2014-2015
ANNUAL REPORT

BECKMAN INSTITUTE
FOR ADVANCED SCIENCE AND TECHNOLOGY

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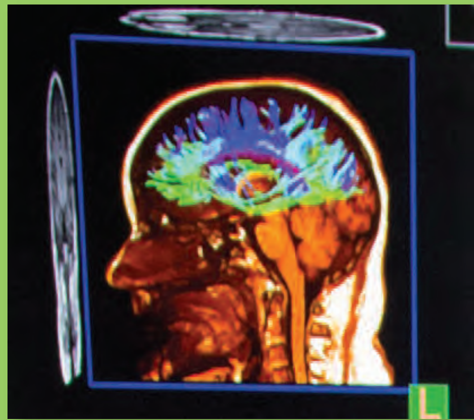
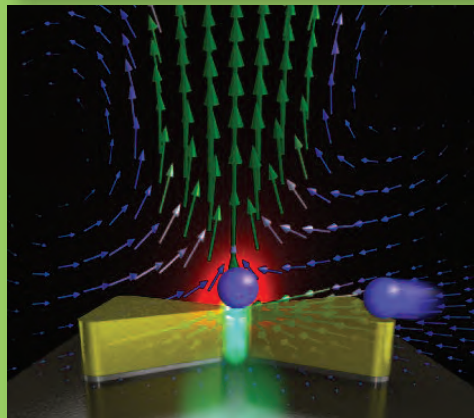
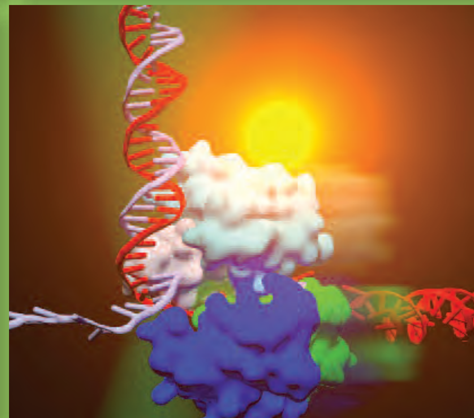






Art Kramer

The past year saw a whirlwind of activity at the Beckman Institute for Advanced Science and Technology. Not only did we celebrate our 25th anniversary with a reunion of former Beckman Postdoctoral Fellows, Beckman directors, and the Beckman Foundation Board, we also held our biennial Open House (see page 56). Chad Mirkin spoke at our SmithGroup lecture in October and our Senior Fellow, Christophe Chipot, gave an exciting lecture and demonstration on chemistry, spherification, and *avant garde* cuisine.

Those events are just a number of ways that we highlight the numerous research activities of the Institute. In the past year, we've created a new strategic initiative: the Illinois Language and Learning Initiative (ILLI), headed by Kara Federmeier and Jennifer Cole. ILLI is creating a unique space for researchers interested in language from biological and psychological perspectives to collaborate with researchers from Illinois' top-ranked engineering programs. INSIGHT, a brain training project that integrates cognitive science, neuroscience, computational science, exercise physiology, and nutritional science, headed by Aron Barbey, along with an interdisciplinary team of Beckman faculty, postdocs and students, had a successful first year that led to increased funding for year two.

Our faculty have received numerous awards for their research breakthroughs: Joseph Lyding, of the Nanoelectronics and Nanomaterials Group, and Dan Roth, from the Artificial Intelligence Group, were elected Fellows of the American Association for the Advancement of Science. Lyding was also named the recipient of the Foresight Institute Feynman Prize for experimental work.

Jeffrey Moore, of the Autonomous Materials Systems Group, has been named a Howard Hughes Medical Institute Professor. Rohit Bhargava, of the Bioimaging Science and Technology Group, was chosen as a Fellow of the American Institute for Medical and Biological Engineering (AIMBE) "for pioneering the development of chemical imaging technology and the use of optical spectroscopic methods for digital pathology."

Zhi-Pei Liang, in the Bioimaging Science and Technology Group, was selected to receive the 2015 Institute of Electrical and Electronics Engineers (IEEE) in Medicine and Biology Society (EMBS) Distinguished Service Award for "outstanding service to EMBS and the field of biomedical engineering."

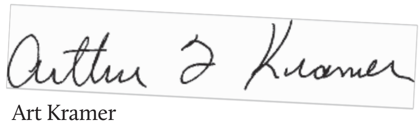
Gary Dell, from the Cognitive Science Group, John Rogers, from the 3D Micro- and Nanosystems Group, Taekjip Ha, affiliate faculty member, and Cathy Murphy, from Nanoelectronics and Nanosystems, were elected to the National Academy of Sciences in recognition of their distinguished and continuing achievements in original research. Ha, Dell, and J. Kathryn Bock, also from the Cognitive Science Group, were elected to the American Academy of Arts and Sciences, one of the longest-standing honorary societies in the nation.

I have been serving on a panel of the President's Council of Advisors on Science and Technology that deals with "Aging and Technology," and l contributed to the Institute of Medicine (IOM) of the National Academies Study on Cognitive Aging, which assessed the public health dimensions of cognitive aging with an emphasis on definitions and terminology, epidemiology and surveillance, prevention and intervention, education of health professionals, and public awareness and education.

The upcoming year holds some exciting changes for the Institute: the Biological Intelligence and Human-Computer Intelligent Interaction research themes are planning a merger that will allow faculty to participate in more than one research group, expanding not only research potential, but also providing a way to invite more collaboration between disciplines. The new University of Illinois College of Medicine, with a focus on biomedical engineering, strengthens Beckman's already existing ties to Carle Foundation Hospital. Both Beckman and the hospital can benefit through translational medical research and imaging technologies that can be conducted in the Beckman facilities in conjunction with physicians at Carle.

The research highlighted in this annual report is but a small sampling of what goes on at the Beckman Institute throughout the year. Our faculty, research, administrative, and facilities staffs are among the best at the University of Illinois and they continue to push the limits, not only in their labs and offices, but also in creating fields of research that incorporate tools, applications, and knowledge from diverse academic disciplines.

It's truly a pleasure to share in their accomplishments. Thank you for being a part of this collaborative effort.



Art Kramer
Director
Beckman Institute for Advanced Science and Technology

"It's been 25 years, but every time I walk into this building, I get this warm, wonderful feeling about the place. It's a beautiful place."

Theodore "Ted" Brown

Gary Dell, professor of psychology and member of Beckman's Cognitive Science Group, reminisces with Dale Barr, former Beckman Postdoctoral Fellow, Morton Weir, University of Illinois chancellor emeritus, and Stanley Ikenberry, Illinois president emeritus.

Founding Beckman Director Theodore "Ted" Brown illustrates a point during his remarks at the 25^{th} anniversary celebration.

Founding Director of the Beckman Institute Theodore "Ted" Brown was one of the speakers who celebrated 25 years of interdisciplinary research at the Beckman Institute on October 9-10, 2014.

Members of the Beckman Foundation Board and current and former University of Illinois administrators shared memories of Arnold O. Beckman and his wife, Mabel, as well as details of the founding of the first interdisciplinary research institute.

Ted Brown, founding director of the Institute; Arthur Kramer, director of the Beckman Institute; and Jiri Jonas, Pierre Wiltzius, and Tamer Başar, former directors of the Institute, spoke at the opening ceremony of a daylong symposium, which featured presentations by current and past Beckman Institute Postdoctoral Fellows, many of whom contribute their success in academia and industry to the support provided by the Beckman Foundation and the Beckman Institute.

More details about the presentations and video of the presentations can be found at go.illinois.edu/25anniversary.

Former and current Beckman Postdoctoral Fellows attended the celebration (from left to right): Joel Voss, Timothy Nokes-Malach, Srinivas Akella, Dale Barr, Joseph Toscano, Ilia Solov'yov, Slava Rotkin, Abhishek Singharoy, Chandramallika Basak, Ilya Zharov, Gillian Hamilton, Preethi Jyothi, Ming Hsu, Mathews Jacob, and Chao Ma.

Beckman Director Art Kramer was joined by former directors of the Institute and University of Illinois administrators who had been involved in its founding. Pictured with Kramer are Tamer Başar (director, 2008-2010), Stanley Ikenberry (U of I president emeritus), Morton Weir (U of I chancellor emeritus) Theodore "Ted" Brown (founding director, 1987-1993), Pierre Wiltzius (director, 2001-2008), and Jiri Jonas (director, 1993-2001).

Kara Federmeier

Biological Intelligence Profile

What's something that people would be surprised to know about you?

Perhaps one thing that people would find surprising about her, says Federmeier, is that she recently became a certified barbeque judge.

She and her husband visited an Illinois barbeque competition sponsored by the Kansas City Barbeque Society, which oversees a lot of barbeque competitions.

"We saw people doing the judging and we asked, 'How do you get to be a judge?' It turns out you can take classes and you can learn to be a certified barbeque judge, so you can be the person who gets to try all the fabulous barbeque, so we went and did it and we got certified."

The couple completed their training in Chicago in 2014. They haven't actually participated as judges in a competition yet, but they are hoping to get an opportunity soon.

"Part of the judging is always going to be about your own tastes, but we definitely learned some things about what makes great barbeque. For example, sometimes people think that, for ribs, the meat should be falling off, but the official line is that it should not. It needs to be tender, but still needs to be well attached to the bone."

Kara Federmeier says she's "utterly predictable."

"I had wanted to be a scientist from a fairly young age," said Federmeier. "My dad was a chemistry teacher, and I liked science."

So perhaps it's not surprising that Federmeier, professor of psychology and full-time faculty member in Beckman's Cognitive Neuroscience Group, studies how predictability figures into language processing in the human brain.

Federmeier began her career by showing that the brain gets ready for—predicts—future words when people are reading or listening to sentences. Her work now is focused on understanding how this prediction takes place and how it matters for what people understand and remember about what they hear or read.

One of her current studies is examining how substituting a word for an expected word affects someone's memory.

"We use sentences like 'When the two of them met, one of them held out his … .' Most people think you'll say 'hand,' but then you give them 'badge.'"

The word "badge," said Federmeier, is still understandable in the context of the sentence. "You can still figure out what it means, but it creates a slightly different scenario. We've shown that there is a brain response that occurs in situations like this, where people predict one thing and get something else that is surprising but makes sense."

The question is, what does that brain response do?

"We don't know if that response is the brain trying to 'turn off' its expectation for 'hand' or trying to make sense of the unexpected word, or both. We can test that by seeing what people remember about these words later—are you better or worse at remembering that you saw 'badge' when the brain's response is greater? And when do you misremember seeing the word 'hand' instead?"

These kinds of experiments, Federmeier explained, not only help answer questions about how the brain comprehends language, but have other applications as well.

"When designing a textbook, do you want to surprise people, to make things more memorable? Or will that hurt students' ability to remember what you want them to, because they were predicting something else?"

Federmeier's lab, the Cognition and Brain Lab, incorporates electrophysiology, measuring the flow of ions in brain tissue by placing electrodes on a subject's head, into the studies. This allows them to very precisely follow brain processing over time.

"We can follow the brain as it goes through the whole process of understanding a word … first figuring out what letters are there and in what order and then determining what the word means, while also realizing that the meaning of the word isn't what had been predicted and deciding what to do about that," said Federmeier. "For language, time is everything. Words are coming in very quickly and the processes used to understand them have to be even faster. So we need methods that have really good timing."

Interestingly, Federmeier and colleagues have found that older adults are less likely to make predictions when they are processing language.

"We find that older adults as a group are not doing as much prediction," said Federmeier. "They're processing a little more passively. So they're constructing the meaning of the sentence, but they're not forming these really strong expectations about what's coming up next. This makes comprehension less efficient, maybe, but it could also help them if they have to deal with something unexpected."

Federmeier's lab is trying to figure out why this happens.

"There is a subset of older adults that looks just like young adults in terms of comprehension results, and they tend to be adults that score high on tests that are known as verbal fluency," said Federmeier.

In those tests, someone is given a category and has to list as many items in that category as they can in a short amount of time.

"We think that fluency gives us a measure of the strength of the connections between frontal lobe areas that do language production and the temporal lobe areas that are processing the meaning of words and comprehending," Federmeier explained. "So it seems like these adults have really healthy, active connections, and they tend to predict."

However, most older adults aren't making predictions because for some reason it's harder for them to do so. Likewise, young adults can be made to temporarily stop predicting if their predictions turn out not to be useful.

"Prediction is strategic," said Federmeier. "We can change the kind of language people are getting, so that the brain seems to recognize that its predictions aren't working, and it will stop making predictions in those cases."

Federmeier said it makes sense for this to happen because there are pros and cons to prediction.

"This is one of those interesting tradeoffs," said Federmeier. "Prediction is great if you get what you're predicting. If you predict 'hand,' and you get 'hand,' your processing for 'hand' is really easy. You were already ready to perceive it, you were all ready for the meaning of it—but the trade-off comes when you don't get 'hand' and now you have to go back and kind of undo that work."

Federmeier explained that the brain deals with the pros and cons of prediction by using the two hemispheres of the brain differently.

"It's useful to look at the hemispheres because you essentially have two different processing mechanisms taking place within one single person," said Federmeier. "That's easier than having to compare across groups of people who might be doing different things, with all the concomitant differences between people that are hard to control for.

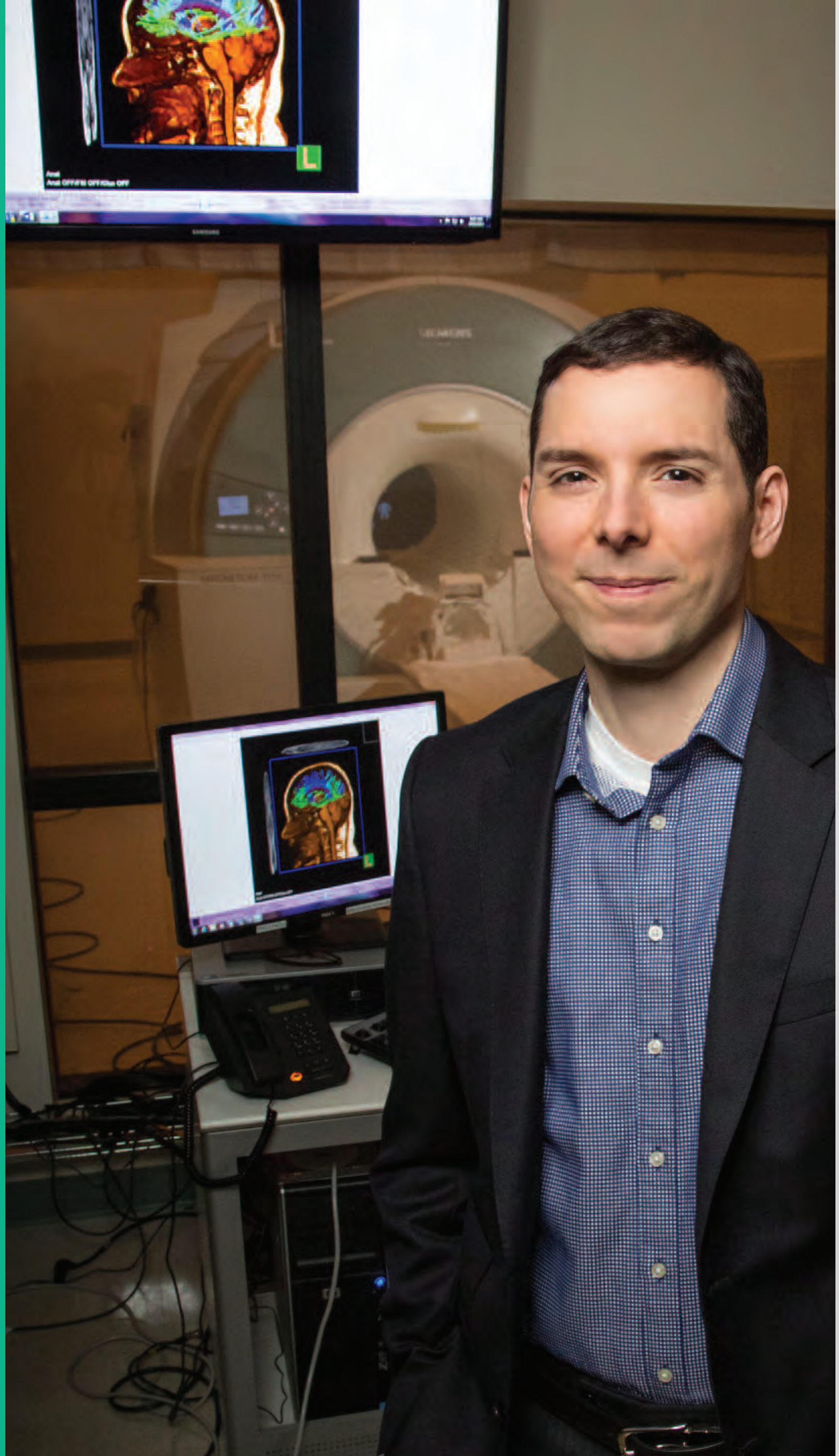
"It's the left hemisphere that seems to be very active in its processing of language, doing prediction, particularly in young adults. It's the hemisphere that controls speech and controls language production, so it makes sense that it is good at taking the meaning from the sentence and using that to figure out what words should be coming up next and getting ready for those words. But the right hemisphere is also comprehending language, just more passively—kind of like the older adults."

Federmeier's research combines her love of language (her mother is a retired English teacher) and her love of science.

"There's just something particularly fascinating about language, which is really the pinnacle of human cognitive abilities," she said. "It's the thing that other species don't seem to be able to do, at least to the same degree, and it brings together all the other cognitive abilities—perception, attention, memory, and concepts."

BioIntel
HIGHLIGHTS

The Biological Intelligence (BioIntel) research theme is comprehensive in scope as researchers seek to understand the brain, cognition, and behavior from the molecular and cellular levels to higher expressions of intelligence like memory and attention, and human behavior. BioIntel research groups (and their areas of study) are: Cognitive Science (higher mental processes, such as language, memory, information processing, and learning); Cognitive Neuroscience (the relationships between brain physiology and structure, and cognitive functions like memory, emotion, and attention); and NeuroTech (brain organization and function, including how information is coded and processed by neural systems and the molecular and cellular origins of disorders and brain plasticity).



Brain-Injured Patients Need Therapies Based on Cognitive Neuroscience

Patients with traumatic brain injuries are not benefiting from recent advances in cognitive neuroscience research—and they should be, scientists reported in a special issue of *Current Opinion in Behavioral Sciences*.

Those who treat brain-injured patients rarely make use of new scientific discoveries about the workings of the brain. Instead, doctors, nurses, and emergency personnel rely on a decades-old tool, the Glasgow coma scale, to categorize brain injuries as mild, moderate, or severe. Brain scans are sometimes performed to help identify damaged regions, and then most patients receive one or more of the following four diagnoses: coma (no response to sensory stimulation), delirium (impaired ability to sustain attention), amnesia (impaired memory) and dysexecutive syndrome (impaired ability to engage in goal-directed thought).

These crude classifications reveal little about the underlying brain mechanisms that are damaged as a result of brain trauma, said Aron Barbey, of the Cognitive Neuroscience Group and professor of neuroscience, psychology, and speech and hearing science. He and his colleagues propose that doctors take a deeper look at the brain networks that enable the regulation and control of attention, memory, and thought—termed "cognitive control processes"—and use this knowledge to develop more targeted treatment strategies.

Sexual Harassment and Assault are Common on Scientific Field Studies

A survey of men and women with experience in field studies in anthropology, archaeology, geology, and other scientific disciplines reveals that many of them—particularly those who are trainees—suffered or witnessed sexual harassment or sexual assault while at work in the field.

A majority of the survey respondents (64 percent) said they had experienced sexual harassment (inappropriate sexual remarks, comments about physical beauty or jokes about cognitive sex differences, for example). And more than 20 percent reported they had been the victims of sexual assault (unwanted physical contact of a sexual nature, including touching, physical threats, or rape).

The survey and analysis comes after a preliminary survey offered evidence that many of those engaged in biological anthropology field research—most of them junior women, but also men—were sexually harassed and/or assaulted while conducting field research far from home.

"Fieldwork is often what stirs the first interest in science in a young person, and research has shown that scientists who do more fieldwork write more papers and get more grants," says **Kate Clancy** of Beckman's Cognitive Science Group and assistant professor of anthropology, who led the study's analysis. "We worry this is at least one mechanism driving women from science."

Fructose Intake Can Increase Body Fat and Decrease Physical Activity

In the last 40 years, fructose, a simple carbohydrate derived from fruit and vegetables, has been on the increase in American diets. Because of the addition of high-fructose corn syrup to many soft drinks and processed baked goods, fructose currently accounts for 10 percent of caloric intake for U.S. citizens. Male adolescents are the top fructose consumers, deriving between 15 to 23 percent of their calories from fructose—three to four times more than the maximum levels recommended by the American Heart Association.

A recent study at the Beckman Institute found that, matched calorie for calorie with the simple sugar glucose, fructose causes significant weight gain, physical inactivity, and body fat deposition.

The researchers, under the direction of **Justin Rhodes** of the NeuroTech Group and professor of psychology at Illinois, studied two groups of mice for two-and-a-half months: one group was fed a diet in which 18 percent of the calories came from fructose, mimicking the intake of adolescents in the United States, and the other was fed 18 percent from glucose.

The results showed that the fructose-fed mice displayed significantly increased body weight, liver mass, and fat mass in comparison to the glucose-fed mice.

Gabriele Gratton and Monica Fabiani have revealed correlations between arterial health and aging.

New Technique for Imaging Brain Activity

Led by psychology professors **Monica Fabiani** and **Gabriele Gratton**, of the Cognitive Neuroscience Group, researchers at the Beckman Institute have developed a new technique that can noninvasively image the pulse pressure and elasticity of the arteries of the brain, revealing correlations between arterial health and aging.

Brain artery support, which makes up the cerebrovascular system, is crucial for healthy brain aging and preventing diseases like Alzheimer's and other forms of dementia.

The researchers routinely record optical imaging data by shining near-infrared light into the brain to measure neural activity. Their idea to measure pulse pressure through optical imaging came from observing in previous studies that the arterial pulse produced strong signals in the optical data, which they normally do not use to study brain function. Realizing the value in this overlooked data, they launched a new study that focused on data from 53 participants aged 55 to 87 years.

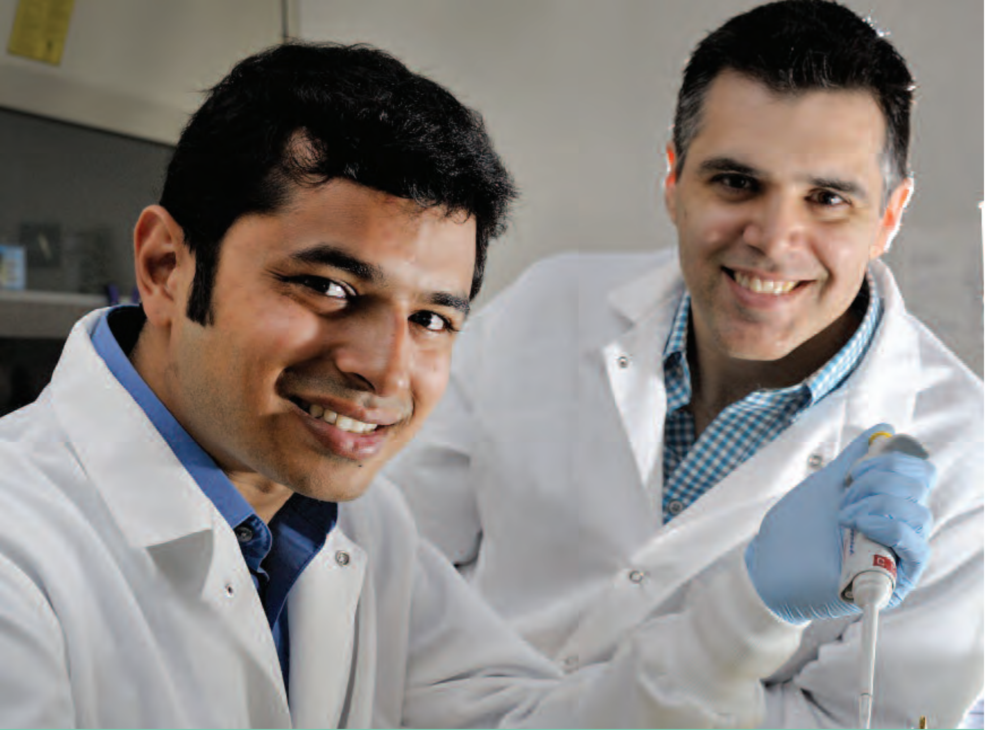
The initial results using this new technique find that arterial stiffness is directly correlated with cardiorespiratory fitness: the more fit people are, the more elastic their arteries. Because arterial stiffening is a cause of reduced brain blood flow, stiff arteries can lead to a faster rate of cognitive decline and an increased chance of stroke, especially in older adults.

Activation Networks in the Brain

In the past year, First Lady Michelle Obama incorrectly referred to Democratic Senate candidate Rep. Bruce Braley as "Bruce Bailey" several times. A video of the event surely made Democratic operatives cringe and Republicans fist-bump. Meanwhile, cognitive scientists just nodded and smiled.

Cognitive scientists describe the process of saying a word with the metaphor of interactions among networks of neurons. Populations of cells corresponding to words send activation (neural firing) to populations of cells corresponding to the speech sounds they require. Activation flows back and forth between levels until a winner is established.

These activation networks have been implemented computationally by people like Gary Dell, of the Cognitive Science Group and professor of psychology. Dell's research can aid in predicting the kinds of speech errors people make. Interestingly, this exact same mechanism also offers a nice account of all sorts of other abilities: how people make decisions, categorize objects, perceive speech, process music, and even how children learn new words. That is, these embarrassing speech errors may be an unavoidable consequence of the general principles by which the brain processes information.



Amogh P. Belagodu and Roberto Galvez, of the NeuroTech Group, research therapies that can alleviate the symptoms of Fragile X.

Cancer Medication Can Help Fragile X Symptoms

Fragile X syndrome (FX) is a genetic condition that causes intellectual disability, behavioral and learning challenges, and various physical characteristics.

Roberto Galvez, from Beckman's NeuroTech Group and assistant professor of psychology, and colleagues have discovered that the cancer medication Avastin (bevacizumab) can be used to help Fragile X.

Fragile X affects more males than females, and usually with greater severity. Behavioral characteristics can include Attention Deficit Disorder (ADD), Attention Deficit Hyperactivity Disorder (ADHD), autism, and autistic behaviors. Physical features of those who have Fragile X may include large ears, long face, soft skin, and large testicles in post-pubertal males.

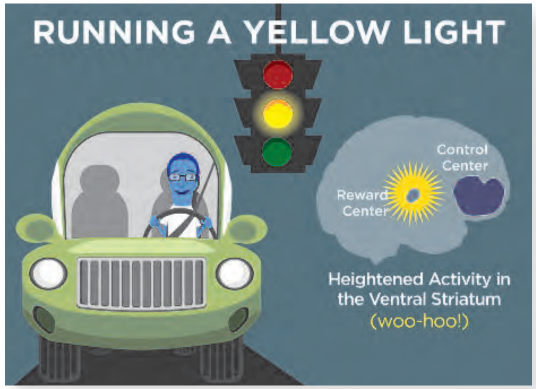
Cognitively, those suffering from Fragile X can experience memory impairments and a drop in IQ scores relative to their peers as they age. The underlying cause for the cognitive defects and some of the physical defects has been identified as increased dendritic spine density.

Vascular endothelial growth factor-A (VEGF-A) has been shown to stimulate growth of both vasculature and dendrites. Based on a finding that mice with FX exhibit excessive vasculature in a part of the brain known as the primary visual cortex, Galvez's lab has shown that VEGF-A is elevated in the brain of FX mice.

In adult mice, the researchers have blocked VEGF-A with the use of Avastin, which is currently used to block new blood vessel formation in some cancers.

Adolescent Brains Negotiating Risk

Eva Telzer, of the Cognitive Neuroscience Group and professor of psychology, and colleagues found that a mother's presence changes brain activity in an adolescent who is contemplating risky behavior.



Infographic: Julie McMahon

In the study, 14-year-old subjects completed a simulated driving task while researchers tracked blood flow in their brains. In one trial, the teen driver was alone; in another, the teen's mother was present and watching.

Telzer and her colleagues observed that teens driving alone found risky decisions rewarding. Blood flow to the ventral striatum, a "reward center" in the brain, increased significantly when teen drivers chose to ignore a yellow stoplight and drove through the intersection anyway.

Previous research has demonstrated that the ventral striatum is more sensitive to rewards in adolescence than during any other developmental period, Telzer said.

Not surprisingly, teens stepped on the brakes significantly more often at yellow lights when their moms were present than when they were alone.

Another brain region, the prefrontal cortex (PFC), kicked into gear when the teens put on the brakes—but only when their mom was watching, the researchers found. The PFC is important to behavioral regulation, also called "cognitive control."

The PFC (the control center) and the ventral striatum (the reward center) are key brain regions involved in adolescent risk-taking behavior. But in the absence of a well-developed control center, adolescents are more susceptible to the stimulating allure of risky behavior.

Human-Computer Intelligent Interaction Profile

What's something that people would be surprised to know about you?

The first thing I did when I came to Illinois was build a climbing gym in my garage. When I was in California, I did a lot of technical climbing, like bouldering, anything up to 30 feet. I really enjoyed it, so, since the landscape doesn't allow for that here, we just took the back half of the garage and built a little cave that you can traverse back and forth. My kids are 5 and 7, and they love it.

I also eat entirely vegan, since 2012. I'm blessed with a very supportive family, which makes it easy.

Tim Bretl

Tim Bretl investigates two distinct areas of research: robotics and neuroscience. Yet Bretl's research, enabled by a multidisciplinary team of students, merges the two disparate areas in applications that aim to positively impact society.

"It has been wonderful to work in these two areas because although they sound different, all my projects overlap. A lot of the same tools can be applied to all my projects," said Bretl, who received his Ph.D. in 2006 from Stanford in aeronautics and astronautics and is now an associate professor of aerospace engineering. "I enjoy working with a diverse group of people who have expertise different from my own, and I'm lucky to have a great group of students who come to me with good ideas."

One of Bretl's four active projects is based in the area of robotic manipulation, specifically focused on how robots interact with flexible or deformable materials in manufacturing.

