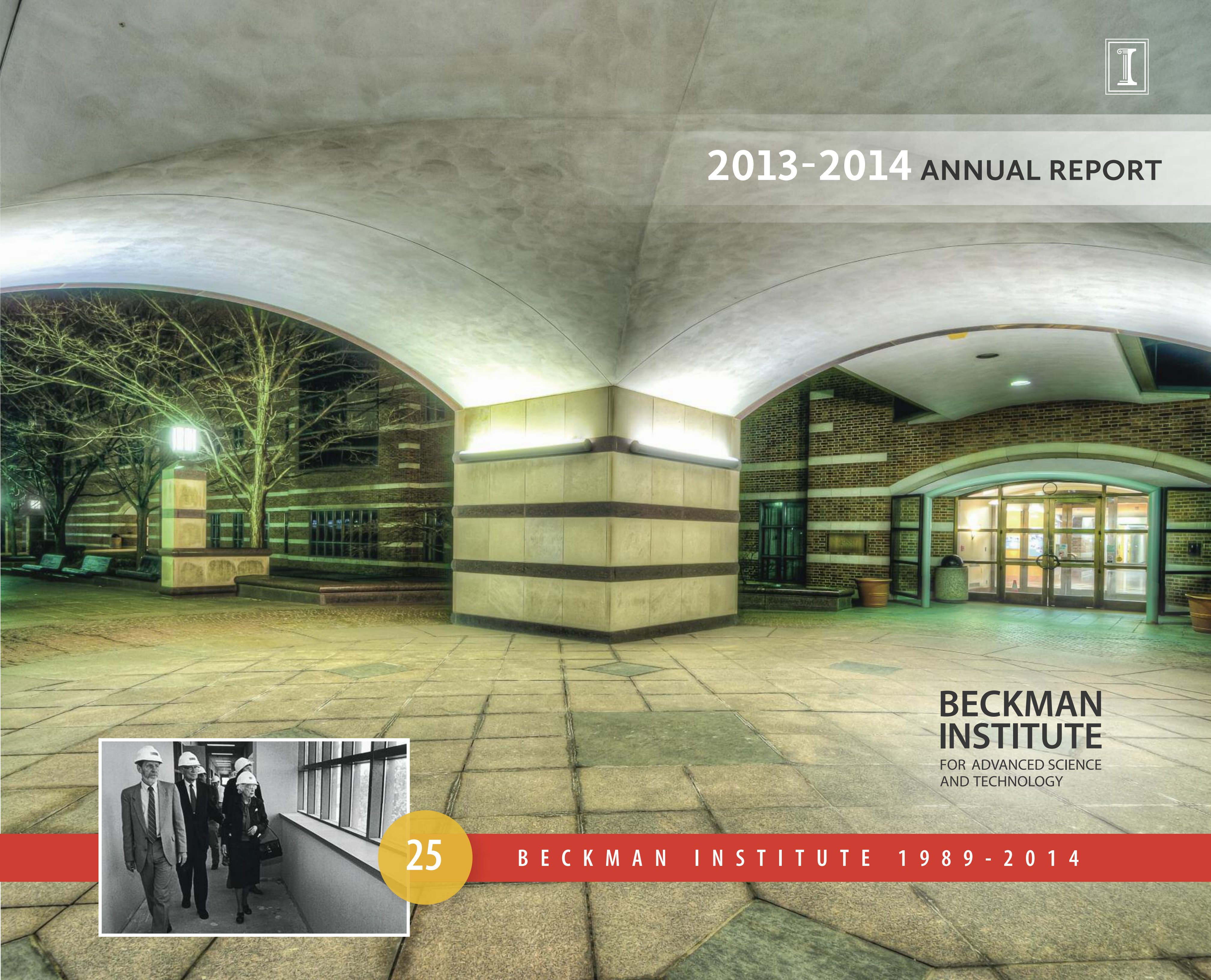

2013-2014 ANNUAL REPORT

BECKMAN INSTITUTE
FOR ADVANCED SCIENCE AND TECHNOLOGY

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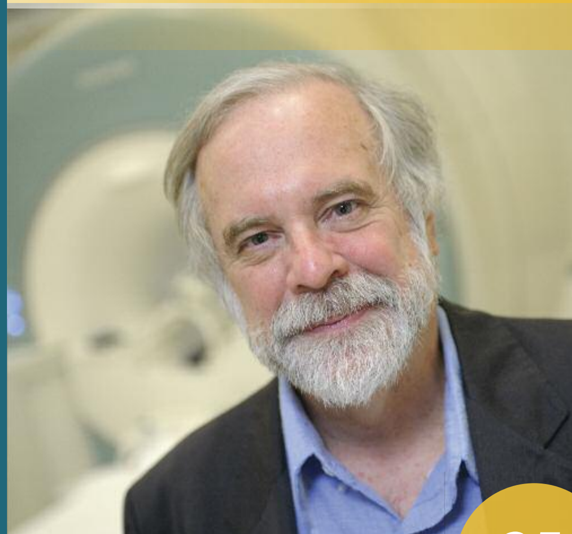
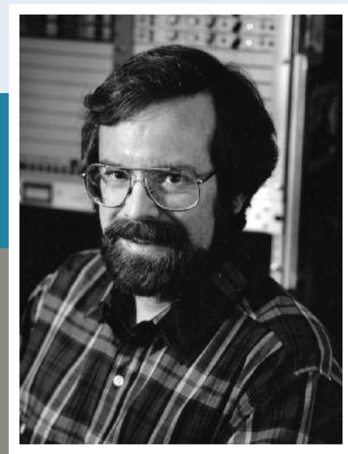
BECKMAN INSTITUTE 1989-2014

THE YEAR IN **REVIEW**

DIRECTOR'S OVERVIEW 2013-14



BECKMAN SCRAPBOOK 25



Above Beckman Director Art Kramer today, and, right, in the early days of the Beckman Institute.

This year we're pleased to be celebrating the 25th anniversary of the Beckman Institute for Advanced Science and Technology. For an institution a quarter century seems relatively young, but this year has been an opportunity to reflect on the innovative movement in 1989 that bridged what was seen as a monumental divide between disparate disciplines at the University of Illinois.

Today the words "interdisciplinary" and "multidisciplinary" are common catchphrases among university administrations and researchers throughout the world, but, in 1989, the forward thinking of the first Beckman director, Ted Brown, as well as University of Illinois faculty members like

William Greenough and Karl Hess, provided a new development in how research should be conducted—across disciplinary boundaries. Thanks to the generosity of Arnold and Mabel Beckman, that concept was firmly established within the brick and glass façade of the Beckman Institute.

Now more than 200 faculty members represent 11 colleges and more than 50 different departments as diverse as engineering, speech and hearing science, psychology, computer science, physics, education, biochemistry, neuroscience, anthropology, and linguistics.

Our new research grants for this fiscal year alone total more than $29 million. The grants span all of the research themes and are complemented and supported by the equipment grants provided by the Arnold and Mabel Beckman Foundation funds, which are used to continually enhance the centralized research facilities, ensuring that these facilities remain on the cutting edge of research support capabilities.

A new INSIGHT "brain training" project was awarded this year to Aron Barbey from the Biological Intelligence theme by the Intelligence Advanced Research Projects Activity (IARPA). Barbey's team, including faculty from psychology, kinesiology and community health, computer science, neuroscience, and food science and human nutrition, is working to develop evidence-based methodologies and computational models that may improve the quality of human judgment and reasoning in complex, real-world environments.

Gabriel Popescu, from Integrative Imaging, has conducted groundbreaking work on *in vivo* cell imaging. Elizabeth Stine-Morrow, who recently became co-chair of the Human-Computer Intelligent Interaction research theme, continues to do innovative research on how to age well; others in the theme examine how exercise affects our cognitive and brain health, and develop technological methods to detect unusual sounds in long recordings.

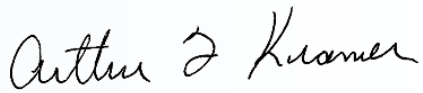
John Rogers, in Molecular and Electronic Nanostructures (M&ENS), continues his work into transient electronics that can monitor the health of a user, while Emad Tajkhorshid and collaborators have successfully simulated the molecular dance moves that a multi-drug resistance membrane transporter undertakes as it pumps compounds out of a cell, in order to help with drug design.

This year, Beckman faculty have been recognized for their groundbreaking research. Stephen Boppart, co-chair of the Integrative Imaging research theme, received the Illinois Proof of Concept Award from the University of Illinois Office of Technology Management for his Quantitative Pneumatic Otoscope project, which provides a standard surface view of the eardrum, and also sees through the eardrum to visualize middle ear contents using optical coherence tomography. John Rogers was elected to the American Academy of Arts and Sciences, and Joe Lyding from M&ENS received the Award for Research Excellence in Nanotechnology from the Bio/Nano Interface Center at the University of Pennsylvania. More information on awards presented to Beckman faculty can be found beginning on page 26.

Of course, in our year of remembering important accomplishments, we also remember those who made such accomplishments possible. William Greenough, one of the founding Beckman faculty members, died in December. Bill had been a leader in changing scientific thinking when it comes to nervous system development and the brain. He helped take the concept of brain plasticity from theory to experimental proof to accepted science.

One of Beckman's longest serving theme co-chairs, Thomas Huang, stepped down this year. Tom is well-known not only for his research into signal processing and pattern recognition, but also for his mentoring of numerous students. This year, we were proud to announce the inaugural Thomas and Margaret Huang Award for Graduate Research to support students in Human-Computer Intelligent Interaction, and to honor the many contributions to science of Tom and his wife, Margaret. Tom will still be involved in research at the Beckman Institute, and we look forward to his continued contributions.

Throughout this report, we've not only taken a look back at our illustrious past, but have also asked our featured researchers to take a look into their respective fields to see what the future holds. As Zhi-Pei Liang from Integrative Imaging points out, no one field will be able to make progress without incorporating technological and scientific breakthroughs from other fields. The Beckman Institute plans to be at the forefront of enabling those collaborative breakthroughs for the next 25 years and beyond.



Art Kramer
Director
Beckman Institute for Advanced Science and Technology

BIOLOGICAL INTELLIGENCE (BIOINTEL)

When the Beckman Institute opened 25 years ago, neurodevelopmental toxicology, which examines the effects of environmental toxicants on neurodevelopment and behavior, was in its infancy. **Susan Schantz**, a professor of comparative biosciences and Beckman researcher in the NeuroTech Group, believes that within a relatively short period of time, the field has made some very important advances.

One, according to Schantz, resulted from the arrival of epigenetics, the study of heritable changes in gene activity that are not caused by changes in the DNA sequence.

"We've always known that early developmental exposures have long-lasting effects," said Schantz, "but what's the mechanism for that? Epigenetics explains how you can have early exposures that permanently alter gene expression and lead to health problems later on, or that cause a non-genomic change that is expressed later in life when there's some other kind of triggering factor."

Another important contribution, says Schantz, is the knowledge that the environment can contribute to neurodevelopmental and neurodegenerative diseases, such as attention deficit hyperactivity disorder (ADHD), autism, and Parkinson's disease.

"I think in the past we were focused on understanding the genetic causes of these diseases," said Schantz. "Now there is a focus on gene-environment interaction, which means people get a disease because they have a susceptible genome *and* are exposed to particular environmental factors."

Schantz is the director of the new Illinois Children's Environmental Health and Disease Prevention Center at the Beckman Institute.

The center, funded by a five-year, $8 million grant from the Environmental Protection Agency and the National Institute of Environmental Health Sciences, is an extension of a formative center, which was established in 2010 to study exposure to bisphenol A (BPA) and phthalates.

BPA is used in shatterproof plastics, dental fillings, electronics, and the linings of metal food and drink containers. Studies have found BPA in human urine, blood, breast milk, and the amniotic fluid of pregnant women. Phthalates, which are used in plastics, cosmetics, building materials, wrappers, textiles, toys, and in the coating of some time-release medications, have been shown to cause birth defects in rodents given high exposure.

The center is interested in both prenatal and adolescent exposures to these chemicals, and how they affect reproductive system and nervous system development and behavior. The center hosts four closely linked research projects: two human cohort studies and two laboratory animal studies, as well as an outreach component.

A pilot birth cohort study conducted during the formative stage initially looked at 157 mother-infant pairs. The current study, called the Illinois Kids Development Study (I-KIDS), expands the smaller study considerably. Researchers are recruiting 600 women during their first trimester of pregnancy, so that they can follow at least 500 additional children to examine the effects of BPA, phthalates, and other endocrine-disrupting chemicals, including the antibacterial agent triclosan, on infant and child development. The first baby of the new cohort was born in June 2014, and children from the original cohort, who are now nearly three-and-a-half years old, are still being followed.

In an interdisciplinary approach to research, this study is incorporating techniques commonly used in other disciplines for evaluation and data collection.

"We had pretty novel ideas about how we were going to assess infants, looking at cognitive function beginning at birth, using approaches that aren't typically used in epidemiology," said Schantz. "We take methods typically used in developmental psychology to study cognitive development and are revising the data collection approach so that we can use these approaches in the context of a large epidemiological research study."

Another study in the center examines adolescents who were part of a similar birth cohort. Parallel to these studies in humans, research with laboratory animals is assessing both reproductive development and function, and neurodevelopment and function, relative to the animals' exposure to the same chemicals.

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.

A "research translation" program aims to build a public conversation about the scientific consensus on the everyday consumer chemicals that may influence child health. (For more information on the center, see page 39.)

Schantz focuses her research mainly on chemicals in consumer products, but she has also looked at exposures to polychlorinated biphenyls (PCBs). Although all of the chemicals she studies can have detrimental effects on human health and neurodevelopment, there are many differences in their prevalence and their effects.

"BPA is very different from PCBs," said Schantz. "It's not stable, it's metabolized very readily in the body. PCBs bioaccumulate in your body—you store them in your body fat. But BPA has a very short half-life: you take it in, you break it down, and it's gone. It doesn't build up. But the problem is that it's very widely used in many consumer products, so everybody's exposed every day to BPA. One of the biggest problems with BPA is that it affects development, which is problematic because that's when the brain and organs are forming."

Additional studies have shown that early exposure to PCBs causes hearing loss due to functional changes in the outer hair cells of the cochlea and that these changes are linked to audiogenic seizures in rats. Schantz works with Dan Llano, Beckman full-time faculty member in the NeuroTech Group, on laboratory animal studies that look at how PCBs affect development of the auditory system.

Another collaborative Beckman project is developing a new method for eye tracking, which is one method used to evaluate the cognitive function of infants. Most eye tracking devices use infrared cameras, which are costly and require special expertise to set up and run. Schantz is working with the Image Formation and Processing Group, led by Thomas Huang, to develop new visible light eye tracking procedures for infants.

"We're trying to see if we can develop ways we can accurately track an infant's eye movements with just a computer webcam and a laptop computer. We're working closely with (Beckman affiliate faculty member) Dan Hyde on that. I don't think I would really have ever gotten into this if someone hadn't said, 'You should really talk to these computer vision people. They might be able to help you.' That's the intellectual environment that Beckman provides."

BECKMAN SCRAPBOOK

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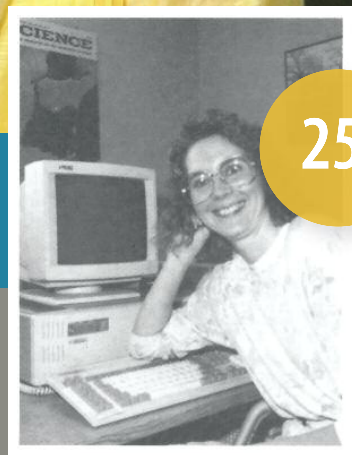


Susan Schantz, above in 2013, and right circa 1991.

Susan Schantz

Looking Forward

Schantz is excited about the possibilities that the National Children's Study offers for studies in neurodevelopmental toxicology.

The multi-year research study will examine the effects of environmental influences on the health and development of 100,000 children across the United States, following them from before birth until age 21. The goal is to improve the health and well-being of children.

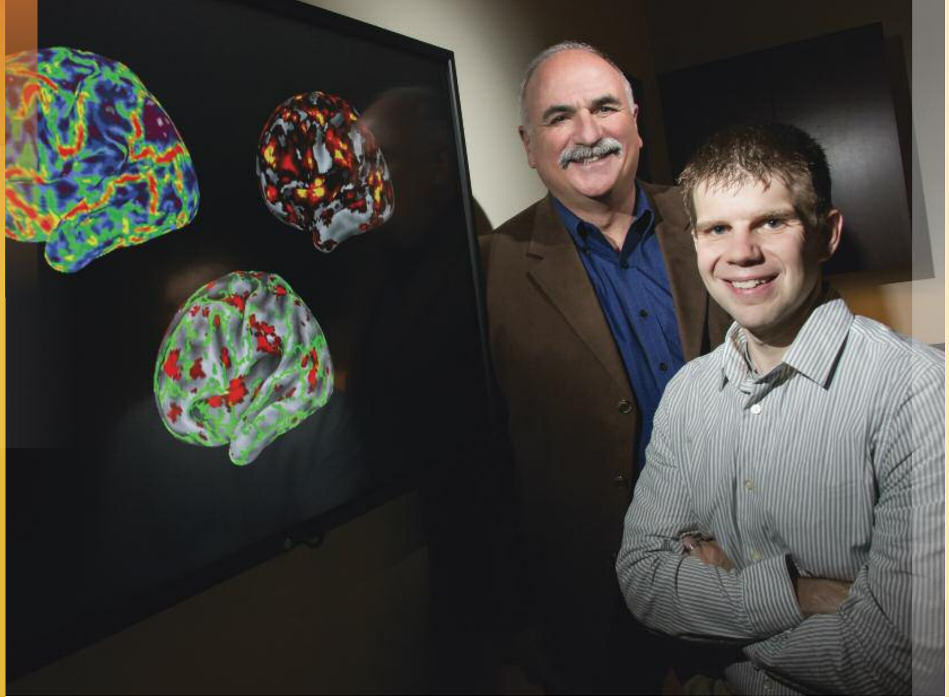
"The plan is to look at all sorts of environmental exposures, but also other things like social factors and other environmental factors and how these things affect the growth and development of children," said Schantz. "In particular for some rare diseases, like certain types of childhood cancers, you really need a large sample size to understand them."

Research done at the Illinois center could help to inform the national study.

"The Children's Centers are conducting smaller studies around the country on various types of exposures and using different approaches," said Schantz. "But we've learned a lot about what works, what doesn't work, and factors that are important to consider, so there's been an effort over time to use lessons we've learned in the Children's Centers to help inform the National Children's Study."

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). In the past year, research in BioIntel looked at creating tiny bio-hybrid machines, how genes influence the brain's recovery after a traumatic brain injury, and how gestures can affect memory.



Neal Cohen, left, and Jim Monti, right, are finding better ways to diagnose Alzheimer's disease.

Cognitive Test Can Differentiate Between Alzheimer's and Normal Aging

Memory impairments and other early symptoms of Alzheimer's are often difficult to differentiate from the effects of normal aging, making it hard for doctors to recommend treatment for those affected until the disease has progressed substantially.

Previous studies have shown that a part of the brain called the hippocampus is important to relational memory—the "ability to bind together various items of an event," said **Jim Monti**, a postdoctoral research associate who led the work with **Neal Cohen**. Being able to connect a person's name with his or her face is one example of relational memory. These two pieces of information are stored in different parts of the brain, but the hippocampus "binds" them so that the next time you see that person, you remember his or her name, Monti said.

Participants were shown a circle divided into three parts, each having a unique design. Similar to the process of name-and-face binding, the hippocampus works to bind these three pieces of the circle together. After the participants studied a circle, they would pick its exact match from a series of 10 circles, presented one at a time.

People with very mild Alzheimer's disease did worse overall on the task than those in the healthy aging group, who, in turn, did worse than a group of young adults. The task also revealed an additional memory impairment unique to those with very mild Alzheimer's disease, indicating the changes in cognition that result from Alzheimer's are qualitatively different than in healthy aging. This unique impairment allows researchers to statistically differentiate between those who did and those who did not have Alzheimer's more accurately than some of the classical tests used for Alzheimer's diagnosis.

The Relationship Between Memory and Gestures

Gesturing is not just a habit or a reflex. According to researchers, gesturing can help us remember things.

Kara Federmeier and **Duane Watson** led a study that recruited 50 undergraduates to complete a number of tests. Some of the tests investigated vocabulary, while others tapped into verbal working memory—the ability to hold, shift, and tweak words in our minds. Then the students watched a sequence of short *Tom and Jerry* cartoon clips, pausing after each to describe what had taken place.

Students with poorer verbal working memory (though not a poorer vocabulary) tended to gesture more frequently when recounting the clips. The researchers hypothesize that gestures may help us organize our thoughts, perhaps by "chunking" or otherwise guiding them into more easily processed units. When speech planning gets hairy, gestures usher in efficiency, sparing us resources to retrieve a word from the deepest reaches of memory, or avoid a grammatical speech error, or simply put things as eloquently as we'd like.

The theory offers a nice explanation for why we gesture more when speaking is difficult, and why people with shorter working memory spans might generally gesture more to compensate.

It's Better to Give than to Receive

Eva Telzer and her colleagues found that adolescents who get pleasure from pro-social activities are less likely to become depressed.

The study found that 15- and 16-year-olds who find pleasure in pro-social activities, such as giving their money to family members, are less likely to become depressed than those who get a bigger thrill from taking risks or keeping the money for themselves.

