USC Mark and Mary Stevens Neuroimaging and Informatics Institute

Opening of the USC Stevens Hall for Neuroimaging. From left: Rohit Varma, Sean Stevens, Mark and Mary Stevens, C. L. Max Nikias, Niki C. Nikias, Ghada Irani and Arthur W. Toga

Photo by Gus Ruelas

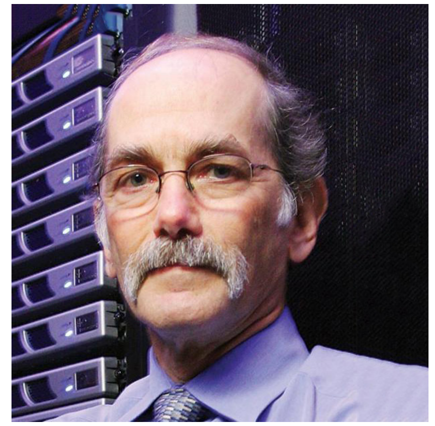
Summer 2017

Impact Report

INI

DIRECTOR'S NOTE

Summer 2017



We've settled into our new home, the Mary and Mark Stevens Hall of Neuroimaging. The Stevens' visionary gift has allowed us to build a state-of-the-art facility, tailored to our unique brand of multi-disciplinary investigation.

Our Siemens Terra scanner, the first ever 7T designed for dual research and clinical applications, was installed at INI's Center for Image Acquisition.

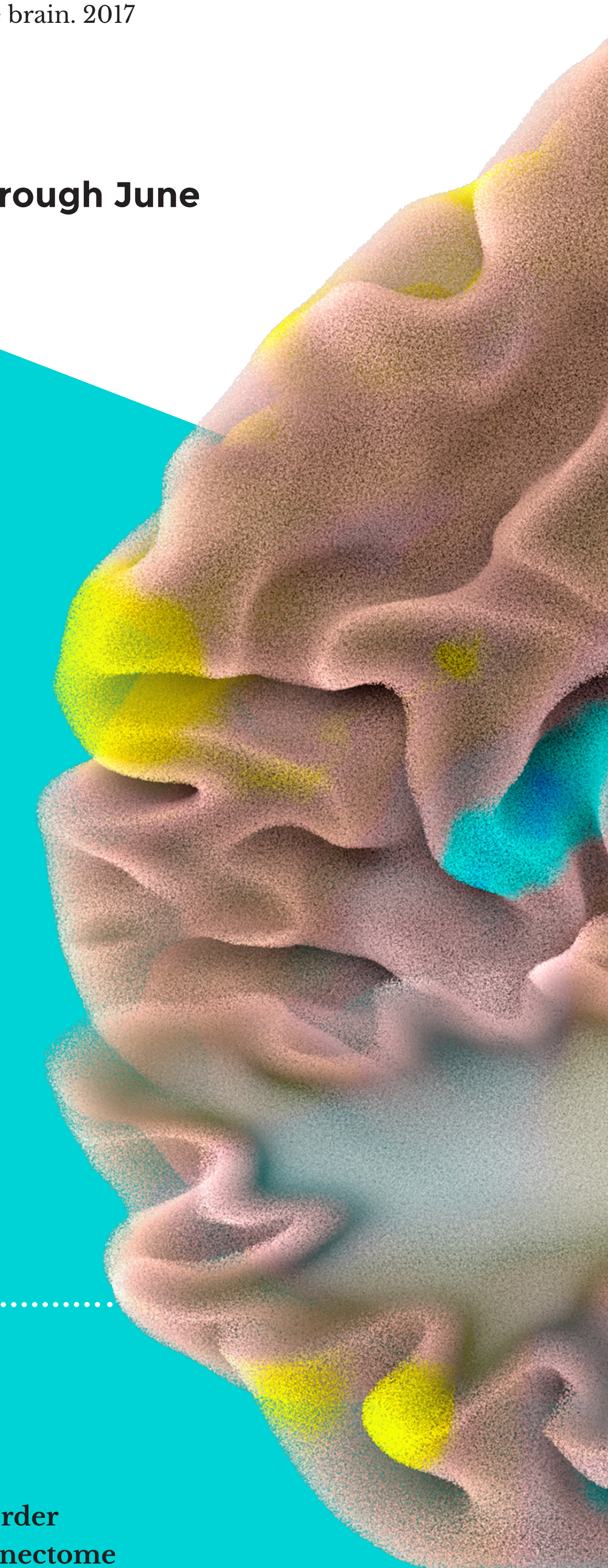
We've undertaken several new landmark research collaborations, including a $21.7 million NIH-funded examination of posttraumatic epilepsy.

As we build on our tradition of excellence, INI's new home is nurturing our growth into one of the world's great centers for neuroimaging and informatics.

Arthur W. Toga
Director, USC Mary and Mark Stevens Neuroimaging and Informatics Institute
Provost Professor of Ophthalmology, Neurology, Psychiatry and the Behavioral Sciences, Radiology and Biomedical Engineering
Ghada Irani Chair in Neuroscience

INI Impact

The research team at the Stevens Neuroimaging and Informatics Institute strives for measurable progress toward understanding the brain. 2017 has been a great year so far.



