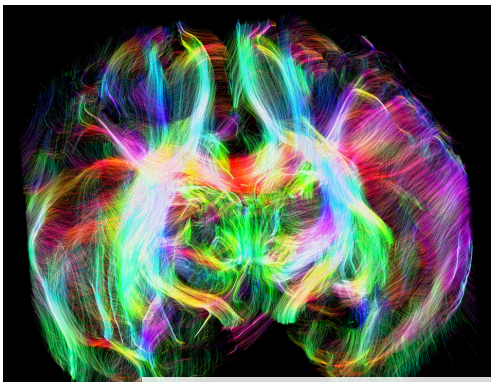


Image credit: Jennifer McNab

Brain rejuvenation

Team Leaders: Tony Wyss-Coray (neurology) and Aaron Gitler (genetics)

Ongoing Phase 2 project

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. The Stanford Brain Rejuvenation Project is focused on harnessing a powerful new approach to discover, characterize and utilize brain rejuvenation factors harbored in the blood to improve human health and to combat neurodegenerative diseases. 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 to develop innovative therapeutic strategies.

Seed Grants

The impact of early medial temporal lobe Tau in human cognitive aging

Elizabeth Mormino (neurology) and Anthony Wagner (psychology)

Ongoing project

The pathological changes of Alzheimer's disease (AD) begin years before clinical symptoms are noticeable, and may contribute to decline in memory among putatively 'healthy' older individuals. Positron emission tomography (PET) allows the visualization of early AD pathology — the abnormal aggregation of the Tau protein that is also common among older normal adults. Interestingly, the accumulation of the Tau protein begins in the medial temporal lobe, a brain region essential for memory formation. By combining PET imaging with high-resolution magnetic resonance imaging (MRI) to measure the structure and function of the medial temporal lobe, the team aims to understand how this early AD pathology influences memory in healthy older individuals and whether these early changes can predict who is most at risk for AD dementia.

A novel sigma-1 receptor PET radioligand as a probe of ketamine's rapid therapeutic action in disorders of human brain and behavior

Carolyn Rodriguez (psychiatry and behavioral sciences), Frederick Chin (radiology), David Lyons (psychiatry and behavioral sciences), Alan Schatzberg (psychiatry and

behavioral sciences) and Pamela Flood (anesthesia)

Ongoing project

Major Depressive Disorder (MDD) and Obsessive Compulsive Disorder (OCD) are among the leading causes of disability worldwide, but standard medications provide only minimal relief. A recent discovery by Dr. Rodriguez shows that ketamine could treat symptoms of MDD and OCD within hours. Coincidentally, ketamine is also a powerful dissociative, a class of hallucinogenic drugs. Interestingly, the degree of dissociation strongly predicts a more robust clinical response, raising the question of whether the troublesome side effect may hold a clue to how ketamine acts to reduce psychiatric symptoms. This interdisciplinary collaboration is developing and validating a new method to study the mechanisms underlying ketamine's biochemical action and its effects on dissociation and treatment effectiveness.

Research Accelerator

New tools, analytic methods and conceptual approaches for harnessing plasticity in the human brain

Amit Etkin (psychiatry and behavioral sciences), Gary Glover (radiology), James Gross (psychology), Manish Saggar (psychiatry and behavioral sciences), Surya Ganguli (applied physics), Brian Knutson (psychology)

Ongoing project

Our ability to non-invasively manipulate human neural activity – both for gaining a more causal understanding of normal brain function and to therapeutically remediate dysfunctional circuits – remains very limited. Critical to advancing these capacities are a more robust understanding of which patient-relevant brain circuits are most important for which cognitive operations, how these circuits can be best modulated through repetitive transcranial magnetic stimulation, and how to advance societal understanding of mental illness so that new technologies best impact the lives of individuals in need. Projects range from tool development and experimental work in healthy individuals to complex data analysis and computational modeling, and ultimately to a larger-scale engagement with societal attitudes through educational interventions.

StrokeCog

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

Ongoing project

StrokeCog, focused on cognitive problems after stroke, is an extension of the Stroke Collaborative Action Network (SCAN), a previously funded Big Idea project, and is a key component of the Stanford Stroke Recovery Program. While common, the exact mechanisms of post-stroke cognitive decline are not well understood. StrokeCog funds a large prospective cohort study aimed at determining whether neuroinflammation plays an important role in the development of post-stroke cognitive decline. In addition, this funding continues to support SCAN investigators with their clinical pilot studies via a clinical core. The core helps investigators with study design, stroke subject recruitment, and regulatory requirements for human research such as institutional review board applications and compliance.