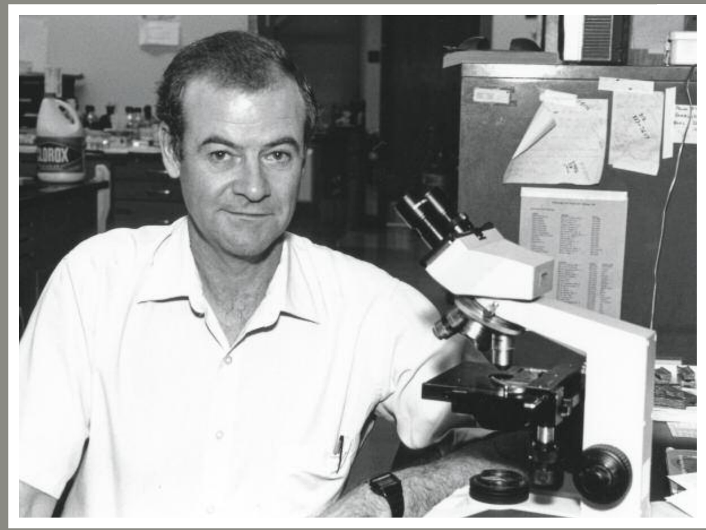
The study focused on the ventral striatum, a brain region that regulates feelings of pleasure in response to rewards. Previous research has shown that ventral striatum activity tends to be more pronounced in adolescence, suggesting that people at this age experience the pleasure of rewards more intensely than younger children or adults.

Adolescence also is a time of heightened risk-taking, which may be related to young people's increased sensitivity to rewards, said Telzer (below), who led the research.

Depressive symptoms also tend to increase during this time, she said.

Using a functional brain scan, the researchers measured ventral striatum activity in adolescents who engaged in tasks that involved either giving money to others, keeping the money, or making risky financial decisions in the hope of earning a reward. The team tested the subjects' depressive symptoms initially and at the end of a year.

The researchers found that activity in the ventral striatum in response to different rewards predicted whether the subjects' depressive symptoms would worsen—or lessen—over time.



Greenough Leads Field in Neuroplasticity

William "Bill" Greenough was one of Beckman's original faculty members in a program that, in 1989, was named Neuronal Pattern Analysis. That program was the foundation for the current Biological Intelligence research theme.

Greenough, who died in December 2013, was a pioneer in the field of neuroplasticity—the concept that the brain continues to change and adapt over a lifetime. He was a leader in changing scientific thinking when it comes to nervous system development and the brain. Greenough helped take the concept of brain plasticity from theory to experimental proof to accepted science.

That change in perspective has paved the way for entire research lines about how exercise, task performance, and other factors can affect the physiology of the brain as new neurons and synapses are formed throughout the lifespan. The theory of brain plasticity was to become a hallmark of psychology research at the University of Illinois and the Beckman Institute, helping to lay the groundwork for more specific lines of research that followed over the years, such as those involving the cognitive benefits of exercise.

In addition, BioIntel's other original co-chair, **Marie Banich**, was a leader in studying the neurological bases of attention function. Together, Greenough and Banich led the formation of the theme, which included current BioIntel co-chairs **Jennifer Cole** and **Mark Nelson** from the start.

Making Unhappy Memories Happy

Researchers at the Beckman Institute, led by **Florin Dolcos**, studied the behavioral and neural mechanisms of focusing away from emotion during recollection of personal emotional memories, and found that thinking about the contextual elements of the memories significantly reduced their emotional impact.

"Sometimes we dwell on how sad, embarrassed, or hurt we felt during an event, and that makes us feel worse and worse. This is what happens in clinical depression—ruminating on the negative aspects of a memory," Dolcos said. "But we found that instead of thinking about your emotions during a negative memory, looking away from the worst emotions and thinking about the context, like a friend who was there, what the weather was like, or anything else non-emotional that was part of the memory, will rather effortlessly take your mind away from the unwanted emotions associated with that memory."

This simple strategy, the study suggests, is a promising alternative to other emotion-regulation strategies, like suppression or reappraisal. Not only does this strategy allow for effective short-term emotion regulation, but it has the possibility of lessening the severity of a negative memory with prolonged use.

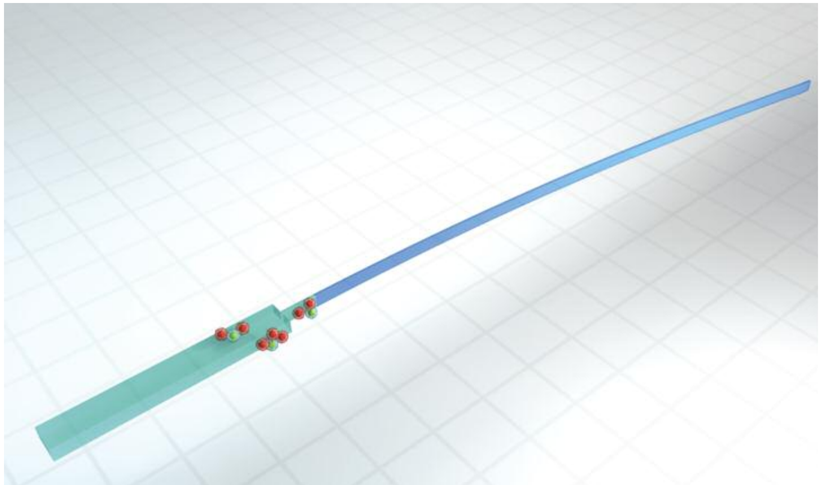
Creating a Tiny Robot that Swims

A team of engineers, led by **Taher Saif**, has developed a class of tiny bio-hybrid machines that swim like sperm, the first synthetic structures that can traverse the viscous fluids of biological environments on their own.

The bio-bots are modeled after single-celled creatures with long tails called flagella—for example, sperm. The researchers begin by creating the body of the bio-bot from a flexible polymer. Then they culture heart cells near the junction of the head and the tail. The cells self-align and synchronize to beat together, sending a wave down the tail that propels the bio-bot forward.

This self-organization is a remarkable emergent phenomenon, Saif said, and how the cells communicate with each other on the flexible polymer tail is yet to be fully understood. But the cells must beat together, in the right direction, for the tail to move.

The team also built two-tailed bots, which they found can swim even faster. Multiple tails open up the possibility of navigation. The researchers envision future bots that could sense chemicals or light and navigate toward a target for medical or environmental applications.



Researchers, led by Taher Saif, developed tiny, synthetic machines that can swim by themselves, powered by beating heart cells.

Photo by Alex Jerez Roman, Beckman Institute for Advanced Science and Technology

Thinking Better after Exercise

Justin Rhodes (above) reported in *Scientific American* why taking an afternoon stroll may help with our thought processes. A growing body of evidence suggests we think and learn better when we walk or do another form of exercise.

Research shows that when we exercise, blood pressure, and blood flow increase everywhere in the body, including the brain. More blood means more energy and oxygen, which makes our brain perform better.

Another explanation for why working up a sweat enhances our mental capacity is that the hippocampus, a part of the brain critical for learning and memory, is highly active during exercise. When the neurons in the hippocampus are active, research shows that our cognitive function improves. Earlier studies in mice have revealed that running enhances spatial learning. Other recent work indicates that aerobic exercise can actually reverse hippocampal shrinkage, which occurs naturally with age, and can consequently boost memory in older adults. Yet another study found that students who exercise perform better on tests than their less athletic peers.

The big question of why we evolved to get a mental boost from a trip to the gym, however, remains unanswered.

One Gene Influences Recovery from Traumatic Brain Injury

An important contributor to recovery from traumatic brain injury (TBI) is an individual's genetic predisposition. Having a "good" or "bad" variant of a gene can predispose an individual to a better or worse outcome following TBI. A study led by **Aron Barbey** (below) has highlighted the contribution that genetic predisposition plays in determining general intelligence following TBI.

The study measured TBI outcomes in 156 Vietnam veterans who suffered penetrating head injuries. All study participants had damage to the prefrontal cortex, a brain region that is critical for general intelligence.

Barbey's research group controlled for the size and location of subjects' brain injuries, in addition to intelligence level prior to injury. The researchers investigated whether general intelligence following brain injury was predicted by a gene known to play an important role in neural plasticity, called brain-derived neurotrophic factor (BDNF). The researchers found that a single polymorphism (a difference in one "letter" of the sequence) in the BDNF gene accounted for significant differences in intelligence following brain injury (among those with similar injuries and comparable intelligence before being injured). The findings reveal genetic factors that predict cognitive outcome following TBI and help to identify potential targets for rehabilitation, Barbey said.

HUMAN-COMPUTER INTELLIGENT INTERACTION (HCII)

Thomas Huang is one of the few remaining Beckman originals. He played a significant role in the preliminary building committees, and, when the doors opened in 1989, Huang eagerly moved his lab to Beckman, forming the Image Formation and Processing Group.

"There was definitely a need for the Beckman Institute. Problems were becoming more and more complicated in society, so it seemed necessary to have an interdisciplinary approach," Huang said. "It really makes a difference when you get people physically together versus just remotely collaborating—work gets done."

Huang's career represents the interdisciplinary nature of the Institute. As an educator, mentor, and researcher, he has been awarded the highest recognition in three distinct fields: signal processing, pattern recognition, and computer vision—an enormous accomplishment, demonstrating his commitment to interdisciplinary research.

"This is an amazing aspect of his research," said Zhi-Pei Liang, a co-chair of Integrative Imaging who has worked with Huang for many years. "Most researchers are happy to get to the top of a narrow field, but Tom has impacted three areas. That shows how influential his career has been."

In addition to his research accomplishments, Huang has also mentored more than 100 Ph.D. students in his career.

"The one thing I have found over the years is—whatever I have accomplished, it's entirely due to my students, so my career has really been the blessing of great students," Huang said. "Mentoring students is the accomplishment I am most proud of. That's one of the reasons I chose teaching as a career. I do research, I teach, but even if I don't do well in research, I'm always educating students."

His care for his students has not gone unnoticed. This past year, two Beckman student researchers were awarded the inaugural Thomas and Margaret Huang Award for Graduate Research, which was established by Huang's former students James J. Kuch and Chang Wen Chen. The award honors the contributions Huang and his wife, Margaret, have made to science, engineering, and society at large.

"He is an inspiration to his students, not only through his lifetime achievement and his contributions to science, but also how he brings so much passion, energy, and creativity to the work," Liang said. "He is a role model to many of us, and his work has impacted our society significantly, far beyond his papers, his books, and his many prestigious awards indicate."

Huang's career has spanned three major universities. He received his Doctor of Science (Sc.D.) in 1963 from MIT, and then stayed at MIT as a faculty member for 10 years. In 1973 he moved to Purdue for seven years, and then moved to the University of Illinois in 1980.

"My original intention was to stay in one place for about 10 years and then move to another place to avoid becoming stale, but then I was trapped here by the Beckman Institute," Huang said, with a laugh. "The environment here was too good—I couldn't possibly move anywhere else."

Throughout his career, Huang has made a wide range of pioneering and fundamental contributions to image and signal processing, pattern recognition, computer vision, multimedia, and human-computer interface. He has contributed to 21 books, more than 600 journal and conference papers, and has been elected to the National Academy of Engineering (USA), Chinese Academy of Engineering, Chinese Academy of Sciences, and Academia Sinica (Taiwan).

Huang's visionary work early on in his career helped shape current practices in imaging. Before Huang's work, there were very few ways to store an image: photographic negatives and video cassettes. His work was instrumental in developing compression standards for CDs, for example.

"Because of Tom's pioneering work, there are now a seemingly endless numbers of ways to capture, store, and share images," Liang said. "He has contributed more than anyone else to the technical underpinning of current international fax, image, and video compression standards. Without these standards, it simply would not be possible for us to store and transmit the huge amounts of multimedia data that all of us encounter on a daily basis."

In pattern recognition and computer vision, Huang's contribution when he first came to the U of I was his creative formulation and solution of the problems of 3D motion estimation from 2D image sequences, a long-standing problem in the field at the time. 3D motion estimation has had many important applications, including navigation and orientation in the 3D world, video coding, and object tracking. Recent advances in 3D urban modeling programs, such as Google's StreetView, have foundations in Huang's work in the 1980s and 1990s.

His paper titled "Image Retrieval: Current Techniques, Promising Directions, and Open Issues" in the *Journal of Visual Communication and Image Representation,* received the "Most Cited Paper of the Decade Award" in 2010. It has been cited 564 times by other articles in the journal and more than 1,000 times in Google Scholar since first appearing in 1999.

Huang continues to build collaborations and develop research projects across a wide spectrum at Beckman.

"We are concentrating on three areas right now: big data, deep neural net learning, and high-performance computing, and the three seem to come together," Huang said.

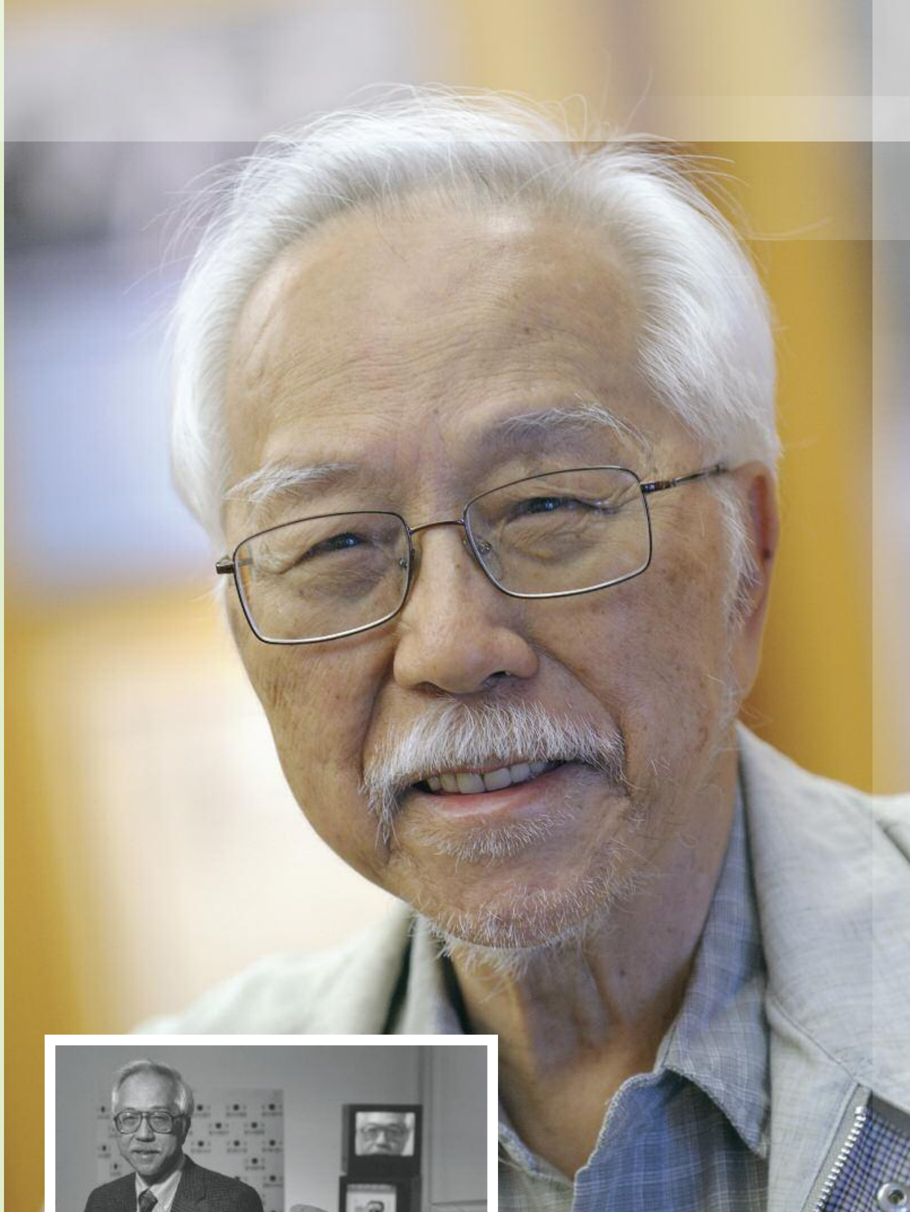
One of the projects he and his students are working on is focusing on the human-computer interface, especially in emotional recognition in education and learning. They're working to build algorithms that can read the emotions of people through their facial expressions, as well as tell their age, ethnicity, and gender. This tool could be effective in online learning environments.

"We're developing a framework to create a responsive, real-time online education experience," said Huang. "If you have an online computer learning system where the computer is interacting with the students, what the computer does should be based on the emotion and cognitive state of the student. We're trying to estimate that by using noninvasive methods—so by the facial expressions picked up by a webcam on the computer, for example."

If the student uses a computer as a tutor, this real-time feedback would allow the computer, at each interchange, to decide what to say next, with this decision based on the state of the student—not just what the student is saying, but how the student looks: puzzled, bored, etc.

Despite all the success he's had in his five decades of research, Huang remains a humble leader within the Beckman Institute, the University of Illinois, and society at large.

"His technical accomplishments are extraordinary, his impact on the field is amazing, but he is an even better person and colleague," Liang said. "He is an enormous strength to this institution."



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Thomas Huang

BECKMAN SCRAPBOOK

As a Beckman original, Thomas Huang has shaped the history of the Beckman Institute and been a leader in the fields of signal processing, pattern recognition, and computer vision. Left, Huang circa 2000.

Looking Forward

"The biggest change in the last 25 years (mostly in the last five years) in my research is the emergence of the triad: big data, deep learning, and high-performance computing. Ours is the age of big data, which is characterized by the 3V model: volume, variety, and velocity.

"The approach of deep learning, especially deep neural networks (DNN), appears very effective for analyzing big data. On the other hand, the training of DNN requires huge amounts of data, which could be provided by big data available on the web.

"All this is impossible without high-performance computing, since high data volume and rapid rate of change make big data analysis extremely computationally intensive. Thus, the triad of big data, deep learning, and high-performance computing are truly made for each other.

"I foresee that the future of my field will continue to be shaped by these three areas. Additionally, in the next 25 years, my prediction and hope is that there will be large-scale collaborative research linking closely neuroscience and machine learning, leading to a deep understanding of how the human brain works in processing and understanding multimodal data."

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.

Childhood Fitness and Obesity Affect Cognitive Function

As the rate of childhood obesity becomes a more pressing problem, a growing amount of evidence shows that getting aerobic exercise can help students with a variety of cognitive tasks.

A study of students ages 9 and 10 showed that those with higher levels of physical fitness performed better on mental tests. The researchers, led by **Charles Hillman** and **Art Kramer**, had the kids memorize names and locations on a map of a made-up region. Students in the top 30 percent of their age group for aerobic fitness were better able to learn and recall the fictitious names and locations than those in the lowest 30 percent for aerobic fitness.

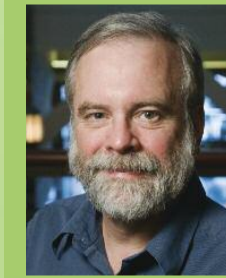
Research from Hillman's lab also found that obese children are slower than healthy-weight children to recognize when they have made an error and correct it. The research is the first to show that weight status not only affects how quickly children react to stimuli but also relates to the level of activity that occurs in the cerebral cortex during action monitoring.

"I like to explain action monitoring this way: When you're typing, you don't have to be looking at your keyboard or your screen to realize that you've made a keystroke error. That's because action monitoring is occurring in your brain's prefrontal cortex," said Hillman.

In the study, preadolescent children were asked to determine the direction a fish was facing, with surrounding fish either pointing the same direction or the opposite direction, which either facilitated or hindered their ability to respond correctly, respectively.

"We found that obese children were considerably slower to respond to stimuli, and they also were less accurate following an error than healthy-weight children," Hillman said.

Exercise and Brain Health Closely Linked

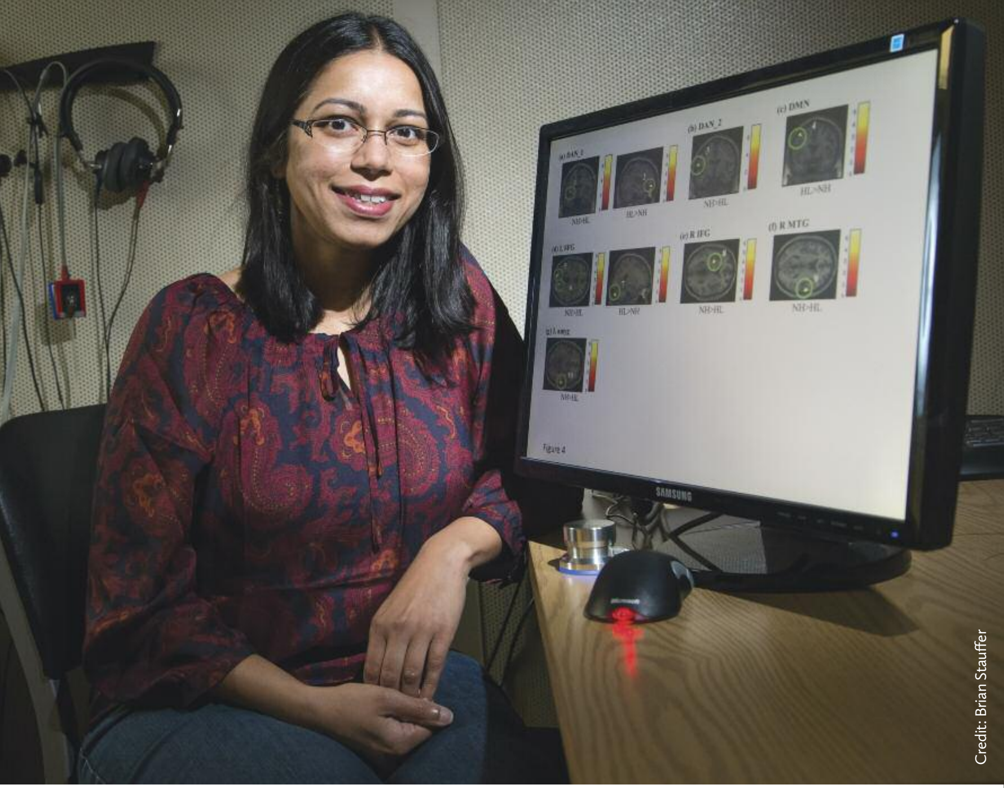


Increasing exercise levels can improve many aspects of brain health, as evidenced by a number of studies at the Beckman Institute and other universities. These have found that exercise and physical activity can reduce the risk of dementia such as Alzheimer's disease by 30 to 40 percent, says **Art Kramer**. Beckman researchers have found that exercise can increase the size of the hippocampus, a region of the brain important for a number of aspects of memory, in a group of older participants.