"An example of this work is automated manufacturing of cars," said Bretl. "One thing that you have to do is install wiring in the cars. The wiring is generally bundled together and very flexible, and it's very hard to automate its installation. We are doing a bunch of theoretical and algorithmic work to try to automate that process with a robot."

Bretl, a member of Beckman's Artificial Intelligence Group, also works on a construction drone project, a collaboration between Mani Golparvar-Fard, assistant professor of civil and environmental engineering, and Derek Hoiem, assistant professor of computer science and a member in Beckman's Human Perception and Performance Group.

The group aims to use drones, mainly quadcopters, to automate inspection of large-scale construction sites. Currently, construction progress is monitored by workers who walk around the site, take pictures, analyze the data, and make decisions about resources based on how the construction is progressing.

With the drones, the process will happen autonomously, saving both time and money.

Bretl's focus on the project is automating the process of data collection through the aerial robots. His team is developing methods of navigation and control that get the robots safely from one place to another on the site, take photos at ideal places, and guarantee that enough video is taken to support the visual analysis. Software then analyzes the video and makes recommendations for construction progress.

"There's a huge need for this automation—it could potentially save millions of dollars in the construction industry," said Bretl.

Bretl also works on the development of upper-limb prosthetic devices. He and graduate student Aadeel Akhtar are building a prosthetic hand that connects to the user with electrodes that read muscle activity (called an electromyographic [EMG]-based interface) and incorporates sensory feedback.

"Developing prosthetics is all about building effective communication with the device," said Bretl. "There's the EMG interface that translates muscle activity into commands for the device—so how the person tells the device what to do—and then there's how the device tells the person what it's doing—so that's sensory feedback—and we do all of that."

Researchers from a number of disciplines are involved in this project, including John Rogers, a member of Beckman's 3D Micro- and Nanosystems Group and professor of materials science and engineering, who specializes in the development of the electrodes used for the EMG interface. The group also works with the Rehabilitation Institute of Chicago, where the prosthetics will ultimately be applied and tested on amputees.

Bretl and Akhtar are taking the prosthetics to the commercial marketplace soon—Akhtar won the Cozad New Venture Competition in April 2015 and is now funded by the University to advance PSYONIC, a start-up company that builds prosthetic hands for less than $1,000, compared to the $30,000 to $40,000 that current devices cost. The researchers hope that the application can improve the lives of people with amputations worldwide, especially in developing countries.

The last of Bretl's active projects, which are all funded by the National Science Foundation, involves brain-computer interfaces (BCI). His team is developing an interface that uses brain activity gathered from an electroencephalogram (EEG) to allow people to do anything from typing words to flying an aircraft.

Though the applications are endless, Bretl says one of the main objectives is to help people with severe motor disabilities interact more fully with the world around them.

Finding a way for BCIs to work would be a significant scientific accomplishment.

"You have to understand a lot about brain function and how that's reflected in EEG activity," said Bretl. "So in thinking about how to get BCIs to work, it causes you to ask questions about the brain that tend to be a little different than what has traditionally been asked in neuroscience, and this could provide new insight for the scientific community."

Robotics has always been a passion for Bretl, who, during his graduate studies at Stanford, worked on the algorithms that helped control the movement of the robotic legs that were used in Mars rovers. His interest in neuroscience began from collaborations with Todd Coleman, a former University of Illinois professor who specialized in network information theory.

"I mean, who doesn't love robots? You figure out how to tell them what to do, and they do it—it's a lot of fun," Bretl said. "Even on the neuroscience side, a prosthetic hand is a robot that happens to be attached to a person. Robotics opens up a whole set of humanitarian applications and interesting science."

Bretl plans to pursue more projects that have humanitarian applications by developing robotics that are commercially viable, including the automated drone monitoring of construction sites and prosthetic devices.

"I'm trying to steer my group toward doing more applied work that has direct and beneficial impact on real people or society, which can be a challenge," said Bretl. "My own contributions in the past have tended to be fairly theoretical, but applied work is a lot of fun. In particular, I try to do projects that are relevant to the community here."

His efforts to impact the community led him to a unique teaching position in the Education Justice Project, a program in which University of Illinois professors teach college-level courses at the Danville Correctional Center to "demonstrate the positive impacts of higher education upon incarcerated people, their families, the communities from which they come, the host institution, and society as a whole," according to the Education Justice Project web site.

Bretl taught a full course in robotics in spring 2013 and plans to teach another in spring 2016. He will cover topics taught in AE 353, a junior-level control theory course in the Department of Aerospace Engineering.

"It's an incredible program and pretty unique in the country," said Bretl. "It's a pleasure to be part of it and a real opportunity for professors here."

Bretl values the opportunity to positively impact society, whether it's in his research or his teaching. He also received the College of Engineering Collins Award for Innovative Teaching and the AE Teacher of the Year Award, recognizing his excellence as a professor in undergraduate courses.

"Faculty are given a lot of freedom to do what we consider to have value. Projects that matter to people here in my community—both inside and outside the university—are what I want to spend my time on."

HCII
HIGHLIGHTS

The Human-Computer Intelligent Interaction (HCII) research theme has a mission that both utilizes and develops advanced technology, while also pursuing a greater understanding of the human side of the human-machine interface. HCII accomplishes its goals of enhancing human-computer interactions, technology optimization, and understanding cognitive processes and behavior through research in three main groups: Artificial Intelligence, Human Perception and Performance, and Image Formation and Processing. HCII researchers work in areas as diverse as language acquisition, computer vision and signal processing, human brain function and cognition, robotics, and speech and hearing science and technology.

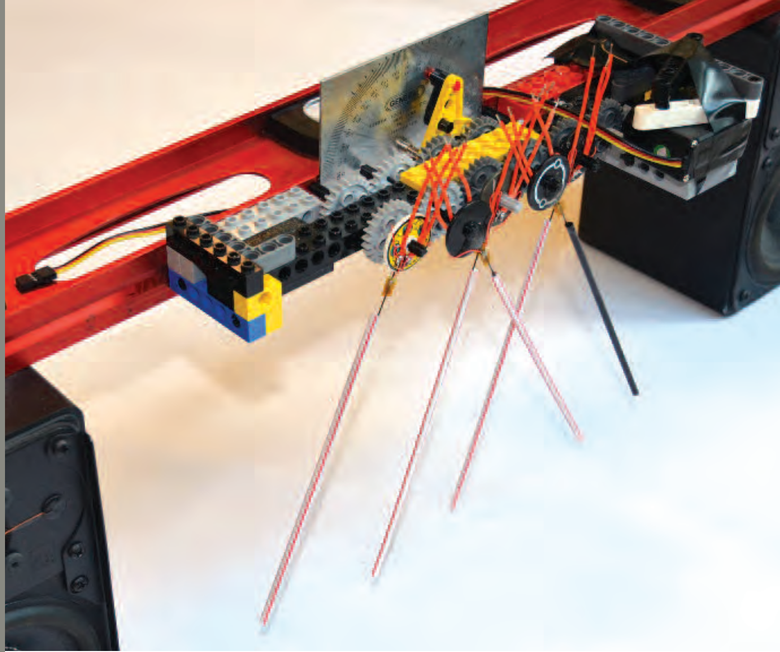


Photo credit: Meg Dickinson

Researchers developed a sensor array that mimics whiskers in order to measure the movement of fluid in dark environments.

Robotic Whiskers Measure How Fluid Moves

Many mammals, including seals and rats, rely on their whiskers to sense their way through dark environments. Inspired by these animals, scientists at the University of Illinois and Illinois' Advanced Digital Sciences Center (ADSC) in Singapore developed a robotic "whisker" tactile sensor array designed to produce tomographic images by measuring fluid flow.

The research was co-led by **Douglas Jones** of Beckman's Image Formation and Processing Group and a professor of electrical and computer engineering.

The whisker array is constructed of five elastic wires, covered with plastic straws, and each whisker is about 15 cm long and 3 mm wide. Strain gauges attached at the base measure movement in each whisker, and these signals are used to build an image of the fluid flow as it passes the array.

The whisker array offers an alternative to existing systems for navigating, tracking, or detecting in smoky or murky environments where current sensory systems are generally based on radar, sonar, or vision and may suffer shortcomings such as poor resolution or blind zones.

"This may even find use in biomedical applications, such as cardiac surgery," said Cagdas Tuna, a postdoctoral student at ADSC. "A thin-whiskered catheter tip could be used during surgery to track the relative position inside the heart, potentially reducing the risk of injury, or atrial fibrillation."

Language Transcription with No Native-Language Transcribers

Speech technology has the potential to provide database access, simultaneous translation, and text/voice messaging services to anybody, in any language, dramatically reducing linguistic barriers to economic success.

However, speech technology has failed to achieve its potential because successful speech technology requires a large amount of language data. Current methods require about 1,000 hours of transcribed speech per language, transcribed at a cost of about 6,000 hours of human labor. Additionally, the human transcribers must be computer-literate, and they must be native speakers of the language being transcribed.

In many languages, the idea of recruiting hundreds of computer-literate native speakers is impractical, sometimes even absurd. **Mark Hasegawa-Johnson**, of the Artificial Intelligence Group and professor of electrical and computer engineering, and his team propose to develop probabilistic transcription methods capable of generating speech training data in languages with no native-language transcribers.

They plan to base it on three transcription methods: using automatic speech recognition software to transcribe pre-trained languages other than the one being transcribed; asking humans who don't speak the target language to transcribe it as if it were a sequence of nonsense syllables; and asking humans who don't speak the target language to listen to its extracted syllables and recording electrical activity in their brain to determine possible phonetic transcriptions of the speech.

Students and professors from the U.S. Air Force Test Pilot School and the University of Illinois test a safer flight control system being developed by Naira Hovakimyan (second from left), member of the Human Perception and Performance Group.

Adaptive Flight Control

Naira Hovakimyan, in the Human Perception and Performance Group, and her research team have developed a predictable, reliable, repeatable, and safe flight control system that was successfully tested for the first time on a manned aircraft—representing an important step toward the introduction of the technology into commercial aviation.

"The flight control systems on today's commercial aircraft have been tested and matured for decades and are considered very safe," said Hovakimyan, a mechanical science and engineering professor. "But despite their safety, there is still great need for new technologies that could prevent more accidents."

In the study, students in the U.S. Air Force Test Pilot School flew Hovakimyan's L1 adaptive control technology. The team performed a rigorous evaluation of the system within varying flight conditions.

After just two days of testing above 10,000 feet, the team executed a total of eight touch-and-go landings with the L1 controller engaged, and despite planned failure configurations, the L1 control system was able to override the problems and maintain predictable and safe handling with consistent and uniform performance.

Her ultimate goal is to see the major airlines adopt this technology as a backup flight control system.

"If anything goes wrong, this would kick in. If there's one switch that a pilot can turn on when the aircraft is in trouble, I want to see that happen," said Hovakimyan.

Post-Deployment Military Couples

After the post-deployment homecoming speeches and ceremonies are over, what comes next for military couples?

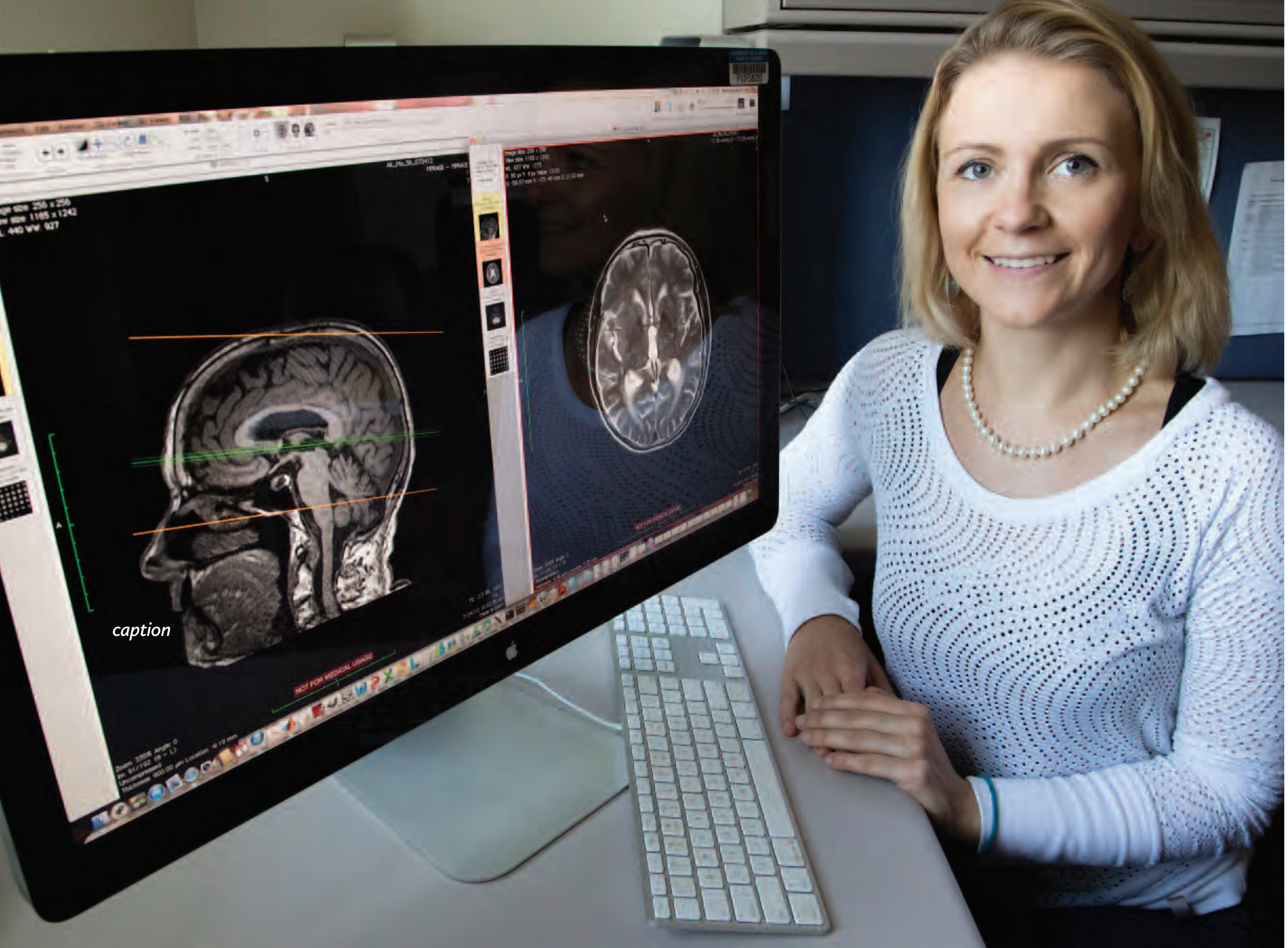
Twin sisters **Leanne Knobloch**, from Beckman's Human Perception and Performance Group and professor of communication, and Lynne Knobloch-Fedders, from the Family Institute at Northwestern University, want to know.

Military couples can find it unexpectedly difficult to readjust to life together after long months of deployment. Excitement and joy can give way to feelings of exhaustion and disappointment. And these troubles can seem even worse if partners had dreams of a perfect reunion.

"Post-deployment is a new chapter that's very complex for military families," Knobloch said, "and yet it's gotten little research attention. The vast majority thrive despite the challenges; they're incredibly resilient. A significant minority of families struggle."

Knobloch is working to unlock the mysteries of what helps military couples make a smooth transition from deployment to reintegration. Her team is studying couples from the first days of the reunion to eight months later, and they are assessing the couple's relationship based on online surveys conducted individually each month.

"We are excited about our project because it will identify the obstacles and opportunities military couples face during the months after reunion," said Knobloch. "We think our findings will be very useful for shaping programming to help military couples with the transition."

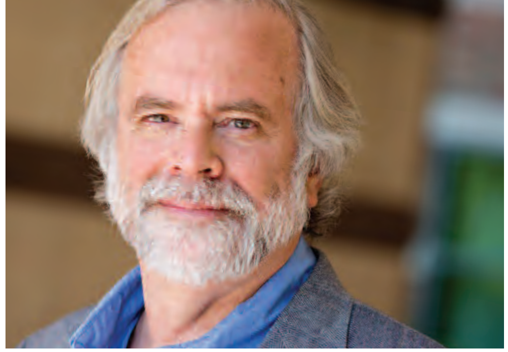


Variability in Brain Activity is Linked to Better Memory and Fluid Intelligence

Agnieszka Burzynska, a postdoctoral researcher in the lab of **Art Kramer** of the Human Perception and Performance Group, led a study relating brain function and structure to cognitive abilities in 91 healthy non-demented older adults.

Specifically, the researchers used the magnetic resonance imaging (MRI) in the Beckman's Biomedical Imaging Center to investigate the moment-to-moment variability in brain activity, measured as the blood oxygenation level-dependent (BOLD) signal. They found that older adults who had greater variability in neural activity in specific brain regions performed better on fluid ability and memory tasks. Furthermore, they showed that greater variability in brain activity and cognitive functions were supported by greater micro-structural integrity of the white matter in the brain.

"We think that greater variability in brain function in certain regions allows more flexible or adaptive information processing, especially during highly demanding memory and reasoning tasks, which require someone to remember information, form associations, or perform abstract mental operations," said Burzynska.



Driver's Conversation Partner Influences Safety

A study led by **Art Kramer**, director of the Beckman Institute and professor of psychology, offers insights into how talking on a cellphone or to a passenger while driving affects one's performance behind the wheel.

To find which aspects of talking to a passenger most affect a driver's performance, the researchers set up four scenarios in a driving simulator: a driver alone, a driver speaking to a passenger, a driver speaking on a hands-free cellphone to someone, and a driver speaking on a hands-free cellphone to someone who could see both the driver and the driver's view via videophone.

As expected, driving alone was the safest option, and speaking to someone on a cellphone was the most dangerous. However, the most interesting results involved the fourth driving scenario—talking on a cellphone to someone who could see them and the road.

"Drivers were less likely to be involved in a collision when their remote partner could see what they were seeing," said John Gaspar, a graduate student in Kramer's lab.

Seeing the driver and watching what was going on in traffic during the conversation allowed the non-driving partner to stop speaking, for example, when something unexpected occurred on the road, Gaspar said.

The findings demonstrate that a passenger or conversation partner can contribute significantly to the safety of the driving experience, Kramer said.

Yoga Helps Cognition in Older Adults

Practicing hatha yoga three times a week for eight weeks improved sedentary older adults' performance on cognitive tasks that are relevant to everyday life, according to a study led by **Edward McAuley**, in the Human Perception and Performance Group and professor of kinesiology and community health, and co-leader Neha Gothe, now a professor at Wayne State University.

The findings involved 108 adults between the ages of 55 and 79 years of age, 61 of whom attended hatha yoga classes. The others met for the same number and length of sessions and engaged in stretching and toning exercises instead of yoga.

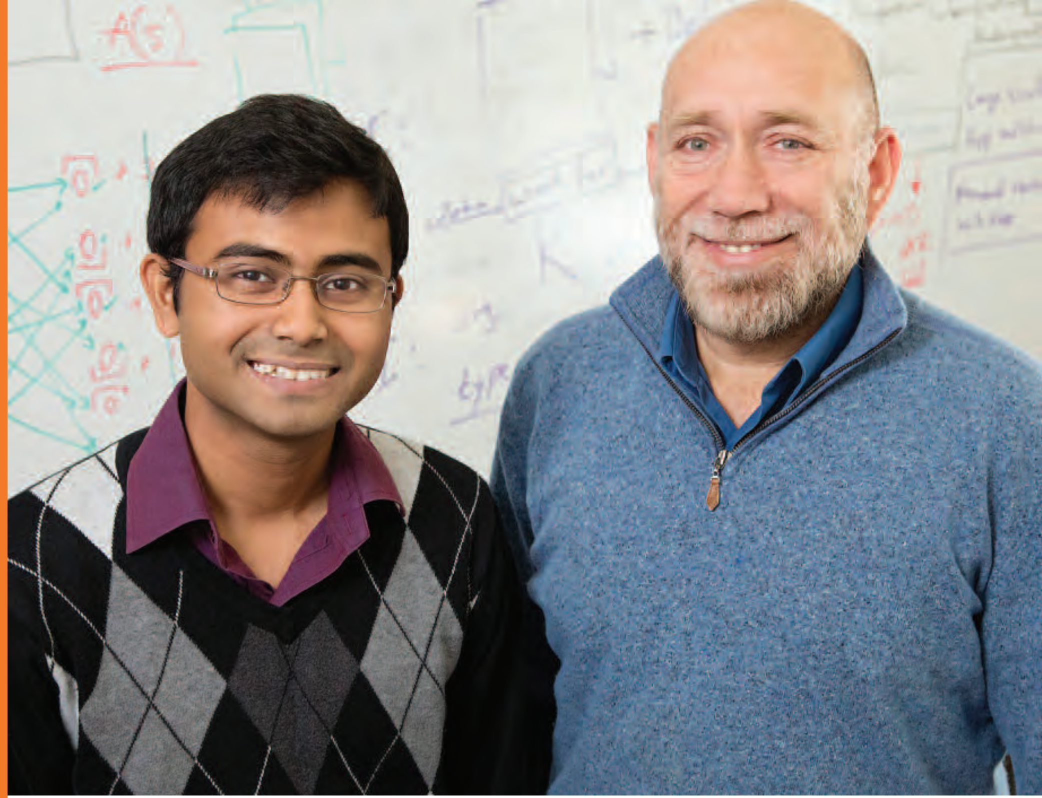
"Participants in the yoga intervention group showed significant improvements in working memory capacity, which involves continually updating and manipulating information," McAuley said. "They were also able to perform the task at hand quickly and accurately, without getting distracted. These mental functions are relevant to our everyday functioning, as we multitask and plan our day-to-day activities."

The stretching-and-toning group saw no significant change in cognitive performance over time.

Hatha yoga is an ancient spiritual practice that involves meditation and focused breathing while an individual moves through a series of stylized postures, said Gothe.

Practicing hatha yoga three times a week has been found to improve older adults' cognitive abilities.

Courtesy of Neha Gothe



Subhro Roy, left, and Dan Roth developed software to help computers understand math concepts expressed in text. This will improve data accessibility, search engines, and education.

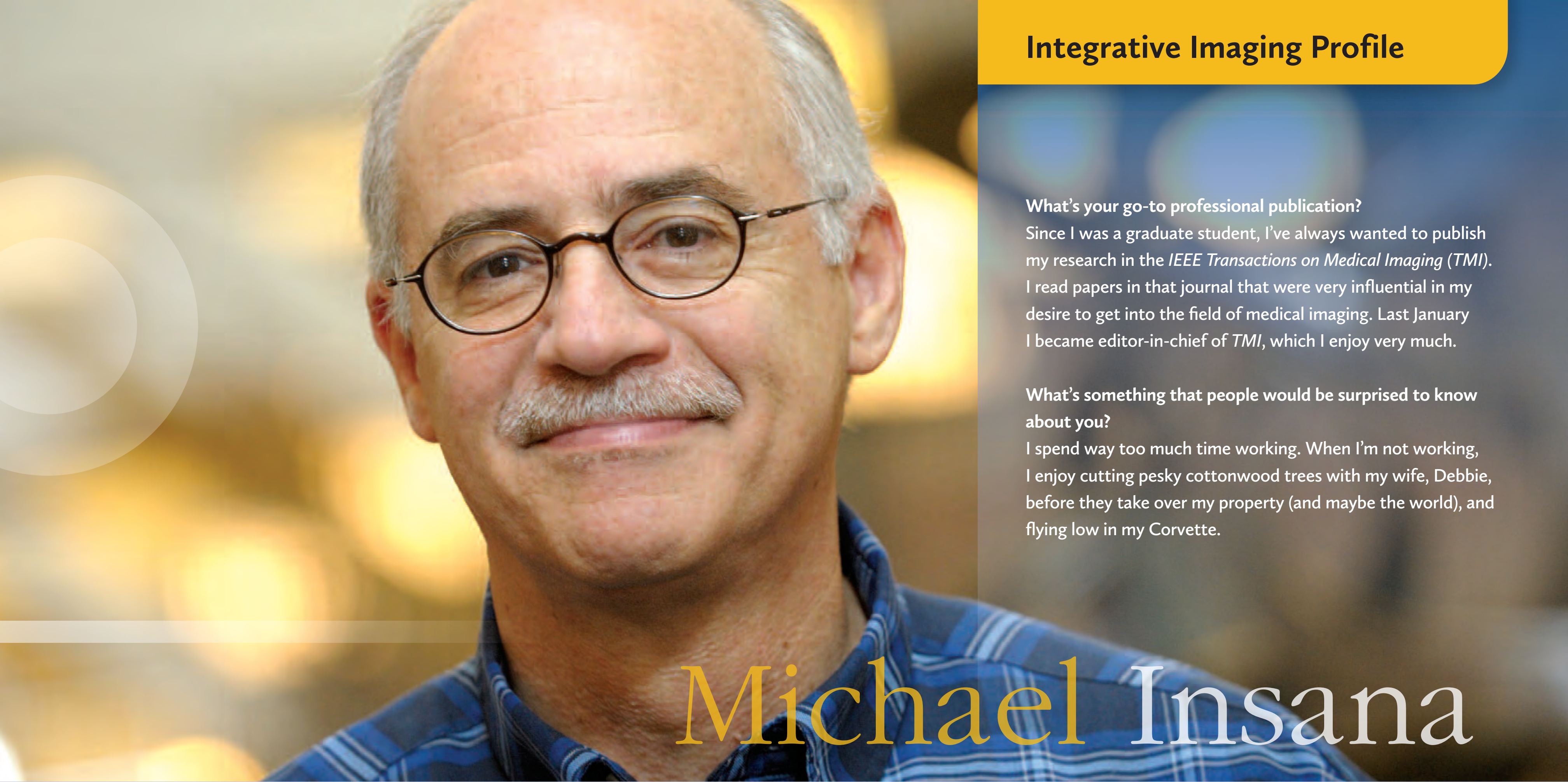
Translating Words into Math

Thanks to new software developed by **Dan Roth**, of the Artificial Intelligence Group, machines now can learn to understand mathematical reasoning expressed in language, which could greatly improve search engines and access to data as well as boost mathematics education.

Roth, a computer science professor, said one of the bigger challenges was teaching the computer to identify quantities and units in text regardless of how they are expressed, something humans do unconsciously when reading. Secondly, the software has to decide what to do with the identified numbers—how to construct a mathematical expression from the text.

"There is a lot of data available in news archives and public records, but it cannot be accessed in a meaningful way," Roth said. "For example, if people want to know what percentage of a state's budget has been spent on education over the past 20 years, a query like that won't give the desired result with a keyword search performed today in a search engine like Google. But if the engine were able to do quantitative reasoning, it would infer from the text the type of information the user is looking for."

A key application of this technology is the ability to understand and solve math word problems and eventually, help students learn how to solve the problems more efficiently as well.



Integrative Imaging Profile

What's your go-to professional publication?
Since I was a graduate student, I've always wanted to publish my research in the *IEEE Transactions on Medical Imaging* (*TMI*). I read papers in that journal that were very influential in my desire to get into the field of medical imaging. Last January I became editor-in-chief of *TMI*, which I enjoy very much.

What's something that people would be surprised to know about you?
I spend way too much time working. When I'm not working, I enjoy cutting pesky cottonwood trees with my wife, Debbie, before they take over my property (and maybe the world), and flying low in my Corvette.

Michael Insana

Michael Insana develops novel ultrasound techniques and instruments for imaging soft tissue microstructure, elasticity, and blood flow in order to understand basic biological mechanisms, disease progression, and therapeutic responses.

A member of the Bioimaging Science and Technology Group and head of the Ultrasonic Imaging Laboratory at Beckman, Insana is interested in what he knows as "image science."

"In medicine, imaging provides windows into the body that indicate everything from large anatomical changes to molecular signaling among cells," said Insana. "It is a world of infinite possibility and relevance that has held my attention for more than 30 years."

Ultrasound, according to Insana, is fast, safe, and inexpensive. Although known primarily for its use in obstetrics and for cardiovascular assessments, ultrasound technology has vastly advanced in recent years, Insana explained. Because of technical advancements leading to high-resolution images and better tissue contrast at high frame rates, ultrasound can be used in numerous ways not thought of previously.

Big data is also of interest to researchers in imaging, said Insana.

"In medical imaging, the images contain much more information than we typically use to diagnose patients," said Insana. "For example, what could we learn about variations in physiological properties among the population so we could better define what is normal and abnormal?"

Insana cautions that patient privacy must always be considered in the research.

"Currently we determine what information is needed for diagnosis and then go out and acquire it. Yet maybe that acquisition, in the form of patient images and medical records, can teach us what is most important about health and disease. New types of machine-learning algorithms, like those used in computer vision to recognize faces in a crowd, are mining image data in ways that allow us to discover the biomarkers of health."

Insana is working with Jamshid Ghaboussi from the Department of Civil and Environmental Engineering, and Cameron Hoerig, a student in the Department of Bioengineering, to develop informational modeling techniques that probe patients and let the tissue deformation and force patterns on the patient's skin inform them about the mechanical properties of tissues below.

"It costs society a tremendous amount of money to acquire patient data each year," said Insana. "In the future we hope machine intelligence techniques will help us squeeze every drop of important information from that investment."

Insana also investigates the fundamentals of imaging system design and performance evaluation, signal processing, detection, and estimation. He and his team have been developing applications for imaging the elasticity of breast tissue, a diagnostic technique for the noninvasive visualization of soft tissue stiffness, for detection of disease progression.

"In the past five years, I have become interested in understanding the principles that govern the behavior of large complex systems, like the human body," said Insana. "The science and engineering in imaging science and large complex systems are similar."

Insana and his collaborators have worked with radiologists to find diagnostic features commonly used to diagnose disease; then they express those features mathematically and enhance diagnostic performance and data processing using statistical decision theory and optimal strategies for data processing.

The techniques and instruments that Insana has been developing help in understanding, for example, the basic mechanisms of cancerous lesion formation, metastatic progression, responses to therapy, and sources of image contrast.

In 2007, Insana ran a pilot study looking at a fast, inexpensive, and safe way to image breast-tissue elasticity using ultrasound.

"Changes in tissue stiffness are often early indicators of the inflammation associated with precancerous conditions," said Insana. "We performed a pilot study at the University of California-Davis in Sacramento because of my connections there. Of the 21 patients studied, and, much to everyone's surprise, we correctly diagnosed every lesion when comparted to biopsy results."

Insana's project, SAVE (Sub-Hertz Analysis of Viscoelasticity), is continuing at Mayo Clinic, with support from the National Institutes of Health.