2017: January through June

$19.5 million active research funding

65 peer-reviewed publications

22 new team members

108 collaborations in 18 countries in the LONI Image and Data Archive

115 active research grants

Discoveries in:

Alzheimer's Disease
Schizophrenia
Autism Spectrum Disorder
Huntington's Disease
Stroke
Traumatic Brain Injury
Depression
Frontotemporal Dementia
Obsessive Compulsive Disorder
Epilepsy
Bipolar Disorder
Human Connectome
Mouse Connectome
Imaging Genetics
Human Development
Neuroimaging Techniques

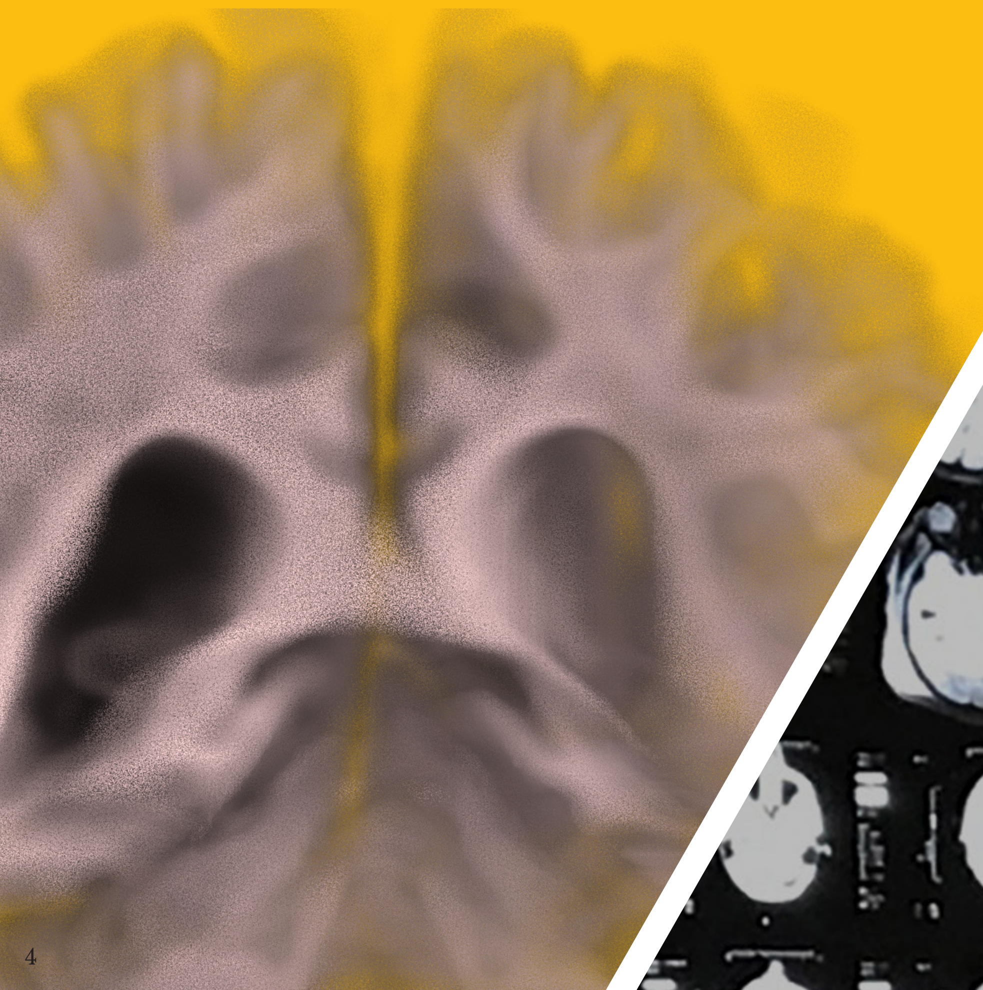
Treatments for neurological diseases aren't often deemed "fun," but INI's Judy Pa may soon change that. Pa, an assistant professor of neurology, is launching a pilot study called NeuroRiderVR, which integrates fitness and brain exercises into a gamified program that may decrease the risk of Alzheimer's Disease.

She received a $40,000 grant, which covers one year of research and development, from the Southern California Clinical and Translational Science Institute. Pa and her team will build their own stationary exercise bike and design a corresponding virtual obstacle course.

"We're developing a platform to bring people in who may be at risk, and put them in an environment to train their brains in a way that we think will be beneficial," said Pa.

Bikers, furnished with VR headsets, will collect objects throughout the obstacle course in a sort of "treasure hunt," and the program will be tailored to resonate with specific generations. For example, as part of research and development for NeuroRiderVR, Pa and her team discovered that older adult players enjoy collecting antiques and memorabilia—including gold coins, relics, and items related to hobbies like music.

Pa's team will test young adults, healthy older adults, and older adults displaying early signs of cognitive impairment. They will use a variety of tools to assess participants before and after the intervention, including brain imaging, physical assessments, and cognitive tests.