Exercise also stimulates BDNF production, according to Kramer. BDNF, or brain-derived neurotrophic factor, is produced in a number of regions of the brain and body, and is one of a series of protein molecules that stimulate cellular growth.

Studies by Kramer, in collaboration with Beckman faculty members **Edward McAuley** and **Charles Hillman**, demonstrated that walking three times a week for 40 minutes at one's natural pace is enough to help combat the effects of aging and increases brain connectivity and cognitive performance. Even for people who have been very sedentary, Kramer says, exercise "improves cognition and helps people perform better on things like planning, scheduling, multitasking, and working memory."

In addition to exercise, there are other ways to improve brain function. Kramer says learning a new skill, like a new language, dancing, or quilting, appears to enhance brain function and help with memory loss.



Credit: Brian Stauffer

People with Tinnitus Process Emotions Differently than Their Peers

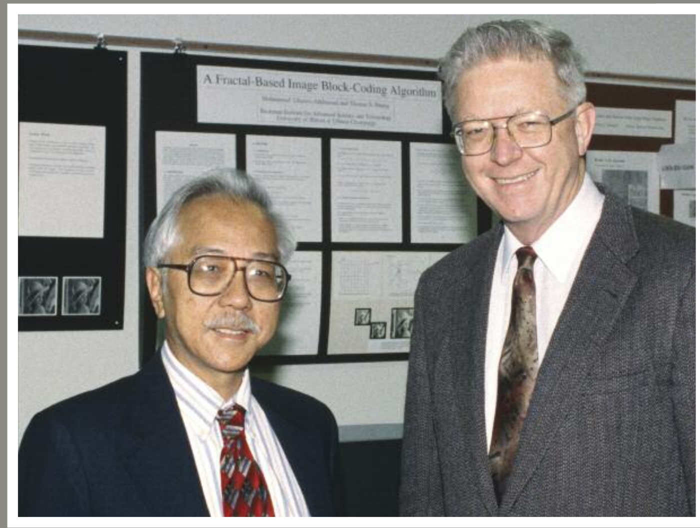
Fatima Husain and her colleagues found that people with tinnitus, a condition in which a person hears a ringing sound despite the lack of an actual sound, process emotions in a different part of the brain than those without the condition.

Husain (above) said previous studies showed that tinnitus is associated with increased stress, anxiety, irritability, and depression, all of which are affiliated with the brain's emotional processing systems.

"Obviously, when you hear annoying noises constantly that you can't control, it may affect your emotional processing systems," Husain said.

When listening to a variety of pleasant, unpleasant, and emotionally neutral sounds, activity in the amygdala, a brain region associated with emotional processing, was lower in the tinnitus and hearing-loss patients than in people with normal hearing. Tinnitus patients also showed more activity than normal-hearing people in two other brain regions associated with emotion, the parahippocampus and the insula. The findings surprised Husain.

"We thought that because people with tinnitus constantly hear a bothersome, unpleasant stimulus, they would have an even higher amount of activity in the amygdala when hearing emotional sounds, but it was lesser," she said. "Because they've had to adjust to the tinnitus sound, some plasticity in the brain has occurred. They have had to reduce amygdalar activity and reroute it to other parts of the brain, perhaps because the amygdala cannot be active all the time due to this annoying sound."



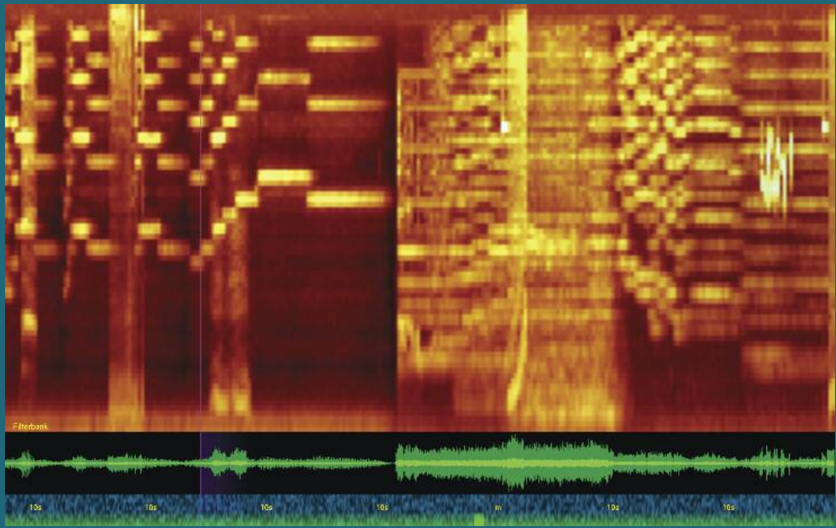
Thomas Huang (left), and George McConkie (right), the original co-chairs of HCII.

McConkie Integral to Origins of Human Perception and Performance Group

The roots of the Human Perception and Performance Group can be traced back to researchers working in a diverse set of fields and research areas. Many were faculty from the Department of Psychology, with longtime research lines in areas relating to human factors research, such as aviation. Others have had success in groundbreaking studies involving distracted driving and the cognitive benefits of interventions such as exercise.

George McConkie, the first co-chair with **Thomas Huang** of HCII, was a faculty member from the Department of Educational Psychology who bridged many of these areas and was a pioneer in using technology, particularly eye-tracking, to measure performance. McConkie's interests in cognitive psychology and visual perception, with a focus on how people acquire and perceive visual information from displays, made him a key part of collaborations involving human factors.

McConkie teamed with Beckman Director **Art Kramer** and faculty member **Christopher Wickens** in the 1990s to study human navigation using 2D and 3D visualization tools for assessments of human attention and perception. He also was part of a large cross-disciplinary effort aimed at improving the human-computer interface by recognizing the user's emotional state, developing different interactional styles for the computer, and new ways to interact with the Internet.



The Timeliner sorts through audio recordings and indicates unusual sounds with visual cues. This spectrogram displays readings from an orchestral piece. The Timeliner (orange lines) interprets the recording (bottom, green display), and marks unusual sounds. In this recording, the unusual sounds of a video game, a robin chirping, and a bell dinging are shown by the bright white dot in the middle, the white squiggle at right, and the white dot at extreme right, respectively.

Studies Determine What Sounds Draw Human Attention

It sounds like a tricky riddle. If you have an eight-hour recording, and you want to know how many unusual noises are on it, how long will it take you to find out?

Eight hours, right?

Not exactly. With a new computer program developed with the help of **Mark Hasegawa-Johnson** and **Thomas Huang**, humans can now easily sort through long recordings while quickly picking out sounds that don't belong.

Hasegawa-Johnson and Huang devised a way to study what sounds grab human attention, which hadn't been studied previously. Hasegawa-Johnson and his research group used those results, as well as Huang's research on what grabs human attention visually, to create a tool for humans to easily and quickly find unusual sounds in recordings.

With this technology, Hasegawa-Johnson and his students helped Camille Goudeseune, a computer systems analyst at Beckman's Illinois Simulator Laboratory, build software called Timeliner, which sorts through hours of recordings and indicates unusual sounds with spikes of orange lines.

Hasegawa-Johnson said he wants to use this research to improve speech recognition algorithms, with the ultimate goal of allowing humans to pick out acoustically notable changes in audio for quick transcription.

Computer Creates Optimal Flavor Combinations

One of **Lav Varshney**'s recent research projects was to test if a human trait—creativity—can be encoded on a computer. The results were some tasty and unique flavor combinations.

In a project with IBM, Varshney created a computer system that chooses the ingredients for recipes. The combination of ingredients may not make sense to humans, but the computer system bases the mixtures on the molecular structure of the chemicals involved. The algorithm Varshney created draws on data from hedonic psychophysics, or a quantification of whether people like certain flavor compounds at the molecular level, and the chemistry of food.

For example, black pepper, saffron, and cocoa powder in a dessert may not sound like an obvious combination, but this is one of the creative concoctions the software program produced.

In the future, Varshney is envisioning several practical uses. Personalized web applications could offer recipe recommendations based on a person's medical needs and flavor preferences. School lunches could be optimized for kids' palates, making healthy options good tasting options as well. Finally, the computer could create recipes that will automatically adapt to incorporate local, seasonal ingredients, making agriculture more sustainable.

"In five years, computers will know what you like to eat better than you do," Varshney said.

Further work in understanding flavor has Varshney investigating ways to create food combinations that cancel out unpleasant smells from food (e.g., sauerkraut) or recipes that hide the flavor of a disliked food in a flavorful food, so that the disliked food can no longer be tasted (a promising solution for picky eaters).

Varshney is also looking at other potential domains for computational creativity, such as an algorithm that creates custom travel itineraries, fashion ensembles, or even scientific ideas.

Credit: IBM

Lav Varshney has created an algorithm that formulates recipes maximized for pleasantness. A computer concocted the recipe for this Ecuadorian strawberry dessert, recommending it be made with strawberries, confectioner's sugar, salt, black pepper, lemon, lime, heavy cream, whole milk yogurt, dry yeast, flour, canola oil, eggs, peanuts, and cocoa powder.

Making Reality out of Virtual Reality

Steve LaValle has been collaborating with Oculus VR, the company that created the virtual reality goggles called the Rift. The Oculus Rift looks somewhat like an over-sized pair of ski goggles, and, when worn, users enter a completely immersive virtual world. LaValle is working with Oculus to make the user forget the goggles exist at all. When the user turns slightly, to peer around the corner of a virtual building, the view, which is displayed on two lenses inside the device, should shift naturally.

LaValle's team is using an array of relatively new devices—particularly micromachined gyroscopes, accelerometers, and infrared LEDs—to track the movement of the head in order to create this seamless virtual environment.

"Thanks to these modern sensors, we can predict where the head will be to within a few milliseconds," LaValle said. "We end up with very responsive head-tracking from that."

Researchers in HCII, under the direction of Art Kramer, are also developing means to use the Oculus Rift in cognitive training. According to the researchers, an immersive virtual space could make cognitive training more effective and engaging. Virtual reality has always been expensive and complicated, but the low price of the Oculus Rift headset makes it possible to create immersive virtual experiences at very low cost.

One experiment, called the Holodeck Project, is incorporating haptic gloves with built-in vibration feedback. Motion sensors determine when a user "touches" an object in the virtual world and make it possible to feel such virtual objects. A new omni-directional treadmill will allow a user to explore the virtual world. By combining these emerging technologies, researchers hope to create a convincing 3D virtual reality environment (a "holodeck") that runs off of a laptop computer.

Steve LaValle has provided an Oculus Rift to Beckman researchers in order to create virtual research environments.

Staying Healthy as Population Ages

The science of aging is a relatively new field, and it will only grow as the world's population continues to live longer. Research in the Adult Learning Lab, led by **Elizabeth Stine-Morrow**, focuses on adult age differences in learning and language process, with a goal of learning how to age well.

"We don't know how to be old because old age is relatively young. It's something new to us," said Stine-Morrow. "A century ago, the average life span was 45 or 50 years and 4 to 5 percent of the population was over 65," she said. "By 2050, it's going to be over a fifth of the population."

Stine-Morrow and her lab lead a program called Senior Odyssey, which aims to promote cognitive health and well-being in adults age 60 or over through participation in creative, problem-solving activities. They lead small groups of older adults who get together to engage in puzzles, brainteasers, and other creative problems.

The increase in mental engagement from these sessions has proven to be very helpful in boosting cognition in the older adults. Additionally, engagement was found to increase their openness to new experiences, researchers report, demonstrating that a non-drug intervention in older adults can change a personality trait once thought to be fixed throughout the lifespan.

PROFILE OF ZHI-PEI LIANG

INTEGRATIVE IMAGING (INTIM)

Zhi-Pei Liang, a co-chair of the Beckman Institute's Integrative Imaging research theme and Franklin W. Woeltge Professor of Electrical and Computer Engineering, is a world-class expert in magnetic resonance imaging (MRI). After receiving his Ph.D. in biomedical engineering from Case Western Reserve University in 1989, he was recruited to the University of Illinois by the inventor of MRI, the late Nobel Laureate Paul Lauterbur, who was Liang's mentor, close friend, and colleague for almost 20 years.

Liang became interested in MRI when he was a graduate student at Case Western Reserve University, after attending a lecture given by Lauterbur. He was amazed by the capabilities and potential of MRI and decided to pursue his Ph.D. thesis research in this area.

"Paul had the strongest influence on me, my research, and my approach to pursuing scientific dreams," said Liang.

Liang describes his research in this way: "Nuclear spins are one of the most interesting quantum-mechanical systems. Using the signals generated from these systems, MRI has revolutionized biology and medicine over the last three decades. However, current MRI technology has not yet fully exploited the potential of the nuclear magnetic resonance phenomenon to unravel the mysteries of biology and life. Our goal has been to develop new generations of MRI technology to provide unprecedented capabilities for structural, physiological, and functional imaging."

Liang's group has made key contributions to the theory, algorithms, and biomedical applications of model-based MRI. His group is one of the very few in the world that can tackle MRI problems in domains ranging from physics (quantum mechanics and electromagnetics) to signal processing (image reconstruction and machine learning).

"As Abraham Maslow put it, 'If the only tool you have is a hammer, you tend to treat everything as it were a nail.' Our students are well trained in spin physics, engineering, and signal processing, and we have been able to tackle MRI problems from end to end," Liang said.

Liang's research approach has been very fruitful. For example, in tackling the problems of real-time cardiac imaging, Liang and his students used MR physics and signal processing theory to develop a new imaging technique based on the theory of partially separable functions. Their technique can produce high-quality cardiac images from a very small number of measurements, making four-dimensional cardiac imaging possible. This work has resulted in two best paper awards and one NIH R01 grant. Recently, Liang's group has made another major research breakthrough: molecular imaging using intrinsic NMR signals. Their technology is expected to have a profound impact on the field.

"It is exciting," Liang said. "Molecular imaging has been a dream of imaging scientists for decades. Governments and industries have invested billions in this area. However, most existing techniques have to inject molecular probes and molecular reporters into the subject to get molecular information, so their research and clinical applications have been rather limited. Our technique can be a major step forward to change all of that."

The University is applying for a patent for Liang's new technology.

Research from Liang's group has been recognized by numerous prestigious awards, including the Sylvia Sorkin Greenfield Award, I.I. Rabi Award, IEEE-ISBI 2010 Best Paper Award, IEEE-EMBC 2010 Best Paper Award, IEEE-EMBC 2011 Best Paper Award, the Otto Schmitt Award from the International Federation for Medical and Biological Engineering in 2012, and a Technical Achievement Award from the IEEE Engineering in Medicine and Biology Society in 2014. Liang is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), the International Society for Magnetic Resonance in Medicine (ISMRM), and American Institute for Medical and Biological Engineering (AIMBE). He was elected to the International Academy of Medical and Biological Engineering in 2012.

Liang said his accomplishments are due in large part to the outstanding academic environment at Illinois and particularly the Beckman Institute.

"My research is very interdisciplinary, which fits well with the Beckman academic culture," said Liang. "I also have wonderful colleagues and top-notch students here. It is an honor and privilege to be a member of this great Institute. Illinois is a fantastic place for doing NMR and MRI work. Pioneering work such as the discovery of spin echoes and the discovery of Overhauser effect was done here, which is very inspiring!"

The Integrative Imaging research theme was created at the Beckman Institute just over five years ago.

"The creation of this theme has further enhanced the outstanding research infrastructure and environment in imaging," Liang said.

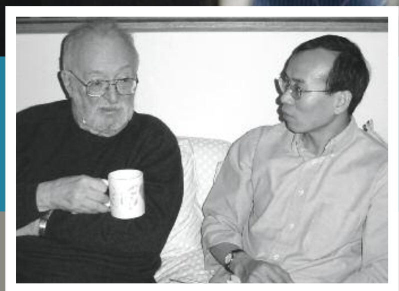
Looking forward, Liang thinks the best time for biomedical imaging is still ahead.

"Biomedical imaging has been around for more than 100 years since the discovery of the x-ray by Rontgen in 1895. We have witnessed unbelievable progress in biomedical imaging science and technology, which have had tremendous scientific, medical, and societal impacts," Liang said. "Imaging technology has been traditionally focused on capturing biological anatomical information, but if a disease has already progressed to the level that you can see structural changes, that's perhaps too late. Next-generation imaging technologies will provide new imaging capabilities to enable physiological and biochemical imaging in high resolution so that we can effectively characterize the physiological states of a biological system and thus detect or predict a disease at very early stages.

"Achieving this goal could fundamentally affect the way we perform health care as we don't have to treat a biological system as having only two states: normal or diseased."

Beckman researchers are poised to bring next-generation imaging technologies into being.

"Illinois has one of the most comprehensive imaging programs, covering imaging modalities from MRI, optical imaging, ultrasound imaging, to nuclear imaging," said Liang. "More importantly, we have people here working on imaging physics, mathematics, computation, machine learning, and biomedical applications under one roof. Their synergistic interactions will sooner or later lead to breakthroughs unobtainable by disciplinary research."



Nobel Laureate Paul Lauterbur (left) served as a mentor to Zhi-Pei Liang. Photo circa 2004.

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BECKMAN SCRAPBOOK

Zhi-Pei Liang

Looking Forward

"Scientific curiosities and wars (yes, wars) have been the drivers for scientific research and technology developments for the entire human history," said Liang. "Now, our society is confronting major challenges of human health and health care. For the coming decades, I believe, addressing health and healthcare problems will be a key driving force for science and technological development."

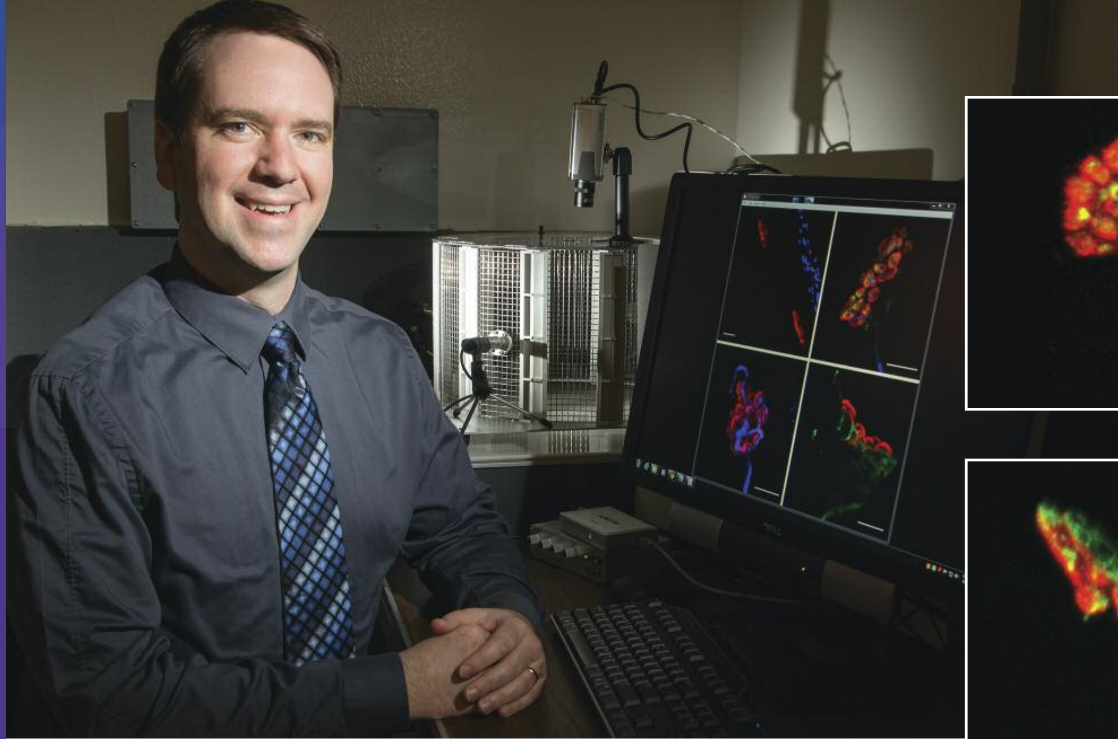
MRI technology development will continue to be a major focus, but MR will work in concert with other technologies and other fields. Imaging technology breakthroughs are no longer component based, according to Liang, but require an integrated approach to technology innovations.