"We are continuing to refine and expand the study to make the technique reliable in any clinical environment," Insana explained. "As expected, there are challenges in applying a small uniform compressive force and accurately tracking tissue movements. We have acquired more patient data and continue to be optimistic that we can achieve reliably reproducible results.

"It's a little like watching ants on an ant hill without your glasses," Insana explained. "You can see that things are moving but it's hard to make out exactly where each ant is going. The 'ants' in tissue elasticity images are tissue parts that are too small to see in the ultrasound images. Through image processing programs, we can clarify the movement significantly, and then we can estimate mechanical properties."

In addition to improving the detection and treatment of breast cancer, the research could also be applied to vascular and kidney diseases.

Insana has recently filed a patent disclosure with Sara Bahramian, a student in electrical and computer engineering, for a technique that enhances the appearance of microcalcifications in breast lesions.

"Often microcalcifications, tiny bits of bone, grow in aggressive breast cancers as the body tries to quickly build new blood vessels using a wound healing mechanism," said Insana. "X-rays see these well, but ultrasound doesn't. Since we study imaging systems by tracking the flow of patient information, we were able to find a point where information was lost. That lost information is vital to enhancing breast cancer detection using sonography."

Insana, a professor of bioengineering, was recently award a Willett professorship from the College of Engineering at Illinois. He was recognized for his contributions to translational research in the development of novel ultrasonic instrumentation and methods for imaging soft tissue microstructure, viscoelasticity, and blood flow.

IntIm HIGHLIGHTS

The Integrative Imaging (IntIm) research theme brings together people and technologies to create advances in imaging science that have real-world impacts in both research and clinical settings. Research in IntIm is divided into two groups: the Bioacoustics Research Laboratory (BRL) and the Bioimaging Science and Technology Group (BST). Research in this theme includes working to design and engineer new imaging instruments and methods, optimizing current techniques, and conducting scientific research that relies on imaging. The researchers in this area are improving methods such as ultrasound and magnetic resonance imaging, creating new methods based on technologies like computed tomography and optical imaging, and applying the instruments and techniques for important biomedical purposes. Basic and applied research involving the life sciences that could also have real-world translational medical imaging outcomes is a pillar of this theme.

Stem Cells Aid Muscle Repair and Strengthening after Resistance Exercise

A new study in mice reveals that mesenchymal stem cells (MSCs) help rejuvenate skeletal muscle after resistance exercise.

By injecting MSCs into mouse leg muscles prior to several bouts of eccentric exercise (similar to the lengthening contractions performed during resistance training in humans that result in mild muscle damage), researchers were able to increase the rate of repair and enhance the growth and strength of those muscles in the exercising mice.

The findings may one day lead to new interventions to combat age-related declines in muscle structure and function, said **Marni Boppart** of the Bioimaging Science and Technology Group and associate professor of kinesiology and community health, who led the research.

MSCs occur naturally in the body and may differentiate into several different cell types. They form part of the stroma, the connective tissue that supports organs and other tissues.

MSCs also excrete growth factors and, according to the new study, stimulate muscle precursor cells, called satellite cells, to expand inside the tissue and contribute to repair following injury. Once present and activated, satellite cells actually fuse to the damaged muscle fibers and form new fibers to reconstruct the muscle and enhance strength.

The Ellison Medical Foundation and the National Science Foundation supported this work.

Study Reveals Optimal Particle Size for Anticancer Nanomedicines

Nanomedicines consisting of nanoparticles for targeted drug delivery to specific tissues and cells offer new solutions for cancer diagnosis and therapy. Understanding the interdependency of physiochemical properties of nanomedicines, in correlation to their biological responses and functions, is crucial for their further development as cancer-fighters.

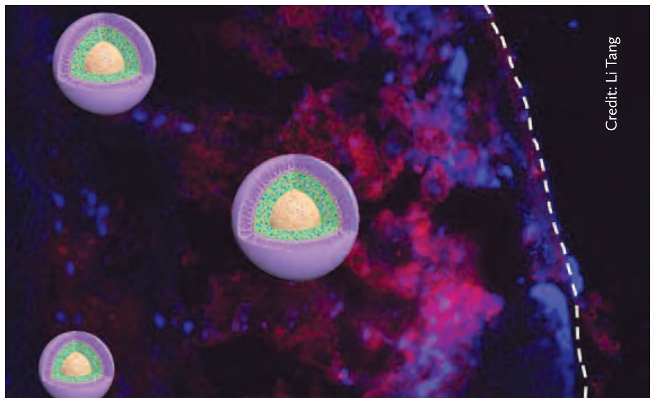
In a recent study, **Jianjun Cheng**, a materials science and engineering professor and member of Beckman's Bioimaging Science and Technology Group, and his collaborators systematically evaluated the size-dependent biological profiles of three monodisperse drug-silica nanoconjugates at 20, 50, and 200 nm.

The 50 nm particle size provided the optimal combination of deep tumor tissue penetration, efficient cancer cell internalization, as well as slow tumor clearance, exhibiting the highest efficacy against both primary and metastatic tumors *in vivo.*

To further develop insight into the size dependency of nanomedicines in tumor accumulation and retention, the researchers developed a mathematical model of the spatio-temporal distribution of nanoparticles within a spherically symmetric tumor. The results are extremely important to guide the future research in designing new nanomedicines for cancer treatment, Cheng noted.

In addition, a new nanomedicine developed by the researchers—with precisely engineered size at the optimal size range—effectively inhibited a human breast cancer and prevented metastasis in animals, showing promise for the treatment of a variety of cancers in humans.

The nanomedicine (pictured in red) with the optimal size shows the highest tumor tissue retention (blue) integrated over time, which is the collective outcome of deep tumor tissue penetration, efficient cancer cell internalization, as well as slow tumor clearance.



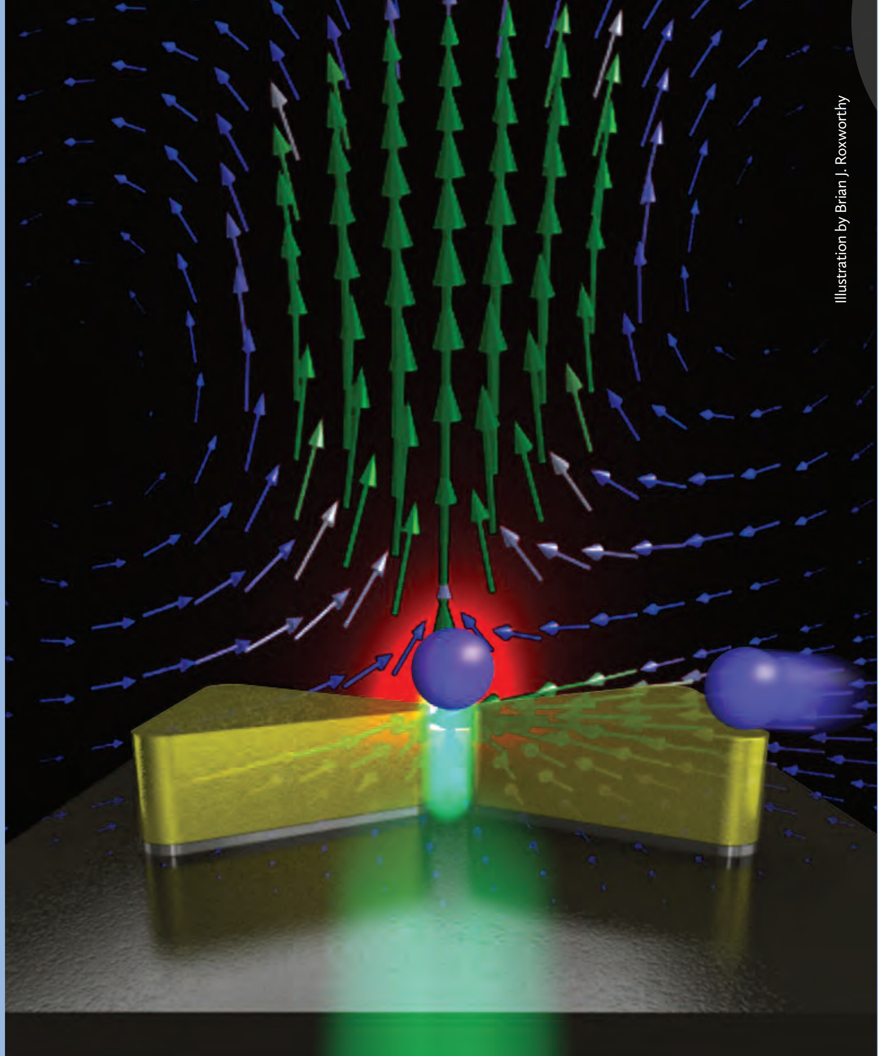


Illustration by Brian J. Roxworthy

Kimani Toussaint's research group has been investigating convection currents surrounding plasmonic nanotweezers that draw particles into the optical trap.

Novel, Tunable Nanoattenas

An interdisciplinary research team has developed a novel, tunable nanoantenna that paves the way for new kinds of plasmonic-based optomechanical systems whereby plasmonic field enhancement can actuate mechanical motion.

"Recently, there has been a lot of interest in fabricating metal-based nanotextured surfaces that are pre-programmed to alter the properties of light in a specific way after incoming light interacts with it," explained **Kimani Toussaint**, associate professor of mechanical science and engineering and member of the Bioimaging Science and Technology Group, who led the research. "For our approach, one can take a nanoarray structure that was already fabricated and further reconfigure the plasmonic, and, hence, optical properties of select antennas. Therefore, researchers can decide after fabrication, rather than before, how they want their nanostructure to modify light."

The researchers have developed a metal, pillar-bowtie nanoantenna (p-BNA) array template on 500-nanometer tall glass pillars (or posts). In doing so, they demonstrated that the gap size for either individual or multiple p-BNAs can be tuned down to approximately 5 nm (approximately four times smaller than what is currently achievable using conventional electron-beam lithography techniques).

The work demonstrates electron beam-based manipulation of nanoparticles an order of magnitude larger than previously possible, using a simple scanning electron microscope operating at only a fraction of the electron energies of previous work.

Credit: Rohit Bhargava

Breast tissue is computationally stained using data from infrared imaging without actually staining the tissue, enabling multiple stains on the same sample. From left, the image shows a Hematoxylin and Eosin stain (pink-blue), molecular staining for epithelial cells (brown color), and Masson's trichrome (blue, red at right).

New Technique Paints Tissue Samples with Light

One infrared scan can give pathologists a window into the structures and molecules inside tissues and cells, enabling fast and broad diagnostic assessments, thanks to an imaging technique developed by researchers led by **Rohit Bhargava**, of the Bioimaging Science and Technology Group, and clinical partners.

Using a combination of advanced microscope imaging and computer analysis, the new technique can give pathologists and researchers precise information without using chemical stains or dyes.

"Any sample can be analyzed for desired stains without material cost, time, or effort, while leaving precious tissue pristine for downstream analyses," Bhargava, a professor of bioengineering, said.

To study tissue samples, doctors and researchers use stains or dyes that stick to the particular structure or molecule they are looking for. Staining can be a long and exacting process, and the added chemicals can damage cells. Doctors also have to choose which things to test for, because it's not always possible to obtain multiple samples for multiple stains from one biopsy.

The new, advanced infrared imaging technique uses no chemical stains, instead scanning the sample with infrared light to directly measure the chemical composition of the cells. The computer then translates spectral information from the microscope into chemical stain patterns, without the muss or fuss of applying dyes to the cells.

Blood Loses Oxygen the Longer It is Stored

It may look like fresh blood and flow like fresh blood, but the longer blood is stored, the less it can carry oxygen into the tiny microcapillaries of the body, says a new study from a team of researchers led by electrical and computer engineering professor **Gabriel Popescu**, of the Bioimaging Science and Technology Group.

Using advanced optical techniques, the researchers measured the stiffness of the membrane surrounding red blood cells over time. They found that, even though the cells retain their shape and hemoglobin content, the membranes get stiffer, which steadily decreases the cells' functionality.

Nearly 14 million units of blood are banked annually in the United States. The established "shelf life" for blood in blood banks is 42 days. During that time, a lot of changes can happen to the blood cells—they can become damaged or rupture. But much of the blood keeps its shape and, by all appearances, looks like it did the day it was donated.

Popescu and his colleagues wanted to quantitatively measure blood cells over time to see what changed and what stayed the same, to help determine what effect older blood could have on a patient. They used a special optical technique called spatial light interference microscopy (SLIM), a method developed in Popescu's lab at Illinois in 2011.

From left, William O'Brien, Aiguo Han, and John Erdman, Jr., are investigating noninvasive image-based methods to evaluate the liver in adults with nonalcoholic fatty liver disease.

New Methods to Evaluate Liver Disease

Nonalcoholic fatty liver disease (NAFLD), the most common cause of chronic liver disease in the United States, affects 30 percent of adult Americans, may progress to nonalcoholic steatohepatitis and end-stage liver disease, and is a risk factor for diabetes and cardiovascular disease. The diagnosis, grading, and staging of NAFLD currently is based on a liver biopsy with histologic analysis.

Bioacoustics Research Laboratory researchers **John W. Erdman, Jr.**, professor emeritus of food science and human nutrition, and **William D. O'Brien, Jr.**, professor emeritus of electrical and computer engineering, are investigating noninvasive image-based methods to evaluate the liver in adults with NAFLD.

Clinical work with colleagues at the University of California at San Diego (UCSD), along with **Aiguo Han**, a postdoctoral student in the lab, has demonstrated success with quantitative ultrasound (QUS) to quantify liver fat content in patients. Over the past 15 years or so, the Bioacoustics Research Laboratory has been conducting research to validate and refine the QUS technology, and has successfully applied it both diagnostically and therapeutically.

Since the UCSD-Illinois collaboration was developed, a significant study with 204 patients has been published that demonstrated a close relationship between a QUS outcome and the liver fat content, even at early stages of NAFLD.

Ultrasonic Hammer Sets Off Tiny Explosions

Giving new meaning to the term "sonic boom," Illinois chemists have used sound to trigger microscopic explosions.

Using an "ultrasonic hammer," the researchers triggered tiny but intensely hot explosions in volatile materials, giving insight into how explosives work and how to control them. Led by chemistry professors **Ken Suslick,** of Beckman's Bioimaging Science and Technology Group, and Dana Dlott, a professor of chemistry at Illinois, the researchers published their findings in the journal *Nature Communications.*

Explosive materials often are shock-sensitive, meaning they can be triggered by hitting or dropping them. Scientists have long thought that the impact triggers the explosion by creating hot spots in the material, but these hot spots have never been directly observed, making it difficult for researchers to understand the dynamics of such explosions or how to control them.

The researchers used the ultrasonic hammer to bombard the material with ultrasound waves, watching with a fast infrared camera to detect any localized heating. They saw that the ultrasound triggered local hot spots and tiny explosions within the material in real time as hot spots formed.

Thanks to the infrared camera, the researchers were able to see where the hot spots formed and how hot they got. They were able to produce hot spots at targeted locations with temperatures soaring at rates of 40,000 degrees Farenheit per second.

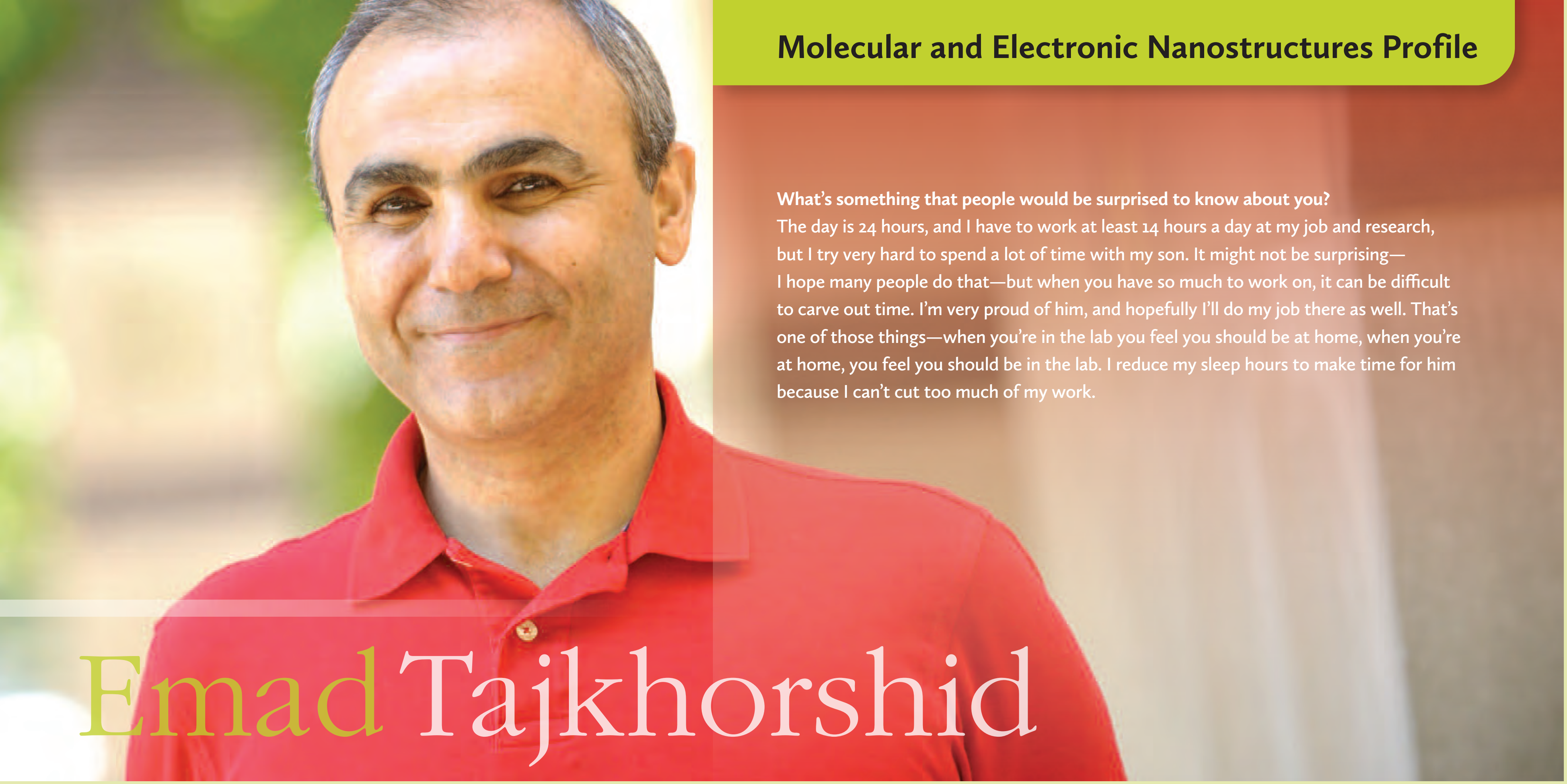
Venom as a Cancer-Fighting Drug

Venom from snakes, bees, and scorpions contains proteins and peptides which, when separated from the other components and tested individually, can act as potent therapeutics for many diseases. Their activity could potentially block the growth and spread of the disease, other researchers have reported.

Dipanjan Pan, of the Bioimaging Science and Technology Group, and his team say that some of substances found in any of these venoms could be effective antitumor agents. But just injecting venoms into a patient would have serious side effects. Among these could be damage to heart muscle or nerve cells, unwanted clotting or, alternately, bleeding under the skin.

Pan, assistant professor in bioengineering, says his team, in two similar studies, identified substances in the venom that keeps the cancer cells from multiplying. Bees and scorpions make so little venom that it's not feasible to extract it and separate out the substance time after time for lab testing or for later clinical use, so the peptidotoxins were synthesized in the lab.

To figure out whether peptidotoxins would be entrapped stably inside a nanoparticle, they conducted computational studies to screen compatibility of the nanoshell and the toxin. Physico-chemical and *in vitro* biological characterization followed, confirming that the peptide toxins go directly to the tumor, where they bind to cancer stem cells, blocking their growth and spread.



Molecular and Electronic Nanostructures Profile

What's something that people would be surprised to know about you?
The day is 24 hours, and I have to work at least 14 hours a day at my job and research, but I try very hard to spend a lot of time with my son. It might not be surprising—I hope many people do that—but when you have so much to work on, it can be difficult to carve out time. I'm very proud of him, and hopefully I'll do my job there as well. That's one of those things—when you're in the lab you feel you should be at home, when you're at home, you feel you should be in the lab. I reduce my sleep hours to make time for him because I can't cut too much of my work.

Emad Tajkhorshid

In every living cell, specialized proteins work to transport materials across the cell's membrane, moving them in and out of the cell. These transport proteins are at the molecular-scale, so the motions are extremely small and, therefore, difficult to detect. However, understanding these molecular movements during the transport cycle holds the key to more effective drug design when fighting neurological and metabolic disorders, and even cancer.

Emad Tajkhorshid, a professor of biophysics and biochemistry, loves the challenge of "going after uncharted territories in the molecular world." Visualizing the entire process of protein transportation across membranes has taken Tajkhorshid and colleagues a number of years, but they have met the challenge: They are the first in the world to be able to describe at an atomic level the entire motion of a transporter protein during its cycle.

"Up until this, all we knew was what the protein looked like at the beginning of the transport cycle, and what it looked like at the end," said Tajkhorshid. "Based on our advanced simulation results, now we know, step by step, how it opens, grabs a substrate, closes, and opens the other end to let the substrate out."

One of the transporter proteins studied by Tajkhorshid is a protein found in a cell membrane that has evolved to pump drugs, usually those toxic to the cell, out of the cell as a protective mechanism. The toxic drugs, however, could be those that are targeting cancer cells, and the action of the protein causes the cells to develop resistance to those potentially life-saving drugs.

"If we understand how this protein functions, maybe we can design an inhibitor that stops that mechanism and makes anti-cancer drugs more effective," said Tajkhorshid. "It's a very important area of drug design and development—to know how and to optimize the way the drugs are absorbed, distributed, and metabolized in the body, the processes which are all affected by transporters."

In an experimental lab, visualizing these protein movements is impossible—the transport cycle involves changes that are too small and too fast to observe naturally.

Tajkhorshid specializes in computational approaches instead, using computers to solve the mystery of how proteins move and how these motions furnish efficient and selective transport of materials.

"We tell the computer what the rules are in terms of what is physically and biologically possible. The rules are based in theoretical physics, chemistry, spectroscopy, and other frameworks, and the computer can determine the movement based on those rules," said Tajkhorshid. "However, weighing a program down with rules of behavior can cause it to become slow. The computation of such complex systems and complicated processes can become too much for the program to handle."

In order to overcome the slow processing speed, Tajkhorshid uses a series of advanced computational algorithms, coupled with the power of supercomputers, including the Blue Waters supercomputer located at the National Center for Supercomputing Applications (NCSA) at the University of Illinois and Titan at the U.S. Department of Energy's Oak Ridge National Laboratory.

To take advantage of the full power that the supercomputers offer, Tajkhorshid's group—comprised of computer scientists, biophysicists, physical chemists, and others—developed a novel computational algorithm that helps them determine the route the transporter protein is most likely to take when moving its cargo across the cell membrane.

"We devised a new computational approach that is based on the idea of leveraging the large capacity of supercomputers to run many simulations simultaneously," said Tajkhorshid. "Before we attempt to calculate the protein structural change and movement during the transport cycle, we have to explore a large number of initial potential transition pathways—a very efficient process on supercomputers—and then we develop theoretical frameworks that determine which one of these pathways has the greatest potential to be the pathway for the very long final calculation. Then we just run that big calculation once, saving us a lot of time and computing power.

"By design, the technology of computer simulation allows us to go beyond what can be done by experiments, but, in order to anchor our results in reality, we have made it a practice to make testable hypotheses that can be validated experimentally."

Tajkhorshid's options for what protein to study are "nearly limitless"—in this era of modern structural biology and biophysics there are endless simulations that will give scientists deep insight into the mechanism of protein nanomachines and other exciting biological systems.

"That's the thing about membranes—everything that gets into the cell, or out of it, has to cross a membrane," Tajkhorshid said. "If you take a drug that's supposed to go from the stomach to the blood, it has to cross membranes several times. The drug's ability to absorb into membranes directly impacts its effectiveness, so we need to look at its interactions with membranes and membrane proteins that are often actively involved in trafficking drugs across the membrane."

As one of the leaders in computational imaging, Tajkhorshid's team always has new problems to solve. "We're really excited about the work we do—in all our projects, we stay relevant to the problems of society," said Tajkhorshid.

Tajkhorshid has been at the Beckman Institute since he joined the Theoretical and Computational Biophysics Group (TCBG) as a postdoc. In 2007, Tajkhorshid earned a position as a tenure-track professor and started the Computational Structural Biology and Molecular Biophysics Lab. He was promoted to a full professor in 2013.

His current work focuses on computational simulations, but his early studies were focused on chemistry, math, and physics. In his native country of Iran, Tajkhorshid received his doctorate in pharmacology, and he earned a second Ph.D. in biophysics in Germany.

"It was clear to me that by focusing on computation and molecular simulation, I could take advantage of all those skills," Tajkhorshid said. "That's how I became interested in molecular simulation. When I came here as a postdoc, I got really excited by how much you can see with computational and simulation methods—how many details you can see as to how molecules may work."

During his time as a postdoc at TCBG, he demonstrated how water molecules pass through a channel across a membrane, a result which was published in *Science.*

Leading his own lab has added to his list of accomplishments, with the opportunity to teach and mentor students being at the top of his list, Tajkhorshid said.

"I love to teach," he said. "I spend a lot of time doing research, but I also love to transfer the acquired knowledge and to interact with my students. We have some of the brightest young minds on this campus, and it's very exciting and rewarding to work with them."

The combined expertise of his students has led to his group's success in computationally understanding how protein transporters work, something he hopes will continue to expand and develop in the future.

"Creating a reliable model for membrane protein transport was the combination of having thought about a really important problem for an extended amount of time, several years even, and collaborating closely with people who are truly interested in and excited about understanding how transporters work," he said. "I have excellent researchers in the group and access to unique computational resources. It all really came together."

M&ENS
HIGHLIGHTS

The Molecular and Electronic Nanostructures (M&ENS) research theme brings together scientists from disciplines as diverse as biology, engineering, physics, and chemistry, with the goals of both understanding and working with nanoscale structures and processes. The five research groups comprising M&ENS are: 3D Micro- and Nanosystems, Autonomous Materials Systems, Computational Multiscale Nanosystems, Nanoelectronics and Nanomaterials, and Theoretical and Computational Biophysics. Within these groups, M&ENS researchers develop and use computational tools for simulating biological processes and for designing nanosystems, fashioning nanoelectronics for applications in biomedicine and consumer products, and constructing autonomous multifunctional materials systems.

Electronic Heart Membrane

Scientists, including **John Rogers**, materials science and engineering professor and member of the 3D Micro- and Nanosystems Group, have created a revolutionary new electronic membrane that could replace pacemakers, fitting over a heart to keep it beating regularly over an indefinite period of time.

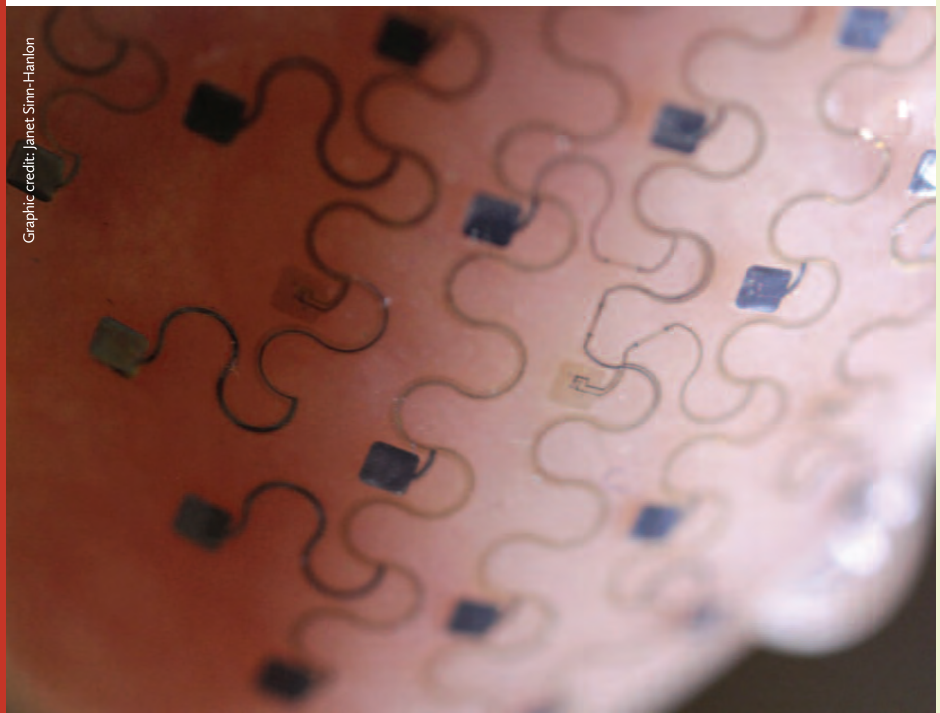
Rogers builds stretchable electronic sheets, with active material layers that are just 10 nanometers thick, for devices that could be placed within or around an organ such as the heart and do their jobs without causing harm. Rogers calls them "soft electronics."

With the help of high-resolution imaging technology, the thin, elastic membrane can be custom made to fit snugly over the real heart. The devise uses "a spider-web-like network of sensors and electrodes" that are integrated in the membrane and interact with the rest of the body to regulate the heartbeat.

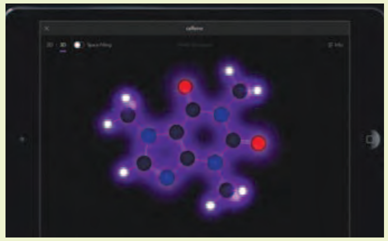
"This artificial pericardium (heart membrane) is instrumented with high quality, man-made devices that can sense and interact with the heart in different ways that are relevant to clinical cardiology," Rogers said.

This methodology allows the device to keep the heart beating even when a heart attack or arrhythmia occurs. Researchers have developed a prototype for a rabbit heart, and it may arrive to human hearts in the next 10 to 15 years.

John Rogers created a custom-fitted membrane that expands and contracts with the heart, and could one day deliver electric shocks in response to a heart attack.



Graphic credit: Janet Sinn-Hanlon



In conjunction with Beckman's Theoretical and Computational Biophysics Group, Theo Gray created the app "Molecules by Theodore Gray," available on iTunes.