Neuroscience Meets Virtual Reality

Researchers at the USC Stevens Neuroimaging and Informatics Institute are exploring a new frontier: using VR to study the brain. We've applied the technology to every step of the process, from patient treatment to the analysis and visualization of data.

REHABILITATE

Before launching the Neural Plasticity and Neurorehabilitation Lab (NPNL) at USC, Sook-Lei Liew worked to rehabilitate stroke patients through occupational therapy. But the lack of treatment options for those who suffered severe strokes spurred her transition into exploratory research.

"As a therapist, I didn't know who was going to recover," Liew said. "And for the people who weren't recovering, I didn't have anything else I could give them. That was really frustrating and a little bit heartbreaking."

Her latest creation, REINVENT—Rehabilitation Environment using the Integration of Neuromuscular-based Virtual Enhancements for Neural Training—may be able to help patients who don't respond to traditional stroke recovery methods.

This low-cost, portable brain-computer interface consists of an electroencephalography (EEG) cap and surface electromyography (EMG) electrodes, which read signals from a patient's brain and muscles; a movement tracker; a VR headset; and a laptop to run the VR software.

"We take signals from your brain, and we take signals from your muscles," Liew explained. "When those signals indicate that you're trying to move, then in Virtual Reality your arm moves, even if your arm doesn't really move in the real world."

REINVENT builds on existing stroke rehab techniques, which reinforce motor commands in the brain that generate movement in the body. While severe stroke patients exhibit the same motor commands, the signals don't effectively translate into movement. Adding the VR component gives clinicians a way to reinforce these attempts to move, even when no visible motion takes place.

At this year's SXSW Film Awards, REINVENT received a special jury recognition for innovative use of Virtual Reality Room-Scale Technology in the field of health.

ANALYZE

A key initial step in the analysis of MRI data, called segmentation, separates the brain into labeled regions to enable close examination of various structures. This step is mostly automated, but the process isn't perfect.

"While we have quite a few automated tools for segmenting brain regions such as the hippocampus, their accuracy is not satisfactory for critical tasks such as measuring treatment effects in clinical trials," said Yonggang Shi, an assistant professor of neurology at INI who develops mathematical frameworks and algorithms to analyze neuroimaging data.

But the alternative—manual segmentation—is "very time-consuming and tedious," said Dominique Duncan, an assistant professor of neurology at INI. "It's a major bottleneck in the experimental process."

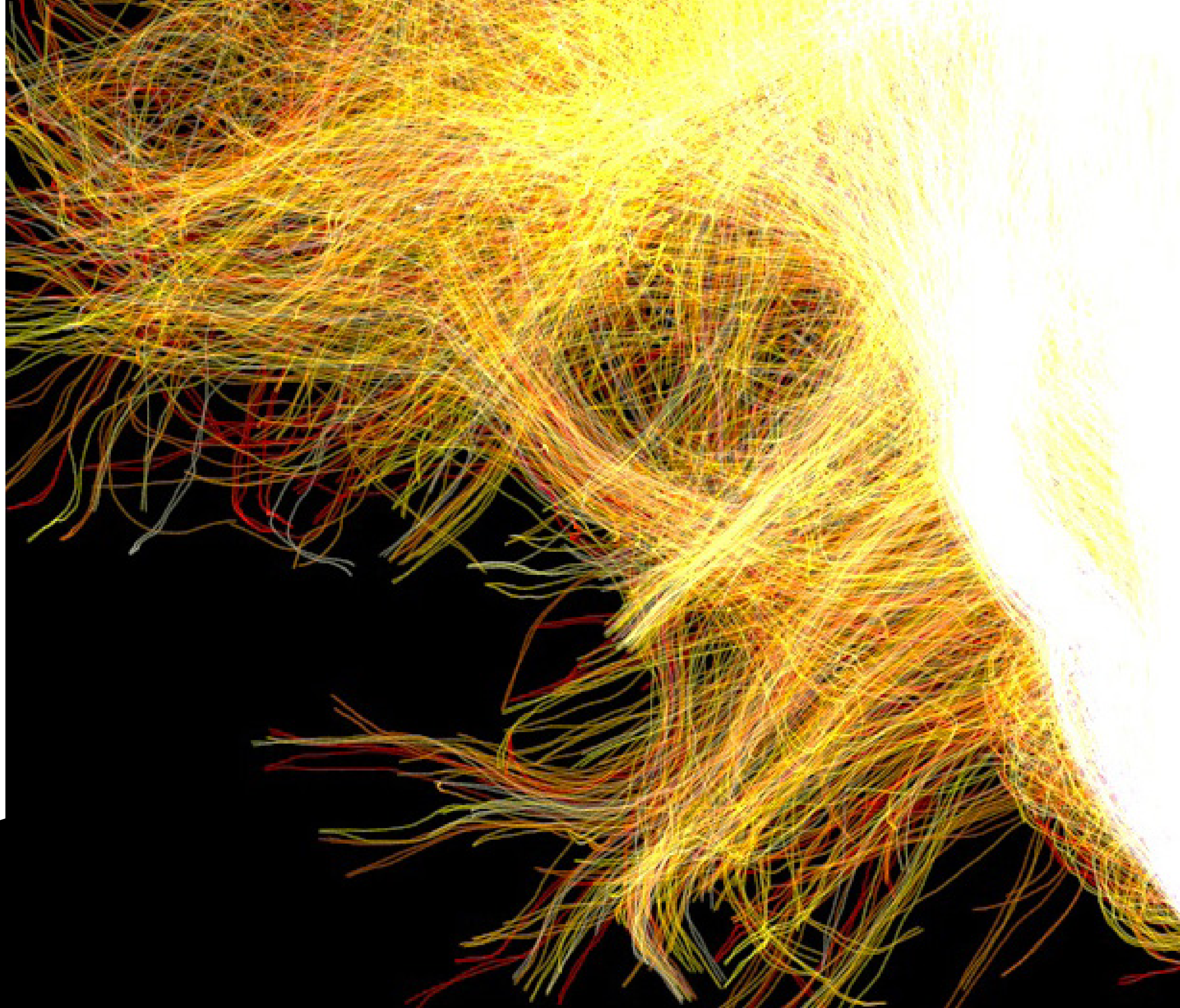
Hoping to design a more efficient means of segmenting MRI data, Duncan secured a Vive VR headset from consumer electronics company HTC and partnered with RareFaction Interactive. The company programmed and helped Duncan design a new tool, the Virtual Brain Segmenter (VBS).