"For many decades, imaging technology development has been following a similar model: first, a physical phenomenon was discovered, then imaging technology was developed, and then biomedical applications followed. Such a technology innovation model does not apply to today's imaging research because, as far as imaging physics is concerned, no fundamental discoveries can be expected —everything from gamma rays to radio waves is known. However, imaging research is not a mature field; revolutionary imaging technologies can still be and will be developed to solve health and healthcare problems."

According to Liang, next-generation MRI technology will come from the effective, innovative application and integration of quantum mechanics, electromagnetics, computing, signal processing, and biology.

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 Integrative Imaging is divided into two groups, the Bioacoustics Research Laboratory (BRL) and the Bioimaging Science and Technology Group (BST). Their research efforts include those who are working to design and engineer new imaging instruments and methods as well as to optimize current techniques, those for whom imaging is an integral part of doing scientific research, and some who are engaged in both efforts. They 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.



Vocal Training Can Alleviate Atrophy in Larynx Muscles

A study shows that the vocal training of older rats reduces some of the voice problems related to aging.

Aaron Johnson, who led the new study along with colleagues at the University of Wisconsin, said that aging can cause the muscles of the larynx, the organ that contains the vocal folds, to atrophy. This condition, called presbyphonia, may be treatable with vocal training.

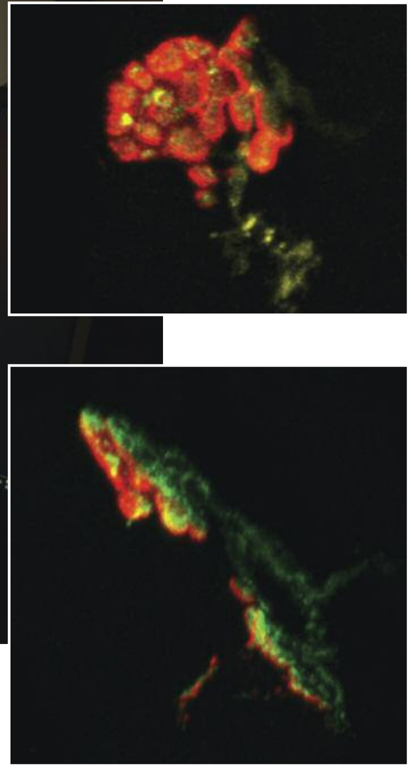
In a healthy, young larynx, the vocal folds completely close and open during vibration. In people with presbyphonia, however, the atrophied vocal folds do not close properly, resulting in a gap during vocal fold vibration and a breathy and/or weak voice quality.

Age-related degradation of the neuromuscular junction (NMJ), or the interface between the nerve that signals the vocal muscle to work and the muscle itself, contributes to muscle atrophy and the symptoms of presbyphonia by causing weakness and fatigue in the laryngeal muscles.

Because rats and humans utilize similar neuromuscular mechanisms to vocalize, rats make ideal subjects for studying the effects of age and vocal training on the nerves and muscles of the voice.

In this recent study, young and old male rats were either trained to increase their number of ultrasonic vocalizations or put into a non-trained control group. In the control group, researchers found age-related differences in both vocalizations and NMJs. However, vocal training ameliorated some of these differences, including vocal intensity and NMJ motor endplate dispersion.

This is the first study demonstrating an impact of vocal training on both vocalizations and underlying neuromuscular mechanisms.



Rat thyroarytenoid muscle, the main muscle of the vocal fold. The red stain is of the acetylcholine receptor clusters of the motor endplate on the post-synaptic side of the NMJ, and the yellow stain is the nerve terminal membrane on the pre-synaptic side of the NMJ.

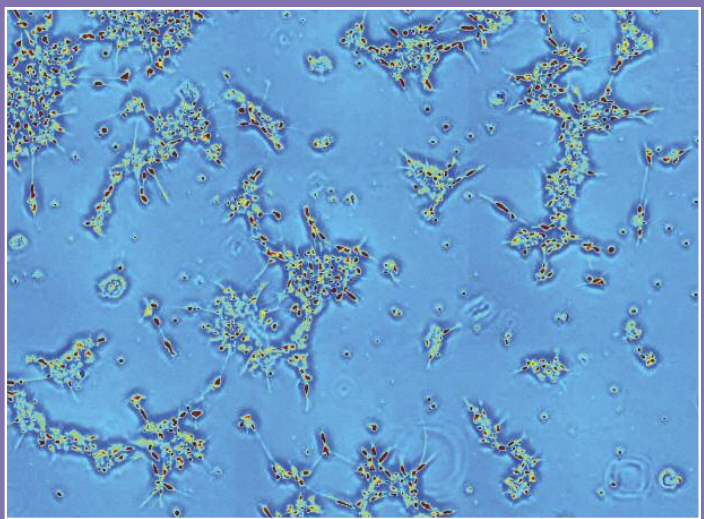
New Technique Shines Light on Human Neural Networks

Using spatial light interference microscopy (SLIM) techniques developed by Gabriel Popescu, director of the Quantitative Light Imaging Laboratory, researchers were able to show for the first time how human embryonic stem cell-derived neurons within a network grow, organize spatially, and dynamically transport materials to one another.

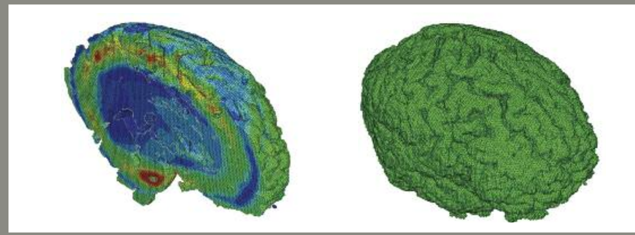
The SLIM technique measures the optical path length shift distribution, or the effective length of the path that light follows through the sample.

The study examines how the cells begin forming new connections, establishing a network. Once some connections have been made, the neurons divert attention from looking for more connections and begin to communicate with one another—exchanging materials and information. According to the researchers, the communication process begins after about 10 hours; for the first 10 hours the studies show that the main neuronal activity is dedicated to creating mass in the form of neural extensions or neurites, which allows them to extend their reach.

Popescu hopes that his work will help in building machines that can help with health-related questions, including Alzheimer's, memory-related conditions, and aging. The first step is to identify the deterministic behavior of the neural cells and discover treatments that enhance this predictable behavior.



Credit: Quantitative Light Imaging Laboratory



As reported in the 2008-09 annual report, Beckman researchers Martin Ostoja-Starzewski and Brad Sutton developed 3D finite element (FE) models for transient dynamic response of cranium and brain tissues. The image at left shows a frame taken at 6 ms that shows spherically convergent waves of von Mises stress on the brain. The image at right shows an FE mesh of the brain after eight smoothing iterations.

Latest Addition to Beckman Research Portfolio

Integrative Imaging became a research theme at the Beckman Institute in 2009. Although new to Beckman, research in the theme was happening in fields as diverse as neuroscience, biomedicine, and engineering.

Integrative Imaging is composed of two groups. The first, the Bioacoustics Research Lab, has its beginnings in 1946, immediately after World War II. William J. (Bill) Fry (1918-1968) along with his brother Francis J. (Frank) Fry (1920-2005) founded the laboratory, with a goal of studying the central nervous system with sufficient comprehensiveness to begin to understand intimate details of structure and function. William O'Brien and Michael Oelze contributed to early research with a project using high-intensity focused ultrasound as a cancer treatment.

The second group within IntIm, Bioimaging Science and Technology, is led by Michael Insana, who developed an optical technique using optical coherence tomography for noninvasive or minimally invasive detection of breast cancer while at the Beckman.

Other researchers include Scott Carney, who applies theory to the development of algorithms for improved signal performance, while Brad Sutton applies engineering applications to improve images, and Zhi-Pei Liang improves MRI signals, image processing, and pattern recognition.

Stephen Boppart, theme co-chair, works with optical coherence tomography (OCT), which has been developed to be a multipurpose tool for clinical diagnoses. Marni Boppart focuses on the impact of exercise on the body and whether exercise alone is enough to counteract age-related conditions. Rohit Bhargava pioneers infrared chemical imaging, and Kenneth Watkin's research combines chemistry with imaging to deliver therapeutic compounds for cancer treatment and diagnosis.

Ling-Jian Meng has a research focus on developing new nuclear imaging techniques such as sensors based on room temperature detectors, while Wawrzyniec Dobrucki has research interests in multimodal imaging and, particularly, imaging strategies for assessing angiogenesis in animal models for studies of disease. The work by other researchers in the theme is featured in this section.

Test for Disease-Causing Bacteria

A research team that included **Ken Suslick** (below) has helped develop a faster, simpler test for detecting the presence of disease-causing bacteria.

Disease-causing bacteria stink—literally—and the odor released by some of the nastiest microbes has become the basis for a faster and simpler new way to diagnose blood infections and identify the specific bacteria.

The new test produces results in 24 hours, compared to as much as 72 hours required for the test hospitals now use, and is suitable for use in developing countries and other areas that lack expensive equipment in hospital labs.

Sepsis, or blood poisoning, is a toxic response to blood-borne infections that kills more than 250,000 people each year in the United States alone. The domestic healthcare costs to treat sepsis exceed $20 billion. In such a medical emergency, every minute counts, and giving patients the right antibiotics and other treatment can save lives.

The device consists of a plastic bottle, small enough to fit in the palm of a hand, filled with nutrient solution for bacteria to grow. Attached to the inside is a chemical sensing array (CSA), an "artificial nose," with 36 pigment dots. The dots change color in response to signature odor chemicals released by bacteria.

A blood sample from a patient is injected into the bottle, which goes onto a simple shaker device to agitate the nutrient solution and encourage bacterial growth. Any bacteria present in the blood sample will grow and release a signature odor that changes the colors of pigment dots on the sensor. The test is complete within a day, and the results can be read in a pattern of color changes unique to each strain of bacteria.

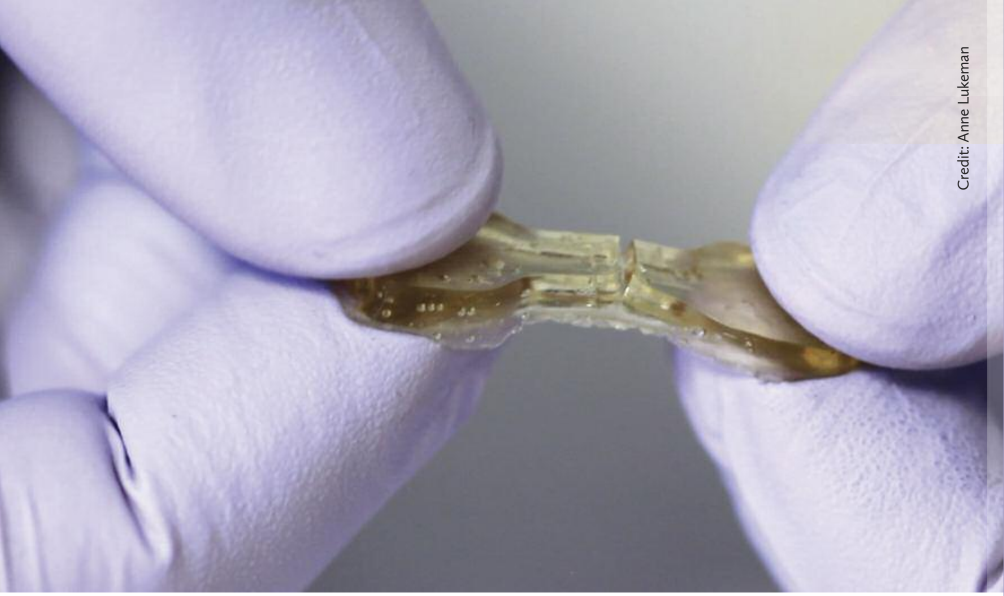
Scaffolds Heal Gaps in Bone

Two hundred and six bones in an adult human body make up the skeleton, one of the body's vital mechanical systems. **Amy Wagoner Johnson** is exploring the internal structure of bone itself.

Wagoner Johnson's main work with bone involves creating ceramic "scaffolds" to heal large gaps in bone. These gaps can occur either with serious trauma or the removal of diseased bone due to such diseases as osteoporosis or bone cancer.

"If the defect is too big, the bone won't bridge the defect on its own," Wagoner Johnson said. "So the idea is to put a scaffold in there that allows bone to grow in, called an osteoconductive structure. And there are factors that don't just allow the bone to grow in, but actually encourage it to do so, and so we try to figure out what kind of variables encourage bone formation."

There are a quite a lot of these variables. The material of the scaffold is a calcium phosphate material called hydroxyapatite, which is a more natural material than the polymers that most other bone scaffolds are made of and more likely to be accepted by the body. The structure of the scaffold also has a large effect on how well the bone grows into it (if at all), and Wagoner Johnson's team found that the microstructure plays an important role.



Credit: Anne Lukeman

Removable Paint and Self-Healing Plastics

Thanks to new dynamic materials, removable paint and self-healing plastics soon could be household products, according to a research team led by **Jianjun Cheng**.

Other self-healing material systems have focused on solid, strong materials. However, the new study uses softer elastic materials made of polyurea, one of the most widely used classes of polymers in consumer goods such as paints, coatings, elastics, and plastics.

After the polymer is cut or torn, the researchers press the two pieces back together and let the sample sit for about a day to heal—no extra chemicals or catalysts required. The materials can heal at room temperature, but the process can be sped up by curing at slightly higher temperatures (37 degrees Celsius, or about body temperature). The polymer bonds back together on the molecular level nearly as strongly as before it was cut. In fact, tests found that some healed samples, stretched to their limits, tore in a new place rather than the healed spot, evidence that the samples had healed completely.

The researchers use commercially available ingredients to create their polymer. By slightly tweaking the structure of the molecules that join up to make the polymer, they can make the bonds between the molecules longer so that they can more easily pull apart and stick back together—the key for healing. This molecular-level re-bonding is called dynamic chemistry.

Stem Cells Take Initial Step Toward Development

Ning Wang led a team that found the precise combination of mechanical forces, chemistry, and timing to help stem cells differentiate into three germ layers, the first step toward developing specialized tissues and organs. It is the first time this critical step has been demonstrated in a laboratory.

During fetal development, all the specialized tissues and organs of the body form out of a small ball of stem cells. First, the ball of generalized cells separates into three different cell lines, called germ layers, which will become different systems of the body. This crucial first step has eluded researchers in the lab. No one has yet been able to induce the cells to form the three distinct germ layers in the correct order—endoderm on the inside, mesoderm in the middle, and ectoderm on the outside. This represents a major hurdle in the application of stem cells to regenerative medicine, since researchers need to understand how tissues develop before they can reliably re-create the process.

Wang's team demonstrated that not only is it possible for mouse embryonic stem cells to form three distinct germ layers in the lab, but also that achieving the separation requires a careful combination of correct timing, chemical factors, and mechanical environment. The team uses cell lines that fluoresce in different colors when they become part of a germ layer, which allows the researchers to monitor the process dynamically.

The researchers deposited the stem cells in a very soft gel matrix, attempting to re-create the properties of the womb. They found that several mechanical forces played a role in how the cells organized and differentiated—the stiffness of the gel, the forces each cell exerts on its neighbors, and the matrix of proteins that the cells themselves deposit as a scaffolding to give the developing embryo structure.

Wang (below) hopes that other researchers will be able to use the technique to bridge the gap between stem cells and tissue engineering.

MOLECULAR AND ELECTRONIC NANOSTRUCTURES (M&ENS)

"Ever since I was a kid, I have been trying to understand nature and to find solutions to problems. I like to search for solutions, especially when the problem has not been solved by other people. I try to see if I can bring my own explanation or interpretation to experimental observations. And the Beckman Institute is very good place to be to solve problems."

Jean-Pierre Leburton has been solving problems at the Beckman Institute for 25 years, and has fashioned a remarkable career as an original member of the Beckman Institute. He began his research at the Institute working with former Beckman faculty member Karl Hess on topics such as semiconductors physics, in a career that has continued to this day with a research approach that he says is "on the borderline between applied physics and electrical engineering."

Throughout his career, Leburton has investigated how physics could create devices with novel functionality and higher performances. Along the way, he brought in two key components that would drive his work forward: considering smaller objects and incorporating biological concepts.

"I realized that in order to increase the performance or the functionality of a device, one needs to consider smaller and smaller material structures by exploiting quantum effects, or effects that occur at the very, very small scale," Leburton said.

Once working at the nanoscale level, he then found biology could play an interesting role in his otherwise physics-centered work.

"When I first came here, I wasn't involved with life sciences," Leburton said. "But Beckman provides an environment to build connections between life sciences and physical sciences. Through my interactions with other faculty members, I found that there was a scientific convergence between biology and nanoelectronics that would allow us to manipulate bio-objects at the molecular level to increase their functionality and performance."

One of the hybrid projects Leburton works on is a nanoscale transistor that harnesses the remarkable electrical properties of graphene, a novel mono-atomic layer carbon material, to sequence individual strands of DNA (roughly a billionth of a meter wide).

The graphene is electrically charged and threads DNA strands through a nanopore in a solid-state, multilayer semiconductor membrane, unlocking the sequence of a person's whole genome.

This device has the potential to revolutionize modern medicine, as it would provide a cheap, efficient, and quick way to sequence DNA of individual patients, allowing for personalized health care. No longer will patients receive the same medicine, dosage, or treatment plan—each patient will get the care that best fits his or her genetic makeup.

"For me as a physicist, the theoretical part is interesting, but as an engineer, I wish to find applications of my work," Leburton said. "This research will certainly be very beneficial for humanity and society."

Oxford Nanopore Technologies, a company that develops nanopore equipment to sequence DNA, funds part of the research on this new graphene-based approach.

Leburton joined forces with Beckman researchers **Rashid Bashir** and **Aleksei Aksimentiev** to integrate their theoretical and experimental efforts.

"This project fits very well within the research scope of the Beckman Institute because it brings together scientists with different expertise," Leburton said. "Bashir is a bioengineer, Aksimentiev is a theoretical biophysicist, and I am an electrical engineer with a physics background. People who otherwise would have pursued their research in their own department can work on a project at the crossroad among different disciplines."

In this particular case, it merges the completely separate fields of biology and basic nanoelectronics.

"My vision is that in the future, we will start to investigate an increasing number of problems that require a broad scope of expertise, transcending traditional disciplines. This kind of bio-electronic device that is benefiting from merged disciplines was not thinkable about 15 years ago," Leburton said. "If you can combine the functionality of the biological system with the speed and reliability of solid-state technology, this will bring tremendous technological advances in society and solve a lot of problems, especially in medicine."

In addition to this project, Leburton continues to investigate the connection between physics and nanoscale device functionality.

"I'm looking at the implications of size effects, like what happens when you take material structures and you reduce their sizes," Leburton said. "Anytime I can find a new function for a device, especially as one considers smaller and smaller scales, I'm happy—that's what I find interesting."

Leburton earned his Ph.D. in theoretical solid-state physics at the University of Liege in Belgium in 1978. After working two years for Siemens in Germany, he took the opportunity to come to Illinois in 1981 as a visiting professor and postdoc for Hess.

"I always wanted to come to the United States, and I particularly wanted to work with Karl, but I didn't have the intention to pursue a career here," he said. "I came for one year, then two years, and then I decided to stay. This is one of the greatest places in the United States to do research."

Some of his future work involves implementing high-resolution simulation of the DNA sequencing transistor into an operational computer model, to provide directions as well as feedback to the experimental effort.

"That's the thing with solving problems," Leburton said. "In the process of solving them, you find new interesting effects, which allows you to make a proposal for new projects and devices that serve a different function or operation. There's always more to learn."

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BECKMAN SCRAPBOOK

As a Beckman original, Jean-Pierre Leburton has been a pioneer in using physics to develop devices with novel functionality and higher performances. Inset photo circa 1992.

Jean-Pierre Leburton

Looking Forward

"Recent advances in my field have been driven by the need to manipulate physical objects on a smaller and smaller scale. In this context, the emergence of new mono-atomic layer materials, such as carbon nanotubes, graphene, or transition metal dichalcogenides (MoS_2), opens new avenues for novel multifunctional electronic or optical devices, such as the solid-state transistor using graphene, which I propose to use to sequence DNA. The fact that graphene is so thin—only one atom thick—made it possible to sense and manipulate DNA molecules on the atomic scale.

"Additionally, the convergence of technological interests between nanoelectronics and biology provides new ways to increase device functionality and performances at the molecular level. The advantage of biology is its complexity and its enormous capability to store and manipulate information, but it doesn't process information that efficiently—it is slow and not very stable. On the opposite side, information processing in semiconductor technology is relatively simple and very reliable, fast, and stable. Merging the two capabilities would result in a quite remarkable system.

"In the next 25 years, I foresee particular advances in the synthesis of semiconductor and biotechnologies, especially on brain research related activities, where electronics could play an important role in biological information processing."

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.