App Brings Molecules to Life

In collaboration with **Klaus Schulten** and the Theoretical and Computational Biophysics Group (TCBG), Theodore Gray's company, Touchpress, has created an app for the Apple operating system that brings molecules to life in a handheld device.

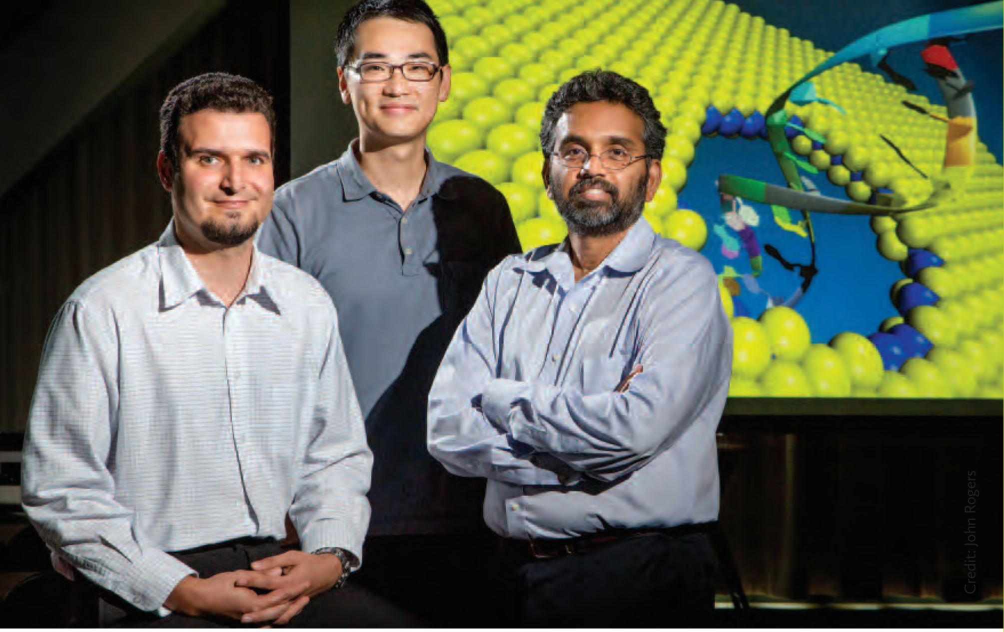
"What is the best thing you could do to present (a molecule) to somebody?" asked Theo Gray, a scientist and author of *Molecules: The Elements and the Architecture of Everything.* "What's the closest that you can come to actually handing it to them, so they could pick it up and look at it themselves?"

How about an app? With the help of the computational expertise in TCBG, Gray created "Molecules by Theodore Gray," an app that allows people to use all 10 fingers to examine in great detail more than 350 molecules, which they can also twist, turn, and tie into knots.

"Every student who learns about typical molecules can do it now in a playful manner and realize that molecules are not dead and frozen, but that they move," said Schulten, head of TCBG, and professor of physics at Illinois.

Getting molecules into everyone's hands has been a goal for Gray. Pictures can't show the actual nature of how molecules behave.

"By providing an interactive simulation, you can give people a good intuitive feeling for what a molecule is like and how it moves and how it behaves, and translate that into human scale," said Gray.



Researchers, including from left, Amir Barati Farimani, Kyoungmin Min, and Narayana Aluru, found that the material molybdenum disulfide could be the most efficient yet found for DNA sequencing, making personalized medicine more accessible.

DNA Sequencing

Researchers led by **Narayana Aluru**, of the Computational Multiscale Nanosystems Group, have found that nanopores in the material molybdenum disulfide (MoS_2) could sequence DNA more accurately, quickly, and inexpensively than anything yet available.

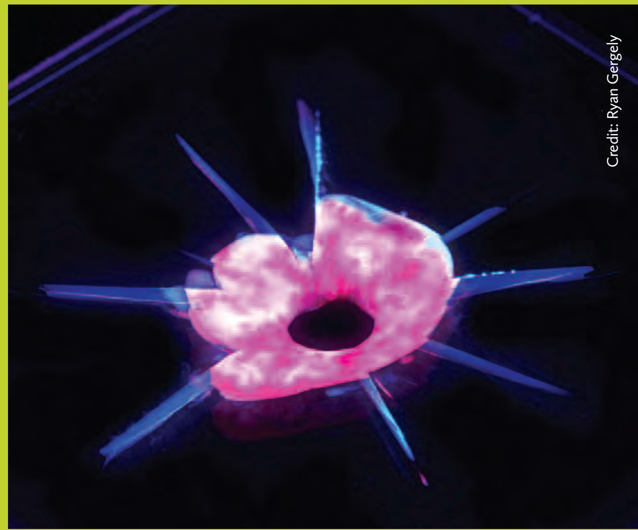
Making the DNA-sequencing process as easy and efficient as possible holds many possibilities for personalized medicine—by sequencing each patient's DNA, doctors would be able to deliver tailored and targeted therapy based on individual need.

"One of the big areas in science is to sequence the human genome for under $1,000," said Aluru, a professor of mechanical science and engineering. "There is a hunt to find the right material. We've used MoS_2 for other problems, and we thought, why don't we see how it does for DNA sequencing?"

The researchers found MoS_2 outperforms all other materials used for nanopore DNA sequencing—even graphene.

In nanopore sequencing, a DNA strand is threaded through a tiny hole in a material—in this case, MoS_2—by an electric current, and variations in the current determine the sequence of the DNA. In graphene, the DNA sticks to the material. With MoS_2, it threads through the nanopore cleanly and quickly.

Now, the researchers are exploring whether they can achieve even greater performance by coupling MoS_2 with another material to form a low-cost, fast, and accurate DNA sequencing device.



Scott White, Nancy Sottos, and Jeffrey Moore have developed materials that not only heal, but regenerate. The restorative material is delivered through two isolated fluid streams and immediately gels and later hardens, resulting in recovery of the entire damaged region.

Regenerating Plastic

So far, efforts to develop materials that fix themselves the way biological tissue mends itself have been limited.

Scott White, **Nancy Sottos**, and **Jeffrey Moore**, of Beckman's Autonomous Materials Systems Group, developed one of the first versions in 2001, but that material could only heal microscopic cracks. Now, the team has developed materials that not only heal, but regenerate.

"We have demonstrated repair of a nonliving, synthetic materials system in a way that is reminiscent of repair-by-regrowth as seen in some living systems," said Moore, a professor of chemistry.

In a bullet-size hole, researchers pumped restorative material through two isolated fluid streams. Upon contact, the two liquids immediately gel and later harden, resulting in recovery of the entire damaged region.

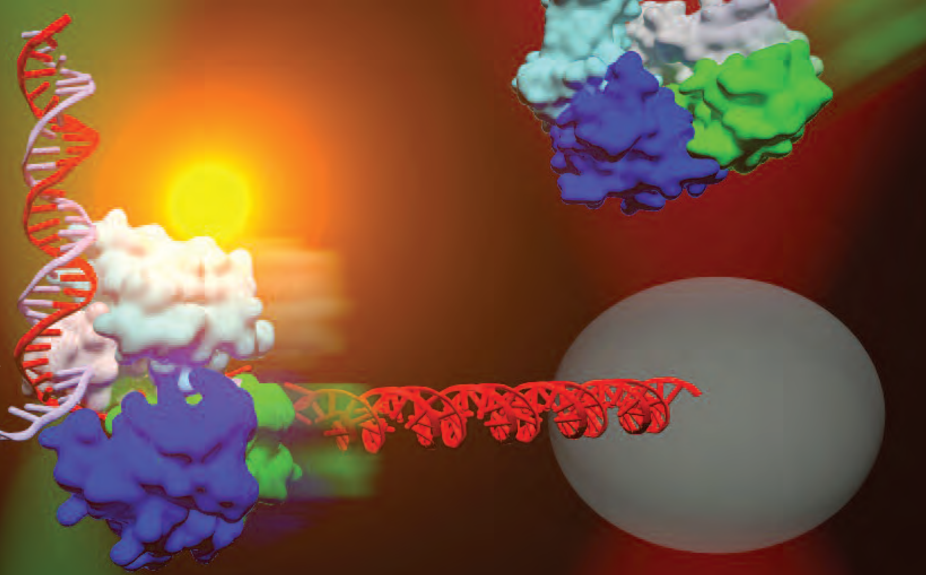
"For the first time, we've shown that you can regenerate lost material in a structural polymer. That's the kicker here," said White, a professor of materials science and engineering. "Prior to this work, if you cut off a piece of material, it's gone. Now we've shown that the material can actually regrow."

The team demonstrated their regenerating system on the two biggest classes of commercial plastics: thermoplastics and thermosets. In previous work, they have established systems compliant with manufacturing processes, and they envision vascular networks built into the commercial plastics and polymers and filled with these regenerative agents, ready to be deployed whenever damage occurs.

Scientists Observe Structure-Function Relationship in Proteins

By combining two highly innovative experimental techniques, scientists have for the first time simultaneously observed the structure and the correlated function of specific proteins critical in the repair of DNA.

Scientists who study biological systems at the molecular level have looked at the structure of protein molecules or the specific tasks they perform. Until recently, the most advanced laboratory experiments could only investigate one of the two, structure or function, at a time, and, from the results, deduce the other. This indirect method often doesn't provide definitive answers.



Credit: Matt Comstock

The DNA repair helicase UvrD can exist in an "open" (green, blue, cyan, and gray-colored protein, upper right) or "closed" (middle) conformation. An instrument combining optical traps (red cones) and a single-molecule fluorescence microscope (green cones) is used to measure directly the relationship between these two structural states and their respective functions on DNA.

Now teams led by Beckman affiliate **Taekjip Ha** and Yann Chemla, both professors of physics, have combined two techniques—simultaneous fluorescence microscopy and optical trapping—to directly examine the structure-function relationship in proteins and showed that a protein called a helicase unzips DNA only in the closed structural state.

They also engineered helicases, fastening them in either the closed or the open state by using a cross-linking molecule as "tape."

With the help of this technique, the team found that when locked in the closed position, it becomes a "superhelicase" capable of unwinding double-stranded DNA over a great distance. Locked in the open position, the helicase was defunct—it performed no task.

The ability to bioengineer molecules to perform specific tasks holds promise for applications, including rapid DNA sequencing with nanopore technology.

Brian Cunningham (left) and Kenny Long developed a cradle and app for the iPhone to make a handheld biosensor that uses the phone's own camera and processing power to detect any kind of biological molecule or cell.

Handheld Biosensor

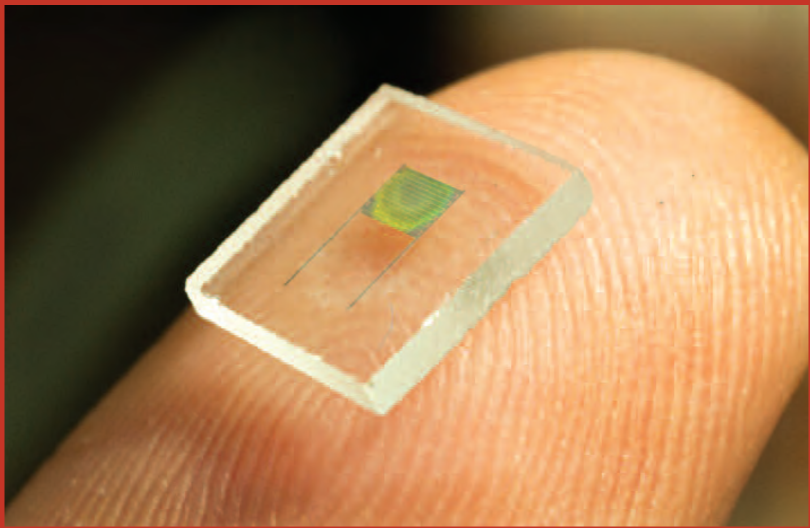
Illinois researchers, led by **Brian Cunningham** from the Nanoelectronics and Nanomaterials Group and professor of bioengineering and electrical and computer engineering, have developed a cradle and app for the iPhone to make a handheld biosensor that uses the phone's own camera and processing power.

The camera functions as a high-resolution laboratory spectrometer to provide measurements that match the sensitivity performance of large and expensive laboratory instruments for popular analytic tests used in medical diagnostics, food safety, and other applications.

"In our research, we focused on conducting common biological tests—assays—for two different proteins, one that measures inflammation, such as what might occur due to cancer, diabetes, or other diseases, and another used to detect the peanut allergen," Cunningham said.

These assays detect the presence of substances such as proteins by passing light through a liquid sample. The concentration of the substance is determined by the color of the liquid.

The app uses the phone's camera to spread the light's wavelengths over the camera's pixels, made possible by a cradle the team constructed that contains a series of lenses and optical filters. The cradle holds the phone's camera in alignment with the optical components.



Paul Braun, William King, and John Rogers created a holographically patterned microbattery with applications in electronic devices.

3D Microbattery for On-Chip Integration

By combining 3D holographic lithography and 2D photolithography, researchers from Beckman, including **Paul Braun**, **William King**, and **John Rogers** of the 3D Micro- and Nanosystems Group, have demonstrated a high-performance 3D microbattery suitable for large-scale on-chip integration with microelectronic devices.

"This 3D microbattery has exceptional performance and scalability, and we think it will be of importance for many applications," said Braun, a professor of materials science and engineering. "Microscale devices typically utilize power supplied off-chip because of difficulties in miniaturizing energy storage technologies. A miniaturized high-energy and high-power on-chip battery would be highly desirable for applications including autonomous microscale actuators, distributed wireless sensors and transmitters, monitors, and portable and implantable medical devices."

Microscale batteries can deliver energy at the actual point of energy usage, providing capabilities for miniaturizing electronic devices and enhancing their performance.

"Micro-engineered battery architectures, combined with high energy material such as tin, offer exciting new battery features including high energy capacity and good cycle lives, which provide the ability to power practical devices," said King, a professor of mechanical science and engineering.

Researchers Discover How Glass Surfaces Move in Light

Martin Gruebele, professor of chemistry, and **Joe Lyding**, professor of electrical and computer engineering, led a team that developed a way to watch how nanometer-sized bundles of atoms move around on the surface of semiconducting glass, and how their motion changes when a laser shines onto the glass. Both Gruebele and Lyding are members of the Nanoelectronics and Nanomaterials Group.

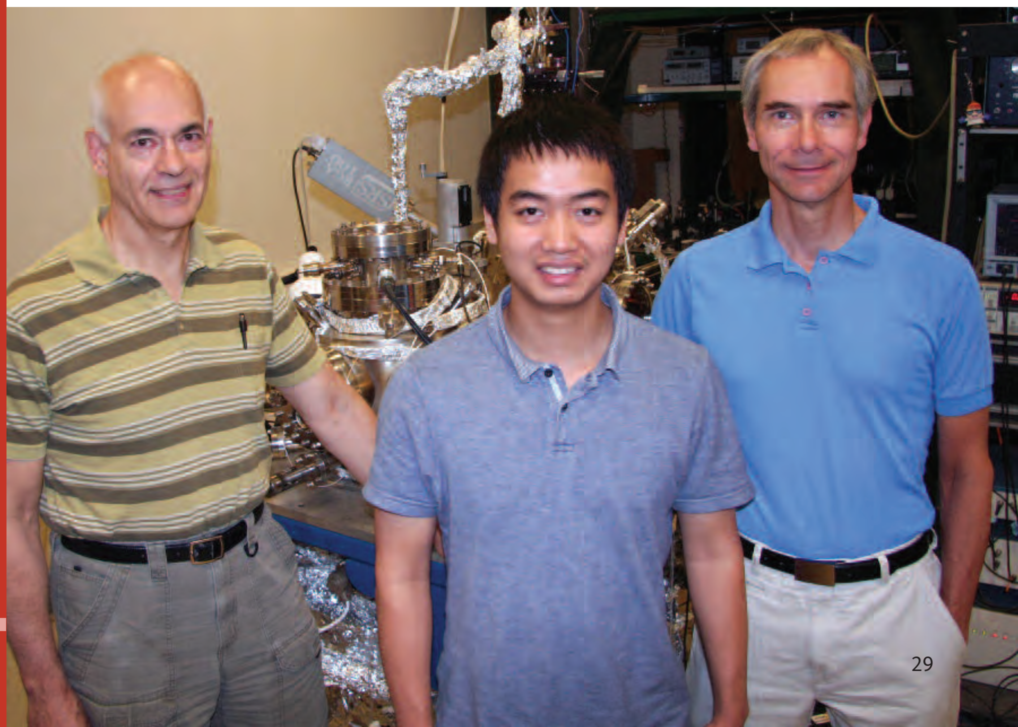
Studying transport in glasses could provide new insight into improved glassy materials and light-controlled glasses.

Unlike in atomic liquids, where atoms move more or less independently, bundles of atoms move together in glasses. Time-resolved scanning tunneling microscopy (TR-STM) showed that exciting the atomic bundles with laser light gets them hopping much faster.

"We think that the photo-darkening of glasses and related processes for optical control of advanced glass materials could go through a purely electronic mechanism, without heating," Gruebele said. "Understanding how these mechanisms work at a fundamental level is going to give people more handles on tailoring the optical properties of glasses."

They plan to use time-resolved atomic force microscopy (TR-AFM) next to study ordinary window glass, as well as exotic lanthanum alloys that form a glassy metal.

From left, Joe Lyding, Duc Nguyen, and Martin Gruebele used time-resolved scanning tunneling microscopy to understand how atoms move on the surface of glass.



BIOINTEL SELECTED FACULTY AWARDS, PATENTS, GRANTS, AND PUBLICATIONS

Covering July 1, 2014-June 30, 2015

FACULTY

(name followed by home department)

Cognitive Neuroscience

Dolores Albarracin, *Psychology*
Aron Barbey, *Speech and Hearing Science*
Diane M. Beck, *Psychology*
Neal J. Cohen, *Psychology*
Florin Dolcos, *Psychology*
Monica Fabiani, *Psychology*
Kara D. Federmeier, *Psychology*
Susan M. Garnsey, *Psychology*
Gabriele Gratton, *Psychology*
Christopher M. Grindrod, *Speech and Hearing Science*
Wendy Heller, *Psychology*
Rosalba Hernandez, *Social Work*
Daniel Hyde, *Psychology*
Melissa Littlefield, *English*
Torrey Loucks, *Speech and Hearing Science*
Gregory A. Miller, *Psychology*
Sung Soo Shin, *Art and Design*
Eva Telzer, *Psychology*
Sharon Y. Tettegah, *Curriculum and Instruction*

Cognitive Science

Eurydice Bauer, *Curriculum and Instruction*
Aaron S. Benjamin, *Psychology*
Daniel Berry, *Educational Psychology*
J. Kathryn Bock, *Psychology*
Sarah Brown-Schmidt, *Psychology*
Kiel Christianson, *Educational Psychology*
Kathryn Clancy, *Anthropology*
Jennifer S. Cole, *Linguistics*
Gary S. Dell, *Psychology*
Laura S. DeThorne, *Speech and Hearing Science*
Cynthia L. Fisher, *Psychology*
Robin B. Kar, *Law*
Jose Mestre, *Physics*
Jerome L. Packard, *East Asian Languages and Cultures*
Michelle Perry, *Educational Psychology*
Charles C. Roseman, *Anthropology*
Brian H. Ross, *Psychology*
Chilin Shih, *East Asian Languages and Cultures*
Darren Tanner, *Linguistics*
Marina Terkourafi, *Linguistics*
Duane G. Watson, *Psychology*

NeuroTech

Thomas J. Anastasio, *Molecular and Integrative Physiology*
Stephanie S. Ceman, *Medical Cell and Structural Biology*
Charles L. Cox, *Pharmacology*
Roberto Galvez, *Psychology*
Martha L. Gillette, *Medical Cell and Structural Biology*
Rhanor Gillette, *Molecular and Integrative Physiology*
Graham Huesmann, *Molecular and Integrative Physiology*
Janice M. Juraska, *Psychology*
Daniel Llano, *Molecular and Integrative Physiology*
Mark E. Nelson, *Molecular and Integrative Physiology*
Justin S. Rhodes, *Psychology*
Gene E. Robinson, *Entomology*
Edward J. Roy, *Pathology*
Taher Saif, *Mechanical Science and Engineering*
Susan Schantz, *Comparative Biosciences*
Nathan E. Schroeder, *Crop Sciences*
Jonathan V. Sweedler, *Chemistry*

SELECTED HONORS AND AWARDS

Monica Fabiani
Editor-in-chief of the journal *Psychophysiology*, 2015

SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the Biological Intelligence research theme were inventors on the following patent issued (1.3% of the 76 patents issued to campus) during FY2015.

Muhammed Taher Abu Saif and Wonmo Kang, "Apparatus and Method for *in situ* Testing of Microscale and Nanoscale Samples," patent issued April 28, 2015, patent number 9,019,512.

GRANTS AWARDED

($7,279,611)

Martha Gillette, **Gabriel Popescu**, **John Rogers**, and **Jonathan Sweedler**, NSF, "Brain Eager: Multiscale Dynamics and Emergent Properties of Suprachiasmatic Circuits in Real Time," 9/1/2014 – 8/31/2016, $300,000.

Jonathan Sweedler, NIH, "Synaptic Phenotype Development and Plasticity in the Fragile X Mouse," 7/1/2013 – 6/30/2014, $109,282.

Jeffrey Woods, Rodney Johnson, Keith Kelley, Robert McCusker, George Fahey, Kelly Swanson, **Justin Rhodes**, and **Jonathan Sweedler**, Abbott Nutrition, "Impact of Fiber on the Gut Microbiome and Cognition in Mice," 8/16/2014 – 8/15/2016, $99,158.

Gabriele Gratton, **Monica Fabiani**, Renee Baillargeon, **Cynthia Fisher**, and **Daniel Hyde**, Abbott Nutrition, "Investigating the Effects of Nutrition on the Maturation of Brain Networks Associated with Memory in Infants," 8/16/2014 – 8/15/2016, $768,429.

Jonathan Sweedler and Rubakhin Stanislav, Abbott Nutrition, "Enhanced Chemical Characterization Efforts for Selected CNLM Projects," 8/16/2014 – 8/15/2016, $537,881.

Jonathan Sweedler and **Martha Gillette**, Abbott Nutrition, "Diet-Modified Brain Chemistry and Plasticity: Nutrition as a Case Study," 8/16/2014 – 8/15/2016, $422,463.

Justin Rhodes, Abbott Nutrition, "Impact of Nutrients on Neonatal Brain Development and Function," 8/16/2014 – 8/15/2016, $500,000.

Aron Barbey, **Neal Cohen**, and **Arthur Kramer**, Abbott Nutrition, "Nutritional Enhancement of Cognitive and Physical Performance in Active Duty Air Force Personnel: A Randomized Controlled Trial," 8/16/2014 – 8/15/2016, $984,176.

Joshua Gulley and **Roberto Galvez**, Abbott Nutrition, "Neural Mechanisms of Nutrient-Induced Cognitive Enhancement," 8/16/2014 – 8/15/2016, $568,263.

Supida Monaikul and **Susan Schantz**, MRC-SOT, "2014 MRC-SOT Young Investigator Award," 10/20/2014 – 10/19/2015, $1,500.

Diane Beck, ONR, "Top-Down and Bottom-Up Brain Mechanisms at Multiple Spatial and Temporal Scales: Experimental Investigation and Computation Modeling," 7/1/2014 – 6/30/2019, $1,155,000.

Susan Schantz, Jodi Flaws, **Janice Juraska**, and Barbara Fiese, NIH, "Novel Methods to Assess the Effects of Chemicals on Child Development," 6/1/2015 – 5/31/2017, $113,474.

Susan Schantz and Jodi Flaws, NIH, "Research Training Program in Environmental Toxicology," 7/1/2015 – 6/30/2020, $1,719,985.

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Beckman faculty names are in bold-face type.

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Monti, J. M.; Cooke, G. E.; Watson, P. D.; Voss, M. W.; **Kramer, A. F.**; **Cohen, N. J.**, Relating Hippocampus to Relational Memory Processing across Domains and Delays. *Journal of Cognitive Neuroscience* 2015, *27,* (2), 234-245, DOI:10.1162/Jocn_a_00717.

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Ryskin, R. A.; **Brown-Schmidt, S.**, Do Adults Show a Curse of Knowledge in False-Belief Reasoning? A Robust Estimate of the True Effect Size. *PLOS One* 2014, *9,* (3), DOI:ARTN e92406 DOI:10.1371/journal.pone.0092406.

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Tullis, J. G.; **Benjamin, A. S.**; **Ross, B. H.**, The Reminding Effect: Presentation of Associates Enhances Memory for Related Words in a List. *Journal of Experimental Psychology-General* 2014, *143,* (4), 1526-1540, DOI:10.1037/A0036036.

Wang, H.; Wang, B.; Jackson, K.; Miller, C. M.; Hasadsri, L.; **Llano, D.**; Rubin, R.; Zimmerman, J.; Johnson, C.; **Sutton, B.**, A Novel Head-Neck Cooling Device for Concussion Injury in Contact Sports. *Translational Neuroscience* 2015, *6,* (1), 20-31, DOI:10.1515/tnsci-2015-0004.

Yee, L. T. S.; Warren, D. E.; Voss, J. L.; Duff, M. C.; Tranel, D.; **Cohen, N. J.**, The Hippocampus Uses Information Just Encountered to Guide Efficient Ongoing Behavior. *Hippocampus* 2014, *24,* (2), 154-164, DOI:10.1002/Hipo.22211.

Yoon, H.; Shiftehfar, R.; Cho, S.; Spencer, B. F.; **Nelson, M. E.**; Agha, G., Victim Localization and Assessment System for Emergency Responders. *Journal of Computing in Civil Engineering* 2015, DOI:10.1061/(ASCE)CP.1943-5487.0000483.

Covering July 1, 2014-June 30, 2015

FACULTY

(name followed by home department)

Artificial Intelligence

Narendra Ahuja, *Electrical and Computer Engineering*
Jont Allen, *Electrical and Computer Engineering*
Richard Berlin, *Surgery*
Timothy W. Bretl, *Aerospace Engineering*
Gerald F. Dejong, *Computer Science*
Corina R. Girju, *Linguistics*
Mark A. Hasegawa-Johnson, *Electrical and Computer Engineering*
Elizabeth Hsiao-Wecksler, *Mechanical Science and Engineering*
Seth A. Hutchinson, *Electrical and Computer Engineering*
Mark Johnson, *Internal Medicine*
Steven M. Lavalle, *Computer Science*
Stephen E. Levinson, *Electrical and Computer Engineering*
Silvina A. Montrul, *Spanish, Italian, and Portuguese*
Dan Roth, *Computer Science*
Lane O. B. Schwartz, *Linguistics*
Lui Sha, *Computer Science*
Ryan Shosted, *Linguistics*
Paris Smaragdis, *Computer Science*
Karen White, *Internal Medicine*

Human Perception and Performance

Matthew W. Dye, *Speech and Hearing Science*
Wai-Tat Fu, *Computer Science*
Manuel E. Hernandez, *Kinesiology and Community Health*
Charles H. Hillman, *Kinesiology and Community Health*
Derek Hoiem, *Computer Science*
Naira Hovakimyan, *Mechanical Science and Engineering*
Fatima T. Husain, *Speech and Hearing Science*
David E. Irwin, *Psychology*
Harrison H. M. Kim, *Industrial and Enterprise Systems Engineering*
Alex Kirlik, *Computer Science*
Leanne Knobloch, *Communications*
Arthur F. Kramer, *Psychology*
Charissa Lansing, *Speech and Hearing Science*
Robb Lindgren, *Curriculum and Instruction*
Alejandro Lleras, *Psychology*
Edward McAuley, *Kinesiology and Community Health*
Deana C. McDonagh, *Art and Design*
Emma M. Mercier, *Curriculum and Instruction*
Zahra Mohaghegh Ahmadabadi, *Nuclear, Plasma, and Radiological Engineering*
Daniel G. Morrow, *Educational Psychology*
Sean P. Mullen, *Kinesiology and Community Health*
Jennifer K. Robbennolt, *Law*
K. Arden Rowell, *Law*
Daniel J. Simons, *Psychology*
Jacob J. Sosnoff, *Kinesiology and Community Health*
Elizabeth A. L. Stine-Morrow, *Educational Psychology*
Michael Twidale, *Library and Information Science*
Ranxiao Wang, *Psychology*
Kevin Wise, *Advertising*
Zhengyu (Mike) Yao, *Advertising*

Image Formation and Processing

Brian P. Bailey, *Computer Science*
Yoram Bresler, *Electrical and Computer Engineering*
Robert J. Brunner, *Astronomy*
Minh N. Do, *Electrical and Computer Engineering*
George K. Francis, *Mathematics*
Jiawei Han, *Computer Science*
Thomas S. Huang, *Electrical and Computer Engineering*
Douglas L. Jones, *Electrical and Computer Engineering*
Pierre Moulin, *Electrical and Computer Engineering*
Klara Nahrstedt, *Computer Science*
Lav Varshney, *Electrical and Computer Engineering*

SELECTED HONORS AND AWARDS

Klara Nahrstedt
Computing Research Association's Computing Community Consortium Council, 2015
Award for Outstanding Technical Contributions to Multimedia Computing, Communications and Applications, Association for Computing Machinery Special Interest Group on Multimedia (SIGMM), 2014

Dan Roth
AAAS Fellow, 2014

INVENTION DISCLOSURES

Faculty members from the Human-Computer Intelligent Interaction research theme were inventors on seven invention disclosures (3.5% of the 202 invention disclosures filed by campus) during FY2015.

SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the Human-Computer Intelligent Interaction research theme were inventors on three of the following patent applications (1.6% of the 191 patent applications filed by campus) and one patent issued (1.3% of the 76 patents issued to campus) during FY2015.

Jont Allen and Feipeng Li, "System and Methods for Identifying Speech Sound Features," patent issued March 17, 2015, patent number 8,983,832.

Chenzhang Xiao, Deen Farooq, **Elizabeth Hsiao-Wecksler**, Gaurav Singh, Girish Krishnan, Matthew Petrucci, Mazharul Islam, Morgan Boes, Placid Ferreira, Sameh Tawfick, Ye Oo, and Ziming Wang, "Pneumatics for Orthotics," patent filed October 10, 2014, application number 62/062,624.

Ding Liu, **Thomas Huang**, and Zhaowen Wang, "A Recurrent Deep Neural Network for Single Image Super-Resolution," patent filed November 12, 2014, application number 62/078,694.