Armed with the VR headset and two handheld controllers, users can walk freely around and through brain scan data as they manually correct segmentation errors. In a preliminary test, participants completed a short correction task 68 seconds faster using VBS compared with a traditional computer program.

Users also unanimously preferred VBS to the alternative method; many even said they had fun. Next, Duncan hopes to gamify VBS to render it even more accessible to non-experts. A game-like design would allow researchers to attract additional users, effectively crowdsourcing the error correction process.

Above all, a faster segmentation program saves valuable time and energy during imaging analysis.

"If we can make these corrections faster, it will ultimately speed up research on neurological diseases," Duncan said.



VISUALIZE

Neuroimaging data is highly complex, and the tools currently available to visualize it don't always enhance our understanding of results. Tyler Ard, assistant professor of research at INI, wants to change this.

"Humans are basically visual critters," he said. "If we really want to see what's happening in our data, we can't just throw algorithms at it. That can be misleading."

Ard used Unity, a VR rendering engine, to create an immersive space for visualizing brain imaging data. Neuro Imaging in Virtual Reality (NIVR) quite literally adds a new dimension to the data researchers acquire from brain scans.

As soon as users strap on VR goggles, they enter a room-scale experience that resembles outer space. Looming large in front of them is a 3D model of a real subject's brain.

The program offers several modes for exploring our most complex organ: a volumetric viewer, a highly detailed "near-field" rendering, an anatomy viewer, and a connectivity map. One setting even allows the user to step inside a larger-than-life brain and view structures from within.

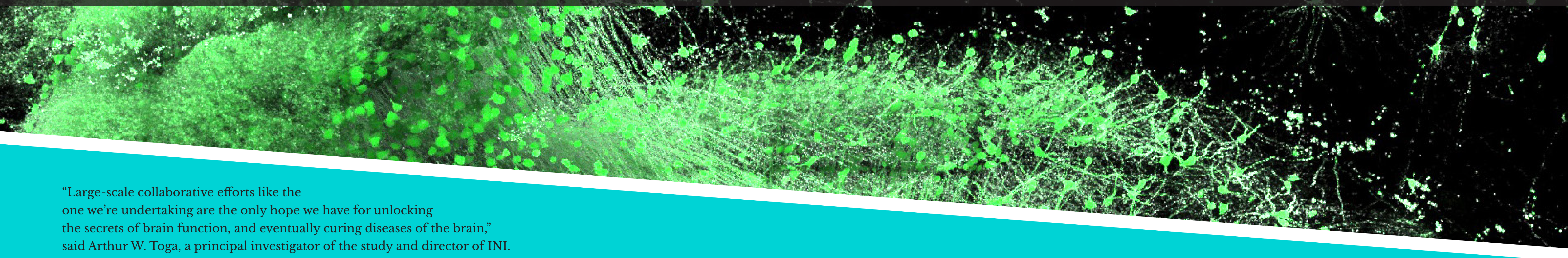
In future, NIVR can be adapted for use by students and clinicians in addition to researchers. It may help doctors identify abnormalities in a patient's brain, and can serve as a useful tool for teaching brain anatomy.

"Neuroimaging data is naturally 3D, but we're constrained to 2D screens when we view it," Ard said. "This is an exploration into a more intuitive way to interact with our data."

USC Neuroimaging Team Joins International Epilepsy Effort

Featured: Epilepsy & Bioinformatics

Researchers at the Stevens Neuroimaging and Informatics Institute will help lead the $21.7 million collaborative study, aimed at finding a cure.



"Large-scale collaborative efforts like the one we're undertaking are the only hope we have for unlocking the secrets of brain function, and eventually curing diseases of the brain," said Arthur W. Toga, a principal investigator of the study and director of INI.