Muscle-Powered Bio-Bots Walk on Command

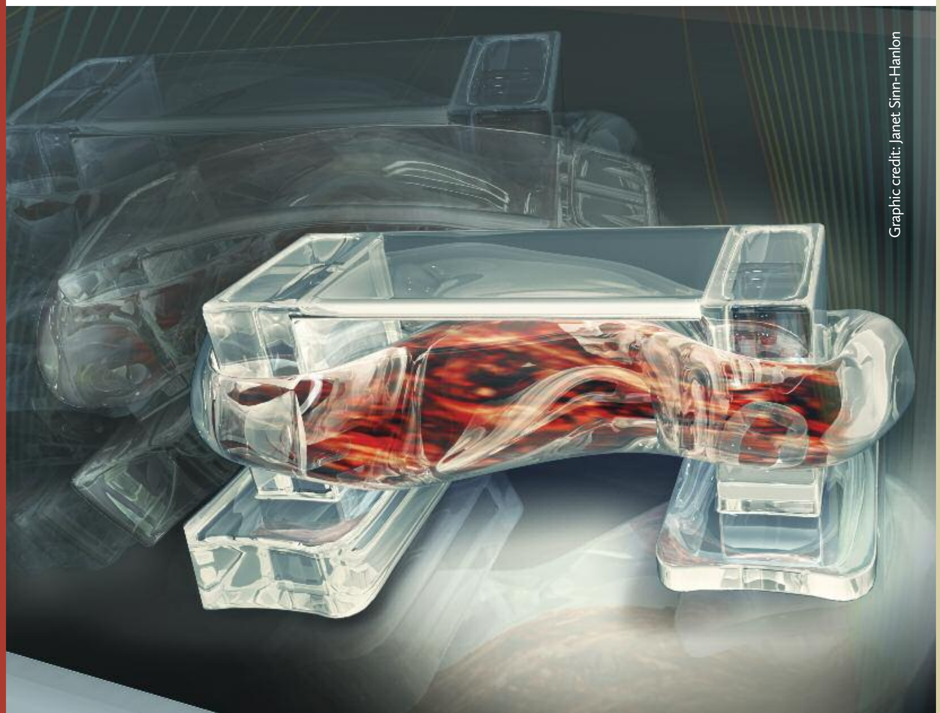
Engineers at the University of Illinois at Urbana-Champaign, including **Rashid Bashir** and **Taher Saif**, have created miniature biological robots, or “bio-bots,” that are powered by muscle cells and controlled with electrical pulses, giving researchers unprecedented command over their function.

“Biological actuation driven by cells is a fundamental need for any kind of biological machine you want to build,” said Bashir. “We’re trying to integrate these principles of engineering with biology in a way that can be used to design and develop biological machines and systems for environmental and medical applications. Biology is tremendously powerful, and if we can somehow learn to harness its advantages for useful applications, it could bring about a lot of great things.”

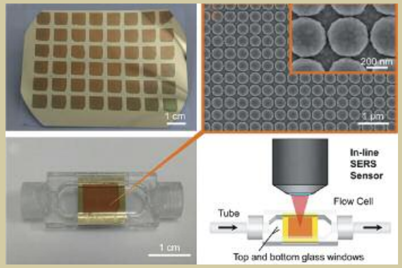
Bashir’s group has been a pioneer in designing and building bio-bots, less than a centimeter in size, made of flexible 3D printed hydrogels and living cells. Previously, the group demonstrated bio-bots that “walk” on their own, powered by beating heart cells from rats. However, heart cells constantly contract, denying researchers control over the bot’s motion. This makes it difficult to use heart cells to engineer a bio-bot that can be turned on and off, sped up or slowed down.

The new bio-bots are powered by a strip of skeletal muscle cells that can be triggered by an electric pulse. This gives the researchers a simple way to control the bio-bots and opens the possibilities for other forward design principles, so engineers can customize bio-bots for specific applications.

Tiny walking “bio-bots” are powered by muscle cells and controlled by an electric field.



Graphic credit: Janet Sinn-Hanlon



Credit: Brian Cunningham and Hsin-Hu Wu

The plasmonic nanodome array surface enhances the Raman signals.

Safe IV Drug Delivery

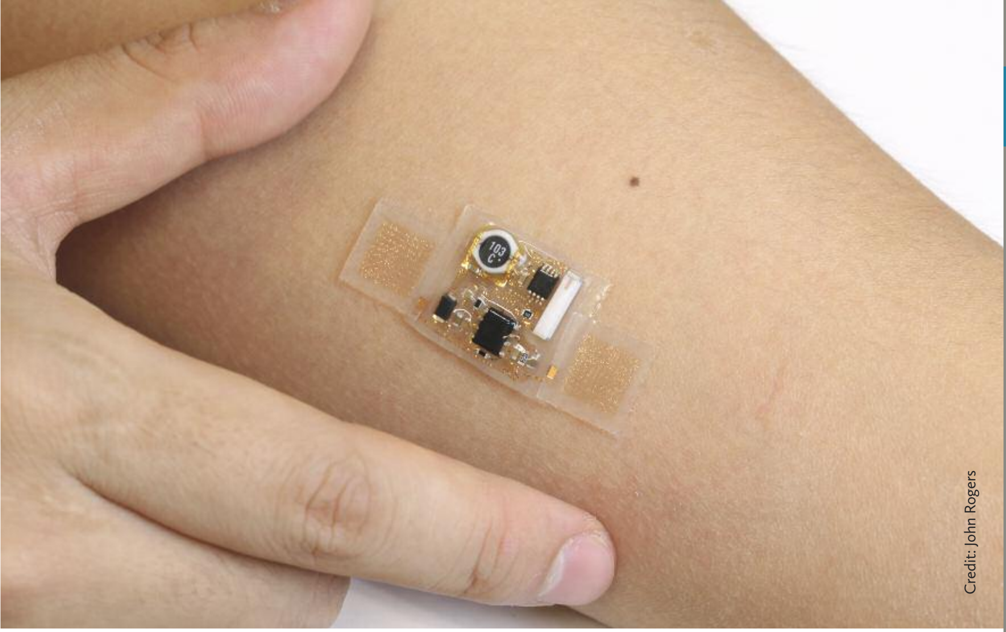
A new optical device developed by a team led by **Brian Cunningham** and Hsin-Yu Wu, electrical and computer engineering graduate student, can identify the contents of the fluid in an intravenous (IV) line in real-time, offering a promising way to improve the safety of IV drug delivery.

The vulnerability of IV drug-delivery systems due to human error is a chief concern in hospital safety, Cunningham said. Errors can include incorrect dosage, unintentional substitution of one drug for another, and co-delivery of incompatible drugs.

More than 60 percent of life-threatening errors during hospitalization are attributed to the administration of incorrect dosages or combinations of IV drugs. Methods that detect and track drug administration in real-time would add an extra layer of protection to IV drug delivery.

Cunningham has produced biomedical tubing that uses surface enhanced Raman spectroscopy (SERS) to monitor the contents and concentrations of drugs within a patient’s IV line.

The tubing can detect 10 pharmaceutical compounds for a period of up to five days. For four of the drugs, the signal magnitude was dependent upon the drug concentration, and combinations of compounds could also be detected, giving a much more detailed picture of a patient’s medication.



Thin, soft, stick-on patches that move seamlessly with the body could be the new future of wireless health monitoring.

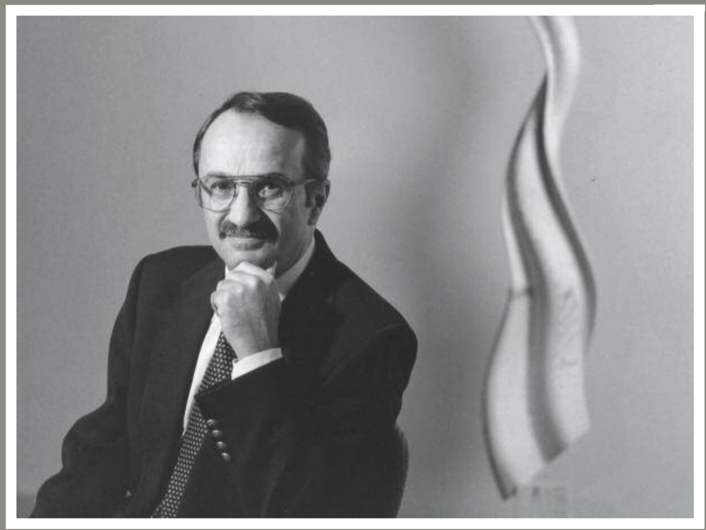
Stick-On Electronic Patches for Health Monitoring

John Rogers and engineers at the University of Illinois and Northwestern University have developed thin, soft, stick-on patches that stretch and move with the skin and incorporate commercial, off-the-shelf, chip-based electronics for sophisticated wireless health monitoring.

The patches stick to the skin like a temporary tattoo and incorporate a unique microfluidic construction with wires folded like origami to allow the patch to bend and flex without being constrained by the rigid electronics components. The patches could be used for everyday health tracking—wirelessly sending updates to your cellphone or computer—and could revolutionize clinical monitoring such as EKG and EEG testing—no bulky wires, pads, or tape needed.

The researchers hope that the device could not only monitor health but also could help identify problems before the patient may be aware. For example, according to Rogers, data analysis could detect motions associated with Parkinson's disease at its onset.

"The application of stretchable electronics to medicine has a lot of potential," said Yonggang Huang, the Northwestern University professor who co-led the work with Rogers. "If we can continuously monitor our health with a comfortable, small device that attaches to our skin, it could be possible to catch health conditions before experiencing pain, discomfort, and illness."



Hess Pioneered Semiconductor Theory and Research

Exploring the interface between basic physical science and applications involving electronics has been an integral part of research at the Beckman Institute since it opened in 1989. Much of the research in Molecular and Electronics Nanostructures over the years has focused on electronics applications and semiconductor theory and research—the latter being an early foundation of work at Beckman thanks in large part to one of the Institute's founding fathers, **Karl Hess**.

Hess, who retired in 2006, had a research focus on the transport of electrons, and became a leading theoretician in the realm of semiconductor transistors, just as computer circuitry grew smaller and led to ever-greater processing power in the latter part of the 20th Century. Hess, who has the rare distinction of being named a Fellow at both the National Academy of Sciences and National Academy of Engineering, made contributions in many areas, including computer simulation, optoelectronics, and quantum computing, with his most well-known and far-reaching impact in the field of semiconductor physics.

Even though he is a theorist, Hess has always been mindful of the need to consider potential applications when doing research.

"From my earliest youth, I always wanted to do something that was useful for people," Hess said. "I always had some purely mathematical interests in my student years, but I figured that is not where I want to spend the bulk of my life. I wanted to do something that is useful, at least see some immediate application of it, some technological basis."

Transporting Molecules Across Membranes

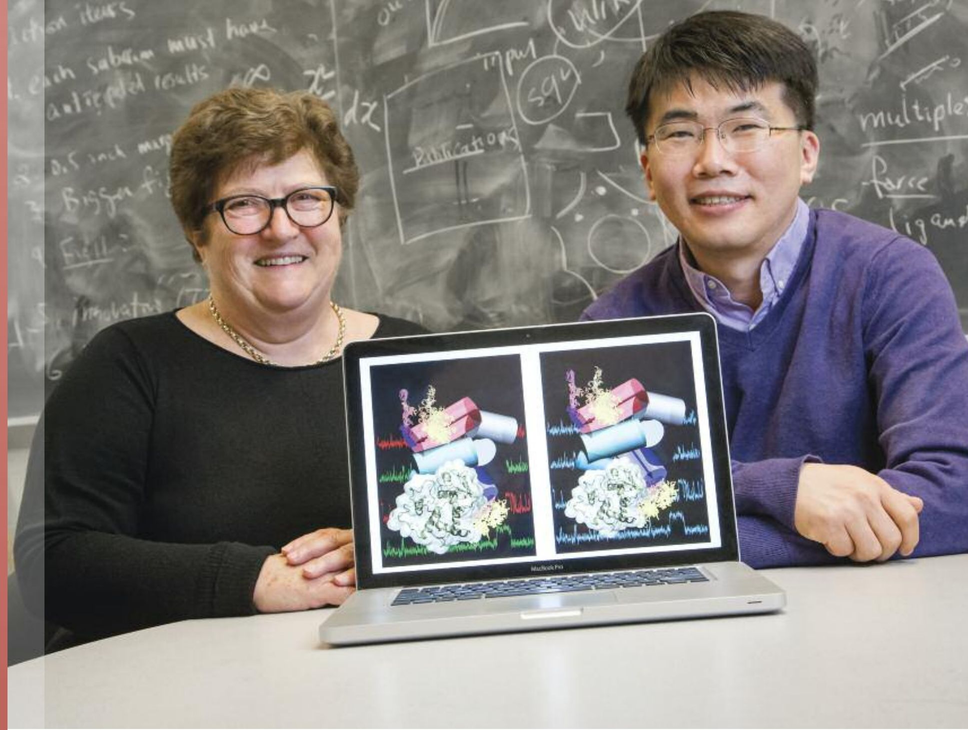
Emad Tajkhorshid and his collaborators have successfully simulated the molecular dance moves that a multi-drug resistance membrane transporter undertakes as it pumps compounds out of a cell.

This is the first time researchers have been able to simulate the motion of a complex membrane transporter in its native environment in full atomic detail. The results give drug developers vital new targets to help combat drug-resistant cancers and other diseases.

The transporter in the study belongs to an ancient family of proteins that carry a variety of large molecules across membranes, said Tajkhorshid. It is the bacterial version of a transporter in human cells (called p-glycoprotein) that helps pump drugs out of the cell. P-glycoprotein is overexpressed in some cancer cells, helping the cells eject drugs meant to kill them.

"There is a lot of research going on in pharmaceutical companies trying to find an inhibitor of p-glycoprotein," Tajkhorshid said. "If we can understand the transport cycle, we have a much larger repertoire of structures for rational drug design."

Postdoctoral researcher Mahmoud Moradi, left, and Emad Tajkhorshid, right, discovered how a transporter protein changes its shape to shuttle other molecules across the cell membrane.



How the Ribosome Assembles Itself

Ribosomes, the cellular machines that build proteins, are themselves made up of dozens of proteins and a few looping strands of RNA. A new study, led by **Zaida Luthey-Schulten** (above left), **Taekjip Ha** (right), and Johns Hopkins University biophysics professor Sarah Woodson, offers new clues about how the ribosome, the master assembler of proteins, also assembles itself.

"The ribosome has more than 50 different parts—it has the complexity of a sewing machine in terms of the number of parts," said Luthey-Schulten. "A sewing machine assembles other things but it cannot assemble itself if you have the parts lying around. The ribosome, however, can do that. It's quite amazing."

Knowing how the ribosome is put together offers new antibiotic targets, said Ha.

"Instead of waiting until your enemy has fully assembled its army, you want to intervene early to prevent that from happening," he said. "We know that this protein/RNA region has unique signatures in bacteria, so maybe we can target this process while keeping the human ribosome intact."

3D Vascular System Allows Autonomous and Repeated Healing

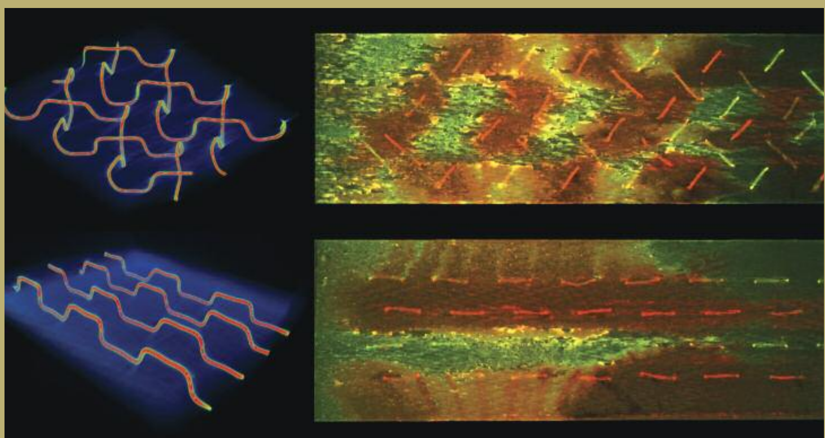
Internal damage in fiber-reinforced composites, materials used in structures of modern airplanes and automobiles, is difficult to detect and nearly impossible to repair by conventional methods. A small, internal crack can quickly develop into irreversible damage from delamination, a process in which the layers separate. This remains one of the most significant factors limiting more widespread use of composite materials.

However, fiber-composite materials can now heal autonomously through a self-healing system developed by **Nancy Sottos**, **Scott White**, and **Jeff Moore**.

The researchers created 3D vascular networks—patterns of microchannels filled with healing chemistries—that thread through a fiber-reinforced composite. When damage occurs, the networks within the material break apart and allow the healing chemistries to mix and polymerize, autonomously healing the material, over multiple cycles.

Fiberglass and other composite materials are widely used in aerospace, the automotive industry, by the Navy, and even in sporting goods because of their high strength-to-weight ratio—they pack a lot of structural strength into a very lean package. However, because the woven laminates are stacked in layers, it is easier for the structure to separate between the layers, making this self-healing system a promising solution to a long-standing problem for composite materials and greatly extending their lifetime and reliability.

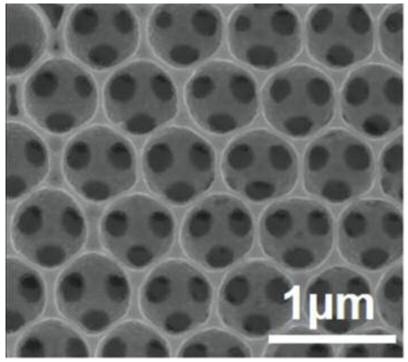
3D microvascular networks for self-healing composites: Researchers were able to achieve more effective self-healing with the herringbone vascular network (top) over a parallel design (bottom), evidenced by the increased mixing (orange-yellow) of individual healing agents (red and green) across a fracture surface.



Credit: Jason Patrick

More Efficient Solar Cells

"In theory, conventional single-junction solar cells can only achieve an efficiency level of about 34 percent, but in practice they don't achieve that," said **Paul Braun**. "That's because they throw away the majority of the sun's energy."



Scientists have created a heat-resistant thermal emitter that could significantly improve the efficiency of solar cells. The novel component is designed to convert heat from the sun into infrared light, which can then be absorbed by solar cells to make electricity—a technology known as thermophotovoltaics.

Thermophotovoltaic devices are designed to overcome that limitation. Instead of sending sunlight directly to the solar cell, thermophotovoltaic systems have an intermediate component that consists of two parts: an absorber that heats up when exposed to sunlight, and an emitter that converts the heat to a narrower range of wavelengths of infrared light, which is then beamed to the solar cell. This raises the theoretical efficiency of the cell to about 80 percent.

Braun's team created a new thermal emitter by coating tungsten emitters in a nanolayer of a ceramic material called hafnium dioxide, and it remained stable at temperatures as high as 2,500 degrees Fahrenheit.

"We've demonstrated that the tailoring of optical properties at high temperatures is possible," Braun said. "Hafnium and tungsten are abundant, low-cost materials, and the process used to make these heat-resistant emitters is well established. Hopefully these results will motivate the thermophotovoltaics community to take another look at ceramics and other classes of materials that haven't been considered."

Photo Credit: Kevin Arpin and Paul Braun, University of Illinois at Urbana-Champaign.

Covering July 1, 2013-June 30, 2014

Faculty
(name followed by home department)

Cognitive Neuroscience
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*
Brian D. Gonsalves, *Psychology*
Gabriele Gratton, *Psychology*
Christopher M. Grindrod, *Speech and Hearing Science*
Wendy Heller, *Psychology*
Daniel Hyde, *Psychology*
Melissa Littlefield, *English & Kinesiology and Community Health*
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
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*
Jose Mestre, *Physics*
Jerome L. Packard, *East Asian Languages and Cultures*
Michelle Perry, *Educational Psychology*
Brian H. Ross, *Psychology*
Chilin Shih, *East Asian Languages and Cultures*
Darren Tanner, *Linguistics*
Annie Tremblay, *French*
Jonathan Waskan, *Philosophy*
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*
William Greenough, *Psychology*
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

Aaron Benjamin
Fellow, Psychonomic Society, 2014

Jennifer Cole
Center for Advanced Study Research Fellow, Institute for Phonetics and Speech Processing, Ludwig Maximilian University of Munich, April-July 2014
Member, Board on Behavioral, Cognitive and Sensory Sciences, National Research Council, National Academy of Sciences, 2013-2015

Justin Rhodes
Evelyn Satinoff Professorial Scholar, Psychology, University of Illinois, 2013-2014
Outstanding Advisor Award, Medical Scholars Program, University of Illinois, 2013

Jonathan Sweedler
Malcom E. Pruitt Award, Council for Chemical Research, 2013
The Analytical Chemistry Award, The American Chemical Society, 2013

INVENTION DISCLOSURES

Faculty members from the Biological Intelligence research theme were inventors on one invention disclosure (0.6 % of the 179 invention disclosures filed by campus) during FY2014.

SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the Biological Intelligence research theme were inventors on the following patent application (0.5% of the 202 patent applications filed by campus) during FY2014.

Roberto Galvez, "Treatment for Fragile X and Cognitive Defects," patent filed May 30, 2014, application number 62/005,473.

GRANTS AWARDED

($22,920,004)

Susan Schantz, Jodi Flaws, Barbara Fiese, Brenda Koester, Sidonie Lavergne, Andrea Aguiar, CheMyong Ko, Yuan-Xiang Pan, Rex Hess, and **Janice Juraska**, NIH, "Novel Methods to Assess Effects on Child Development," 6/15/2013 – 5/31/2016, $3,823,456.

Neal Cohen, Rodney Johnson, Ryan Larsen, and **Brad Sutton**, CNLM-Abbott Nutrition, "Controlled Trials in 'At Risk' Humans to Establish the Cognitive Benefits of Nutrient Mixture and Underlying Mechanisms of Action," 5/16/2013 – 5/15/2016, $2,344,000.