Lui Sha and **Richard Berlin**, "Computational Pathophysiological Model Based ICU Situation Awareness System," patent filed November 24, 2014, application number 62/083,425.

GRANTS AWARDED

($1,415,136)

Arthur Kramer, NIH, "Influence of Fitness on Brain and Cognition," 7/15/2014 – 5/31/2015, $5,000.

Elizabeth Stine-Morrow, NIH, "Emotion, Aging, and Decision Making," 10/1/2014 – 9/30/2019, $319,241.

Mark Hasegawa-Johnson and **Thomas Huang**, Google, "Google ATAP Continuous Authentication Program," 10/28/2014 – 5/15/2015, $90,000.

Thomas Huang, MIT-Lincoln Laboratory, "Unsupervised Deep Neural Network Architectures for Multimodal Learning," 10/1/2014 – 9/30/2015, $45,000.

Mark Hasegawa-Johnson, QTAR, "The Family as the Unit of Intervention for Speech-Generating Augmentative/Assistive Communication," 1/11/2015 – 1/10/2018, $255,895.

Charles Hillman, **Arthur Kramer**, **Neal Cohen**, and Naiman Khan, Abbott Nutrition, "The Effects of Fortified Nutritional Supplementation on Cognition, Memory, and Achievement," 5/16/2012 – 5/15/2017, $700,000.

SELECTED PUBLICATIONS

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Al-Sabbagh, R.; **Girju, R.**; Diesner, J., A Unified Framework to Identify and Extract Uncertainty, Cues, Holders, and Scopes in One Fell-Swoop. In *CICLing 2015, Part I, LNCS 9041.* Gelbukh, E., Ed.; Springer International Publishing, Switzerland, 2015, 310-334.

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Carignan, C.; **Shosted, R. K.**; Fu, M. J.; **Liang, Z. P.**; **Sutton, B. P.**, A Real-Time MRI Investigation of the Role of Lingual and Pharyngeal

 Beckman faculty names are in bold-face type.

Articulation in the Production of the Nasal Vowel System of French. *Journal of Phonetics* 2015, *50,* 34-51, DOI:10.1016/j.wocn.2015.01.001.

Chaddock-Heyman, L.; **Hillman, C. H.**; **Cohen, N. J.**; **Kramer, A. F.**, The Importance of Physical Activity and Aerobic Fitness for Cognitive Control and Memory in Children. *Monographs of the Society for Research in Child Development* 2014, *79,* (4), 25-50, DOI:10.1111/Mono.12129.

Chen, A.; **Hasegawa-Johnson, M. A.**, Mixed Stereo Audio Classification Using a Stereo-Input Mixed-to-Panned Level Feature. *IEEE-ACM Transactions on Audio Speech and Language Processing* 2014, *22,* (12), 2025-2033, DOI:10.1109/Taslp.2014.2359628.

Chin, J.; Payne, B.; Gao, X. F.; Conner-Garcia, T.; Graumlich, J. F.; Murray, M. D.; **Morrow, D. G.**; **Stine-Morrow, E. A. L.**, Memory and Comprehension for Health Information among Older Adults: Distinguishing the Effects of Domain-General and Domain-Specific Knowledge. *Memory* 2015, *23,* (4), 577-589, DOI:10.1080/09658211.2014.912331.

Dani, A. P.; Chung, S. J.; **Hutchinson, S.**, Observer Design for Stochastic Nonlinear Systems via Contraction-Based Incremental Stability. *IEEE Transactions on Automatic Control* 2015, *60,* (3), 700-714, DOI:10.1109/Tac.2014.2357671.

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Hill, P. L.; Payne, B. R.; Jackson, J. J.; **Stine-Morrow, E. A. L.**; Roberts, B. W., Perceived Social Support Predicts Increased Conscientiousness During Older Adulthood. *Journals of Gerontology Series B-Psychological Sciences and Social Sciences* 2014, *69,* (4), 543-547, DOI:10.1093/geronb/gbt024.

Huang, P. S.; Kim, M.; **Hasegawa-Johnson, M.**; **Smaragdis, P.**, Deep Learning for Monaural Speech Separation. *2014 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)* 2014.

Husain, F. T.; Akrofi, K.; Carpenter-Thompson, J. R.; Schmidt, S. A., Alterations to the Attention System in Adults with Tinnitus Are Modality Specific. *Brain Research* 2015, DOI:10.1016/j.brainres.2015.05.010.

Jones, D. L.; Jones, R. L.; Ratnam, R., Calling Dynamics and Call Synchronization in a Local Group of Unison Bout Callers. *Journal of Comparative Physiology A-Neuroethology Sensory Neural and Behavioral Physiology* 2014, *200,* (1), 93-107, DOI:10.1007/s00359-013-0867-x.

Kim, K.; Lin, K. H.; Walther, D. B.; **Hasegawa-Johnson, M. A.**; **Huang, T. S.**, Automatic Detection of Auditory Salience with Optimized Linear Filters Derived from Human Annotation. *Pattern Recognition Letters* 2014, *38,* 78-85, DOI:10.1016/j.patrec.2013.11.010.

Li, C.; **Girju, R.**, Extracting Adjoined Causality Using Structural Information, *Proceedings of the 2nd International Conference of the American Pragmatics Association (AMPRA)*, UCLA, California, October 17-19, 2014.

Lu, J. W.; Liong, V. E.; Wang, G.; **Moulin, P.**, Joint Feature Learning for Face Recognition. *IEEE Transactions on Information Forensics and Security* 2015, *10,* (7), 1371-1383, DOI:10.1109/Tifs.2015.2408431.

Mereu, S.; Zacks, J. M.; Kurby, C. A.; **Lleras, A.**, The Role of Prediction in Perception: Evidence from Interrupted Visual Search. *Journal of Experimental Psychology-Human Perception and Performance* 2014, *40,* (4), 1372-1389, DOI:10.1037/A0036646.

Miller, S. R.; **Bailey, B. P.**; **Kirlik, A.**, Exploring the Utility of Bayesian Truth Serum for Assessing Design Knowledge. *Human-Computer Interaction* 2014, *29,* (5-6), 487-515, DOI:10.1080/07370024.2013.870393.

Min, D. B.; Choi, S.; Lu, J. B.; Ham, B.; Sohn, K.; **Do, M. N.**, Fast Global Image Smoothing Based on Weighted Least Squares. *IEEE Transactions on Image Processing* 2014, *23,* (12), 5638-5653, DOI:10.1109/Tip.2014.2366600.

Nath, V.; **Levinson, S. E.**, *Autonomous Robotics and Deep Learning*; Springerbriefs in Computer Science, Zdonik, S., Shekhar, S., Katz, J., Wu, X., Jain, L. C., Padua, D., Shen, X., Eds., Springer International Publishing, 2014, 66, DOI:10.1007/978-3-319-05603-6.

Nguyen, T. H.; Sridharan, S.; Marcias, V.; Balla, A. K.; **Do, M. N.**; **Popescu, G.**, Prostate Cancer Diagnosis Using Quantitative Phase Imaging and Machine Learning. *Quantitative Phase Imaging* 2015, *9336*, DOI:ARTN 933619 DOI:10.1117/12.2080321.

Norton, J. J. S.; Lee, D. S.; Lee, J. W.; Lee, W.; Kwon, O.; Won, P.; Jung, S. Y.; Cheng, H. Y.; Jeong, J. W.; Akce, A.; Umunna, S.; Na, I.; Kwon, Y. H.; Wang, X. Q.; Liu, Z. J.; Paik, U.; Huang, Y. G.; **Bretl, T.**; Yeo, W. H.; **Rogers, J. A.**, Soft, Curved Electrode Systems Capable of Integration on the Auricle as a Persistent Brain-Computer Interface. *Proceedings of the National Academy of Sciences of the United States of America* 2015, *112,* (13), 3920-3925, DOI:10.1073/pnas.1424875112.

Payne, B. R.; Grison, S.; Gao, X. F.; **Christianson, K.**; **Morrow, D. G.**; **Stine-Morrow, E. A. L.**, Aging and Individual Differences in Binding During Sentence Understanding: Evidence from Temporary and Global Syntactic Attachment Ambiguities. *Cognition* 2014, *130,* (2), 157-173, DOI:10.1016/j.cognition.2013.10.005.

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Stothart, C. R.; **Simons, D. J.**; Boot, W. R.; **Kramer, A. F.**, Is the Effect of Aerobic Exercise on Cognition a Placebo Effect? *PLOS One* 2014, *9,* (10), DOI:ARTN e109557 DOI:10.1371/journal.pone.0109557.

Street, W. N.; **Wang, R. F.**, Differentiating Spatial Memory from Spatial Transformations. *Journal of Experimental Psychology-Learning Memory and Cognition* 2014, *40,* (2), 602-608, DOI:10.1037/A0035279.

Thomas, J.; **McDonagh, D.**; Canning, L., Developing the Arts Entrepreneur: The 'Learning Cloud.' *Design Journal* 2014, *17,* (3), 425-443, DOI:10.2752/175630614x13982745783046.

Toscano, J. C.; **Allen, J. B.**, Across- and within-Consonant Errors for Isolated Syllables in Noise. *Journal of Speech Language and Hearing Research* 2014, *57,* (6), 2293-2307, DOI:10.1044/2014_Jslhr-H-13-0244.

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Vydiswaran, V. G. V.; Zhai, C.; **Roth, D.**; Pirolli, P., Overcoming Bias to Learn About Controversial Topics. *Journal of the Association for Information Science and Technology* 2015, DOI:10.1002/asi.23274.

Zhang, T. Z.; Liu, S.; **Ahuja, N.**; Yang, M. H.; Ghanem, B., Robust Visual Tracking via Consistent Low-Rank Sparse Learning. *International Journal of Computer Vision* 2015, *111,* (2), 171-190, DOI:10.1007/s11263-014-0738-0.

INTIM SELECTED FACULTY AWARDS, PATENTS, GRANTS, AND PUBLICATIONS

Covering July 1, 2014-June 30, 2015

FACULTY

(name followed by home department)

Bioacoustics Research Laboratory

John Erdman, *Food Science and Human Nutrition*
William D. O'Brien, *Electrical and Computer Engineering*
Michael L. Oelze, *Electrical and Computer Engineering*
Douglas Simpson, *Statistics*
Rebecca M. Stumpf, *Anthropology*

Bioimaging Science and Technology

Sayee Anakk, *Molecular and Integrative Physiology*
Ryan Bailey, *Chemistry*
Rohit Bhargava, *Bioengineering*
Marni Boppart, *Kinesiology and Community Health*
Stephen A. Boppart, *Electrical and Computer Engineering*
P. Scott Carney, *Electrical and Computer Engineering*
Jianjun Cheng, *Materials Science and Engineering*
Larry Di Girolamo, *Atmospheric Science*
Ryan Dilger, *Animal Sciences*
Wawrzyneic Dobrucki, *Bioengineering*
Lynford Goddard, *Electrical and Computer Engineering*
Princess Imoukhuede, *Bioengineering*
Michael Insana, *Bioengineering*
Jianming Jin, *Electrical and Computer Engineering*
Aaron S. Johnson, *Speech and Hearing Science*
Mariana E. Kersh, *Mechanical Science and Engineering*
Zhi-Pei Liang, *Electrical and Computer Engineering*
Jian Ma, *Bioengineering*
Ling J. Meng, *Nuclear, Plasma, and Radiological Engineering*
William C. Olivero, *Surgery*
Dipanjan Pan, *Bioengineering*
Gabriel Popescu, *Electrical and Computer Engineering*
Partha Ray, *Surgery*
Martin O. Starzewski, *Mechanical Science and Engineering*
Andrew Suarez, *Animal Biology*
Kenneth S. Suslick, *Chemistry*
Brad Sutton, *Bioengineering*
Valarmathi Thiruvanamalai, *Comparative Biosciences*
Kimani Toussaint, *Mechanical Science and Engineering*
Amy J. Wagoner Johnson, *Mechanical Science and Engineering*
Huan (John) Wang, *Surgery*
Ning Wang, *Mechanical Science and Engineering*
Yongmei M. Wang, *Statistics*
Kenneth L. Watkin, *Speech and Hearing Science*
Brenda A. Wilson, *Microbiology*

SELECTED HONORS AND AWARDS

Rohit Bhargava
Fellow of the American Institute for Medical and Biological Engineering (AIMBE), 2015

Marni Boppart
Fellow in the American College of Sports Medicine (ACSM), 2015

Aaron Johnson
New Investigator Research Award from the American Speech-Language-Hearing Foundation, 2014

Jian Ma
Fellow of the Center for Advanced Studies (CAS) at Illinois, 2015

Dipanjan Pan
Fellow of the Royal Society of Chemistry (RSC), 2015

INVENTION DISCLOSURES

Faculty members from the Integrative Imaging research theme were inventors on seven invention disclosures (3.5% of the 202 invention disclosures filed by campus) during FY2015.

SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the Integrative Imaging research theme were inventors on 15 of the following patent applications (7.9% of the 191 patent applications filed by campus) and 10 patents issued (13.2% of the 76 patents issued to campus) during FY2015.

Jianjun Cheng and Rong Tong, "One-Step Drug-Nanoparticle Preparation," patent issued July 18, 2014, patent number 5,578,655.

Yoram Bresler and Bezhad Sharif, "Auto-Calibrating Parallel MRI Technique with Distortion-Optimal Image Construction," patent issued September 9, 2014, patent number 8,831,318.

Basanta Bhaduri, Hoa Pham, and **Gabriel Popescu**, "Diffraction Phase Microscopy with White Light," patent issued September 16, 2014, patent number 8,837,045.

Ling-Jian Meng, "Detector Apparatus Having a Hybrid Pixel-Waveform Readout System," patent issued October 21, 2014, patent number 8,866,097.

Rohit Bhargava, Xavier Llora, and Anil Kodali, "Tailored Raman Spectroscopic Probes for Ultrasensitive and Highly Multiplexed Assays," patent issued October 28, 2014, patent number 8,873,038.

Gabriel Popescu, Zhuo Wang, and Huafeng Ding, "Characteristic Parameters of Cells and Tissue from Quantitative Phase Imaging," patent issued January 15, 2015, patent number 8,928,887.

Brad Sutton, Anh Van, and Diego Hernando, "Method for Correcting Motion-Induced Phase Errors in Magnetic Resonance Imaging," patent issued March 10, 2015, patent number 8,975,895.

Stephen Boppart, Freddy Nguyen, and Adam Zysk, "Low-Coherence Interferometry and Optical Coherence Tomography for Image-Guided Surgical Treatment of Solid Tumors," patent issued March 17, 2015, patent number 8,983,580.

Jianjun Cheng and Li Tang, "Silica Nanoparticle Agent Conjugates," patent issued May 12, 2015, patent number 9,028,880.

Gabriel Popescu and Zhuo Wang, "Spatial Light Interference Tomography (SLIT)," patent issued June 9, 2015, patent number 9,052,180.

Gabriel Popescu and Ru Wang, "Dispersion-Relation Fluorescence Spectroscopy," patent filed July 2, 2014, application number 14/321,937.

Jianjun Cheng and Jonathan Yen, "Enhanced Non-Viral Gene Delivery to Human Embryonic Stem Cells," patent filed July 28, 2014, application number 62/029,964.

Haohua Tu and **Stephen Boppart**, "Bright Few-Cycle Fiber Source Using Resonant Dispersive Wave Emission in an Optical Fiber," patent filed July 29, 2014, application number 14/445,245.

Nathan Shemonski, Ryan Shelton, and **Stephen Boppart**, "Smart Phone Attachment for 3-D Optical Coherence Tomographic Imaging and Low-Cost Handheld Otoscope with Depth Profiling," patent filed August 8, 2014, application number 62/034,898.

Paul Carney, Martin Schnell, and Rainer Hillenbrand, "Optical Nanoholography," patent filed October 1, 2014, application number 14/389,921.

Hanze Ying, **Jianjun Cheng**, and Yanfeng Zhang, "Dynamic Urea Bonds for Polymers," patent filed October 28, 2014, application number 62/069,385.

Michael Insana and Sara Bahramianparchekoohi, "Retrieving High Spatial Frequency Information in Sonography for Improved Microcalcification Detection," patent filed November 11, 2014, application number 62/078,180.

Adam Zysk, Andrew Cittadine, Anna Lisa Somera, Freddy Nguyen, and **Stephen Boppart**, "Low-Coherence Interferometry and Optical Coherence Tomography for Image-Guided Surgical Treatment of Solid Tumors," patent filed January 9, 2015, application number 14/593,013.

Beckman faculty names are in bold-face type.

Chao Ma, Fan Lam, and **Zhi-Pei Liang**, "A Subspace Approach to High Resolution Spectroscopic Imaging," patent filed January 12, 2015, application number 62/102,315.

Jianju Cheng and Kaimin Cai, "Trigger Responsive Drug Conjugate for High Loading Nanoencapsulates," patent filed February 25, 2015, application number 61/120,821.

Andrew Singer, **Michael Oelze**, and Thomas Riedl, "Ultra Short Range Acoustic Communication and Power Transfer," patent filed May 26, 2015, application number 62/166,643.

Nathan Shemansky, **Paul Carney**, and **Stephen Boppart**, "Phase Measurement, Analysis, and Correction Methods for Coherent Imaging Systems," patent filed June 19, 2015, application number 62/182,116.

Jianjun Cheng, Menghua Xiong, and Ziyuan Song, "Antimicrobial Alpha-Helical Cationic Polypeptides," patent filed June 26, 2015, application number 62/185,345.

Brad Sutton and Curtis Johnson, "Echo-Planar Imaging Magnetic Resonance Elastography Pulse Sequence," patent filed June 29, 2015, application number 62/185,770.

GRANTS AWARDED

($3,013,007)

John Erdman, Abbott Nutrition, "Cognitive Nutrients and the Brain: Production of Isotopically Labeled Nutrients and Development of Animal Models," 5/16/2013 – 5/15/2016, $144,514.

Marni Boppart, NIH, "a7 Integrin-Mediated Hypertrophic Signaling and Growth in Skeletal Muscle," 7/1/2014 – 6/30/2016, $367,623.

Stephen Boppart and **Justin Rhodes**, NSF, "Brain EAGER: Spatially-Resolved *in vivo* Optogenetic Stimulation and Imaging Platform," 9/1/2014 – 8/31/2016, $300,000.

Stephen Boppart, GlaxoSmithKline, "Biophotonics Imaging Lab Pilot Projects for GlaxoSmithKline," 9/1/2014 – 2/28/2015, $66,198.

John Erdman, Abbott Nutrition, "Impact of Natural Vitamin E and Supplemental Lutein on Brain and Eye Development of Infant Primates," 8/16/2014 – 8/15/2016, $1,452,561.

Stephen Boppart, CIMIT, "Differentiation of Bacterial Versus Viral Otitis Media Using Raman Spectroscopy in Primary Care," 6/1/2014 – 5/31/2015, $149,082.

Mani Nakamura, **John Erdman**, and Elizabeth Jeffery, Abbott Nutrition, "Protection of Biomolecules by Dietary Nutrients and Exacerbation of Oxidative Stress by Impaired Nutrient Supply," 1/1/2015 – 3/15/2015, $23,775.

Stephen Boppart, CARLE/GSK, "Skin Residency Study of Topically Applied GSK2894512 Cream in Healthy Volunteers," 4/1/2015 – 10/31/2015, $93,461.

Zhi-Pei Liang, NIH, "Ultra-High Resolution 3D MR Spectroscopic Imaging," 7/1/2015 – 6/30/2017, $415,793.

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Andre, M. P.; Han, A. G.; Heba, E.; Hooker, J.; Loomba, R.; Sirlin, C. B.; **Erdman, J. W.**; **O'Brien, W. D.**, Accurate Diagnosis of Nonalcoholic Fatty Liver Disease in Human Participants via Quantitative Ultrasound. *2014 IEEE International Ultrasonics Symposium (IUS)* 2014 2375-2377, DOI:10.1109/Ultsym.2014.0592.

Bahramian, S.; **Insana, M. F.**, Retrieving High Spatial Frequency Information in Sonography for Improved Microcalcification Detection. *Medical Imaging 2014: Image Perception, Observer Performance, and Technology Assessment* 2014, *9037*, DOI:ARTN 90370w DOI:10.1117/12.2043955.

Baker, M. J.; Trevisan, J.; Bassan, P.; **Bhargava, R.**; Butler, H. J.; Dorling, K. M.; Fielden, P. R.; Fogarty, S. W.; Fullwood, N. J.; Heys, K. A.; Hughes, C.; Lasch, P.; Martin-Hirsch, P. L.; Obinaju, B.; Sockalingum, G. D.; Sule-Suso, J.; Strong, R. J.; Walsh, M. J.; Wood, B. R.; Gardner, P.; Martin, F. L., Using Fourier Transform IR Spectroscopy to Analyze Biological Materials. *Nature Protocols* 2014, *9,* (8), 1771-1791, DOI:10.1038/nprot.2014.110.

Ceballos, S.; Kandel, M.; Sridharan, S.; Monroy, F.; **Popescu, G.**, Nuclear Dynamics in Metastatic Cells Studied by Quantitative Phase Imaging. *Quantitative Phase Imaging* 2015, *9336*, DOI:ARTN 93361q DOI:10.1117/12.2183296.

Christodoulou, A. G.; Kellman, P.; **Liang, Z. P.**, Accelerating Cardiovascular Magnetic Resonance Imaging: Signal Processing Meets Nuclear Spins. *IEEE Signal Processing Magazine* 2014, *31,* (5), 138-143, DOI:10.1109/Msp.2014.2328503.

Coiado, O. C.; Buiochi, E. B.; **O'Brien, W. D.**, Ultrasound-Induced Heart Rate Decrease: Role of the Vagus Nerve. *IEEE Transactions on Ultrasonics Ferroelectrics and Frequency Control* 2015, *62,* (2), 329-336, DOI:10.1109/Tuffc.2014.006755.

Conrad, M. S.; **Sutton, B. P.**; **Dilger, R. N.**; Johnson, R. W., An *in vivo* Three-Dimensional Magnetic Resonance Imaging-Based Averaged Brain Collection of the Neonatal Piglet (Sus Scrofa). *PLOS One* 2014, *9,* (9), DOI:ARTN e107650 DOI:10.1371/journal.pone.0107650.

Deutsch, B.; Reddy, R.; Mayerich, D.; **Bhargava, R.**; **Carney, P. S.**, Compositional Prior Information in Computed Infrared Spectroscopic Imaging. *Journal of the Optical Society of America A-Optics Image Science and Vision* 2015, *32,* (6), 1126-1131, DOI:10.1364/Josaa.32.001126.

Deutsch, B.; Schnell, M.; Hillenbrand, R.; **Carney, P. S.**, Synthetic Optical Holography with Nonlinear-Phase Reference. *Optics Express* 2014, *22,* (22), 26621-26634.

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Fu, M. J.; Zhao, B.; Carignan, C.; **Shosted, R. K.**; Perry, J. L.; Kuehn, D. P.; **Liang, Z. P.**; **Sutton, B. P.**, High-Resolution Dynamic Speech Imaging with Joint Low-Rank and Sparsity Constraints. *Magnetic Resonance in Medicine* 2015, *73,* (5), 1820-1832, DOI:10.1002/Mrm.25302.

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Hubler, Z. M. L.; Shemonski, N. D.; Shelton, R. L.; Monroy, G. L.; Nolan, R. M.; **Boppart, S. A.**, Real-Time Automated Thickness Measurements of the *in vivo* Human Tympanic Membrane Using Optical Coherence Tomography. *Quantitative Imaging in Medicine and Surgery* 2015, *5,* 66-77.

Kaiser, R. H.; Andrews-Hanna, J. R.; Spielberg, J. M.; Warren, S. L.; **Sutton, B. P.**; **Miller, G. A.**; **Heller, W.**; Banich, M. T., Distracted and Down: Neural Mechanisms of Affective Interference in Subclinical Depression. *Social Cognitive and Affective Neuroscience* 2015, *10,* (5), 654-663, DOI:10.1093/Scan/Nsu100.

Kale, S.; Saharan, A.; Koric, S.; **Ostoja-Starzewski, M.**, Scaling and Bounds in Thermal Conductivity of Planar Gaussian Correlated Microstructures. *Journal of Applied Physics* 2015, *117,* 104301, DOI:10.1063/1.4914128.

Kim, J.; Ahmad, A.; Li, J.; Marjanovic, M.; Chaney, E. J.; **Suslick, K. S.**; **Boppart, S. A.**, Intravascular Magnetomotive Optical Coherence Tomography of Targeted Early-Stage Atherosclerotic Changes in *ex vivo* Hyperlipidemic Rabbit Aortas. *Journal of Biophotonics* 2015, DOI:10.1002/jbio.201400128.

Lee, M. K.; Rich, M. H.; Shkumatov, A.; Jeong, J. H.; **Boppart, M. D.**; **Bashir, R.**; **Gillette, M. U.**; Lee, J.; Kong, H., Glacier Moraine Formation-Mimicking Colloidal Particle Assembly in Microchanneled, Bioactive Hydrogel for Guided Vascular Network Construction. *Advanced Healthcare Materials* 2015, *4,* (2), 195-201, DOI:10.1002/adhm.201400153.

Li, J.; **Dobrucki, L. W.**; Marjanovic, M.; Chaney, E. J.; **Suslick, K. S.**; **Boppart, S. A.**, Enhancement and Wavelength-Shifted Emission of Cerenkov Luminescence Using Multifunctional Microspheres. *Physics in Medicine and Biology* 2015, *60,* (2), 727-739, DOI:10.1088/0031-9155/60/2/727.

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Majeed, H.; Kandel, M. E.; Han, K.; Luo, Z. L.; Macias, V.; Tangella, K.; Balla, A.; **Popescu, G.**, Diagnosis of Breast Cancer Biopsies Using Quantitative Phase Imaging. *Quantitative Phase Imaging* 2015, *9336*, DOI:ARTN 93361r DOI:10.1117/12.2080132.

Ostoja-Starzewski, M.; Malyarenko, A., Continuum Mechanics Beyond the Second Law of Thermodynamics. *Proceedings of the Royal Society A* 2014 47020140531, DOI:10.1098/rspa.2014.0531.

Perry, J. L.; **Sutton, B. P.**; Kuehn, D. P.; Gamage, J. K., Using MRI for Assessing Velopharyngeal Structures and Function. *Cleft Palate-Craniofacial Journal* 2014, *51,* (4), 476-485, DOI:10.1597/12-083.

Pincu, Y.; Linden, M. A.; Zou, K.; Baynard, T.; **Boppart, M. D.**, The Effects of High Fat Diet and Moderate Exercise on TGF beta 1 and Collagen Deposition in Mouse Skeletal Muscle. *Cytokine* 2015, *73,* (1), 23-29, DOI:10.1016/j.cyto.2015.01.013.

Popescu, G.; Park, K.; Mir, M.; **Bashir, R.**, New Technologies for Measuring Single Cell Mass. *Lab on a Chip* 2014, *14,* (4), 646-652, DOI:10.1039/C3lc51033f.

Rendeiro, C.; Masnik, A. M.; Mun, J. G.; Du, K.; Clark, D.; **Dilger, R. N.**; Dilger, A. C.; **Rhodes, J. S.**, Fructose Decreases Physical Activity and Increases Body Fat without Affecting Hippocampal Neurogenesis and Learning Relative to an Isocaloric Glucose Diet. *Scientific Reports* 2015, *5,* 9589.

Sannachi, L.; Tadayyon, H.; Sadeghi-Naini, A.; Tran, W.; Gandhi, S.; Wright, F.; **Oelze, M.**; Czarnota, G., Non-Invasive Evaluation of Breast Cancer Response to Chemotherapy Using Quantitative Ultrasonic Backscatter Parameters. *Medical Image Analysis* 2015, *20,* (1), 224-236, DOI:10.1016/j.media.2014.11.009.

Shemonski, N. D.; Adie, S. G.; South, F.; Liu, Y. Z.; **Carney, P. S.**; **Boppart, S. A.**, Computational High-Resolution Optical Imaging of the Living Human Retina. *Nature Photonics* 2015, *9,* 440-443, DOI:10.1038/nphoton.2015.102.

Tiwari, S.; Reddy, V. B.; **Bhargava, R.**; Raman, J., Computational Chemical Imaging for Cardiovascular Pathology: Chemical Microscopic Imaging Accurately Determines Cardiac Transplant Rejection. *PLOS One* 2015, *10,* (5), DOI:ARTN e0125183 DOI:10.1371/journal.pone.0125183.

Van Blarigan, E. L.; Ma, J.; Kenfield, S. A.; Stampfer, M. J.; Sesso, H. D.; Giovannucci, E. L.; Witte, J. S.; **Erdman, J. W.**; Chan, J. M.; Penney, K. L., Plasma Antioxidants, Genetic Variation in SOD2, CAT, GPX1, GPX4, and Prostate Cancer Survival. *Cancer Epidemiology Biomarkers & Prevention* 2014, *23,* (6), 1037-1046, DOI:10.1158/1055-9965.Epi-13-0670.

Xia, J.; **Wang, M. Y.**, Particle Filtering with Sequential Parameter Learning for Nonlinear Bold fMRI Signals. *Advances and Applications in Statistics* 2014, *40,* (1), 61-74.