USC's Laboratory of Neuro Imaging, housed within the Mary and Mark Stevens Neuroimaging and Informatics Institute (INI) at the Keck School of Medicine, has received a $21.7 million grant from the National Institutes of Health to study posttraumatic epilepsy and to understand how it might be treated or prevented.

Epilepsy and other seizure disorders currently afflict more than 5.1 million Americans, according to the Centers for Disease Control and Prevention. The disorder, which may result from head trauma, stroke, or other insults to the nervous system, involves disruption of the brain's electrical signaling, which leads to seizures.

The project, the Epilepsy Bioinformatics Study for Antiepileptogenic Therapy (EpiBioS4Rx), is led by an international consortium of principal investigators across five institutions. A five-year grant funds research efforts through 2021 at USC, UCLA, University of Melbourne, University of Eastern Finland, and the Albert Einstein College of Medicine.

The collaborative nature of the study is what sets it apart from previous efforts to understand and cure epilepsy. While yielding drugs to treat seizures, many studies performed at individual institutions have yet to answer larger questions about the disease, such as how it develops in the first place.

The new study seeks to narrow the gap in understanding by identifying biomarkers associated with the development of epilepsy. Researchers will examine patients and animals with traumatic brain injury, closely monitoring changes in the brain that may signal the onset of the disorder. By harmonizing data from blood, electrophysiology tests, and brain scans, the team hopes to paint a comprehensive picture of how epilepsy arises.

Once the EpiBioS4Rx team identifies reliable biomarkers for the disorder, they plan to enter the preclinical trial phase and test a series of therapeutic drugs on rats. If one or more compounds shows promise in preventing the onset of epilepsy, the group may ultimately apply for authorization to conduct clinical trials with patients.

INI researchers will play a key part in the harmonization and processing of data throughout the study.

"Our role is the informatics and analytics," said Dominique Duncan, assistant professor of neurology at INI. "All the data comes to us; we store, manage, and organize it. We are developing a robust infrastructure to integrate, search, and analyze the multi-modal data. Then we share it publicly with the broader epilepsy community."

Other researchers, even those not involved with EpiBioS4Rx, will be able to access study data online and use it in their own analyses.

"The goal is to encourage collaboration and try to speed up research in the field," Duncan said.

A portion of grant funds will be used to engage with epilepsy patients and their families. This will help researchers identify patients' most pressing concerns, provide educational tools, and encourage participation in clinical studies.

2017: NEW PROJECTS

Paul Thompson, Associate Director of INI and Director of the Imaging Genetics Center, is launching two large collaborative studies in 2017. One investigates how trauma and genetics influence brain structure in several common psychiatric disorders; the other uses connectivity maps to identify biomarkers for early detection of Alzheimer's Disease.

"Our international studies on brain disease now span 35 countries where we gather—day and night—new information on how risk factors such as trauma and stress interact, which ones matter the most, and how to resist them."

Meredith Braskie, Assistant Professor of Research Neurology, is collaborating with Hussein Yassine, assistant professor of medicine at Keck, on two projects. They have received grants from NIH and CTSI to investigate the role of fatty acids, including DHA, in Alzheimer's Disease.

"It's important for us to look at individuals who aren't yet affected by Alzheimer's—we want to learn more about options for early treatment or prevention before cognitive symptoms arise."

Hong-Wei Dong, Associate Professor of Neurology, received funding from NIH to launch Phase III of his Mouse Connectome Project, which aims to assemble the global neural networks of the mouse brain.

"We're combining different technologies to compare neural circuitry across animal models. We'll be looking at connectivity globally, and also at the cellular level."

Hosung Kim, Assistant Professor of Neurology, has received the 2017 Baxter Foundation Faculty Fellowship Award, which provides seed funding to young investigators launching careers in biomedicine. He will use the grant to predict brain development in preterm infants using biomarkers obtained from brain imaging.