Susan Schantz, Jodi Flaws, Barbara Fiese, Brenda Koester, Sidonie Lavergne, Andrea Aguiar, CheMyong Ko, Yuan-Xiang Pan, Rex Hess, and **Janice Juraska**, US-EPA, "Novel Methods to Assess Effects on Child Development," 6/1/2013 – 5/31/2018, $3,962,726.

Jennifer Cole, University of Munich, "Prosodic and Gestural Entrainment in Conversational Interaction Across Diverse Languages (PAGE)," 8/1/2013 – 1/31/2015, $32,175.

Aron Barbey, **Neal Cohen**, **Wai-Tat Fu**, **Charles Hillman**, **Arthur Kramer**, and **John Erdman**, IARPA, "An Integrative System for Enhancing Fluid Intelligence (Gf) Through Human Cognitive, Fitness, HD-tDCS, and Nutritional Intervention (INSIGHT)," 1/13/2014 – 7/5/2017, $12,757,647.

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 Beckman faculty names are in bold-face type.

Benjamin, A. S., Where is the Criterion Noise in Recognition? (Almost) Everyplace You Look: Comment on Kellen, Klauer, and Singmann (2012). *Psychological Review* **2013**, *120,* (3), 720-726, DOI: 10.1037/a0031911.

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Brown-Schmidt, S.; Heller, D., What Language Processing Can Tell Us About Perspective Taking: A Reply to Bezuidenhout (2013). *Journal of Pragmatics* **2014**, *60,* 279-284, DOI: 10.1016/j.pragma.2013.09.003.

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Hasadsri, L.; Wang, B. H.; Lee, J. V.; **Erdman, J. W.**; **Llano, D. A.**; **Barbey, A. K.**; Wszalek, T.; Sharrock, M. F.; Wang, H., Omega-3 Fatty Acids as a Putative Treatment for Traumatic Brain Injury. *Journal of Neurotrauma* **2013**, *30,* (11), 897-906, DOI: 10.1089/neu.2012.2672.

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Jyothi, P.; **Cole, J.**; **Hasegawa-Johnson, M.**; Puri, V. An Investigation of Prosody in Hindi Narrative Speech, *Proceedings of Speech Prosody* Dublin, Ireland, May 20-23, **2014**, Vol. 7.

Kelly, S. A.; Rezende, E. L.; Chappell, M. A.; Gomes, F. R.; Kolb, E. M.; Malisch, J. L.; **Rhodes, J. S.**; Mitchell, G. S.; Garland, T., Exercise Training Effects on Hypoxic and Hypercapnic Ventilatory Responses in Mice Selected for Increased Voluntary Wheel Running. *Experimental Physiology* **2014**, *99,* (2), 403-413.

Lam, T. Q.; **Watson, D. G.**, Repetition Reduction: Lexical Repetition in the Absence of Referent Repetition. *Journal of Experimental Psychology—Learning Memory and Cognition* **2014**, *40,* (3), 829-843, DOI: 10.1037/a0035780.

Le, A. P.; Kang, S.; Thompson, L. B.; Rubakhin, S. S.; **Sweedler, J. V.**; **Rogers, J. A.**; Nuzzo, R. G., Quantitative Reflection Imaging of Fixed Aplysia Californica Pedal Ganglion Neurons on Nanostructured Plasmonic Crystals. *Journal of Physical Chemistry B* **2013**, *117,* (42), 13069-13081, DOI: 10.1021/jp402731f.

Lee, E. K.; **Brown-Schmidt, S.**; **Watson, D. G.**, Ways of Looking Ahead: Hierarchical Planning in Language Production. *Cognition* **2013**, *129,* (3), 544-562, DOI: 10.1016/j.cognition.2013.08.007.

Llano, D. A., Voices Below the Surface: Is There a Role for the Thalamus in Language? *Brain and Language* **2013**, *126,* (1), 20-21, DOI: 10.1016/j.bandl.2012.10.004.

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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.

Poon, E.; Monaikul, S.; Kostyniak, P. J.; Chi, L. H.; **Schantz, S. L.**; Sable, H. J. K., Developmental Exposure to Polychlorinated Biphenyls Reduces Amphetamine Behavioral Sensitization in Long-Evans Rats. *Neurotoxicology and Teratology* **2013**, *38,* 6-12, DOI: 10.1016/j.ntt.2013.04.005.

Sadowski, R. N.; Park, P.; Neese, S. L.; Ferguson, D. C.; **Schantz, S. L.**; **Juraska, J. M.**, Effects of Perinatal Bisphenol A Exposure During Early Development on Radial Arm Maze Behavior in Adult Male and Female Rats. *Neurotoxicology and Teratology* **2014**, *42,* 17-24, DOI: 10.1016/Intt.2014.01.002.

Southey, B. R.; Lee, J. E.; Zamdborg, L.; Atkins, N.; Mitchell, J. W.; Li, M. X.; **Gillette, M. U.**; Kelleher, N. L.; **Sweedler, J. V.**, Comparing Label-Free Quantitative Peptidomics Approaches to Characterize Diurnal Variation of Peptides in the Rat Suprachiasmatic Nucleus. *Analytical Chemistry* **2014**, *86,* (1), 443-452, DOI: 10.1021/ac4023378.

Trude, A. M.; **Tremblay, A.**; **Brown-Schmidt, S.**, Limitations on Adaptation to Foreign Accents. *Journal of Memory and Language* **2013**, *69,* (3), 349-367, DOI: 10.1016/j.jml.2013.05.002.

Zimmerman, B.; **Sutton, B. P.**; Low, K. A.; Fletcher, M. A.; Tan, C. H.; Schneider-Garces, N.; Li, Y. F.; Ouyang, C.; Maclin, E. L.; **Gratton, G.**; **Fabiani, M.**, Cardiorespiratory Fitness Mediates the Effects of Aging on Cerebral Blood Flow. *Frontiers in Aging Neuroscience* **2014**, *6,* 13, DOI: 10.3389/fnagi.2014.00059.

SELECTED FACULTY AWARDS, PATENTS, GRANTS, AND PUBLICATIONS

Covering July 1, 2013-June 30, 2014

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*
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*
Charles H. Hillman, *Kinesiology and Community Health*
Daniel Hoffman, *Curriculum and Instruction*
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*
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, *Industrial Design*
Emma M. Mercier, *Curriculum and Instruction*
Daniel G. Morrow, *Educational Psychology*
Sean P. Mullen, *Kinesiology and Community Health*
Jennifer K. Robbennolt, *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*

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*
Jaiwei 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

Minh N. Do
Fellow, IEEE, 2014

Wai-Tat Fu
Fellow, Hans Institute of Advance Research, Germany, 2013

Edward McAuley
Distinguished Research Mentor Award, Society of Behavioral Medicine, April 2014
Outstanding Career Achievement Award in the Behavioral and Social Sciences, University of Illinois, 2013

Dan Roth
Outstanding Advising Award, Engineering Council, University of Illinois, 2013

INVENTION DISCLOSURES

Invention disclosures

Faculty members from Human-Computer Intelligent Interaction research theme were inventors on one invention disclosure (0.6% of the 179 invention disclosures filed by campus) during FY2014.

SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the Human-Computer Intelligent Interaction research theme were inventors on the following patent application (0.5% of the 202 patent applications filed by campus) during FY2014.

Scott Daigle and **Elizabeth Hsiao-Wecksler**, "Gear-Shifting System for Manually Propelled Wheelchairs," patent filed January 24, 2014, application number 14/234,799.

GRANTS AWARDED

($1,339,979)

Arthur Kramer, DOD-Subaward through Aptima, "PACT II: Portable Adaptive Cognitive Training," 8/1/2013 – 1/31/2015, $367,500.

Thomas Huang, NSF, "RI: Small: Hierarchical Feature Learning by Heterogeneous Networks with Application to Face Verification," 9/1/2013 – 8/31/2015, $408,612.

Elizabeth Stine-Morrow, **Daniel Morrow**, and **Wai-Tat Fu**, NSF, "IBSS EX: Reading in the Wild: The Adaptive Nature of Adult Literacy," 9/1/2013 – 8/31/2015, $250,000.

Charles Hillman, **Neal Cohen**, and Naiman Khan, CNLM-Abbott Nutrition, "The Effects of Fortified Nutritional Supplementation on Cognition, Memory, and Achievement," 5/16/2012 – 5/15/2015, $14,265.

Daniel Morrow, **Mark Hasegawa-Johnson**, **Thomas Huang**, and **Wai-Tat Fu**, NIH, "Collaborative Patient Portals: Computer-based Agents and Patients' Understanding of Numeric Health Information," 5/1/2014 – 4/30/2016, $299,602.

SELECTED PUBLICATIONS

Awni, H.; Norton, J. J. S.; Umunna, S.; **Federmeier, K. D.**; **Bretl, T.**; Towards a Brain Computer Interface Based on the N2pc Event-Related Potential, In *2013 6th International IEEE/EMBS Conference on Neural Engineering.* IEEE, New York, **2013**, 1021-1024.

Babacan, S. D.; Nakajima, S.; **Do, M. N.**, Bayesian Group-Sparse Modeling and Variational Inference. *IEEE Transactions on Signal Processing* **2014**, *62*, (11), 2906-2921, DOI: 10.1109/tsp.2014.2319775.

Chen, S. D.; Chen, Y. Y.; Han, J. W.; **Moulin, P.**, A Feature-Enhanced Ranking-Based Classifier for Multimodal Data and Heterogeneous Information Networks, In *2013 IEEE 13th International Conference on Data Mining.* Xiong, H., Karypis, G., Thuraisingham, B., Cook, D., Wu, X., Eds.; IEEE, New York, **2013**, 997-1002.

Chin, J.; Payne, B. R.; Gao, X.; **Stine-Morrow, E. A. L.**; **Morrow, D. G.**; Conner-Garcia, T.; Graumlich, J. F.; Murray, M. D., Knowledge

Beckman faculty names are in bold-face type.

Influences Comprehension and Memory for Health Information among Older Adults: Distinguishing the Effects of Domain-General and Domain-Specific Knowledge. *Memory* **2014**, DOI: 10.1080/09658211.2014.912331.

Dye, M. W. G.; Hauser, P. C., Sustained Attention, Selective Attention and Cognitive Control in Deaf and Hearing Children. *Hearing Research* **2014**, *309,* 94-102, DOI: 10.1016/j.heares.2013.12.001.

Fabiani, M.; Gordon, B. A.; Maclin, E. L.; Pearson, M. A.; Brumback-Peltz, C. R.; Low, K. A.; **McAuley, E.**; **Sutton, B. P.**; **Kramer, A. F.**; **Gratton, G.**, Neurovascular Coupling in Normal Aging: A Combined Optical, ERP and FMRI Study. *Neuroimage* **2014**, *85,* 592-607, DOI: 10.1016/j.neuroimage.2013.04.113.

Fu, W. T.; Gasper, J.; Kim, S. W.; Effects of an In-Car Augmented Reality System on Improving Safety of Younger and Older Drivers, In *2013 IEEE International Symposium on Mixed and Augmented Reality.* IEEE, New York, **2013**, 59-66.

Goldwasser, D.; **Roth, D.**, Learning from Natural Instructions. *Machine Learning* **2014**, *94,* (2), 205-232, DOI: 10.1007/s10994-013-5407-y.

Huang, P. S.; Deng, L.; **Hasegawa-Johnson, M.**; He, X. D.; Random Features for Kernel Deep Convex Network, In *2013 IEEE International Conference on Acoustics, Speech and Signal Processing.* IEEE, New York, **2013**, 3143-3147.

Husain, F. T.; Schmidt, S. A., Using Resting State Functional Connectivity to Unravel Networks of Tinnitus. *Hearing Research* **2014**, *307,* 153-162, DOI: 10.1016/j.heares.2013.07.010.

Jeong, J. W.; Yeo, W. H.; Akhtar, A.; Norton, J. J. S.; Kwack, Y. J.; Li, S.; Jung, S. Y.; Su, Y. W.; Lee, W.; Xia, J.; Cheng, H. Y.; Huang, Y. G.; Choi, W. S.; **Bretl, T.**; **Rogers, J. A.**, Materials and Optimized Designs for Human-Machine Interfaces via Epidermal Electronics. *Advanced Materials* **2013**, *25,* (47), 6839-6846, DOI: 10.1002/adma.201301921.

Jun, D.; Cohen, D. M.; **Jones, D. L.**; A Direct Algorithm for Joint Optimal Sensor Scheduling and Map State Estimation for Hidden Markov Models, In *2013 IEEE International Conference on Acoustics, Speech and Signal Processing.* IEEE, New York, **2013**, 4212-4215.

Kannampallil, T.; Waicekauskas, K.; **Morrow, D.**; Kopren, K.; **Fu, W. T.**, External Tools for Collaborative Medication Scheduling. *Cognition Technology & Work* **2013**, *15,* (2), 121-131, DOI: 10.1007/s10111-011-0190-7.

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.

Kim, M.; **Smaragdis, P.**, Collaborative Audio Enhancement Using Probabilistic Latent Component Sharing, In *2013 IEEE International Conference on Acoustics, Speech and Signal Processing.* IEEE, New York, **2013**, 896-900.

Kwak, M.; **Kim, H. M.**, Design for Lifecycle Profit with a Simultaneous Consideration of Initial Manufacturing and End-of-Life Remanufacturing. *Engineering Optimization Journal* **2013** (Dec 2013), 1-18, DOI: 10.1080/0305215X.2013.868450.

Liao, Q. V.; **Fu, W. T.**, Age Differences in Credibility Judgments of Online Health Information. *ACM Transactions on Computer-Human Interaction* **2014**, *21,* (1), DOI: 10.1145/2534410.

Meyer, G. P.; **Do, M. N.**; Real-Time 3D Face Modeling with a Commodity Depth Camera, In *Electronic Proceedings of the 2013 IEEE International Conference on Multimedia and Expo Workshops.* IEEE, New York, **2013**.

Mohammadiha, N.; **Smaragdis, P.**; Leijon, A. Simultaneous Noise Classification and Reduction Using *a priori* Learned Models, *IEEE Workshop for Machine Learning in Signal Processing*, Southampton, United Kingdom, September **2013.**

Nath, V.; **Levinson, S. E.** *Autonomous Robotics and Deep Learning*; Springer: New York, NY, **2014**, Vol. VII.

Nguyen, C. T.; Robinson, S. R.; Jung, W.; Novak, M. A.; **Boppart, S. A.**; **Allen, J. B.**, Investigation of Bacterial Biofilm in the Human Middle Ear Using Optical Coherence Tomography and Acoustic Measurements. *Hearing Research* **2013**, *301,* 193-200, DOI: 10.1016/j.heares.2013.04.001.

Paranjape, A. A.; Meier, K. C.; Shi, X. C.; Chung, S. J.; **Hutchinson, S.**, Motion Primitives and 3-D Path Planning for Fast Flight through a Forest, In *2013 IEEE/RSJ International Conference on Intelligent Robots and Systems.* Amato, N., Ed.; IEEE, New York, **2013**, 2940-2947.

Parks, N. A.; **Beck, D. M.**; **Kramer, A. F.**, Enhancement and Suppression in the Visual Field under Perceptual Load. *Frontiers in Psychology* **2013**, *4*, DOI: 10.3389/fpsyg.2013.00275.

Payne, B. R.; **Stine-Morrow, E. A. L.**, Adult Age Differences in Conceptual Integration Processes in Sentence Processing: Evidence from Ex-Gaussian Distributional Analyses of Reading Time. *Psychology and Aging* **2014**, *29,* (2), 213-228.

Raine, L. B.; Lee, H. K.; Saliba, B. J.; Chaddock-Heyman, L.; **Hillman, C. H.**; **Kramer, A. F.**, The Influence of Childhood Aerobic Fitness on Learning and Memory. *Plos One* **2013**, *8,* (9), DOI: 10.1371/journal.pone.0072666.

Riaz, M.; **Girju, R.** Toward a Better Understanding of Causality between Verbal Events: Extraction and Analysis of the Causal Power of Verb-Verb Associations, *14th Annual Conference of the Special Interest Group on Discourse and Dialogue* (*SIGDial*), Metz, France, August **2013**.

Simons, D. J., Unskilled and Optimistic: Overconfident Predictions Despite Calibrated Knowledge of Relative Skill. *Psychonomic Bulletin & Review* **2013**, *20,* (3), 601-607, DOI: 10.3758/s13423-013-0379-2.

Tseng, Y. C.; Glaser, J. I.; Caddigan, E.; **Lleras, A.**, Modeling the Effect of Selection History on Pop-out Visual Search. *Plos One* **2014**, *9,* (3), DOI: 10.1371/journal.pone.0089996.

Voss, M. W.; Heo, S.; Prakash, R. S.; Erickson, K. I.; Alves, H.; Chaddock, L.; Szabo, A. N.; Mailey, E. L.; Wojcicki, T. R.; White, S. M.; Gothe, N.; **McAuley, E.**; **Sutton, B. P.**; **Kramer, A. F.**, The Influence of Aerobic Fitness on Cerebral White Matter Integrity and Cognitive Function in Older Adults: Results of a One-Year Exercise Intervention. *Human Brain Mapping* **2013**, *34,* (11), 2972-2985, DOI: 10.1002/hbm.22119.

Zhang, H. C.; Zhang, Y. N.; **Huang, T. S.**, Pose-Robust Face Recognition via Sparse Representation. *Pattern Recognition* **2013**, *46,* (5), 1511-1521, DOI: 10.1016/j.patcog.2012.10.025.

INTIM SELECTED FACULTY AWARDS, PATENTS, GRANTS, AND PUBLICATIONS

Covering July 1, 2013-June 30, 2014

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 Sciences*
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*
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*
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

Marni Boppart
Guiding Undergraduate Research Award, College of Applied Health Sciences, University of Illinois, 2013

Stephen A. Boppart
Fellow, American Institute for Medical and Biological Engineering (AIMBE), 2014
Innovation Transfer Award, Illinois Office of Technology Management, 2014
Fellow, American Association for the Advancement of Science (AAAS), 2013

P. Scott Carney
Federation of Analytical Chemistry and Spectroscopy Societies Innovation Award, 2012

Jianjun Cheng
Donald Biggar Willett Scholar, College of Engineering, University of Illinois, 2013

John Erdman
Gilbert A. Leveille Award and Leadership, National Institute of Food Technologist Meeting

Michael Insana
Named Editor-in-Chief *IEEE Transactions on Medical Imaging*, February 2014

Zhi-Pei Liang
ISMRM 2013 Magna Cum Laude Merit Award
Franklin W. Woeltge Professor of Electrical and Computer Engineering.

Gabriel Popescu
New Venture Competition Finalist, Office of Technology Management, University of Illinois, 2014
Fellow, International Society of Optics and Photonics (SPIE), 2014

Kenneth S. Suslick
Wilsmore Fellow, University of Melbourne, 2013

Amy Wagoner Johnson
Chair of Excellence, NanoScience Foundation, Grenoble, France, 2014-2016

INVENTION DISCLOSURES

Faculty members from the Integrative Imaging research theme were inventors on 10 invention disclosures (5.6% of the 179 invention disclosures filed by campus) during FY2014.

SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the Integrative Imaging research theme were inventors on 10 of the following patent applications (5% of the 202 patent applications filed by campus) and six patents issued (10.3% of the 78 patents issued to campus) during FY2014.

Huafeng Ding, **Gabriel Popescu**, and Zhou Wang, "Spatial Light Interference Microscopy and Fourier Transform Light Scattering for Cell and Tissue Characterization," patent issued August 27, 2013, patent number 8,520,213.

Stephen Boppart and Haohua Tu, "Compression of Polarized Supercontinuum Pulses Generated in Birefringent All Normal-Dispersion Photonic Crystal Fiber," patent issued September 3, 2013, patent number 8,526,772.

Stephen Boppart and Woong Gyu Jung, "Apparatus for Biomedical Imaging," patent issued November 26, 2013, patent number 8,594,757.

Rohit Bhargava, **Paul Carney**, David Mayerich, and Thomas Van Dijk, "Coherent Optical Mapping of Particles," patent issued December 3, 2013, patent number 8,599,388.

Brad Sutton, "Method for Acquiring Dynamic Motion Images to Guide Functional Magnetic Resonance Imaging Analysis of Motor Tasks," patent issued February 25, 2014, patent number 8,659,294.

Steven Adie, **Stephen Boppart**, and **Paul Carney**, "Computational Adaptive Optics for Interferometric Synthetic Aperture Microscopy and Other Interferometric Imaging," patent issued May 20, 2014, patent number 8,731,272.

Gabriel Popescu and Ru Wang, "Dispersion-Relation Fluorescence Spectroscopy," patent filed August 2, 2013, application number 61/861,469.

Stephen Boppart and Haohua Tu, "Bright Few-Cycle Visible Fiber Sources Using 1550-nm Converted Cherenkov Radiation with Gaussian-Like Spectra," patent filed August 13, 2013, application number 61/865,461.

Stephen Boppart and Ryan Shelton, "Pneumatic Otoscope and Improvements," patent filed August 26, 2013, application number 61/869,805.

Basanta Bhaduri and **Gabriel Popescu**, "Real-Time Spatial Light Interference Microscopy for Dynamic Biomedical Imaging," patent filed August 30, 2013, application number 61/871,916.

Basanta Bhaduri, Hoa Pham, and **Gabriel Popescu**, "Real Time Blood Testing using QPI," patent filed January 13, 2014, application number 61/926,776.

Beckman faculty names are in bold-face type.