M&ENS SELECTED FACULTY AWARDS, PATENTS, GRANTS, AND PUBLICATIONS

Covering July 1, 2014-June 30, 2015

Faculty
(name followed by home department)

3D Micro- and Nanosystems
Rashid Bashir, *Bioengineering*
Paul V. Braun, *Materials Science and Engineering*
Aditi Das, *Comparative Biosciences*
Bruce Fouke, *Geology*
Steve Granick, *Materials Science and Engineering*
Iwona M. Jasiuk, *Mechanical Science and Engineering*
Paul J. Kenis, *Chemical and Biomolecular Engineering*
William P. King, *Mechanical Science and Engineering*
Deborah E. Leckband, *Chemical and Biomolecular Engineering*
Yi Lu, *Chemistry*
John A. Rogers, *Materials Science and Engineering*
Stephen G. Sligar, *Biochemistry*

Autonomous Materials Systems
Ioannis Chasiotis, *Aerospace Engineering*
Philippe H. Geubelle, *Aerospace Engineering*
Jennifer A. Lewis, *Materials Science and Engineering*
Jeffrey S. Moore, *Chemistry*
Nancy R. Sottos, *Materials Science and Engineering*
Scott R. White, *Aerospace Engineering*
Yang Zhang, *Nuclear, Plasma, and Radiological Engineering*

Computational Multiscale Nanosystems
Narayana R. Aluru, *Mechanical Science and Engineering*
Andreas C. Cangellaris, *Electrical and Computer Engineering*
John G. Georgiadis, *Mechanical Science and Engineering*
Eric Jakobsson, *Molecular and Integrative Physiology*
Harley T. Johnson, *Mechanical Science and Engineering*
Olgica Milenkovic, *Electrical and Computer Engineering*
Christopher V. Rao, *Chemical and Biomolecular Engineering*
Umberto Ravaioli, *Electrical and Computer Engineering*
Surya Pratap Vanka, *Mechanical Science and Engineering*

Nanoelectronics and Nanomaterials
Ilesanmi Adesida, *Electrical and Computer Engineering*
Aleksei Aksimentiev, *Physics*
Jean Paul Allain, *Nuclear, Plasma, and Radiological Engineering*
Alexey Bezryadin, *Physics*
Brian T. Cunningham, *Electrical and Computer Engineering*
Matthew J. Gilbert, *Electrical and Computer Engineering*
Gregory S. Girolami, *Chemistry*
Martin H. Gruebele, *Chemistry*
Prashant Jain, *Chemistry*
Jean-Pierre Leburton, *Electrical and Computer Engineering*
Xiuling Li, *Electrical and Computer Engineering*
Joseph W. Lyding, *Electrical and Computer Engineering*
Nancy Makri, *Chemistry*
Catherine Murphy, *Chemistry*
Margery Osborne, *Curriculum and Instruction*
Angus Rockett, *Materials Science and Engineering*
Moonsub Shim, *Materials Science and Engineering*

Theoretical and Computational Biophysics
Laxmikant V. Kale, *Computer Science*
Zaida A. Luthey-Schulten, *Chemistry*
Klaus J. Schulten, *Physics*
John D. Stack, *Physics*
Emadeddin Tajkhorshid, *Pharmacology*

SELECTED HONORS AND AWARDS

Aleksei Aksimentiev
Fellow, National Center for Supercomputing Applications (NCSA), 2015-2016

Narayana Aluru
Fellow, National Center for Supercomputing Applications (NCSA), 2014

Rashid Bashir
Fellow of the International Academy of Medical and Biological Engineering (IAMBE), 2015

Prashant Jain
Beckman Young Investigator Award, 2014

Iwona Jasiuk
Fellow, National Center for Supercomputing Applications (NCSA), 2014

Jean-Pierre Leburton
Fellow of the Center for Advanced Studies (CAS) at Illinois, 2015

Deborah Leckband
Fellow, Biomedical Engineering Society (BMES), 2015

Joseph Lyding
AAAS Fellow, 2014
Award for Outstanding Research from the Prairie Chapter of the American Vacuum Society, 2014

Emad Tajkhorshid
Innovative and Novel Computational Impact on Theory and Experiment Award, 2015

Scott White
American Society for Composites (ASC) Outstanding Research Award, 2014

INVENTION DISCLOSURES

Faculty members from the Molecular and Electronic Nanostructures (M&ENS) research theme were inventors on six invention disclosures (3% of the 202 invention disclosures filed by campus) during FY2015.

SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the M&ENS research theme were inventors on 11 of the following patent applications (5.8% of the 191 patent applications filed by campus) and five patents issued (6.6% of the 76 patents issued to campus) during FY2015.

Joseph Lyding and Scott Schmucker, "Method for the Nanometer-Scale Sharpening of a Metallic Probe," patent issued August 26, 2014, patent number 8,819,861.

Jeffrey Moore, **Scott White**, **Nancy Sottos**, Susan Odom, Mary Caruso, Aaron Finke, and Aaron Jackson, "System for Visual Indication of Mechanical Damage," patent issued September 30, 2014, patent number 8,846,404.

Kathleen Toohey, **Nancy Sottos**, **Jennifer Lewis**, **Jeffrey Moore**, and **Scott White**, "Self-Healing Materials with Microfluidic Networks," patent issued December 30, 2014, patent number 8,920,879.

Scott White, **Jeffrey Moore**, **Nancy Sottos**, Benjamin Blaiszik, Mary Caruso, and Christian Mangun, "Thermally Robust Capsule System, and Composites Including the Capsules," patent issued February 10, 2015, patent number 8,951,639.

Jennifer Lewis, Jennifer Shepherd, Pierre Wiltzius, Ralph Nuzzo, Robert Barry, Robert Shepherd, and Sara Parker, "Viscoelastic Ink for Direct Writing of Hydrogel Structures," patent issued June 2, 2015, patent number 9,045,657.

Hailong Ning, Kevin Arpin, and **Paul Braun**, "Method of Fabricating a Three-Dimensional (3D) Porous Electrode Architecture for a Microbattery," patent filed July 1, 2014, application number 14/321/077.

Chunjie Zhang, Gerry Cano, and **Paul Braun**, "Volume Response Sensors Having Analyte Controlled Reversible Crosslinking," patent filed September 29, 2014, application number PCT/US2014/05807.

Nancy Sottos, Piyush Thakre, and **Scott White**, "Branched Interconnected Microvascular Network in Polymers and Composites using Sacrificial Polylactide Films, Sheets and Plates," patent filed November 7, 2014, application number 14/536,077.

Brett Knull, Jason Patrick, **Jeffrey Moore**, **Nancy Sottos**, and **Scott White**, "Advanced Thermal Processing Techniques of Sacrificial Polylactic Acid," patent filed November 13, 2014, application number 14/540,324.

Beckman faculty names are in bold-face type.

M&ENS SELECTED FACULTY AWARDS, PATENTS, GRANTS, AND PUBLICATIONS

Jeffrey Moore, Joaquin Rodriguez-Lopez, Kevin Cheng, Mei Shen, Nagarjuna Gawalapalli, and Timothy Lichtenstein, "Redox Active Polymers and Colloidal Particles for Flow Batteries," patent filed January 16, 2015, application number 62/104,329.

Aaron Esser-Kahn, Ashley Trimmell, Hefei Dong, Jason Patrick, **Jeffrey Moore**, **Nancy Sottos**, Piyush Thakre, and **Scott White**, "Thermally Degradable Polymeric Fibers," patent filed January 27, 2015, application number 14/606,533.

Brett Krull, Jason Patrick, **Jeffrey Moore**, Kevin Hart, **Nancy Sottos**, and **Scott White**, "Method of Making a Self-Healing Composite System," patent filed January 28, 2015, application number 14/607,759.

Brett Krull, **Jeffrey Moore**, **Nancy Sottos**, Ryan Gergely, **Scott White**, and Windy Santa Cruz, "Multiple Stage Curable Polymer with Controlled Transitions," patent filed February 19, 2015, application number 14/626,327.

Jean-Pierre Leburton, "Tunable Graphene Quantum Point Contact Transistor for DNA Detection and Characterization," patent filed March 2, 2015, application number 62/126,785.

Chaenyung Cha, Hyun Joon Kong, Jae Hyun Jeong, Pinar Zorlutuna, **Rashid Bashir**, and Vincent Chan, "Microvascular Stamp for Patterning of Functional Neovessels," patent filed May 12, 2015, application number 14/709,726.

Marta Baginska, **Nancy Sottos**, **Scott White**, and Sen Kang, "Environmentally Stable Core-Shell Microcapsules with Polymeric Protective Coatings," patent filed May 26, 2015, application number 62/166,575.

GRANTS AWARDED

($3,461,207)

Jean-Pierre Leburton, **Aleksei Aksimentiev**, and **Rashid Bashir**, Oxford Nanopore Technologies, "Multi-Layer Solid State Membranes with Nanochannels for Bio-Molecule Manipulation and Sensing," 6/22/2015 – 6/21/2016, $267,254.

Klaus Schulten, James Phillips, and John Stone, NSF, "The Computational Microscope," 9/1/2014 – 8/31/2017, $40,000.

Umberto Ravaioli, **Catherine Murphy**, Ting Lu, **Oleksii Aksimentiev**, **Rashid Bashir**, **Klaus Schulten**, **Emad Tajkhorshid**, and **Jian Ma**, NSF, "Network for Computational Nanotechnology-NanoBIO Node," 9/1/2014 – 8/31/2015, $143,154.

Nancy Sottos and **Scott White**, Bridgestone, "Self-Healing Materials for Automobile Tires: Phase I Capsule Survival and Self-Healing Materials for Automobile Tires: Phase II Encapsulation of Antizonants and More," 9/1/2014 – 8/31/2015, $140,000.

Scott White, NIH, "Encapsulation and Delivery of Bioactive Compounds for Dentin Biomodification," 9/1/2014 – 8/31/2016, $242,708.

Nancy Sottos and **Scott White**, AFOSR, "Multifunctional Damage Tolerant Composite Materials," 4/1/2014 – 3/31/2017, $501,178.

Klaus Schulten, DOE, "Photosynthetic Antenna Research Center," 8/1/2014 – 7/31/2015, $400,000.

Scott White, **Nancy Sottos**, and **Jeffrey Moore**, AFOSR, "Regeneration of Structural Materials in Adaptive Response to External Stimuli," 5/1/2015 – 4/30/2019, $781,069.

Paul Braun, DTRA, "Surface Directed Molecular Transport, Separation, and Concentration," 3/12/2015 – 7/15/2015, $29,969.

Jeffrey Moore, DARPA, "Metastable Polymers for On-Demand Transient Electronic Packaging," 1/1/2015 – 12/30-2015, $442,350.

Klaus Schulten, NSF, "RAPID: Development of Rapid In-Field Ebola Infection Screening Guided by Biomolecular Simulation and Collaborative Remote Visualization," 7/1/2015 – 6/30/2016, $200,000.

Jean-Pierre Leburton, **Aleksei Aksimentiev**, and **Rashid Bashir**, Oxford Nanopore Technologies, "Multi-Layer Solid State Membranes with Nanochannels for Bio-Molecule Manipulation and Sensing," 6/22/2014 – 6/21/2015, $273,525.

SELECTED PUBLICATIONS

Ahn, Y. O.; Mahinthichaichan, P.; Lee, H. J.; Ouyang, H. L.; Kaluka, D.; Yeh, S. R.; Arjona, D.; Rousseau, D. L.; **Tajkhorshid, E.**; Adelroth, P.; Gennis, R. B., Conformational Coupling between the Active Site and Residues within the K-C-Channel of the Vibrio Cholerae cbb(3)-Type (C-Family) Oxygen Reductase. *Proceedings of the National Academy of Sciences of the United States of America* 2014, *111,* (42), E4419-E4428, DOI:10.1073/pnas.1411676111.

Baginska, M.; Kaitz, J. A.; Jones, A. R.; Long, B. R.; Gewirth, A. A.; **Sottos, N. R.**; **Moore, J. S.**; **White, S. R.**, Electropolymerization of Microencapsulated 3-Hexylthiophene for Lithium-Ion Battery Applications. *Journal of the Electrochemical Society* 2015, *162,* (3), A373-A377, DOI:10.1149/2.0451503jes.

Barry, A. K.; **Wang, N.**; **Leckband, D. E.**, Local VE-cadherin Mechanotransduction Triggers Long-Ranged Remodeling of Endothelial Monolayers. *Journal of Cell Science* 2015, *128,* (7), 1341-1351, DOI:10.1242/Jcs.159954.

Braun, P. V.; Nuzzo, R. G., Batteries: Knowing When Small Is Better. *Nature Nanotechnology* 2014, *9,* 962-963, DOI:10.1038/nnano.2014.263.

Celestine, A.-D. N.; **Sottos, N. R.**; **White, S. R.**, Autonomic Healing of PMMA via Microencapsulated Solvent. *Polymer* 2015, *69,* 241-248.

Diesendruck, C. E.; Peterson, G. I.; Kulik, H. J.; Kaitz, J. A.; Mar, B. D.; May, P. A.; **White, S. R.**; Martinez, T. J.; Boydston, A. J.; **Moore, J. S.**, Mechanically Triggered Heterolytic Unzipping of a Low-Ceiling-Temperature Polymer. *Nature Chemistry* 2014, *6,* (7), 624-629, DOI:10.1038/Nchem.1938.

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Escobar, D. J.; Desai, R.; Ishiyama, N.; Folmsbee, S. S.; Novak, M. N.; Flozak, A. S.; Daugherty, R. L.; Mo, R. G.; Nanavati, D.; Sarpal, R.; **Leckband, D.**; Ikura, M.; Tepass, U.; Gottardi, C. J., Alpha-Catenin Phosphorylation Promotes Intercellular Adhesion through a Dual-Kinase Mechanism. *Journal of Cell Science* 2015, *128,* (6), 1150-1165, DOI:10.1242/Jcs.163824.

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Gergely, R. C. R.; Pety, S. J.; Krull, B. P.; Patrick, J. F.; Doan, T. Q.; Coppola, A. M.; Thakre, P. R.; **Sottos, N. R.**; **Moore, J. S.**; **White, S. R.**, Multidimensional Vascularized Polymers Using Degradable Sacrificial Templates. *Advanced Functional Materials* 2015, *25,* (7), 1043-1052, DOI:10.1002/adfm.201403670.

Girdhar, A.; Sathe, C.; **Schulten, K.**; **Leburton, J. P.**, Tunable Graphene Quantum Point Contact Transistor for DNA Detection and Characterization. *Nanotechnology* 2015, *26,* (13), DOI:ARTN 134005 DOI:10.1088/0957-4484/26/13/134005.

Gonzalez, J.; Sun, K.; Huang, M.; Dillon, S.; **Chasiotis, I.**; Lambros, J., X-Ray Microtomography Characterization of Sn Particle Evolution During Lithiation/Delithiation in Lithium Ion Batteries. *Journal of Power Sources* 2015, *285,* 205-209.

Grady, M. E.; **Geubelle, P. H.**; **Braun, P. V.**; **Sottos, N. R.**, Molecular Tailoring of Interfacial Failure. *Langmuir* 2014, *30,* (37), 11096-11102, DOI:10.1021/La502271k.

Jeong, J. W.; Shin, G.; Il Park, S.; Yu, K. J.; Xu, L. Z.; **Rogers, J. A.**, Soft Materials in Neuroengineering for Hard Problems in Neuroscience. *Neuron* 2015, *86,* (1), 175-186, DOI:10.1016/j.neuron.2014.12.035.

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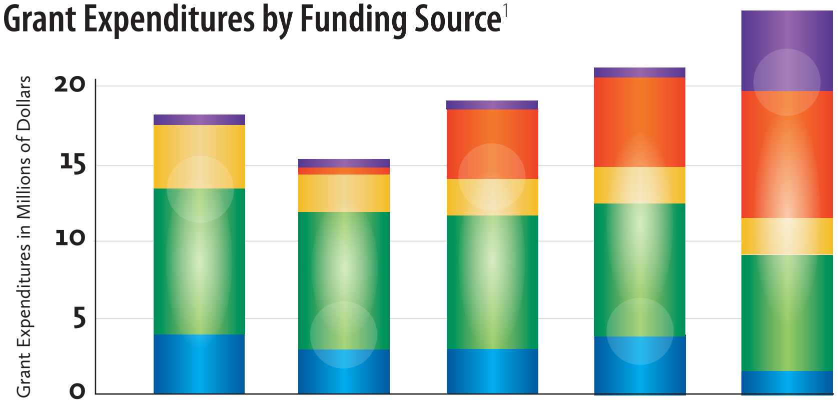
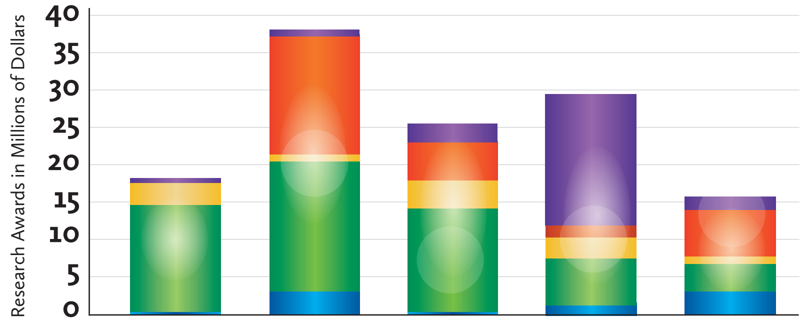
BECKMAN INSTITUTE FUNDING 2014-2015

Grant Expenditures by Funding Source[1]



	FY11	FY12	FY13	FY14	FY15
DOD	$3,869,004	$3,200,338	$3,426,205	$2,328,861	$1,490,392
NIH	$9,705,827	$8,665,427	$8,208,039	$8,718,725	$7,486,994
NSF	$4,050,734	$2,482,559	$2,565,483	$2,398,696	$2,794,666
Abbott[2]	$-	$484,248	$4,183,296	$6,249,854	$7,990,755
Other	$770,525	$575,790	$690,399	$2,839,996	$5,190,458
Total	$18,396,090	$15,408,362	$19,073,422	$22,536,132	$24,953,265

Research Awards by Funding Source[3]



	FY11	FY12	FY13	FY14	FY15
DOD	$3,001	$3,107,121	$2,317	$1,617,249	$2,909,566
NIH	$13,879,105	$17,245,588	$14,121,116	$5,798,307	$3,442,188
NSF	$2,578,574	$876,173	$3,507,298	$3,012,333	$983,154
Abbott[2]	$-	$15,246,982	$5,272,426	$2,381,765	$6,201,220
Other	$894,094	$757,369	$2,324,885	$16,870,368	$1,632,833
Total	$17,354,774	$37,233,233	$25,228,042	$29,680,022	$15,168,961

[1] In addition to those sources itemized in the chart, funding for the Beckman Institute is received from the following sources:
a) The state of Illinois to the University of Illinois and allocated through individual departments: Faculty Salaries
b) The state of Illinois to the Beckman Institute: Administration and Operating Expenses
c) The Arnold and Mabel Beckman Foundation: Beckman Institute Fellows Program, Beckman Institute Graduate Fellows Program, Beckman Institute Equipment Competition, Seed Proposals, and Sponsorships (e.g., symposia, lectures, etc.)

[2] Funding from Abbott Nutrition supports the Center for Nutrition, Learning, and Memory. This is made possible by a partnership between the University of Illinois and Abbott Nutrition. This center includes participation by the Carl R. Woese Institute for Genomic Biology, and departments from the College of Agriculture, Consumer, and Environmental Sciences, the College of Applied Health Sciences, the College of Liberal Arts and Sciences, and the College of Veterinary Medicine.

[3] The Beckman Institute primarily possesses interdisciplinary research grants that have multiple faculty from multiple departments. Total funding for multi-year awards is reported in the fiscal year of the award notice. The numbers reflected on this page include all Beckman awards, including those awarded to faculty, staff, and others.

DOD Department of Defense
NIH National Institutes of Health
NSF National Science Foundation
Abbott Abbott Nutrition

STRATEGIC INITIATIVES

In addition to its major research themes and groups, the Beckman Institute supports the development of emerging strategic initiatives.

Imaging at Illinois

The University of Illinois has a long and rich history of significant achievements in imaging, from the early developments of ultrasound imaging and its bioeffects, to the development of magnetic resonance imaging by the late Paul Lauterbur, who received the Nobel Prize in Medicine in 2003 for his work in establishing this technique. With computational strengths at the National Center for Supercomputing Applications (NCSA) and more than 100 faculty members across many departments, colleges, and institutes, Illinois has made significant contributions in imaging. Imaging and the visualization of images are pervasive elements in our data-rich lives, and Imaging at Illinois, a campus-wide initiative located at the Beckman Institute, has built a collaborative, integrated community of faculty, researchers, and students in imaging science, imaging technology, and the application, use, and interpretation of images.

Resources supporting these efforts include, among others, Beckman's core facilities—the Biomedical Imaging Center, the Illinois Simulator Laboratory, and the Imaging Technology Group—and NCSA.

Imaging at Illinois is led by Integrative Imaging research theme co-chair **Stephen Boppart.**

HABITS **(Health: Attitude, Biology, Information, Technology, Society)**

The Health: Attitudes, Biology, Information, Technology, Society (HABITS) strategic initiative is focused on a topic that has increasing importance as the population ages: health across the lifespan. HABITS capitalizes on the Beckman Institute's extensive expertise in the life sciences, the social and behavioral sciences, and engineering.

Research in HABITS is focused around four themes:

- **Cancer** seeks to take advantage of the world-renowned strength in technology and imaging science at Beckman toward advancing research involving topics like development of biomarkers for disease, and development of computational models.
- **Promoting Successful Aging** includes research into how interventions such as exercise programs and intellectual engagement, or advancing technologies like cochlear implants, may enhance successful aging.
- **Neural Systems: Repair, Replacement, and Augmentation** combines neuroscience and technology toward exploring ways to restore or improve functionality of the nervous system.
- Challenge-inspired education at the interface of biomedical problems and technology seeks to develop innovative new ways to educate the next generation of researchers.

HABITS is led by Beckman faculty member **Rohit Bhargava**.

Social Dimensions of Environmental Policy

The Social Dimensions of Environmental Policy (SDEP) strategic initiative aims to understand the social and political-economic forces shaping just and sustainable environmental policy, while seeking to improve management of earth's environment through research on social and policy dimensions of sustainability. Programs in this initiative integrate natural and social science research on society's responses to climate change and the role of rights and representation in making and implementing sustainable environmental policy.

SDEP houses two research programs:

- **The Program on Democracy and Environmental Policy** conducts research on the establishment, operation, and effect of democratic processes in decisions over the management and use of natural resources. This year the Responsive Forest Governance Initiative (RFGI) project of the Program on Democracy and Environmental Policy published 17 working papers. The 34 researchers, three postdocs, and three directors of RFGI have completed all field research and are currently finalizing a handbook to guide practitioners in the implementation of pro-democracy forestry programs and a synthesis report.
- **The Program on Climate and Society** investigates the social causes and effects of global environmental change and related risks.

SDEP is directed by Beckman faculty member **Jesse Ribot.** In 2015, SDEP is transitioning to a new home in the School of Earth, Society, and Environment.

Illinois Language and Literacy Initiative

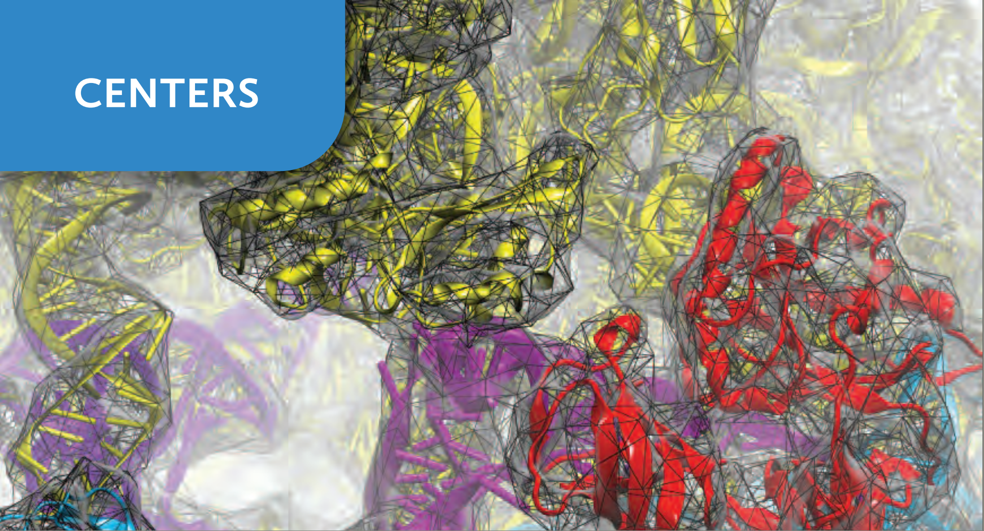
Illinois Language and Literacy Initiative (ILLI) is a strategic initiative to build a campus-wide community of faculty, researchers, and students to collaborate and share resources with regard to language and literacy.

ILLI allows researchers to collaborate in a unique space, through the sharing of ideas and technological breakthroughs. At the Beckman Institute, ILLI researchers interested in language from biological and psychological perspectives collaborate with researchers from Illinois' top-ranked engineering programs to build not only new knowledge, but new tools and applications.

Studies in ILLI involve:

- Research aimed at uncovering the subprocesses involved in both language comprehension and production.
- Studies on language in all its modalities (reading, listening, speaking, signing) and across the full richness of contexts, from reading single words, to conversing with others, to integrating language with other information sources in a classroom or on the internet.
- Work across the lifespan, including the development of concepts and early language skills in (even preterm) infants and children, through changes in language processing in healthy older adults and those with cognitive impairments.
- Investigations of native and second language users, across an impressive sample of the world's languages.
- Work on literacy development, including young and middle-aged adults who are developing literacy skills in their native language.

ILLI is led by Beckman faculty members **Jennifer Cole** and **Kara Federmeier**.



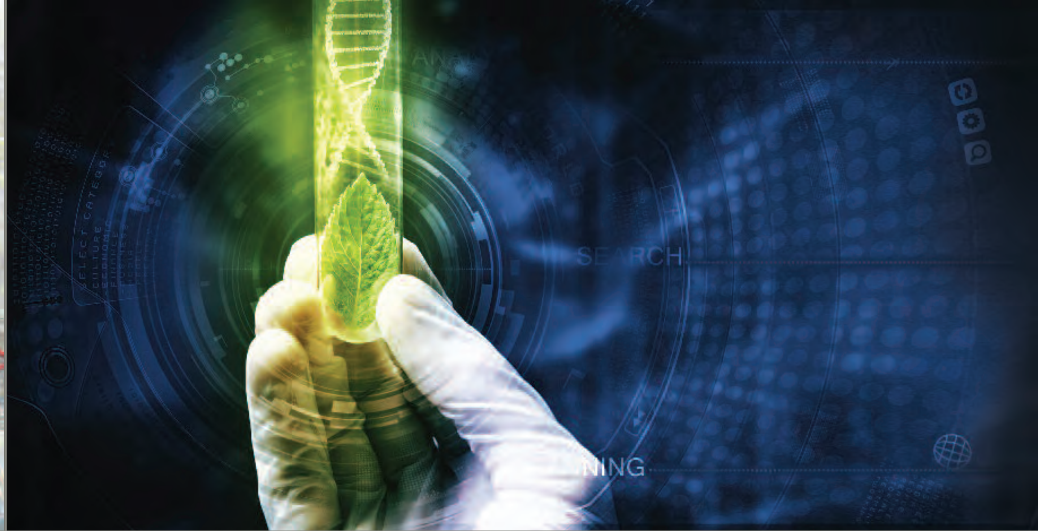
NIH Center for Macromolecular Modeling and Bioinformatics

Klaus Schulten, head of the Theoretical and Computational Biophysics Group (TCBG), is the principal investigator of the NIH Center for Macromolecular Modeling and Bioinformatics, which develops computational tools for biomedical research in molecular cell biology and pharmacology.

A particular emphasis of the center is to base its development on its own intense research program in biomedicine, thereby evolving its computational tools along with the frontiers of the field. The center engages in collaborations with leading experimental laboratories and carries out a highly popular training program in computational biology both through frequent face-to-face training workshops as well as through widespread online distribution of training material.

The center's software is widely used in the biomedical community, and every year increases its user base and sees many thousands of downloads for each new release. Biomedical scientists from the bench to the world's most advanced computer centers utilize the center's software every day, while high school, college, and graduate students utilize training and visualization material provided on the web site to discover for themselves the miracles of living cells.

The center's key strength is a combination of research and development. On the research side, the center is presently engaged in biomedical research on several fronts: fighting viral infections by resolving the infection process of HIV and other viruses in unprecedented detail; unraveling the formation of protein fibrils associated with Alzheimer's disease; furnishing 4th generation DNA sequencing for personalized medicine; and fighting cancer by understanding how chemotherapy drugs act on the cell's cytoskeleton. The center is also engaged in groundbreaking research at the main frontiers of cell biology, from resolving the folding process of proteins in atomistic detail, to describing how signals propagate in the sensory arrays that comprise the bacterial "brain," to seeing the action of the ribosome (an important target for new antibiotics) in chemical detail.



Center for Nutrition, Learning, and Memory

Through scientific discovery and targeted research, the Center for Nutrition, Learning, and Memory (CNLM) drives the understanding of nutrition's impact on cognition. The center is the first interdisciplinary cognition and nutrition research center in the country.

The Center for Nutrition, Learning, and Memory partners with two world-renowned Urbana campus research facilities, the Beckman Institute for Advanced Science and Technology and the Carl R. Woese Institute for Genomic Biology, in collaboration with the Division of Nutritional Sciences and the Neuroscience Program.

The research at the CNLM is led by faculty at Illinois in partnership with the leading scientists in cognition, brain function, and supporting technologies from all over the world. The center hosts an annual research competition to support pioneering, multidisciplinary research, enabling teams of investigators to apply new technologies and thinking from across a wide range of disciplines to take nutrition and cognition research to a new level.

The Center for Nutrition, Learning, and Memory announced its Round 4 awards on July 2, 2015. Projects began in August 2015. The project titles are:

- Longitudinally Dynamic Biomarkers of Healthy Brain Aging in the Illinois Elderly Adult Cohort;
- Optimizing Assessment Tools for Determining Nutritional Enhancement of Learning and Memory;
- Impact of Select Nutrients on Eye and Brain Health;
- Diet-Modified Neuron Physiology Assessments;
- A Short-Term Longitudinal Study of Pre-Term Infant Neurodevelopment;
- Brain and Cognitive Development in Small-for-Gestational Age Piglets;
- Retrospectively Studying the Effects of Early Life Nutrient Intake on Cognitive Function and Brain Health in Preadolescent Children;
- Enhanced Morphological Measurement Capabilities for Selected CNLM Projects;
- Mouse Cognition and Hippocampal Neurogenesis Core Facility; and

Illinois Children's Environmental Health and Disease Prevention Research Center

- Understanding the Effects of Nutritional Supplements on Function and Development of Human Neuronal Cells.

All principal investigators have their primary appointments at the University of Illinois at Urbana-Champaign. The project teams include a diverse group of more than 86 faculty members, postdoctoral students, research assistants, and graduate students from more than 15 University of Illinois departments or units, including six colleges, and collaborators from 15 national and international institutions.

Grants are from one to three years and are administered by the Beckman Institute, with ICR earnings to be distributed to colleges and departments that provide research facilities and administrative support of the awarded projects. The co-directors of the CNLM are **Neal Cohen** (Illinois) and Keith Garleb (Abbott Nutrition). Cohen is a Beckman Institute faculty member, a professor in the Department of Psychology, and the director of the Interdisciplinary Health Sciences Initiative.