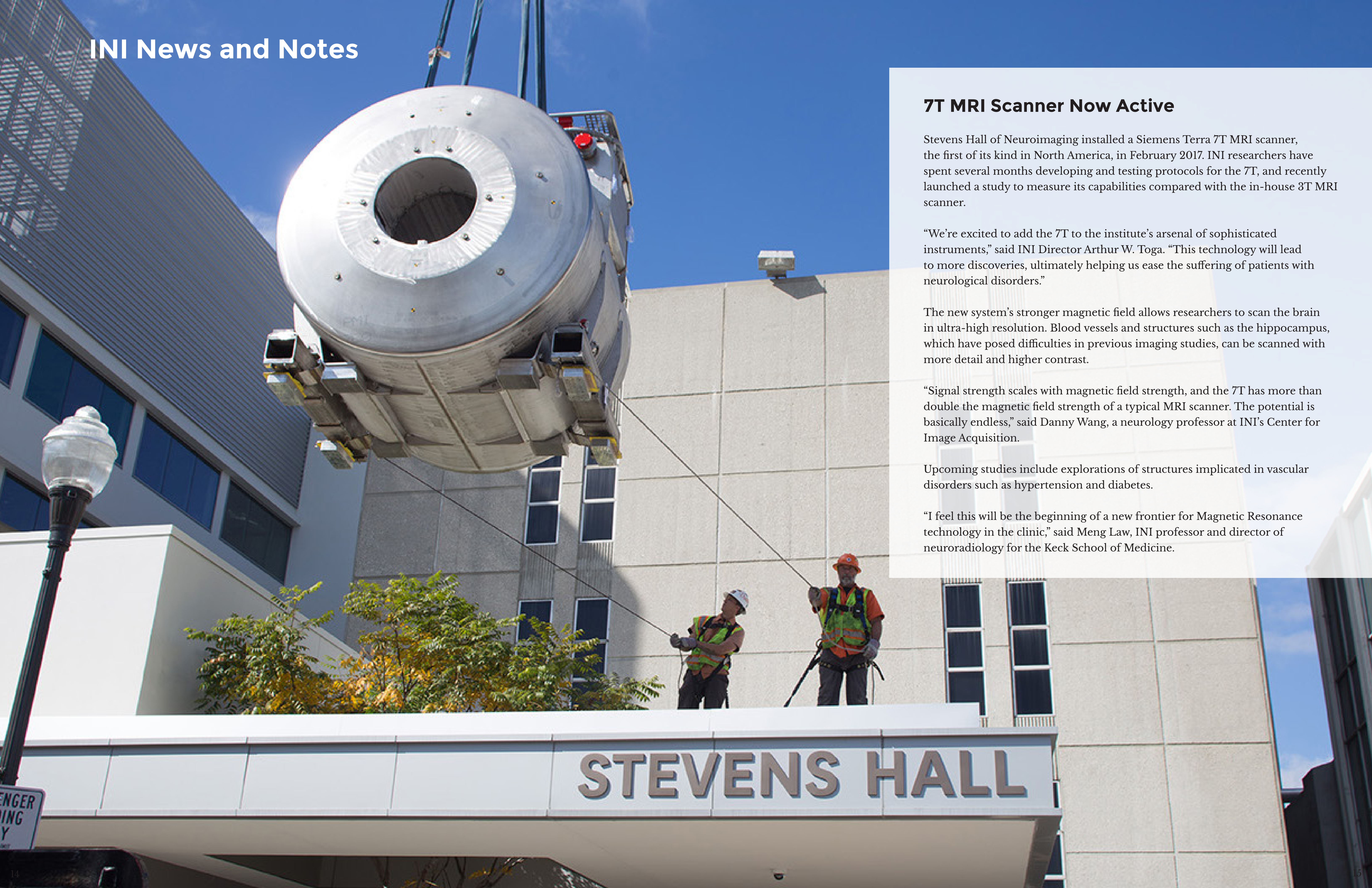
"Even with existing treatments, up to half of preterm newborns develop deficits in motor function, language, or IQ. We may be able to predict these impairments using brain scans, and eventually prevent them."

Jack Van Horn, Associate Professor of Neurology and Director of Education for INI, received funding from NSF to lead the annual Innovation Lab, a workshop focused on training biomedical researchers to maximize big data. This year, participants—including neuroscientists, biostatisticians, and community ecologists—explored big data solutions for researching the human microbiome.

"We're training the next generation of scientists in data science techniques and technologies. They need to be prepared early so that they know how to handle the ever-increasing data we're going to collect."

Danny JJ Wang, Professor of Neurology, secured funding from NIH to develop a novel system for reducing the dose of radiation patients receive during Computed Tomography (CT) perfusion, a useful tool for the early diagnosis of stroke.

"More than 80 million CT scans are performed in the U.S. every year, estimated to cause 40,000 future cases of cancer. This project will develop, evaluate, and commercialize a new imaging platform that reduces the radiation dose by about 75% without compromising imaging speed or quality."



7T MRI Scanner Now Active

Stevens Hall of Neuroimaging installed a Siemens Terra 7T MRI scanner, the first of its kind in North America, in February 2017. INI researchers have spent several months developing and testing protocols for the 7T, and recently launched a study to measure its capabilities compared with the in-house 3T MRI scanner.