Brains behind the institute

Marion Buckwalter

Associate professor of neurology and neurological sciences and of neurosurgery

"The core of any career in science is a desire to discover and understand things that we never knew about before."

Brains behind the institute

Thomas Südhof

Avram Goldstein Professor of molecular and cellular physiology

Being receptive to ideas and knowledge across the disciplines is key. We as scientists need to explore intellectually—not just in our experiments, but in our free time, as many things as we possibly can.

Melanie Hayden Gephart

Associate professor of neurosurgery

At Stanford, "I saw the possibility of combining a fulfilling family life, a vibrant clinical practice, and meaningful contributions through science to develop better treatments for brain cancer."

Tirin Moore

Professor of neurobiology

"Science is a service and a calling—you're trying to add to the body of truth in the world."

Carolyn Rodriguez

Assistant professor of psychiatry and behavioral sciences

"The best moments of my career have been seeing patients experience rapid relief from their OCD symptoms. And it was a reminder of why translational research that delivers direct application to patients is so rewarding."

Creating vital infrastructure

A new research center

It has been a busy year at the site of the future research center that will serve as the hub for the Wu Tsai Neurosciences Institute and Stanford ChEM-H. Construction on the center began in 2017, and this year the structural steel was completed and celebrated with a “topping out” ceremony as the last beam was placed into the structure. After that, the exterior walls and windows followed, and the exterior now resembles the final design for the complex. Inside, the floors for the neuroscience theory center were poured, and the connecting staircases between the second and third floors are being placed. Soon we will have interior walls as well as exterior ones. We have another year’s worth of work, mostly on the interior of facility, before the center opens in September of 2019.

“Topping out” event for the new interdisciplinary research complex

When complete, the 235,000 square foot facility will be home to 24 interdisciplinary neuroscience and 20 ChEM-H laboratories, critical neuroscience core facilities, and vibrant meeting and interaction spaces. By bringing building residents together and drawing in researchers and students from many disciplines across campus, we will create an intellectual collaboration zone where serendipitous encounters could lead to breakthrough neuroscience discoveries — a physical manifestation of Stanford’s commitment to breaking down barriers between disciplines.

Embracing a light-filled courtyard, the neuroscience wing of the center will provide state-of-the-art laboratories with bright, open shared spaces as well as customized zones for specialized equipment and techniques. The first neuroscience occupants of the center, four new hires and 15 existing faculty, were selected from the schools of Humanities & Sciences, Medicine, and Engineering. The occupants were grouped into lab neighborhoods of three to five faculty with shared lab facilities. Within a neighborhood, trainees will work side-by-side with colleagues from different schools and departments. The second floor has a large, bright, two-story open space – the living room – with comfortable furniture, tables and whiteboards where researchers will mingle and interact.

Another unique space is the neuro-theory center. Surrounded with glass and embedded in the living room, this three-story structure within the building places theorists, who often work tucked away from view, front and center physically and intellectually. Reaching the important goal of understanding how the brain computes will require development of novel theoretical and analytical approaches, and the institute hopes to recruit the best and brightest quantitative minds to this center.

Co-localization of the Wu Tsai Neurosciences Institute and ChEM-H in the same building will pay intellectual dividends in the future. New collaborations between neuroscience and ChEM-H faculty have been initiated simply in the course of planning the building; more will certainly ensue when research groups are in situ and ‘collisions’ begin occurring the building common spaces. “I really do believe the future of neuroscience is going to be collaborative,” institute director Bill Newsome says. “Being co-located with ChEM-H will bring neuroscientists in contact with chemists who are interested in biological applications.”

Brains behind the institute

Sergiu Pasca

Assistant professor of psychiatry and behavioral sciences

"Once you get infected with the 'virus of scientific discovery,' it's impossible to recover. Seeing something for the first time, discovering phenomena that nobody else has ever understood, is really exciting—and above everything else, fun."

Mark Schnitzer

Associate professor of biology and of applied physics

It's easy to get distracted by the most recent high-profile results in your field, but developing a sense of what's critical in the long run is crucial.