In 2013 the Illinois Children's Environmental Health Research Center was established at the Beckman Institute. The U.S. Environmental Protection Agency and the National Institute of Environmental Health Sciences jointly awarded $8 million for Illinois to continue building the evidence base on the effects of chemicals in consumer products on the long-term mental and physical health of children. Some of these funds go toward communicating the science to the public, to policymakers, and to institutions that care for children—public health, child care, and medical care. Central questions for translating the research are: how can families reasonably adapt to new knowledge about risks from items they use routinely? And how can national and state policies, approvals, and regulations adapt to protect the health of children?

Led by **Susan Schantz**, from the NeuroTech Group, the center, one of 14 such centers across the United States, aims to increase our understanding of the causes and effects of risks from chemicals in consumer products, primarily bisphenol A (BPA) and phthalates, through the following projects.

1) In partnership with Carle Physician Group, Carle Foundation Hospital, Christie Clinic, and Presence Covenant Hospital, a large prospective birth cohort study, composed of 600 pregnant women in east central Illinois, will follow children through childhood from the time of their mothers' pregnancies. The study tracks the exposure of the women to chemicals over the course of their pregnancies and the development of their children from birth to learn whether higher maternal exposure to the chemicals is associated with adverse physical or neurodevelopmental outcomes in the children.

2) In a long-standing study of 800 adolescents who were part of a similar birth cohort, the Illinois Center is measuring these children's exposures at ages 13 to 17 to the chemicals, in order to relate these adolescents' neurodevelopmental health to these exposures. Susan Korrick, assistant professor in the Department of Environmental Health at Harvard University, is leading this research, one of the first studies to measure the health effects of chemical exposures on children during the rapid development of adolescence.

3) Research with laboratory animals is assessing both reproductive development and function and neurodevelopment and function relative to the animals' exposure to the same chemicals. Inflammation and oxidative stress, two intermediate mechanisms, are also a focus. This laboratory research will help to define the biological mechanisms underlying the health effects in exposed children. These projects are led by Jodi Flaws, professor of comparative biosciences at Illinois, and Janice Juraska, professor of psychology and Beckman affiliate faculty member in the NeuroTech Group.

4) Both the human and animal studies will assess whether obesity—either maternal obesity in the case of prenatal exposures or child obesity in the case of adolescent exposures—interacts with chemical exposure to increase health risks for the child.

5) A research translation program, led by Barbara Fiese, a professor in human development and family studies at Illinois, aims to build a public conversation about the scientific consensus around chemicals found in everyday consumer products that may influence child health. The Community Outreach and Translation Core, with its Community Advisory Board, is beginning a dialogue with the child care and public health sectors of Illinois, and with families, about the impact of exposures to these chemicals on child health, to identify alternatives for avoiding the top sources of risk.

BIOMEDICAL IMAGING CENTER

The Biomedical Imaging Center (BIC) is a core facility dedicated to supporting imaging research and developing new techniques across a variety of imaging modalities including optical, molecular, ultrasound, and magnetic resonance imaging.

The center traces its heritage to the Biomedical Magnetic Resonance Laboratory founded in 1985 by Paul Lauterbur, 2003 winner of the Nobel Prize in Medicine for discoveries in magnetic resonance, which led to the development of modern magnetic resonance imaging (MRI).

The Magnetic Resonance Imaging Laboratory (MRIL) houses a Varian 600 MHz small-bore scanner, as well as two 3 Tesla Trio full-body MRI scanners, which are dedicated to pursue imaging studies in both human and animals. The MRIL has added a neuroimaging cluster data analysis lab, as well as a neuropsych assessment lab. MRIL has substantively expanded clinical collaborations recently.

Aaron Johnson, assistant professor in the Department of Speech and Hearing Science and member of the Bioimaging Science and Technology Group at Beckman, utilized the 3 T scanners to examine the neuromuscular system, particularly how it and the larynx change and atrophy as we age.

The fast, dynamic imaging technology was developed as part of a research collaboration between Zhi-Pei Liang, electrical and computer engineering professor and member of the Bioimaging Science and Technology Group, and Brad Sutton, technical director of BIC and associate professor in bioengineering at Illinois. The researchers designed a special acquisition method that gathered the necessary data for both space and time in two optimized parts of the acquisition, and combined them to achieve high-quality, high-spatial resolution and high-speed imaging.

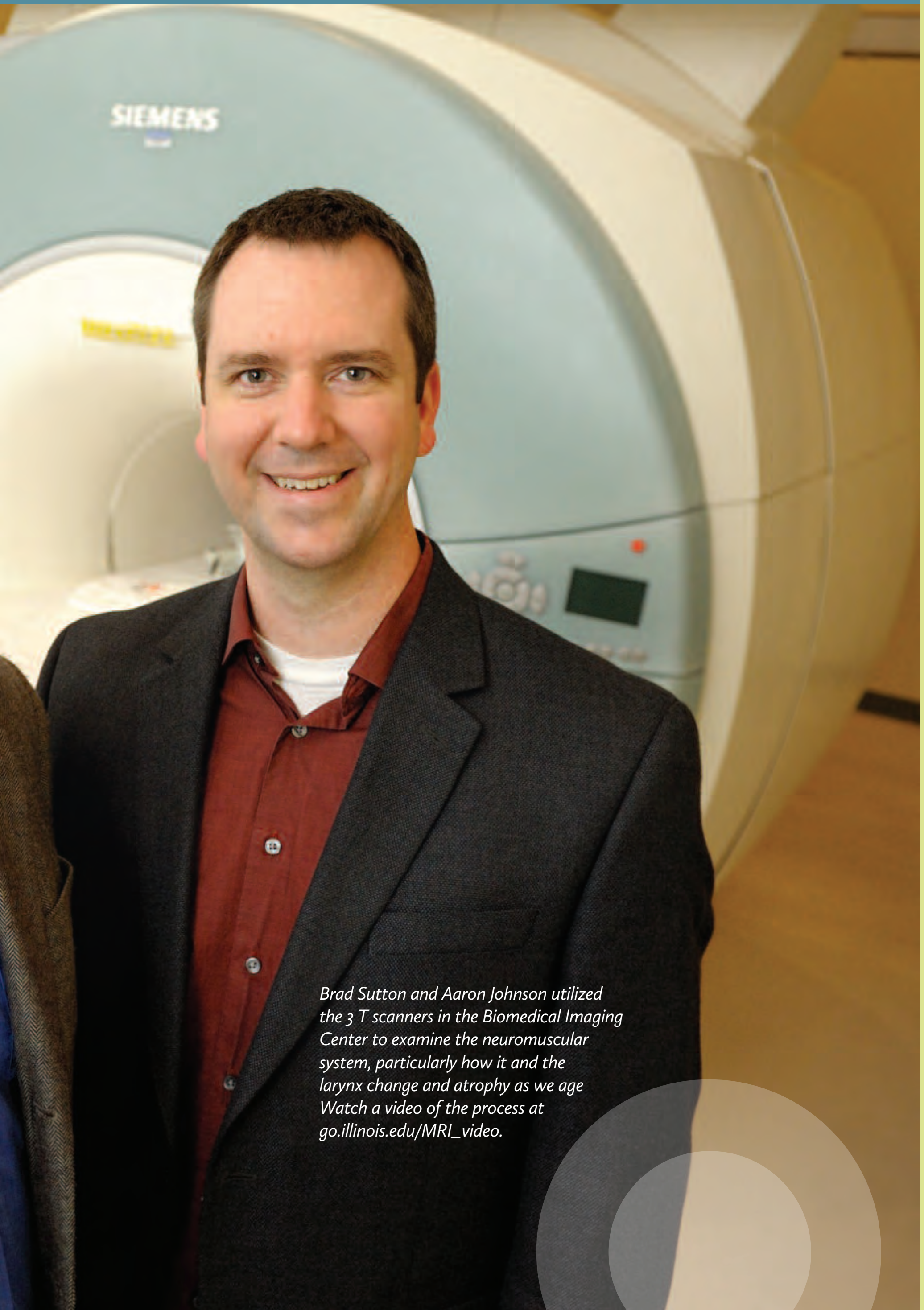
This new technique enabled Johnson to view dynamic images of people speaking in the MRI scanner at 100 frames per second—far more advanced than any other MRI technique in the world. The faster imaging speed is especially useful in studying how rapidly the tongue is moving, along with other muscles in the head and neck used during speech, singing, or swallowing.

The Molecular Imaging Laboratory (MIL) is home to a microPET/SPECT/CT system used in dynamic molecular imaging studies. One project, "Molecular Imaging of Stem Cells Induced Reversal of Vascular Complications in Diabetes," has integrated the expertise from many members of Beckman's Bioimaging Science and Technology Group. Wawrzyniec Dobrucki, assistant professor in bioengineering, worked along with Marni Boppart, associate professor in kinesiology and community health, Andrew Smith, assistant professor in bioengineering, and Iwona Dobrucka, senior research scientist and director of the MIL, to examine how tissue-derived mesenchymal stem cells (MSCs) can be used as a novel regenerative therapy to repair and reverse diabetic vascular complications.

Peripheral arterial disease (PAD) is a circulatory problem in which narrowed arteries result in a lack of blood flow to limbs. It is common and severe among patients with diabetes mellitus (DM). Traditional treatment of PAD has centered on smoking cessation, physical exercise, and drug treatment to increase the dilation of blood vessels. Current therapies rely on mechanical revascularization through either needle punctures to the skin or surgical approaches. Recently, the field of regenerative medicine has moved toward the use of cell-based approaches including use of tissue-derived MSCs. Initial clinical trials demonstrated safety and bioactivity of stem cells injected intramuscularly into the limbs that are not receiving enough blood in patients with PAD.

The principal goal of the project is to assess the potency of muscle-derived MSCs as a regenerative therapy to repair and reverse diabetic vascular complications. The project uses clinically available imaging modalities such as positron emission tomography (PET) and x-ray computed tomography (CT) in combination with radiotracers currently approved or being approved so the technology can easily be translated to clinical settings for diabetic patients with PAD.

Two other labs make up BIC: the Ultrasound Imaging Laboratory, which provides high-frequency ultrasound imaging capabilities; and the Diffuse Optical Imaging Laboratory (DOIL), which houses a frequency-domain diffusive optical imaging system for advanced optical imaging, the largest of its kind in the world.



Brad Sutton and Aaron Johnson utilized the 3 T scanners in the Biomedical Imaging Center to examine the neuromuscular system, particularly how it and the larynx change and atrophy as we age Watch a video of the process at go.illinois.edu/MRI_video.

Biomedical Imaging Center Capabilities

Two Magnetom Trio whole-body 3 T MRI Scanners are in the center, which also houses an Image Processing and Analysis Laboratory and a Neuropsychology Laboratory.

Magnetic Resonance Imaging Laboratory (MRIL)

- **600 MHz Varian NMR System**
  Used for *in vivo* micro-imaging and spectroscopic measurements, including mouse imaging, biological tissue such as stem cells, as well as liquids and non-living samples.
- **Magnetom Trio Whole-Body 3 T MRI Scanners**
  These magnets are the workhorses for many cognitive and human clinical research studies, as well as being used in cardiac and speech dynamic imaging, MR engineering studies to develop new acquisitions, pre-clinical research studies, and imaging many other types of non-biological samples.
- **3 T Trio Mock Magnet**
  The mock magnet looks and sounds like BIC's 3 T Trio scanner but does not have a magnetic field. It is used to familiarize and acclimate human research subjects for experiments in the actual magnet, as well as for tours and other educational outreach programs that explain how magnetic resonance imaging works.

Ultrasound Imaging Laboratory (UIL)

- **High-Resolution Ultrasound**
  A Visualsonics Vevo 2100 High-Frequency Ultrasound Imaging System is designed for imaging smaller animals at high frequencies (up to around 55 megahertz), providing a high degree of resolution to study topics such as disease development and processes in animal models. The UIL has recently secured access to a human ultrasound system and is exploring researchers' interests in pursuing questions in both human and animal subjects.

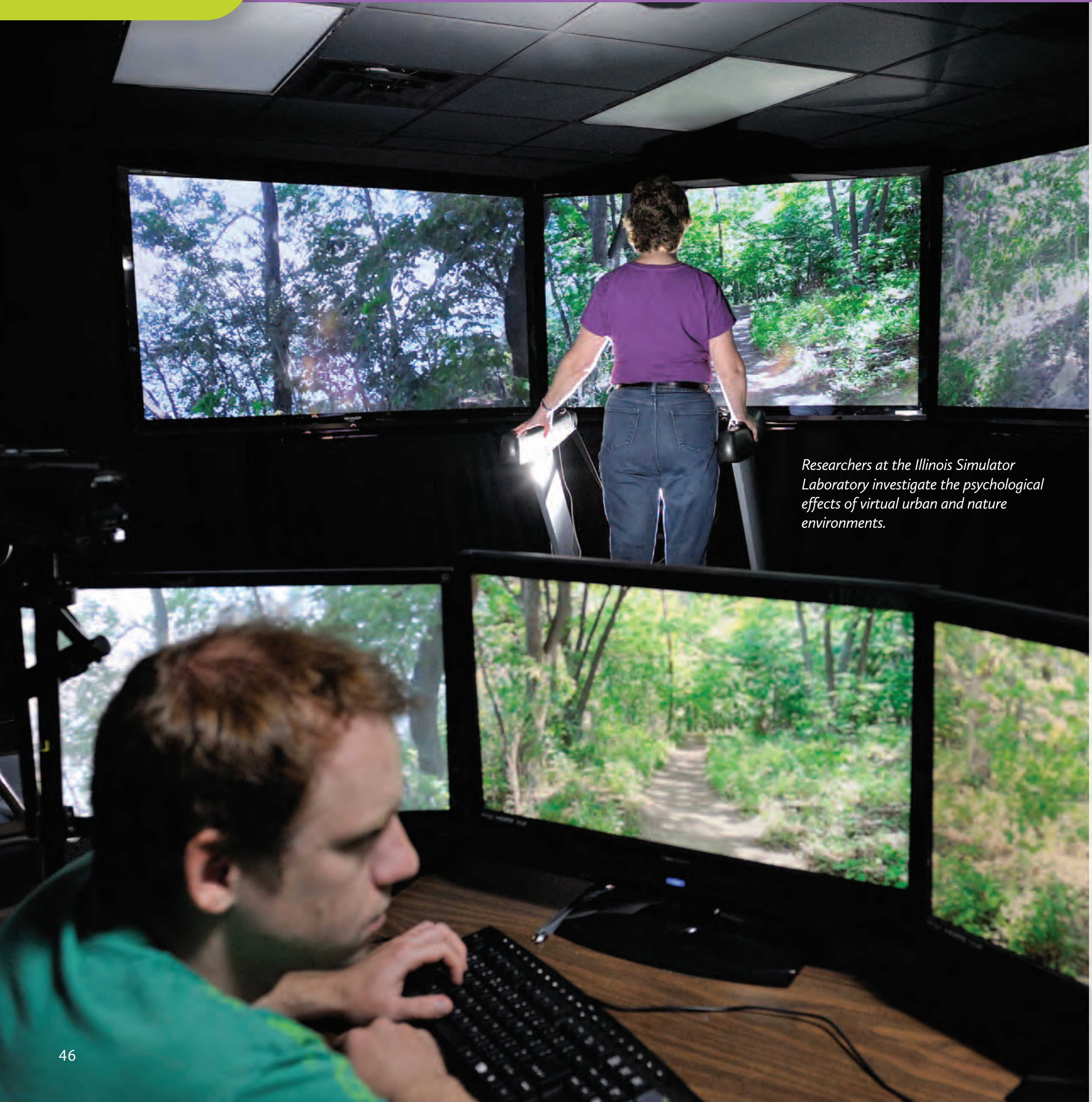
Molecular Imaging Laboratory (MIL)

- **MicroPET/SPECT/CT**
  A Siemens Inveon triple-modality molecular imaging instrument (microPET/SPECT/CT) is used for molecular imaging research in the areas of pre-clinical medical research in cancer and neuroscience; nanomedicine; nanoparticle biodistribution and physiological integration; stem cell tracking and functional integration; nutritional metabolomics; nondestructive evaluation and functional characterization of materials; and microbial and molecular dynamics in environmental media.

Diffuse Optical Imaging Laboratory (DOIL)

- **Frequency-Domain Diffusive Optical Imaging System**
  This imaging system employs an optical tomography imaging method to record both Near-Infrared Spectroscopy (NIRS) and Event-Related Optical Signals (EROS) from the brain. Using an ISS 128-source, 24-detector dual-imagent system from ISS Inc., this technology has the ability to record up to 1,536 channels (source-detector combinations) for human and animal recordings, with the capability of recording four wavelengths.

ILLINOIS SIMULATOR LABORATORY



Researchers at the Illinois Simulator Laboratory investigate the psychological effects of virtual urban and nature environments.

The staff at the facilities at the Beckman Institute, including those at the Illinois Simulator Lab (ISL), aim to provide the newest and best technology for researchers. They continually reconfigure their capabilities in order to meet hardware and software needs for research.

In this past year, the research staff at the ISL has been redesigning the Cube, a virtual reality environment that allows participants to virtually experience the real world.

The Cube was originally built in 2000 through a major research instrumentation grant from the National Science Foundation. It has six projected surfaces—four walls and a floor and ceiling—to create a completely immersive environment. Initially, staff used a large silicon graphics supercomputer to display images on all six screens.

"It was a very impressive setup, but we knew it wouldn't scale over time because it would need more processing power. So we wrote the first software in the world that could take a cluster of computers and make them function as one big supercomputer. It's called Syzygy, and it runs our entire lab now," said Hank Kaczmarski, the director of the ISL.

A new study, led by Beckman Director Art Kramer, uses a virtual environment to investigate whether exploring urban or nature environments will boost creativity.

For this study, the staff built another virtual environment with three 90" LED/LCD displays, which are 10 to 15 times brighter and provide more visual depth at much greater colorimetry than the projectors used for the first Cube. The staff added the latest nVidia graphics cards and built software that allows them to control all three screens from one computer. It's proving to be a less expensive and more functional system than what was used previously.

Researchers captured real-time videos of 30-minute walks through urban and natural environments. The video files comprise large data sets—providing a processing power challenge. But the most difficult hurdle is providing a virtual environment that seamlessly moves with the participant as he or she walks on a treadmill.

"These subjects will walk on a treadmill, but each individual may walk faster or slower than the speed at which the video was shot, so the computer has to keep the images running at the pace the person is walking," said Kaczmarski. "That's pushing the limits of current hardware and software technology."

In order to create new technology for this process, programmers have to rely—and sometimes wait—on updates from the companies that provide the software, while also designing custom software and hardware for the lab.

"It is very cool research, and the process to get it running is just the challenge that comes with such groundbreaking research," said Kaczmarski. "When you're the only one in the world trying to do this work, there are problems to solve."

Other projects planned for the virtual space include displaying data from a functional magnetic resonance image (fMRI) so that researchers can walk through a large, 3D fMRI of a person's brain in real time, allowing for an unprecedented view of the brain that could help researchers better understand its inner workings.

Additionally, researchers are hoping to create virtual avatars that interact with participants to examine how they respond to bullying behavior.

"Bullying is a big issue," said Kaczmarski, "and you want to see how different people interact with bullies, but you want the bully to be consistent with all the subjects. It has to be done in a safe environment, and a virtual environment provides that."

These are just a few of the projects the new technologies enable, thanks to the staff at the ISL who continually update and refine their systems to meet researchers' needs.

"These are the kinds of challenges that the core staff members at the ISL are here to try to solve. It's our job," said Kaczmarski. "The researchers tell us what they want, and sometimes it's things our systems were not designed to do, but we say, 'We'll try.' "

Illinois Simulator Laboratory Capabilities

The CAVE

The CAVE is a four-sided immersive reality environment continuously used for a variety of research projects. Several ImmersaDesks (horizontal and vertical stereo video large-screen display devices) are located in discrete lab spaces in the facility, connected to specialized graphics computers, enabling users to quickly develop, test, and remotely demonstrate new applications and modalities of human-computer interaction.

A second CAVE has been constructed to display three LED/LCD 90" screens of full high-definition stereo-camera-generated video driven by a manual treadmill.

Flight Simulator

Based on a Frasca 142 simulator cockpit, the ISL flight simulator has been continuously updated to meet aviation human factors researchers' requirements with state-of-the-art displays and other technologies. Featuring both a large-screen environment and LCD cockpit displays, the flight simulator has easily expandable graphics-cluster technology and an advanced six-camera eye tracking system. Currently, a NASA/FAA-funded effort is under way by human factors researchers to study the next generation of air traffic control systems.

Driving Simulator

Used extensively by perceptual psychologists examining the way drivers interact with both their environment and the increasingly complex nature of their automobiles, the driving simulator uses a General Motors Saturn automobile that surrounds test subject drivers with eight projected moving images. These images, and a fully integrated eye-tracking system, allow researchers to gather data on how humans interact with the automobile.

Motion Capture Suite

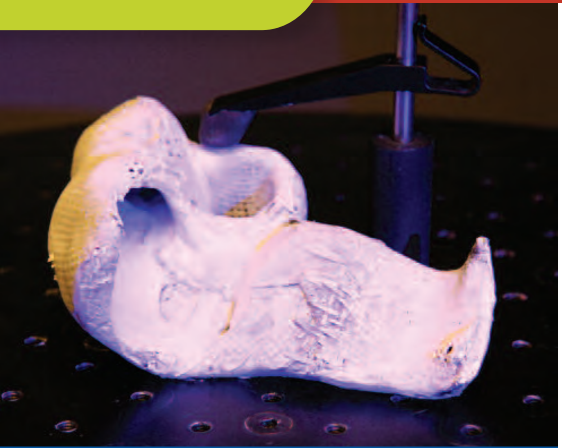
Used by researchers in such diverse fields as kinesiology and mechanical engineering for the analysis of human motion, the Motion Capture Suite features a Motion Analysis 10-camera motion capture system, force feedback plates, video outputs, and gigabit networking that allows researchers to capture human motion at 1,000 times per second, store data for later analysis, or connect with other visualization environments for real-time collaborative research.

The Cube

The Cube, a fully immersive (six-surface) virtual environment, initially funded by a grant from the National Science Foundation, has been upgraded to have higher resolution, more luminance with better chrominance imagery, massive centralized CPU and GPU memory, and significantly faster graphics capable of displaying the large data sets generated by modern scanning machines enabling researchers to get virtually inside their scanned data.

ImmersaDesks

The ISL houses five 7′ diagonal vertical immersive displays called ImmersaDesks, which support monocular and stereo vision; head, eye, and hand tracking; and incorporate surround sound speaker systems. The displays are portable, useful for demonstrating technologies at symposia and workshops, while a horizontal display ImmersaDesk is appropriate for "sand table" style applications such as the current virtual surgery project.



The Imaging Technology Group (ITG) is comprised of the Microscopy Suite and the Visualization Laboratory, which offer a wide array of microscopy- and spectroscopy-related instrumentation and sophisticated image-processing capabilities, including comprehensive graphics assistance, for scientific research. Professional staff train and assist users, and trained users then have access to the facilities 24 hours a day, seven days a week. In a given year the ITG will serve hundreds of students, faculty, and staff from 68 departments on the Illinois campus, in addition to industry and other university researchers on a global level.

Visualization Laboratory (Vis Lab)

Arielle Rausin, an undergraduate student in the College of Business, toured the Visualization Laboratory (Vis Lab) at the Beckman Institute as part of a class that encouraged students to create objects with a 3D printer at the Illinois Maker Lab.

During her training as a member of the Illinois wheelchair track team, she realized that her project for the class could help her with her sport. Athletes use custom racing gloves that help them rotate the wheels of the specialized racing chairs. These gloves come at a price: Rausin's first gloves were $350, took nearly 12 hours to make, and involved melting plastic and then molding them to custom-fit her hands.

"I thought, 'Wouldn't it be cool if I could replicate these gloves without having to go through this long and expensive process,' " said Rausin, who is currently training to qualify for the 2016 Summer Olympics in Rio.

With the help of the 3D scanner in the Vis Lab, Rausin created 3D-printed custom wheelchair racing gloves that are lighter, cheaper, and take less time to make than the standard racing gloves.

"I took one of my gloves, scanned it using the 3D scanner at the Vis Lab to make a digital file of it, and then used a MakerBot 3D printer to replicate it," said Rausin.

With the scanned digital file of the glove, Rausin is able to make unlimited copies for $4 per glove. Even better, she says, is that the material used in the printing and way the glove is printed can improve an athlete's performance.

"One of the best things about (the material) is that it's lightweight—over 100 grams less than the other plastic used in standard

gloves," said Rausin. "That's really important because when we're climbing hills or doing normal strokes, it's much easier to push with lighter gloves and puts less strain on our muscles."

The 3D printer uses a honeycomb structure that makes the glove light and durable.

"The honeycomb structure gives it support while allowing for minimal weight and minimal material cost," said Travis Ross, manager of the Vis Lab. "The array of hollow cells formed between thin vertical walls gives inner strength."

To use the gloves, racers look at the wheel like a clock. They make contact with a metal ring on the wheel that fits into a groove in the glove at 1 o'clock, drive to 4 o'clock, and when they reach 5 or 6 o'clock, they flick their wrists to send the peg back up to 1 o'clock and repeat the cycle. Competitive racers can do this motion about two times a second.

"People work on perfecting their stroke for years, so having a good glove really matters. A lighter glove might also help with repeated motion injuries that many wheelchair racers get," said Rausin. "My teammates were skeptical—they thought the lighter weight would be breakable. So they threw it on the wall of the gym and some of the bigger guys were trying to break it in half. They couldn't."

Rausin and Ross are working with Deana McDonagh, industrial design professor and Beckman faculty member in the Human Perception and Performance Group, to advance the process even further. Instead of scanning an existing glove, the team hopes to design a process that could scan someone's hand and make a glove based on their exact hand structure. This would eliminate the need to scan an expensive, custom glove.

"The sport is growing," said Rausin. "If it was easy to make and produce these gloves, it might be one less barrier people have to enter into wheelchair racing."

Using specialized gloves she made with a 3D printer, Arielle Rausin pushes the pegs of her racing chair alongside her wheelchair track coach, Adam Bleakney. With the help of the Visualization Laboratory, Rausin scanned her original gloves (top left) to make a 3D digital file, and then used the file to 3D print the gloves with a MakerBot from the Illinois Maker Lab. Her new gloves are lighter, cheaper, and take less time to make than standard racing gloves.

Visualization Laboratory Capabilities

Graphics Services
The Vis Lab provides assistance with graphics and illustrations, including cover art and other images for journals and presentations. Working from concepts, photos, or other imagery, the Vis Lab staff members are able to render super high-resolution, professional quality images.

Image Analysis
This capability includes obtaining qualitative and quantitative information from 2D and 3D image sets, including object detection, feature extraction and measurements, cell counting, and other microscopic results for scientific research.

Scientific Visualization
Visualization capabilities include imaging, modeling, and simulating data, presented in various digital media formats: 2D image, 3D image, video, and animation for both analysis and presentation.

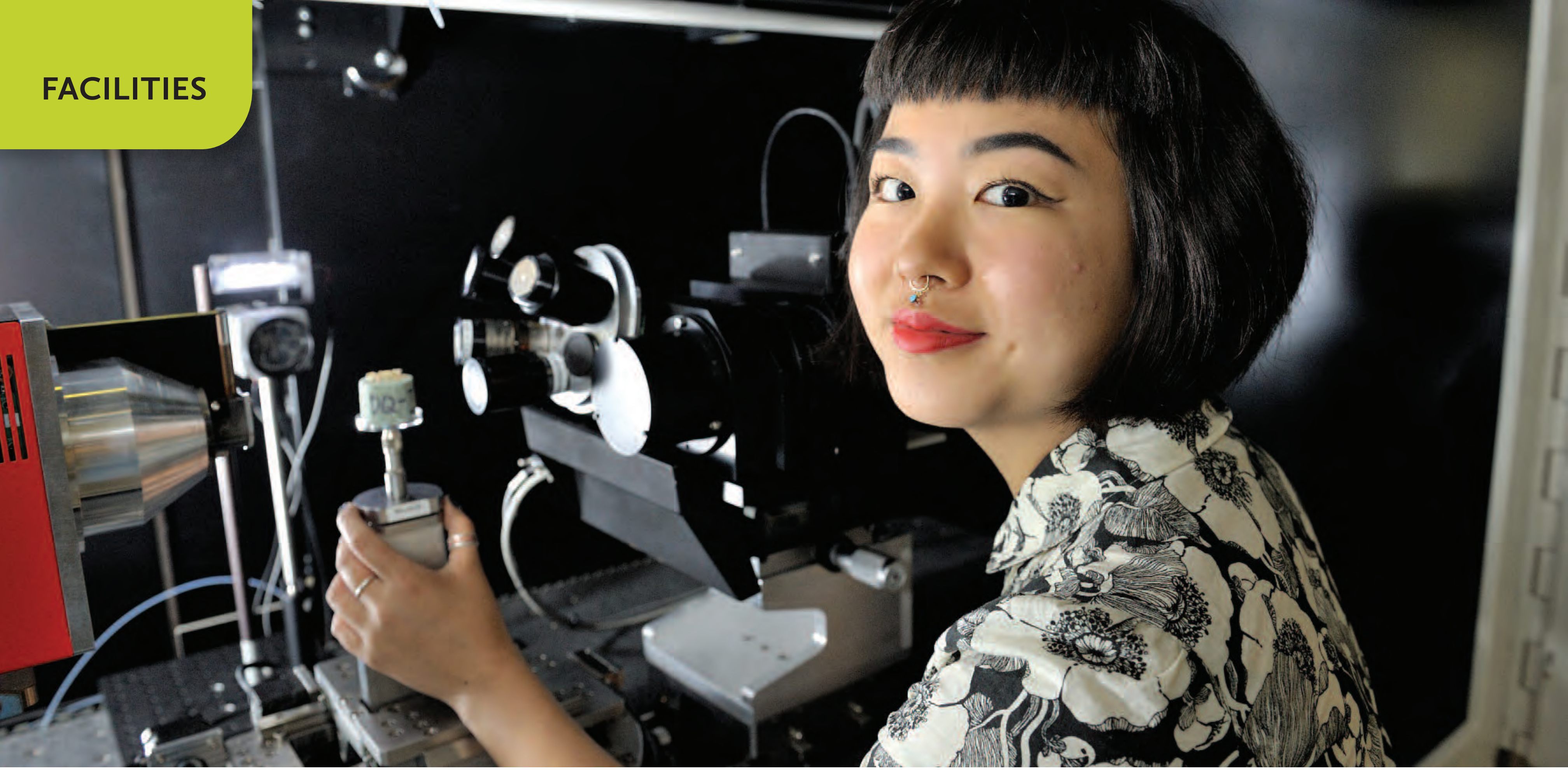
3D Object Scanning
The Vis Lab offers multi-point laser detection to create 3D surface geometry of real-world objects; it is also used for object measurement and 3D modeling.