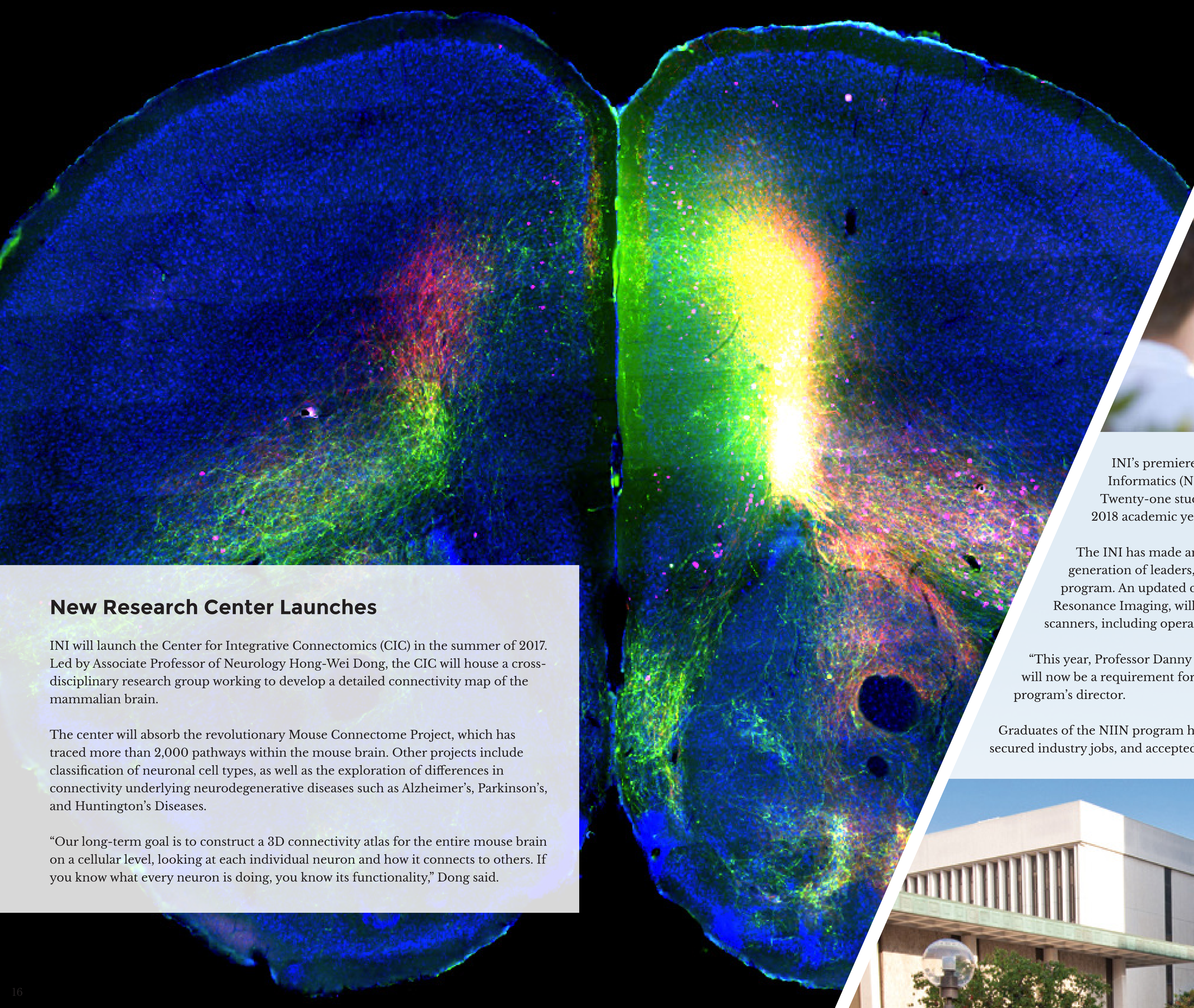
“We’re excited to add the 7T to the institute’s arsenal of sophisticated instruments,” said INI Director Arthur W. Toga. “This technology will lead to more discoveries, ultimately helping us ease the suffering of patients with neurological disorders.”

The new system’s stronger magnetic field allows researchers to scan the brain in ultra-high resolution. Blood vessels and structures such as the hippocampus, which have posed difficulties in previous imaging studies, can be scanned with more detail and higher contrast.

“Signal strength scales with magnetic field strength, and the 7T has more than double the magnetic field strength of a typical MRI scanner. The potential is basically endless,” said Danny Wang, a neurology professor at INI’s Center for Image Acquisition.

Upcoming studies include explorations of structures implicated in vascular disorders such as hypertension and diabetes.

“I feel this will be the beginning of a new frontier for Magnetic Resonance technology in the clinic,” said Meng Law, INI professor and director of neuroradiology for the Keck School of Medicine.



New Research Center Launches

INI will launch the Center for Integrative Connectomics (CIC) in the summer of 2017. Led by Associate Professor of Neurology Hong-Wei Dong, the CIC will house a cross-disciplinary research group working to develop a detailed connectivity map of the mammalian brain.

The center will absorb the revolutionary Mouse Connectome Project, which has traced more than 2,000 pathways within the mouse brain. Other projects include classification of neuronal cell types, as well as the exploration of differences in connectivity underlying neurodegenerative diseases such as Alzheimer's, Parkinson's, and Huntington's Diseases.

"Our long-term goal is to construct a 3D connectivity atlas for the entire mouse brain on a cellular level, looking at each individual neuron and how it connects to others. If you know what every neuron is doing, you know its functionality," Dong said.