Stephen Boppart and Youbo Zhao, "Optical Parametric Amplification of Weak Signals for Imaging Biological Tissue," patent filed January 17, 2014, application number 14/157,840.

Lynford Goddard, **Gabriel Popescu**, and Renjie Zhou, "22 NM Node Wafer Inspection using Diffraction Phase Microscopy and Image Post-Processing and 9 NM Node Wafer Defect Inspection Using Visible Light," patent filed February 3, 2014, application number 61/934,921.

Rohit Bhargava, "Stain-Free Histopathology by Chemical Imaging," patent filed March 14, 2014, application number 14/211,292.

Stephen Boppart and Ryan Shelton, "Quantitative Pneumatic Otoscopy using Coherent Light Ranging Techniques," patent filed June 12, 2014, application number 14/303,134.

S. Darin Babacan, **Paul Carney**, **Lynford Goddard**, Tae Kim, Mustafa Mir, **Gabriel Popescu**, and Renjie Zhou, "White Light Diffraction Tomography of Unlabeled Live Cells," patent filed June 24, 2014, application number 14/313,118.

GRANTS AWARDED
($1,689,431)

Stephen Boppart, GlaxoSmithKline, "Biophotonics Imaging Lab Pilot Projects for GlaxoSmithKline," 5/24/2013 – 8/31/2014, $2,500.

Brad Sutton and **John Georgiadis**, NIH, "CRCNS: U.S.-French Collaboration: Computational Imaging of the Aging Cerebral Microvasculature," 8/16/2013 – 8/15/2016, $394,115.

Zhi-Pei Liang, NIH-Subaward through the University of Chicago, "Advanced Image Reconstruction for EPRI po2 Mapping," 7/15/2013 – 5/31/2018, $264,753.

Wawrzyniec Dobrucki, **Marni Boppart**, and Andrew Smith, NIH, "Molecular Imaging of Stem Cell-Induced Reversal of Vascular Complications and Function in Diabetes Mellitus," 10/1/2013 – 9/30/2014, $94,563.

Brad Sutton, **Zhi-Pei Liang**, and Ryan Larsen, CNLM-Abbott Nutrition, "Developing Advanced MRI Methods for Detecting the Impact of Nutrients on Infant Brain Development," 5/16/2013 – 5/15/2016, $23,500.

Gabriel Popescu and Marina Marjanovic, NIH, "Biophotonics Summer School," 4/1/2014 – 3/31/2015, $10,000.

Stephen Boppart, Neumedicines, Inc., "Intravital Multimodal Microscopy of IL-12 Induced Cell Dynamics in Skin," 1/1/2014 – 5/1/2014, $100,000.

Stephen Boppart, NSF, "Enhanced Optogenetic Control of Neuronal Activity with Tailored Light Stimuli," 5/1/2014 – 4/30/2017, $450,000.

Stephen Boppart and Ryan Shelton, NSF, "Optimized OCT-Video Imaging in a Handheld Scanning Otoscope," 7/1/2014 – 12/31/2014, $50,000.

Stephen Boppart, NSF, "EAGER: Smart Phone Platform for Personal High Resolution 3D Optical Imaging," 7/1/2014 – 6/30/2016, $300,000.

SELECTED PUBLICATIONS

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Polak, S. J.; Rustom, L. E.; Genin, G. M.; Talcott, M.; **Wagoner Johnson, A. J.**, A Mechanism for Effective Cell-Seeding in Rigid, Microporous Substrates. *Acta Biomateriala* **2013**, *9,* (8), 7977-7986.

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Zimmerman, B.; **Sutton, B. P.**; Low, K. A.; Fletcher, M. A.; Tan, C. H.; Schneider-Garces, N.; Li, Y. F.; Ouyang, C.; Maclin, E. L.; **Gratton, G.**; **Fabiani, M.**, Cardiorespiratory Fitness Mediates the Effects of Aging on Cerebral Blood Flow. *Frontiers in Aging Neuroscience* **2014**, *6*, DOI: 10.3389/fnagi.2014.00059.

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

Covering July 1, 2013-June 30, 2014

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*
Pierre Wiltzius, *Materials Science and Engineering*

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*
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*
Eric Pop, *Electrical and Computer Engineering*
Angus Rockett, *Materials Science and Engineering*
Moonsub Shim, *Materials Science and Engineering*
Min-Feng Yu, *Mechanical Science and Engineering*

Theoretical and Computational Biophysics

Laxmikant V. Kale, *Computer Science*
Zaida (Zan) Luthey-Schulten, *Chemistry*
Klaus J. Schulten, *Physics*
John Stack, *Physics*
Emadeddin Tajkhorshid, *Pharmacology*

Beckman faculty names are in bold-face type.

SELECTED HONORS AND AWARDS

Ioannis Chasiotis
A.J. Durelli Award, Society for Experimental Mechanics, 2013

Martin Gruebele
Fellow, National Academy of Sciences, 2013

Laxmikant V. Kale
HP Labs Innovation Research Program Award, 2012

Paul J. Kenis
William H. & Janet G. Lycan Professor, University of Illinois, 2013

William P. King
Fellow, American Association for the Advancement of Science, 2013
Gustus-Larson Memorial Award, ASME, 2013
Best Paper Award, 11th International ISHMT-ASME Heat and Mass Transfer Conference, 2013

Jean-Pierre Leburton
Finalist, Innovation Discover Award, 2013

Deborah E. Leckband
Division Area 15 Plenary Lecture Award, American Institute of Chemical Engineers, 2013

Yi Lu
Associate, Center for Advanced Study, University of Illinois, 2013

Zaida (Zan) Luthey-Schulten
Fellow, Center for Advanced Studies, Ludwig Maximilians University, Munich, Germany, 2014
William and Janet Lycan Chair, Department of Chemistry, University of Illinois, 2014

Joseph W. Lyding
Research Excellence Award, Nano/Bio Interface Center, U. Pennsylvania, 2013

Jeffrey S. Moore
Murchison-Mallory Professor of Chemistry by the Howard Hughes Medical Institute, University of Illinois, 2014

John A. Rogers
Elected to the American Academy for Arts and Sciences, 2014
Engineering Council Award for Excellence in Advising at University of Illinois, 2014
Eringen Medal, Society of Engineering Science, 2014
Elected to the National Academy of Inventors, 2013
Kavli Foundation Innovations in Chemistry Lecture, American Chemical Society, 2013
Permanent Member of the Center for Advanced Study, University of Illinois, 2013
Smithsonian Ingenuity Award for Physical Science, Smithsonian Institution, 2013
Robert Henry Thurston Award, American Society of Mechanical Engineers, 2013
Honoris Causa Doctorate, École Polytechnique Fédérale de Lausanne (EPFL), 2013

Nancy R. Sottos
Nancy Drucker Eminent Faculty Award, College of Engineering, University of Illinois, 2014

INVENTION DISCLOSURES

Faculty members from the Molecular and Electronic Nanostructures research theme were inventors on nine invention disclosures (5% of the 179 invention disclosures filed by campus) during FY2014.

SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the M&ENS research theme were inventors on 20 of the following patent applications (9.9% of the 202 patent applications filed by campus) and 15 patents issued (19.2% of the 78 patents issued to campus) during FY2014.

Mark Shannon and Junghoon Yeom, "Method of Forming a Patterned Layer of a Material on a Substrate," patent issued July 9, 2013, patent number 8,480,942.

Ioannis Chasiotis and Mahommad Naraghi, "Stress Micro Mechanical Test Cell, Device, System and Methods," patent issued August 6, 2013, patent number 8,499,645.

John-Hyun Ahn, Won Mook Choi, Yonggang Huang, Dae-Hyeong Kim, Heung Cho Ko, **John Rogers**, Jizhou Song, and Mark Stoykovich, "Stretchable and Foldable Electronic Devices," patent issued October 8, 2013, patent number 8,552,299.

Yi Lu, Debapriya Mazumdar, and Mehmet Veysel Yigit, "MRI Contrast Agents and High-Throughput Screening by MRI," patent issued October 29, 2013, patent number 8,568,690.

Byunghoon Bae, Richard Masel, and **Mark Shannon**, "Bi-direction Rapid Action Electrostatically Actuated Microvalve," patent issued January 14, 2014, patent number 8,628,055.

Dahl-Young Khang, Keon Jae Lee, Matthew Meitl, Etienne Menard, Ralph Nuzzo, **John Rogers**, Yugang Sun, and Zhengtao Zhu, "Methods and Devices for Fabricating and Assembling Printable Semiconductor Elements," patent issued March 4, 2014, patent number 8,664,699.

Yonggang Huang, David Kaplan, Dae-Hyeong Kim, Brian Litt, Fiorenzo Omenetto, **John Rogers**, and Jonathan Viventi, "Implantable Biomedical Devices on Bioresorbable Substrates," patent issued March 4, 2014, patent number 8,666,471.

Alfred Baca, Ralph Nuzzo, **Angus Rockett**, **John Rogers**, and Jongseung Yoon, "Arrays of Ultrathin Silicon Solar Microcells," patent issued March 25, 2014, patent number 8,679,888.

Maria Gracheva, **Jean-Pierre Leburton**, Gregory Timp, and Julien Vidal, "Solid State Device," patent issued April 22, 2014, patent number 8,702,929.

Brett Beiermann, Benjamin Blaiszik, Jericho Moll, **Nancy Sottos**, and **Scott White**, "Interfacial Functionalization for Self-Healing Composites," patent issued April 22, 2014, patent number 8,703,285.

Jong-Hyun Ahn, Alfred Baca, Heung Cho Ko, Matthew Meitl, Etienne Menard, Michael Motala, Ralph Nuzzo, Sang Il Park, **John Rogers**, Mark Stoykovich, Jongseung Yoo, and Chang-Jae Yu, "Optical Systems Fabricated by Printing-Based Assembly," patent issued May 13, 2014, patent number 8,722,458.

Andrew Carlson, Won Mook Choi, Yonggang Huang, Haqing Jiang, Dahl-Young Khang, Heung Cho Ko, Matthew Meitl, Etienne Menard, Ralph Nuzzo, **John Rogers**, Mark Stoykovich, Yugang Sun, and Zhengtao Zhu, "Controlled Buckling Structures in Semiconductor Interconnects and Nanomembranes for Stretchable Electronics," patent issued May 20, 2014, patent number 8,729,524.

Aleksei Aksimentiev, Jeffrey Comer, Utkur Mirsaidov, Gregory Timp, and Winston Timp, "Characterizing Stretched Polynucleotides in a Synthetic Nanopassage," patent issued June 10, 2014, patent number 8,748,091.

Dahl-Young Khang, Etienne Menard, **John Rogers**, and Yugang Sun, "A Stretchable Form of Single Crystal Silicon for High Performance Electronics on Rubber Substrates," patent issued June 17, 2014, patent number 8,754,396.

Apratim Dhar, Simon Ebbinghaus, **Martin Gruebele**, and Douglas McDonald, "Particle Dynamics Microscopy Using Temperature Jump and Probe Anticorrelation/Correlation Techniques," patent issued June 24, 2014, patent number 8,757,871.

Yi Lu, Debapriya Mazumdar, and Mehmet Veysel Yigit, "MRI Contrast Agents and High-Throughput Screening by MRI," patent filed July 5, 2013, application number 13/936,039.

David Cahill, James Herbison, Benito Marinas, **Jeffrey Moore**, and Ana Saenz De Jubera, "Development of Polyamide Nanofiltration Membrane Modified with Covalently Bonded Amine Terminated Dendrimers," patent filed July 26, 2013, application number 61/859,057.

Jong-Hyun Ahn, Won Mook Choi, Yonggang Huang, Dae-Hyeong Kim, **John Rogers**, Jizhou Song, and Mark Stoykovich, "Stretchable and Foldable Electronic Devices," patent filed August 23, 2013, application number 13/974,963.

Bruno Azeredo, **Nicholas Fang**, Placid Ferreira, Xuefei Han, Keng Hao Hsu, Kyle Jacobs, and Anil Kumar, "Direct Nanoscale Patterning of Surfaces by Electrochemical Imprinting," patent filed August 23, 2013, application number 13/974,902.

Joseph Lyding, Charishma Subbaiah, and Joshua Wood, "Asymmetric Magnetic Field Nanostructure Separation Method, Device and System," patent filed September 10, 2013, application number 14/004,364.

Rashid Bashir and Vincent Chan, "Miniaturized Walking Biological Machines," patent filed September 13, 2013, application number 61/877,676.

Hefei Dong, **Jeffrey Moore**, Stephen Pety, **Nancy Sottos**, and **Scott White**, "Partially Degradable Fibers and Microvascular Materials Formed from the Fibers," patent filed September 27, 2013, application number 14/040,287.

Jean-Pierre Leburton, "Methods and Apparatus Analyzing a Target Material," patent filed October 4, 2013, application number 13/63379.

John Georgiadis, Joseph Holtrop, Curtis Johnson, and **Brad Sutton**, "3D Multislab, Multishot Magnetic Resonance Elastography Pulse Sequence," patent filed October 31, 2013, application number 61/898,053.

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 14, 2013, application number 61/904,032.

Keon Jae Lee, Matthew Meitl, Etienne Menard, Ralph Nuzzo, **John Rogers**, Yugang Sun, and Zhengtao Zhu, "Methods and Devices for Fabricating and Assembling Printable Semiconductor Elements," patent filed January 14, 2014, application number 14/155,010.

Jung Lee, **Yi Lu**, and Mehmet Veysel Yigit, "Alignment of Nanomaterials and Micromaterials," patent filed February 5, 2014, application number 14/173,455.

Alfred Baca, Ralph Nuzzo, **Angus Rockett**, **John Rogers**, and Jongseung Yoon, "Arrays of Ultrathin Silicon Solar Microcells," patent filed February 5, 2014, application number 14/173,525.

John Georgiadis, Curtis Johnson, and **Brad Sutton**, "Method and System for Multi-Shot Spiral Magnetic Resonance Elastography Pulse Sequence," patent filed February 12, 2014, application number 14/178,355.

Jeffrey Moore, "Microcapsules," patent filed February 18, 2014, application number 61/941,066.

Ryan Gergely, Brett Krull, **Jeffrey Moore**, Windy Santa Cruz, **Nancy Sottos**, and **Scott White**, "Multiple Stage Curable Polymer with Controlled Transitions," patent filed April 8, 2014, application number 61/976,793.

GRANTS AWARDED

($3,540,688)

Jeffrey Moore, **Scott White**, **Nancy Sottos**, and **John Rogers**, DOD-DARPA, "Metastable Packaging for Transient Electronic Devices," 4/1/2013 – 10/31/2013, $350,000.

Nancy Sottos, **Scott White**, and **Jeffrey Moore**, NSF, "SusChem/FRG/GOALI: Mechanochemically Based Sustainable Polymers," 8/16/2013 – 8/15/2016, $800,000.

Narayana Aluru, NSF, "Structure, Dynamics and Transport of Multiphase Fluids," 8/1/2013 – 7/31/2016, $352,721.

Jeffrey Moore, **Scott White**, **Nancy Sottos**, and **Paul Braun**, DOD-ONR, "Seeded Reaction Waves in Composites: Fast Structure-Transforming Materials that Respond to Energetic Stimuli," 3/1/2013 – 2/29/2016, $899,749.

Martin Gruebele and **Joseph Lyding**, NSF, "Imaging the Surface Dynamics of Glasses and Photoexcited Molecules," 9/15/2013 – 8/31/2016, $401,000.

Klaus Schulten, **Zaida Luthey-Schulten**, and **Emad Tajkhorshid**, NIH, "Hands-on Workshops on Computational Biophysics," 9/16/2012 – 9/15/2017, $737,218.

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Braun, P. V., Materials Chemistry in 3D Templates for Functional Photonics. *Chemistry of Materials* **2014**, *26,* 277-286, DOI: 10.1021.cm4023437.

Cahill, D. G.; **Braun, P. V.**; Chen, G.; Clarke, D. R.; Fan, S. H.; Goodson, K. E.; Keblinski, P.; **King, W. P.**; Mahan, G. D.; Majumdar, A.; Maris, H. J.; Phillpot, S. R.; **Pop, E.**; Shi, L., Nanoscale Thermal Transport. II. 2003-2012. *Applied Physics Reviews* **2014**, *1,* (1), DOI: 10.1063/1.4832615.

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Do, J. W.; Estrada, D.; Xie, X.; Chang, N. N.; Mallek, J.; **Girolami, G. S.**; **Rogers, J. A.**; **Pop, E.**; **Lyding, J. W.**, Nanosoldering Carbon Nanotube Junctions by Local Chemical Vapor Deposition for Improved Device Performance. *Nano Letters* **2013**, *13,* (12), 5844-5850, DOI: 10.1021/nl4026083.

Girdhar, A.; Sathe, C.; **Schulten, K.**; **Leburton, J. P.**, Graphene Quantum Point Contact Transistor for DNA Sensing. *Proceedings of the National Academy of Sciences of the United States of America* **2013**, *110,* (42), 16748-16753, DOI: 10.1073/pnas.1308885110.

Han, W.; Cheng, R. C.; Maduke, M. C.; **Tajkhorshid, E.**, Water Access Points and Hydration Pathways in CLC H^+/Cl^- Transporters. *Proceedings of the National Academy of Sciences of the United States of America* **2014**, *111,* (5), 1819-1824, DOI: 10.1073/pnas.1317890111.

Jin, H. H.; Mangun, C. L.; Griffin, A. S.; **Moore, J. S.**; **Sottos, N. R.**; **White, S. R.**, Thermally Stable Autonomic Healing in Epoxy Using a Dual-Microcapsule System. *Advanced Materials* **2014**, *26,* (2), 282-287, DOI: 10.1002/adma.201303179.

Johnson, C. L.; McGarry, M. D. J.; Gharibans, A. A.; Weaver, J. B.; Paulsen, K. D.; Wang, H.; **Olivero, W. C.**; **Sutton, B. P.**; **Georgiadis, J. G.**, Local Mechanical Properties of White Matter Structures in the Human Brain. *Neuroimage* **2013**, *79,* 145-152, DOI: 10.1016/j.neuroimage.2013.04.089.

Kim, H.; Abeysirigunawarden, S. C.; Chen, K.; Mayerle, M.; Ragunathan, K.; **Luthey-Schulten, Z.**; Ha, T.; Woodson, S. A., Protein-Guided RNA Dynamics During Early Ribosome Assembly. *Nature* **2014**, *506,* (7488), 334-+, DOI: 10.1038/nature13039.

Kolossov, V. L.; Beaudoin, J. N.; Hanafin, W. P.; DiLiberto, S. J.; **Kenis, P. J. A.**; Gaskins, H. R., Transient Light-Induced Intracellular Oxidation Revealed by Redox Biosensor. *Biochemical and Biophysical Research Communications* **2013**, *439,* (4), 517-521, DOI: 10.1016/j.bbrc.2013.09.011.

Krishnan, D.; **Johnson, H. T.**, Light-Induced Deformation in a Liquid Crystal Elastomer Photonic Crystal. *Journal of the Mechanics and Physics of Solids* **2014**, *62,* 48-56, DOI: 10.1016/j.jmps.2013.08.013.

Kunal, K.; **Aluru, N. R.**, Phonon Mediated Loss in a Graphene Nanoribbon. *Journal of Applied Physics* **2013**, *114,* (8), DOI: 10.1063/1.4818612.

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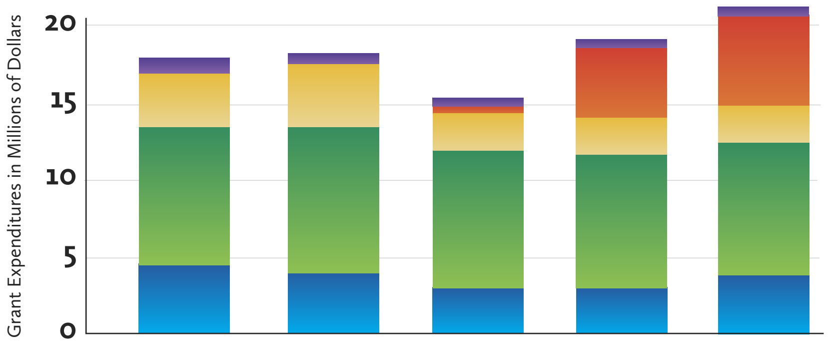
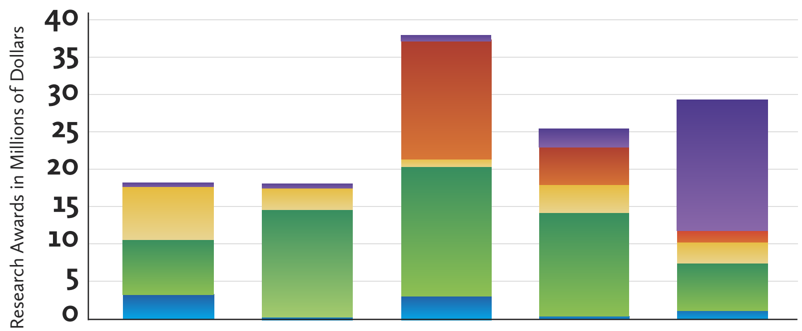
BECKMAN INSTITUTE FUNDING 2013-2014

Grant Expenditures by Funding Source[1]



	FY10	FY11	FY12	FY13	FY14
DOD	$4,358,155	$3,869,004	$3,200,338	$3,426,205	$2,328,861
NIH	$9,072,558	$9,705,827	$8,665,427	$8,208,039	$8,718,725
NSF	$3,403,358	$4,050,734	$2,482,559	$2,565,483	$2,398,696
Abbott[2]	$-	$-	$484,248	$4,183,296	$6,249,854
Other	$1,075,980	$770,525	$575,790	$690,399	$2,839,996
Total	**$17,910,050**	**$18,396,090**	**$15,408,362**	**$19,073,422**	**$22,536,132**

Research Awards by Funding Source[3]



	FY10	FY11	FY12	FY13	FY14
DOD	$2,831,689	$3,001	$3,107,121	$2,317	$1,617,249
NIH	$7,488,077	$13,879,105	$17,245,588	$14,121,116	$5,798,307
NSF	$6,747,793	$2,578,574	$876,173	$3,507,298	$3,012,333
Abbott[2]	$-	$-	$15,246,982	$5,272,426	$2,381,765
Other	$683,834	$894,094	$757,369	$2,324,885	$16,870,368
Total	**$17,751,393**	**$17,354,774**	**$37,233,233**	**$25,228,042**	**$29,680,022**

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, 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 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

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

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:

- 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.
- Understanding Normal and Abnormal Cognition and Emotion investigates the cognitive and emotion-related mechanisms that allow people to seek and maintain mental and physical health throughout the lifespan.
- 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.