3D Modeling
This capability allows for geometric modeling in 3D space, using parameters based both on actual and simulated x-y-z directional, and multi-physics simulation capabilities.

Animation and Video Production
These facilities offer the ability to produce moving image sequences, created as communication resources for scientific presentations and for understanding research findings.

Ultra High-Speed Video Capture and Analysis
The Vis Lab offers both qualitative and quantitative visual motion capture and analysis of dynamic processes, which occur at rates of speed undetectable by human vision or traditional video capture speeds.

Macro Photography and Macro Video
This capability offers high-magnification photography and video to capture research objects and scientific processes for analysis and presentation purposes.



Microscopy Suite

The Microscopy Suite features a range of state-of-the art instruments to provide researchers from various disciplines with the ability to image and analyze a variety of biological, material, and biomaterial specimens. The knowledgeable staff provide training and expertise ranging from sample preparation to light microscopy, from electron microscopy to micro- and nanoCT.

The bioCT scanner, which can collect 3D x-ray datasets, has become integral to the research of Charles Roseman, an associate professor in anthropology and an affiliate faculty member in Beckman's Cognitive Science Group. Roseman, an evolutionary anthropologist, is looking at the natural selection on patterns within and among populations' genetic and phenotypic diversity at various timescales.

"The shoulder and the hip perform a number of critical functions ranging from allowing us to move to providing the physical context for giving birth," said Roseman. "Developing a better understanding of how genes and environments act to build a healthy organism provides crucial context for studying diseases of and injury to the shoulder and hip and for modeling how differences in form and function evolved among species."

"Mice have very similar features of the different parts of the body that are related to the girdles and the limbs," said Florence Lin, one of Roseman's research assistants. "Even though they aren't primates, they have closely related features, and the genes that contribute to the development of these parts of the body are actually very similar, so we can use these genes as a comparative study."

Lin, a 2014 graduate in anthropology, has been scanning various mice bones in order to understand diversity in limb and girdle elements, such as the hip and shoulders. Most recently, she has been scanning more than a thousand tiny mice humeri in order to help identify the set of genes that have been

Florence Lin, a research assistant for Charles Roseman in the Department of Anthropology, uses the Microscopy Suite's bioCT scanner in order to understand natural selection on patterns within and among populations' genetic and phenotypic diversity at various timescales.

instrumental in the growth and development of various biological features.

"We look at primates and humans and try to quantify how their limbs and girdle elements move, in order to see why locomotor behavior has diverged in primates," explained Lin. "We humans are bipedal, a lot of other primates aren't, they walk on all fours or they are mostly arboreal, hanging from trees. They have different structures, so we're looking at why these girdles have contributed and how they've changed to allow us to walk on two feet."

Lin uses the bioCT scanner to examine large groups of the small bones.

"Right now I'm working on mouse humeri," said Lin. "We have a little over a thousand stuffed into florist foam and we place them inside the bio-CT scanner, which rotates and takes about 720 images in a 360-degree motion."

After about an hour, Lin can access the 3D reconstruction, which she then takes to Beckman's Visualization Lab, to crop the images and take measurements that capture different aspects of form and function of the bones.

"We do analysis on size and relationships between different bones," said Lin, noting that a previous study examined the scapula. Roseman uses computer software to perform genetic analyses to identify locations in the genome that produce individual differences.

The Microscopy Suite's bioCT scanner is critical to her work, said Lin. "It's one of the most powerful machines available for imaging in 3D. We want to create these high-resolution images so that we can do specific measurements and get good quality results."

"The bio microCT instrument Florence uses is the most versatile of the CT systems in the Microscopy Suite," said Scott Robinson, manager of the Microscopy Suite. "It can be configured to allow us to minimize the x-ray energy, for example, to provide the best possible contrast, permitting us to image and record subtle differences between sample components.

"It benefits, as well, from the expert maintenance and training provided by Leilei Yin, who supervises all of our CT systems, among his other responsibilities. None of this would be possible, of course, without the leadership of the Beckman Institute, whose support allows us to continue to provide state-of-the-art imaging systems."

Microscopy Suite Capabilities

Micro- and NanoCT

The three micro- and nanoCT instruments permit the collection of 3D x-ray datasets of materials, biomaterials, and biological samples with resolutions ranging from 5 microns to 50 nanometers, with "hard" or "soft" x-rays, and with a variety of choices for magnification/field of view. The micro- and biomicroCT systems now incorporate a tensile and compression stage.

Light Microscopy

Suite users have access to laser scanning confocal microscopes with standard and multiphoton imaging capabilities; an inverted fluorescence microscope with the ability to create seamless mosaics of images in x, y, and z; a highly sophisticated upright microscope with fluorescence and differential contrast interference (DIC) imaging, as well as comprehensive stereology and nerve-tracing software packages; and a high-end stereozoom microscope with color-corrected imaging at 120,000 frames per second and wide lenses for large samples. These are in addition to other light microscopes, light-scattering particle-sizing systems, and instruments capable of a number of different types of spectroscopy, from UV to visible light to NearIR and Raman.

Scanned Probe Microscopy

This includes atomic force microscopy (AFM), with its multitude of permutations; scanning tunneling microscopy (STM); and near-field scanning optical microscopy (NSOM). There is even a specialized STM holder that fits into the transmission electron microscope (TEM).

Electron Microscopy

The environmental scanning electron microscope (ESEM), with a field-emission electron gun and a large number of optional imaging modalities, is an essential component of the Bugscope project, which has run continuously for over 15 years. The transmission electron microscope (TEM), for which the suite has designed and built a variety of specialized holders, has 2-Angstrom resolution and operates at accelerating voltages of up to 200 kV.

Sample Preparation Equipment

The wide range of microscopes and spectroscopy equipment requires a comparable range of sample preparation instrumentation, from critical point dryers to ultramicrotomes to a dual-metal evaporator, which was designed and fabricated in response to requests from numerous researchers.

BECKMAN INSTITUTE POSTDOCTORAL FELLOWSHIP

The Beckman Institute Postdoctoral Fellows Program nurtures independent research in a stimulating and supportive interdisciplinary environment that allows young scientists to advance their research during the period between earning a Ph.D. and beginning a professional career. The Beckman Institute Postdoctoral Fellows are selected based on evidence of professional promise, capacity for independent work, outstanding achievement, and interdisciplinary research interests that correspond to one of more of the Beckman Institute's research themes. Applications for the Beckman Institute Postdoctoral Fellows Program are accepted during the fall semester and the announcement of the selected Fellows is made in the spring semester. The Beckman Institute Postdoctoral Fellows program is generously funded by an annual current-use gift from the Beckman Foundation.

2015 Postdoctoral Fellows

Ana Daugherty

Ana received her Ph.D. in behavioral and cognitive neuroscience from Wayne State University in 2014. She previously worked as a postdoctoral research fellow at the Institute of Gerontology at Wayne State. She is interested in cellular non-heme iron accumulation as a cause of progressive neural and cognitive decline that typifies aging, and its interaction with cardiovascular risk factors that are known to exacerbate decline. To examine these factors, she uses multimodal neuroimaging, cognitive assessment, and advanced statistics to characterize differential brain aging, with a particular interest in the hippocampal formation and its diverse subfields. Ana plans to examine the potential protective effects of physical activity against metabolic vascular risk to potentially abate or even reverse the ill effects on cognitive function. At the Beckman Institute, she plans to work with Neal Cohen in the Cognitive Neuroscience Group, Arthur Kramer and Edward McAuley of the Human Perception and Performance Group, and Brad Sutton of the Bioimaging Science and Technology Group.

Daniel Kleinman

Daniel received his Ph.D. in 2013 in psychology and cognitive science from the University of California, San Diego. He worked as a postdoctoral researcher in the UC San Diego Department of Psychology. His research has addressed three questions: first, how does attention affect language production in bilinguals and monolinguals? Second, how are bilinguals so successful at speaking in their intended language? Third, what kinds of expectations do comprehenders form during language comprehension and how do these expectations interface with the production system?

At the Beckman Institute, Daniel plans to investigate how the attentional requirements of language processing may allow bilinguals and monolinguals to produce and comprehend hard-to-access words more easily in connected speech than in isolation. He plans to work with Gary Dell, Darren Tanner, and Jennifer Cole from the Cognitive Science Group, as well as Kara Federmeier and Gabriele Gratton from the Cognitive Neuroscience Group.

Fan Lam

Fan received his Ph.D. in electrical and computer engineering from the University of Illinois. His research focuses on developing models, algorithms, and theoretical analysis for sparse sampling, de-noising, and parameter estimation in applications to magnetic resonance (MR)-based neuroimaging. He plans to develop and apply MR spectroscopic imaging, functional imaging, and quantitative diffusion imaging techniques to study brain function. At the Beckman Institute, he plans to work with Brad Sutton and Zhi-Pei Liang from the Bioimaging Science and Technology Group, and Gene Robinson of the NeuroTech Group.

Maxwell Robb

Maxwell is interested in developing functional materials that respond to mechanical force to enable autonomic self-signaling and self-healing functionality. He received his Ph.D. in chemistry from the University of California, Santa Barbara, in 2014, and has been working as a postdoctoral research associate with Jeffrey Moore, professor of chemistry and a member of Beckman's Autonomous Materials Systems (AMS) Group. Maxwell plans to continue to work with Moore, as well as Nancy Sottos and Scott White of the AMS Group.

Limei Tian

Limei's research focuses on the design, synthesis, and hierarchical assembly of inorganic materials and their integration with organic materials for various optoelectronic applications. Specifically, she envisions a multimodal sensing system by integrating wireless passive antennas with a powerful optical sensing platform, namely, surface-enhanced Raman scattering. She received her Ph.D. from the Department of Mechanical Engineering and Materials Science at Washington University in 2014. She plans to work with John Rogers and Paul Braun from the 3D Micro- and Nanosystems Group, as well as Rohit Bhargava from the Bioimaging Science and Technology Group.

Yingjie Zhang

Yingjie received a Ph.D. in applied science and technology from UC Berkeley. His Ph.D. research focused on solution-processed electronic materials, where nanoscale building blocks are assembled into functional materials for energy applications. He used various scanning probe-based imaging and spectroscopy techniques to study the electronic structure of individual building blocks (organic molecules or semiconductor quantum dots), and map out the energetic and spatial pathways of charge transport. He also explored novel colloidal quantum dot-based optoelectronic devices based on the percolation transport mechanism with untraditional design of defects. Yingjie plans to work with Martin Gruebele, Xiuling Li, and Joseph Lyding of the Nanoelectronics and Nanomaterials Group at Beckman, where his research will be extended to the angstrom scale. He plans to perform atomic-scale imaging of two dimensional electronic materials, and seek novel quantum device applications such as quantum memory, computing, transistor and sensing, harnessing the charge, spin, and valley degrees of freedom.

2014

Jason Patrick

Jason's research interests span a variety of technical disciplines ranging from structural engineering, materials science, computational mechanics, experimental characterization, and recently microelectronics. He received his Ph.D. from Illinois in civil engineering (structures) in May 2014. His research focuses on the development of authentic biomimetic materials that inherit the evolutionary advantages of dynamic, natural counterparts. He works with Stephen Boppart from Integrative Imaging; Jeffrey Moore, Nancy Sottos, and Scott White from the Autonomous Materials Systems Group, and John Rogers from the 3D Micro- and Nanosystems Group.

Semin Lee
For a hobby, Semin enjoys playing around with molecular building blocks to make new structures. Through his doctoral studies in chemistry at Indiana University, he has learned that this hobby is useful when the molecules have functional applications and becomes even more interesting when they are easy to synthesize, like cyanostar macrocycles that bind anions. Semin works with Rohit Bhargava in the Bioimaging Science and Technology Group, and Jeffrey Moore in the Autonomous Materials Systems Group. His research plan is to synthesize imaging probes that may help elucidate the sequence of protein signaling in breast cancer progression.

Gillian Hamilton
Gillian received her Ph.D. in behavioral neuroscience from the University of Delaware in 2012 and worked as a postdoctoral researcher in Justin Rhodes' lab. She is interested in cellular plasticity in the normal/healthy brain versus the diseased brain and how alterations in brain plasticity impact behavior. Her dissertation focused on the long-term adverse effects of fetal alcohol exposure on the brain and explored the potential beneficial impact of behavioral therapies. At Beckman she works with Rhodes in the NeuroTech Group, and John Rogers in 3D Micro- and Nanosystems. She plans to determine the functional significance of exercise and/or environmentally complexity induced newly generated neurons in the improved performance on hippocampal dependent tasks in a mouse model of fetal alcohol exposure.

Tomasz Wrobel
Tomasz's research interests center on the use of infrared (IR) and Raman imaging in application to biomedical studies. He has experience in spectroscopic techniques, which he worked on for his doctoral dissertation at the Faculty of Chemistry at Jagiellonian University in Poland. At the Beckman Institute, he is developing a platform for imaging prostate cancer tissues using IR spectroscopy with very high spatial resolution. He works with Rohit Bhargava and Scott Carney in the Bioimaging Science and Technology Group, and Minh Do in the Image Formation and Processing Group.

John Biggan
John completed a postdoctoral appointment at the Center for Healthy Living and Longevity at University of Texas at Arlington. He focuses on successful aging through exercise. His research investigates the effects of irisin, which is produced in skeletal muscle and travels via the circulatory system to the brain where it is able to cross the blood-brain barrier and stimulate the release of brain-derived neurotrophic factor (BDNF). At the Beckman, he works with Neal Cohen from the Cognitive Neuroscience Group; Art Kramer and Edward McAuley from Human Perception and Performance; and Justin Rhodes from NeuroTech.

2013

Chao Ma
Chao completed his Ph.D. in electrical and computer engineering at the University of Illinois at Urbana-Champaign in 2013. His research interests include developing advanced magnetic resonance imaging (MRI) techniques to push the limitations of MRI on resolution, signal-to-noise ratio, and imaging speed. As a Beckman Postdoc Fellow, he focuses on developing a novel magnetic resonance spectroscopic imaging (MRSI) technique to enable high-resolution metabolic imaging of the brain. Specifically, he devotes systematic efforts on optimizing signal excitation, data acquisition, and image reconstruction and post-processing, and applying metabolic imaging to study brain functions. Chao works with Yoram Bresler from the Image Formation and Processing Group, Zhi-Pei Liang and Brad Sutton from the Bioimaging Science and Technology Group, as well as Beckman neuroscientists.

Preethi Jyothi
Preethi completed her Ph.D. in computer science at the Ohio State University. Her main research interest is in automatic speech recognition, and more broadly in applied machine learning. She works with Jennifer Cole in the Cognitive Science Group, and Mark Hasegawa-Johnson and Paris Smaragdis in the Artificial Intelligence Group. Her research as a Beckman Fellow focuses on problems in the broad area of multilingual speech recognition, using speech production models motivated by linguistic theories and models of prosody (i.e., cues such as duration, stress, intensity of different parts of the utterance).

Nathan Ward
Nathan completed his Ph.D. in cognition and neural sciences at the University of Utah. His research interests focus on the component processes of multitasking using a multifaceted approach that involves traditional behavioral methods, driving simulation, neuroimaging, and training/transfer regimens. He is interested in knowing how shifting and dividing attention are similar and different in various laboratory and real-world contexts, as well as whether or not these abilities can be trained. He works with Aron Barbey in Cognitive Neuroscience, as well as Art Kramer, Alejandro Lleras, and Dan Simons from the Human Perception and Performance Group.

Renee Sadowski
Renee completed her Ph.D. in neuroscience at the University of Illinois. Her research interests are currently focused on how early developmental exposure to an endocrine-disrupting toxicant, bisphenol A, leads to long-term alterations in cognition and anatomy of the prefrontal cortex. Her studies are based on the hypothesis that early exposure to polychlorinated biphenyls (PCBs) decreases seizure threshold by changing the balance of inhibitory and excitatory circuits in the brain. Results from this study will identify PCB-induced alterations in

neural activity and mechanisms that mediate long-lasting changes in the susceptibility to seizures. In turn, this work can be used to help identify populations that have an increased susceptibility to exhibit seizures. She is working with Daniel Llano and Susan Schantz in the NeuroTech Group.

Abhishek Singharoy
Abhisek was a graduate student of theoretical chemistry at Indiana University. His research at Beckman focuses on molecular dynamics (MD) simulations, which provide biomedical researchers with a new perspective on the dynamics of cellular processes hitherto inaccessible by observation. The study aims at developing a Molecular Dynamics Flexible Fitting (MDFF) software that interprets poorly resolved structures from x-ray crystallography experiments. This software, xMDFF, will be able to refine the phase angles in order to derive atomic models from x-ray data. With this, ADP binding/release induced conformational change in the molecular motor protein dynein will be studied. The research is being performed under the auspices of Wen-Mei W. Hwu in Electrical and Computer Engineering, and Klaus Schulten from the Theoretical and Computational Biophysics Group.

2012

Suma Bhat
Suma earned a Ph.D. in 2010 from the Department of Electrical and Computer Engineering at the University of Illinois at Urbana-Champaign. Her research is in the area of human-computer intelligent interaction, with a primary focus on natural language and speech processing. As a Beckman Fellow she uses multiple elements of communication, such as speech and gesture, for improving virtual reality applications like video conferencing. Suma's goal is to precisely characterize the efficacy of a new online presentation tool, and then to design tools for improved human-to-human interactions in a virtual setting. She works with several Beckman researchers, including Minh Do, Mark Hasegawa-Johnson, and Tom Huang from the Human-Computer Intelligent Interaction research theme, and Jennifer Cole and Kara Federmeier from the Biological Intelligence research theme.

Bradley Deutsch
Bradley earned a Ph.D. in optics in 2011 at the University of Rochester's Institute of Optics. His research involved nanoscale optics, with a Ph.D. emphasis on phase-shifting interferometric methods for near-field optical microscopy and nanoparticle detection. At Beckman he works with Scott Carney and Rohit Bhargava of the Bioimaging Science and Technology Group. Bradley's project as a Beckman Postdoc Fellow focuses on developing an ultramicroscopy technique that encodes spatial information in the spectral domain for improved temporal resolution without a loss of spatial resolution, for use in biology, medicine, and imaging applications.

Sarah Erickson
After earning a Ph.D. in biomedical engineering from Florida International University in 2011, Sarah became a postdoctoral researcher in the university's Optical Imaging Laboratory. Her research interests are in developing diffuse and fluorescence-enhanced optical imaging methods, with a clinical goal of early-stage breast cancer diagnosis. She has used diffuse optical tomography (DOT) toward development of a hand-held based optical imager; as a Fellow she explores applying optical coherence tomography (OCT) and vibrational imaging toward breast cancer diagnosis and intraoperative tumor margin detection in a clinical setting, and for insight into the biochemical changes of malignant tissue for disease prognosis. She works with Integrative Imaging research theme co-chair Stephen Boppart, and collaborates with Rohit Bhargava from the Bioimaging Science and Technology Group, and Martin Gruebele from the Nanoelectronics and Nanomaterials Group.

Heather Lucas
Heather completed her Ph.D. in psychology at Northwestern University in 2012. Her research focus is on the neural bases of human memory systems and changes they undergo during the aging process. At Beckman she works with Cognitive Neuroscience Group members Neal Cohen and Kara Federmeier, and with the Center for Nutrition, Learning, and Memory that Cohen directs. Her research aims as a Fellow include identifying early markers of pathological memory decline with age and characterizing the impact of B-vitamin supplementation on cognitive functioning in older adults. Her research goals include furthering understanding of human memory dysfunction and addressing topics involving our rapidly growing older population, such as nutrition-based interventions for memory decline.

Carle Foundation Hospital—Beckman Institute Fellow

Initiated in spring 2008 with funding from the Carle Foundation Hospital, this Fellows program provides an opportunity for a scientist to spend several years conducting independent, interdisciplinary, translational research in oncology or neuroscience before launching her or his formal academic career. This Fellows program is modeled on the successful Beckman Institute Postdoctoral Fellows program funded by Beckman Foundation funds. The successful candidate is selected for a term of up to three years. The Carle Foundation Hospital—Beckman Institute Fellow is selected on the basis of professional promise, capacity for independent work, interdisciplinary interests, and outstanding achievement to date.

Rachael Rubin (2014-2017)
Rachael, who completed her Ph.D. in cognitive neuroscience at Illinois, is interested in characterizing the consequences of impairments following traumatic brain injury, so that these findings can be translated into treatments and therapies that advance clinical care. She previously was involved in clinical research studies at Carle Foundation Hospital and the University of Iowa Hospital.

2015 BECKMAN GRADUATE FELLOWS

The Beckman Institute Graduate Fellows program provides an excellent opportunity for young scholars who are engaged in thesis research at the M.A., M.S., or Ph.D. level at the University of Illinois at Urbana-Champaign. Beckman Institute Graduate Fellows are competitively selected based on the quality of their proposed work, the likelihood that the work would lead to important new results in their field, and the relevance of the proposed project to existing Beckman Institute research. The Beckman Institute Graduate Fellows each receive a fellowship equivalent to an 11-month 50 percent graduate research assistantship in their home department. Funds are also provided to each Fellow for conference travel to present their research results.

Angela Barragan is a Ph.D. candidate in the Department of Physics. Her research employs quantum chemical density functional theory calculations combined with molecular dynamics simulations in order to investigate the primary electron and proton transfer reactions at the bc1 complex. The objective is to provide a quantitative description of the biophysical mechanism of these charge transfer reactions and demonstrate their coupled nature. She works with Klaus Schulten of the Theoretical and Computational Biophysics Group, as well as Sharon Hammes-Schiffer of the Department of Chemistry, and Anthony Crofts from the Department of Biochemistry.

Hector Lopez Hernandez is a Ph.D. candidate in the Department of Mechanical Science and Engineering. His research is in pursuing a novel class of polymeric materials (metastable polymers) that can be efficiently degraded under a variety of different stimuli for efficient recycling, sustainable engineering, and programmable (transient) lifecycles. He works with Jeffrey Moore, Nancy Sottos, and Scott White from the Autonomous Materials Systems Group, as well as John Rogers from the 3D Micro- and Nanosystems Group.

Cassandra Jacobs is a doctoral student in cognitive psychology. Her research integrates multiple fields of computational and cognitive science, allowing understanding of the mechanisms by which people learn language. She plans to combine various computational techniques from speech processing to identify what cues, if any, signal that idiomatic phrases like "red herring" are said differently from literal phrases like "white house" to see whether listeners can discriminate between these kinds of phrases using the same cues that the algorithm uses. She examines whether listeners use these differences to guide their interpretation of what speakers are talking about. She works with Gary Dell and Duane Watson from Beckman's Cognitive Science Group, and Margaret Fleck from the Department of Computer Science.

Joanne Li uses optical coherence and multiphoton microscopy to quantitatively evaluate the therapeutic efficacy of adipose pericytes, and the healing mechanism of diabetic wounds at the cellular level by characterizing cellular dynamics, collagen regeneration, vasculature reformation, and metabolic activity in skin. Joanne, who is pursuing her Ph.D. in bioengineering, works with Wawrzyniec Dobrucki, Marni Boppart, and Stephen Boppart from the Bioimaging Science and Technology Group.

Aki Nikolaidis is a doctoral student in neuroscience. His research focuses on how individual differences in the brain relate to learning and improvements in untrained tasks, also known as transfer. He plans to use tools from machine learning and network analysis on datasets from two large cognitive training studies to investigate how individual differences in brain structure, connectivity, and metabolism predict individual differences in learning and transfer of training to other cognitive domains. He is working with Aron Barbey from the Cognitive Neuroscience Group, Arthur Kramer of the Human Perception and Performance Group, and Paris Smaragdis from the Artificial Intelligence Group.

Duc Nguyen is a Ph.D. student in physical chemistry. His research interest involves using the ultrahigh stability scanning tunneling microscopes (STMs), developed by the Joseph Lyding group at Beckman, to study surface glassy dynamics and single molecule absorption (SMA). By watching surface of glasses in real time with sub-nm resolution, he tests theories of glasses. He also studies SMA of quantum dots (QDs), carbon nanotubes (CNTs) and intermolecular energy transfer between QD and CNT on different surfaces using STM. Duc works with Martin Gruebele and Joseph Lyding, of the Nanoelectronics and Nanomaterials Group.

Saumya Tiwari is pursuing a Ph.D. in bioengineering. She plans to use infrared spectroscopy to develop detection systems capable of stainless and automated disease detection *in situ*, understand the mechanism of disease development, and develop algorithms for detecting outcomes based on patient data. She is working with Rohit Bhargava and Dipanjan Pan of the Bioimaging Science and Technology Group, as well as Sayeepriyadarshini Anakk from the Department of Molecular and Integrative Physiology, and KV Prasanth from the Department of Cell and Developmental Biology.

Beckman Institute—Senior Fellows Program

Beckman Institute Senior Fellowships give established faculty from other universities the opportunity to do short-term, on-site, interdisciplinary research with other Beckman Institute researchers. This year, the Beckman Institute hosted two senior fellows: Christophe Chipot and Daniel King.

Christophe Chipot

Chipot is the research director at the National Center for Scientific Research (CNRS) in France and the co-director of the Associate International Laboratory (LIA) between CNRS and the University of Illinois. At the Beckman Institute, he worked with Klaus Schulten, director of the Theoretical and Computational Biophysics Group and co-director of LIA, to investigate problems in computational biophysics.

Daniel A. King

King, assistant professor of physics at Eastern Mennonite University, worked with William O'Brien, of Beckman's Bioacoustics Research Laboratory, to study better modeling of nonlinear ultrasound contrast agent dynamics.

2015 Open House

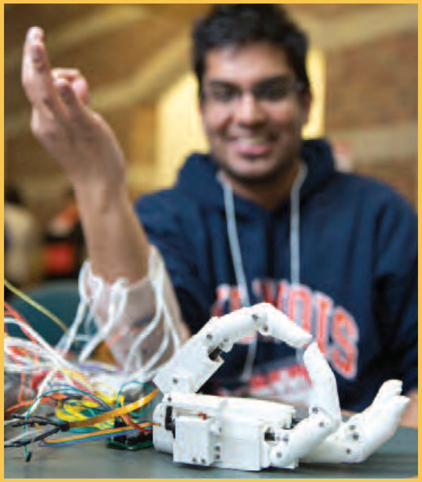
The biennial Open House on March 13-14, 2015, showcased over 40 labs, facilities, and research projects at the Beckman Institute. Attendees interacted with the technology and programs used for research and experiments, giving them an opportunity to experience the research at the Beckman Institute firsthand.

The Microscopy Suite staff demonstrated the fluorescence microscope, the x-ray microcomputed tomography instruments, and the field-emission scanning electron microscope using a Bugscope sample. The Visualization Laboratory showcased their updated 3D scanning and macrophotography abilities. The Biomedical Imaging Center let visitors explore their various labs, including the 14.1 T Inova Microimaging Scanner and the Siemens MicroPET/SPECT/CT scanner. Visitors could test their skills on flight and driving simulators provided by the Illinois Simulator Laboratory.

Children were encouraged to play brain games designed specifically for them in order to sample and understand how brain-machine interfaces work. They also got to see real mouse and fish brains, get a sense of the size of brains of different animals, learn the parts of a neuron, and see how human brains react to brain teasers.

A popular display was the 3D printing of a prosthetic hand, which can be made for less than $1,000. Bert, the iCub robot, which moves its head, arms, hands, waist, and legs, and can see and hear, was also popular with visitors.

The Self-Healing and Sustainability Group showed off "smart" materials, which are inspired by nature and help create an exciting array of new self-healing and sustainable technologies. Justin Rhodes' lab had clownfish on display, and visitors could learn more about their unique social behavior. A 3D journey across the molecules that build all living organisms allowed attendees to experience shapeshifting proteins, insidious viruses, and the intricate chlorophyllosophy of bacteria leaping off the screen one atom at a time.



Above left, a youngster tries on a helmet from the Diffuse Optical Imaging Laboratory in the Biomedical Imaging Center. The lab studies brain function using infrared light. Right, Aadeel Akhtar, a graduate research assistant in the Artificial Intelligence Group, displays a 3D printed prosthetic hand.

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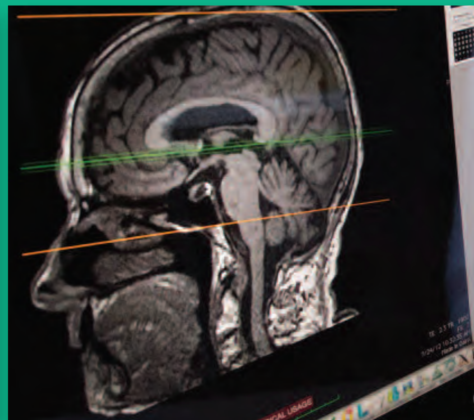
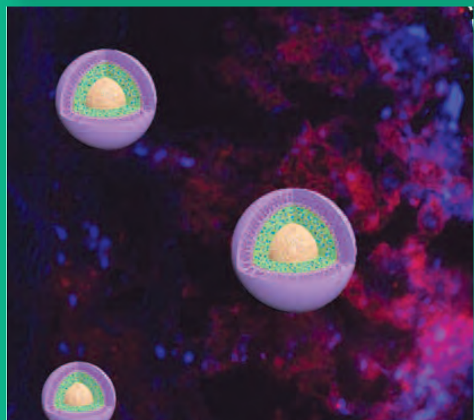
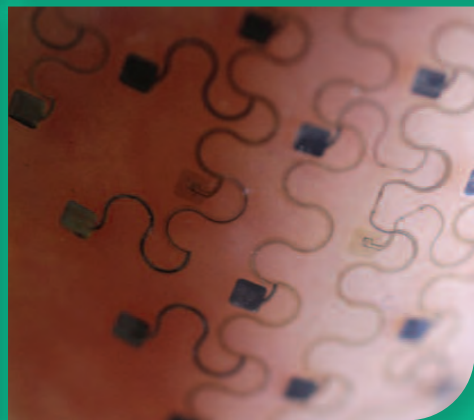

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