Development activities at Wu Tsai Neuro

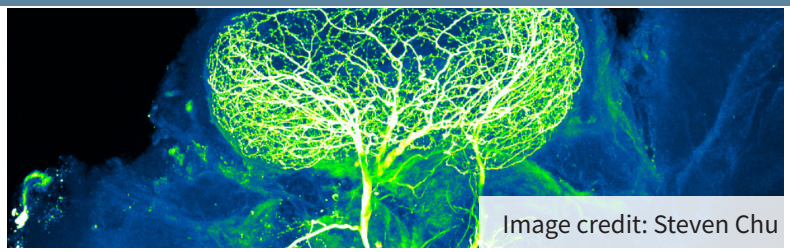


Image credit: Steven Chu

The Wu Tsai Neurosciences Institute celebrated its fifth anniversary with a very well-attended symposium, notable stewardship events and the launch of its new name. The symposium highlighted the strategic connections between neuroscience and artificial intelligence — a collaboration that will continue to be important as the neuro theory center opens in the new research complex. Special events honored Clara Wu Tsai and Joe Tsai for their incredible naming gift as well as thanked many other generous donors and volunteers who have been instrumental in support of people, research and facilities over these first five years. These philanthropic investments have provided foundational pillars to solidify Stanford's interdisciplinary approach to brain science, which engages nearly 450 faculty campus wide.

Additionally, this past year Wu Tsai Neuro secured long-term support for the Big Ideas in Neuroscience program. With the help of presidential matching funds, visionary donors were inspired to make gifts resulting in a total of $30 million to establish a collective endowed fund that will support innovative brain science for years and years to come. This fund, along with additional expendable research funding, enables the institute to provide seed grants, fund Big Ideas and pilot new research ideas like the Neuro: Translate initiative.

Preparations continue for the new interdisciplinary research complex, future home of the Wu Tsai Neurosciences Institute and Stanford ChEM-H, which is slated to open in fall 2019. This innovative space was a focal point for the most recent Interdisciplinary Life Sciences Council meeting and continues to be a fundraising priority. In the upcoming year, the development team seeks to secure an additional $10 million for the construction of the complex, and will begin planning the events around the building dedication.

Another critical fundraising priority for Wu Tsai Neuro is to support talented people. The institute seeks to raise 5 professorships, 11 graduate fellowships and 20 postdoctoral fellowships, all of which are pivotal to strengthening the field of neurosciences across campus. Additional philanthropic gifts will enable Wu Tsai Neuro to continue to strengthen important bridges from basic research to translation to the clinic, build out cross-disciplinary training programs for grad students and postdocs, hire interdisciplinary faculty, provide state-of-the-art shared labs and resources, and invest in targeted, highly promising neuroscience endeavors.

Brains behind the institute

Kwabena Boahen

Professor of bioengineering and of electrical engineering

"Making connections between neurobiology and computer science reminds me that I'm doing what I've always loved: exploring how something works, then finding a better way to do things."

Meet our team

Wu Tsai Neurosciences Institute owes the success of its fifth year to its leadership and to the dedicated team that makes our events and programs happen.

Executive Committee of the Wu Tsai Neuro (L to R): Brian Wandell, Scott Delp, Rob Malenka, Tanya Raschke and Bill Newsome

Executive Committee

William Newsome (neurobiology), Vincent V.C. Woo Director and Harman Family Provostial Professor

Marion Buckwalter (neurology, neurosurgery), Deputy Director

Scott Delp (bioengineering, mechanical engineering), Deputy Director and James H. Clark Professor

Robert Malenka (psychiatry and behavioral sciences), Deputy Director and Nancy Friend Pritzker Professor

Brian Wandell (psychology), Deputy Director and Isaac and Madeline Stein Family Professor

Tanya Raschke, Associate Director for Planning and Operations

Staff

Nathan Collins, Communication Director

Roula El-Asmar, Program Manager

Elise Kleeman, Scientific Program Manager

Cathy Lau, Financial Analyst

Maura McGinnity, Development Director

Daisy Ramirez, Administrative Associate

Tanya Raschke, Associate Director for Planning and Operations

Midori Yoshimura, Digital Media Associate

Staff of the Wu Tsai Neuro (L to R): Bill Newsome, Cathy Lau, Roula El-Asmar, Tanya Raschke, Elise Kleeman and Daisy Ramirez


“Our hope is that the institute will be able to drive discoveries about the brain, translate them into effective therapies and serve our global society.”
-Clara Wu Tsai, ‘88, MA ‘88