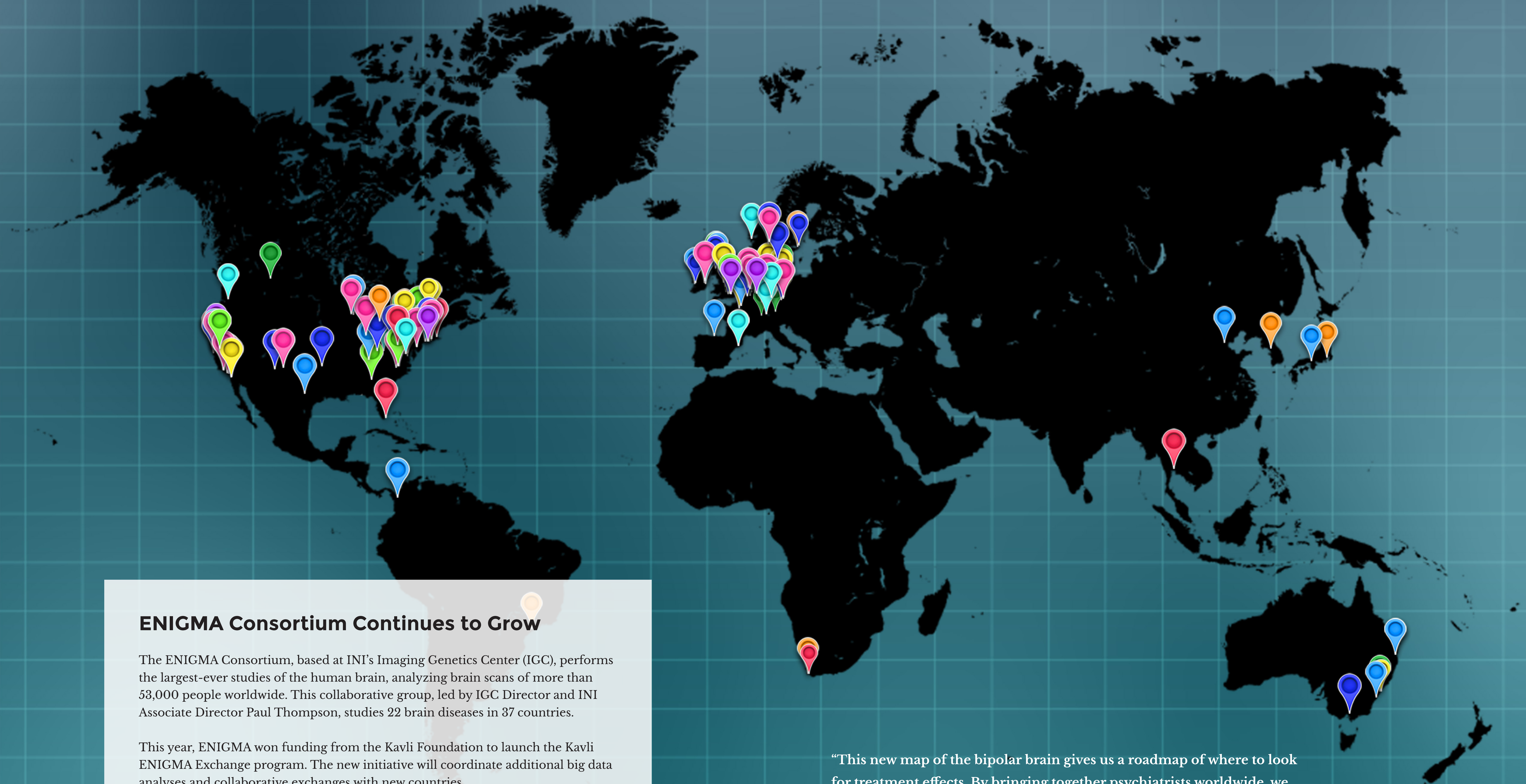
Master's Program Enters its Third Year

INI's premiere master of science program in Neuroimaging and Informatics (NIIN) will welcome its third and largest class in August. Twenty-one students have committed to join the program for the 2017-2018 academic year.

The INI has made an institute-wide commitment to training the next generation of leaders, with a role for nearly every faculty member in the NIIN program. An updated course, Neuroimaging Data Acquisition with Magnetic Resonance Imaging, will give students hands-on training with the onsite MRI scanners, including operating the scanner and undergoing a brain scan.

"This year, Professor Danny Wang will lead the class, and practical scanner training will now be a requirement for students of the program," said Jack Van Horn, the program's director.

Graduates of the NIIN program have attended medical school, joined Ph.D. programs, secured industry jobs, and accepted full-time positions at INI.



ENIGMA Consortium Continues to Grow

The ENIGMA Consortium, based at INI's Imaging Genetics Center (IGC), performs the largest-ever studies of the human brain, analyzing brain scans of more than 53,000 people worldwide. This collaborative group, led by IGC Director and INI Associate Director Paul Thompson, studies 22 brain diseases in 37 countries.

This year, ENIGMA won funding from the Kavli Foundation to launch the Kavli ENIGMA Exchange program. The new initiative will coordinate additional big data analyses and collaborative exchanges with new countries.

ENIGMA also published the largest MRI study to date on bipolar disorder in the May issue of the journal Molecular Psychiatry. The analysis mapped the brains of more than 6,000 people; patients with bipolar disorder displayed thinner gray matter in areas of the brain that control inhibition and motivation. Maps like these help researchers develop targeted therapies as well as early detection and prevention strategies.

"This new map of the bipolar brain gives us a roadmap of where to look for treatment effects. By bringing together psychiatrists worldwide, we now have a new source of power to discover treatments that improve patients' lives."

- Paul Thompson

To learn more about how you can support transformative neuroimaging and informatics research, please contact:
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