HABITS is led by Beckman faculty **Kara Federmeier** and **Rohit Bhargava**.

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**.

Social Dimensions of Environmental Policy (SDEP)

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.
- 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**.

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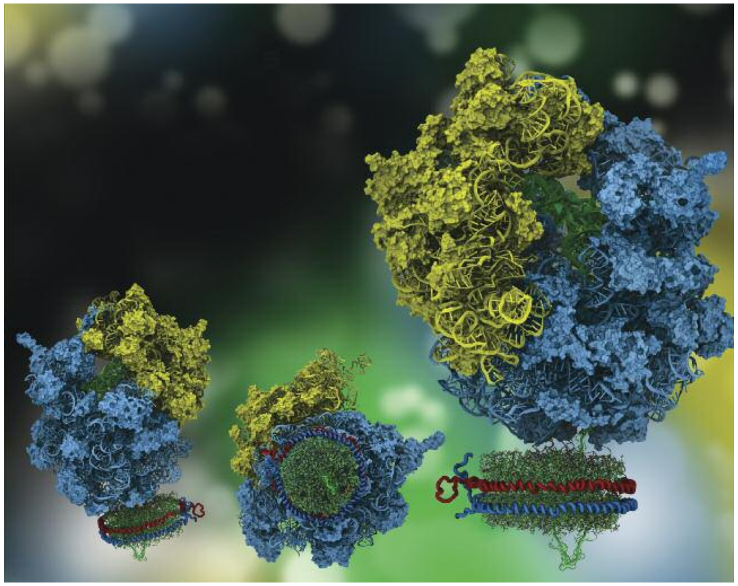
BECKMAN SCRAPBOOK

Ted Brown (left), the Institute's first director, and Arnold Beckman tour the Beckman Institute shortly after it opened in 1989.

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.



Creation of a nascent membrane protein by the ribosome.

Credit: Image created by Bo Liu using the software VMD, which was developed by the Theoretical and Computational Biophysics Group, NIH Center for Macromolecular Modeling and Bioinformatics.

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 4^{th} 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

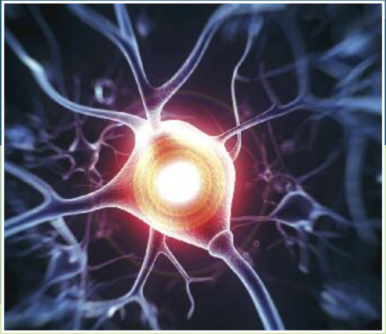
Through scientific discovery and targeted research, the Center for Nutrition, Learning, and Memory (CNLM) drives the understanding of nutrition's impact on cognition. The center is the first interdisciplinary cognition and nutrition research center in the country.

CNLM partners with two world-renowned Urbana campus research facilities, the Beckman Institute for Advanced Science and Technology and the 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.

CNLM announced its Round 3 awards on May 16, 2014. Twenty-three full proposals were received on February 14, 2014, and nine were selected for funding. Projects began in August. The nine project titles are:

- Impact of Infant Formula on Brain and Eye Development
- Investigating the Effects of Nutrition on the Maturation of Brain Networks Associated with Memory in Infants
- A Nutritional Intervention to Enhance Brain and Cognitive Development in Small-for-Gestational-Age Piglets



- Nutritional Enhancement of Cognitive and Physical Performance: A Randomized Controlled Trial
- Diet-Modified Brain Chemistry and Plasticity: Lutein as a Case Study
- Enhanced Chemical Characterization Efforts for Selected CNLM Projects
- Neural Mechanisms of Nutrient-Induced Cognitive Enhancement
- Impact of Fiber on the Gut Microbiome and Cognition in Mice
- Impact of Nutrients on Neonatal Brain Development and Function

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 newly appointed director of the Interdisciplinary Health Sciences Initiative.

Illinois Children's Environmental Health and Disease Prevention Research Center

In 2013 the Illinois Children's Environmental Health Research Center was established at the Beckman Institute at the University of Illinois. 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 tracks 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 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 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.

See page 2 for more details on Susan Schantz and the studies.

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 at Illinois in 1985 by Professor Paul Lauterbur, 2003 winner of the Nobel Prize in Medicine, for his "seminal discoveries concerning the use of magnetic resonance to visualize different structures. These discoveries have led to the development of modern magnetic resonance imaging (MRI), which represents a breakthrough in medical diagnostics and research."

Since then, BIC has grown to include four distinct labs, and changes in the past year, including acquiring another 3 Tesla Trio full-body MRI scanner. With this new machine and many new projects starting, BIC is busier than ever before.

BIC provides magnetic resonance services not only for Beckman researchers, but for researchers around the world. The MRI systems are research-dedicated scanners used to pursue imaging studies in both humans and animals.

The new MRI scanner will assist with the increase in brain imaging being conducted for INSIGHT, a new multidisciplinary study to determine what kind of training best improves adaptive reasoning and fluid intelligence.

INSIGHT is funded by the Intelligence Advanced Research Projects Activity (IARPA), under the Office of the Director of National Intelligence. The project directly supports IARPA's SHARP (Strengthening Human Adaptive Reasoning and Problem-solving) program, the goal of which is to develop evidence-based tools and methods that can improve the quality of human judgment and reasoning in complex, real-world environments.

The study, headed by **Aron Barbey**, is designed to establish a comprehensive and rigorous brain training protocol that incorporates the best available cognitive, physical fitness, neuroscience, and nutritional interventions for the enhancement of fluid intelligence.

In addition to the brain imaging for INSIGHT, BIC is also using the new MRI to increase its research in elastography, which investigates the structure, function, and health of tissues by testing their stiffness. Information about tissues' elasticity provides another means to assess a system's function and integrity.

The MRI is a part of one of the four modality-specific laboratories in BIC. The Magnetic Resonance Imaging Laboratory (MRIL) includes the two 3 T MRI scanners and the 14T (600) MHz Varian NMR system; the Molecular Imaging Laboratory (MIL) is home to a micro-PET/SPECT/CT system used in dynamic molecular imaging studies; the Ultrasound Imaging Laboratory (UIL) provides high-frequency ultrasound imaging capabilities; and the Diffuse Optical Imaging Laboratory (DOIL) houses a frequency-domain diffusive optical imaging system for advanced optical imaging, the largest of its kind in the world.

BIC studies during the past year have utilized the wide variety of modalities available.

Diane Beck is investigating the neural underpinnings of visual awareness. She uses a combination of neuroimaging with high temporal and spatial resolution and direct perturbation of cortical activity to understand the interactions between the frontoparietal and occipitotemporal cortex in the service of visual awareness.

Florin Dolcos has been using MRI to study the brain structures associated with emotion-cognition interactions and the role they play in human behavior.

Fatima Husain used the MRIL to examine how to dissociate the neural bases of chronic tinnitus from those of hearing loss and to link behavioral measures of subjective, chronic tinnitus with brain imaging measures.

Art Kramer investigates the effects of a six-month physical activity intervention on cognitive performance, aerobic fitness, and brain structure and function in healthy low-active and low-fit adults 60 to 80 years old. His lab is also involved with INSIGHT, utilizing the new MRI scanner.

William Olivero is studying volumetric changes in the brain of patients with chronic pain undergoing spinal fusion.

Eva Telzer examines how different social situations affect decision-making across development.

Iwona Dobrucka is evaluating doxorubicin-based anti-cancer therapy in combination with the herbal medicine black cohosh.

Wawrzyniec Dobrucki is using multiple modalities across BIC to develop a novel diagnostic imaging probe for targeted imaging of prostate and breast cancer tumors that will not only improve early detection but also will provide a tool to evaluate targeted therapies in patients.

Jianjun Cheng works in the MIL to develop nanoparticles for *in vivo* x-ray computed tomography imaging.

Yi Lu is using the equipment in MIL to research the selected delivery of an anti-cancer drug with aptamer-functionalized liposomes.

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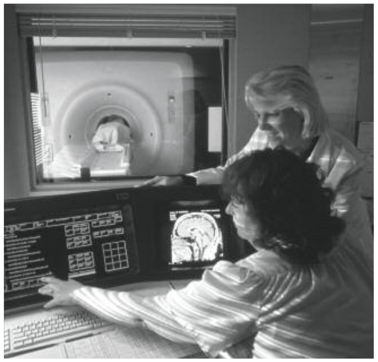
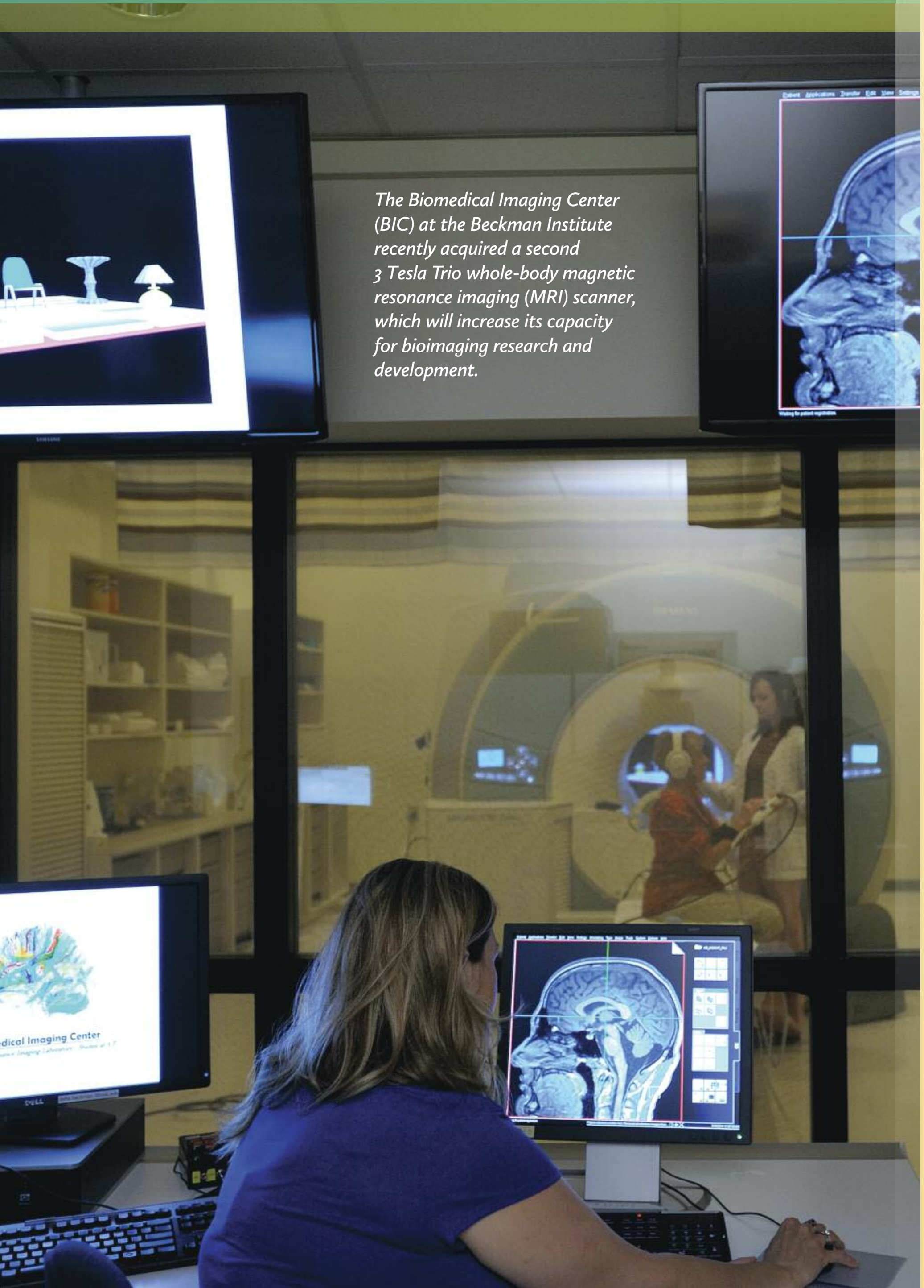


Tracey Wszalek, BIC director (right), and Sherri Kiska, BIC's first technologist (left), work with an MRI scanner in the early days of the Functional Mapping Project collaboration with Carle Hospital, circa 1994.



The Biomedical Imaging Center (BIC) at the Beckman Institute recently acquired a second 3 Tesla Trio whole-body magnetic resonance imaging (MRI) scanner, which will increase its capacity for bioimaging research and development.

Biomedical Imaging Center Capabilities

A new Magnetom Trio whole-body 3 T MRI Scanner was added to the center in the last year. The center is also home to 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 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 animal research studies, animal clinical care scans, 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 answering questions that can be pursued 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

When the Beckman Institute opened its doors, the simulators at the Illinois Simulator Laboratory (ISL) were not yet built or even invented. But like most of the projects and facilities at the Beckman Institute, the ISL became a space for increased collaboration.

The first simulator used in the ISL, the CAVE, was designed in 1995 and almost immediately became the centerpiece of a large, federally funded five-year grant called the Federated Lab for Advanced and Interactive Displays (FedLab), which made a number of significant contributions to basic and applied research relevant to the development of the next generation of advanced displays.

At the time, the National Center for Supercomputing Applications (NCSA) was housed in the Beckman Institute, and, as part of a graduate student project, the Electronic Visualization Lab at the University of Illinois-Chicago created the CAVE, the world's first room-sized immersive environment, and provided the CAVE to NCSA.

"After the first year of the FedLab project, we realized there wasn't enough coordination between the researchers," said Hank Kaczmarski, director of the ISL and former technical program manager for NCSA. "So we created the Integrated Systems Lab (later to be renamed the Illinois Simulator Lab) to provide a space for all the researchers to work together."

After the FedLab project ended, NCSA moved to their new building across the street from Beckman, but Kaczmarski, the CAVE, and the ISL remained. Over time, the ISL would acquire the CUBE, a six-sided virtual reality environment, a driving simulator, a flight simulator, and motion capture studios.

From the beginning, the CAVE has been heavily used for psychology experiments. In many studies, performances of tasks in the CAVE environment are used to measure cognitive functioning before and after an intervention. For example, participants may engage in a pedestrian street-crossing task in the CAVE, where the virtual streets gradually become more busy and more difficult to cross. During the weeks or months in between their visits to the CAVE, participants engage in a variety of interventions, such as taking a theater class or participating in physical exercises for a specified period of time.

The flight simulator, which came to the ISL in 2008, is continually upgraded as new projects from the Federal Aviation Administration (FAA) and NASA are added. One of the projects is led by **Alex Kirlik**, who uses the flight simulator to engineer better ways to alert pilots of dangerous flight situations and how to fix them.

"Imagine that you have automation that is looking out and making sure your plane is operating in a safe area within the sky. What the automation is doing is looking out for you and letting you know when you're starting to exceed the boundaries of safety, and when you do, it tells you that you're getting near the boundaries so you can fix it and start flying safely again," Kirlik said. "It will also provide you with information and guidance on how to get out of the impending problem."

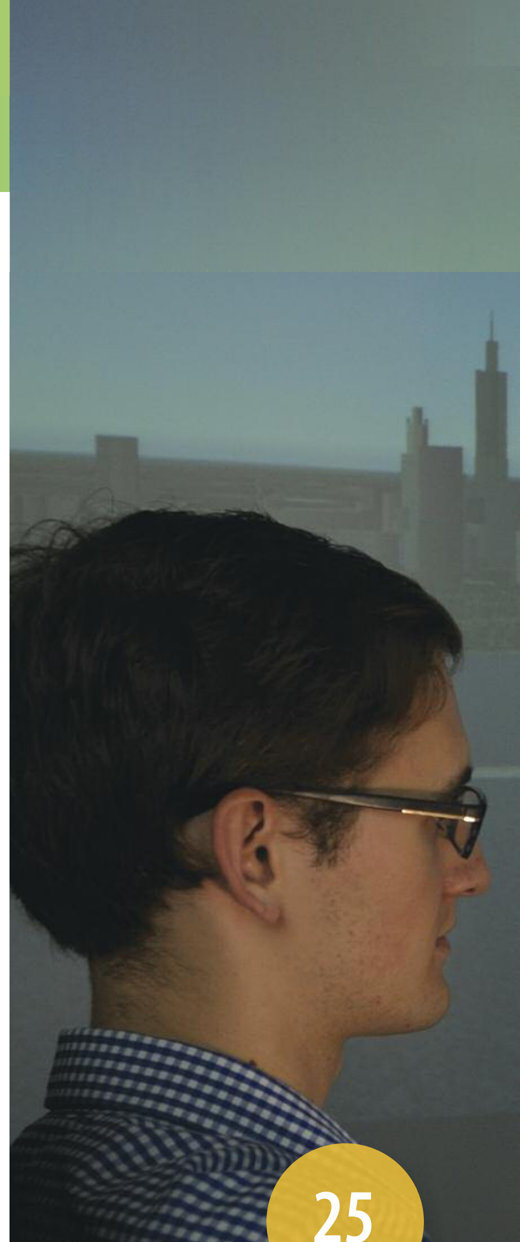
This project, funded by the NSF, looks to improve flying environments, so pilots are better able to respond to emergencies by assigning specific roles to automation and allowing humans to perform the tasks that they do best.

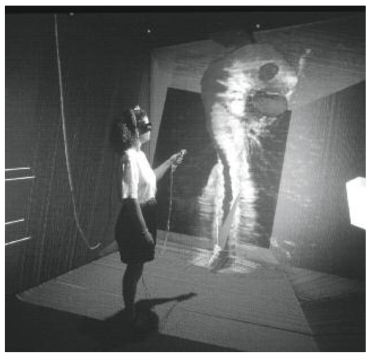
In addition to the flight simulator, the CUBE is expanding and upgrading as well. With six sides, the CUBE provides an entirely immersive virtual environment for participants to explore. A new project is using the CUBE to create virtual urban and nature environments to investigate if there are advantages to a person's mental capabilities if he or she is in a realistic nature environment versus being in a realistic urban environment.

To upgrade the CUBE, ISL employees are equipping it with new LCD displays, which will be 10 to 15 times brighter and provide more visual depth and much greater colorimetry than the projectors used previously.

The ISL continues to be place for state-of-the-art simulation research, with many new projects on the horizon.

"We're growing, and we're excited about several upcoming projects that have the potential to benefit society," said Kaczmarski.





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BECKMAN SCRAPBOOK

At left, former NCSA employee Rachael Brady looks at a model of a spinal cord in the CAVE when it was being developed in the Beckman Institute, circa 1995.

The flight simulator at the ISL supports several projects that are in constant pursuit of creating safer, more intuitive flying environments for pilots. Alex Kirlik investigates ways to engineer safe cyber-physical-human systems. Kirlik and graduate student Ben Seefeldt are creating better ways to display information to pilots so they can respond to emergencies more swiftly and accurately. The researchers are developing a feature on the control panel that dynamically provides information indicating a safe flying zone. If the plane is about to breach that safe zone, the pilot will be alerted and provided with information on how to remedy the situation.

Illinois Simulator Laboratory Capabilities

The CAVE

The CAVE is a four-sided immersive reality environment operated by the ISL, and is 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.

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 kinesiologists 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. Additionally, a new University-funded dance project is returning the motion capture system to its earliest research roots.

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

History was captured in a whole new way in the Visualization Laboratory (Vis Lab) this past year. With a high-quality digital camera, strategic lighting, and 3D image construction software, an 800-year-old stone figurine was brought to life.

Researchers in the Vis Lab compiled hundreds of individual photographs of the Sponemann figurine to create a 3D pdf image that allows users to rotate and zoom in and around the image.

The Illinois State Archeological Survey (ISAS), a division of the Prairie Research Institute at the University of Illinois, worked with Travis Ross, manager of the Vis Lab, and Nathan Bajandes, graphic specialist in the lab, to create these images.

"One of the major concerns of the public is gaining access to objects in storage in scientific repositories. Three-dimensional imaging allows a way to make these items available to a wider audience," said Thomas Emerson, director of ISAS. "In fact, because we can put them up on the web, they are available on a global level, rather than to just the few people who might visit a museum display. Our pilot project with the Sponemann figurine was an effort to determine if this approach was economically and technically feasible."

With the Vis Lab's macro-photography suite, Ross and Bajandes captured several photos of the entire surface of the the 6 x 12″ figurine, and used Agisoft, a program that stiches images together, to reconstruct the high-quality three-dimensional image.

In the future, ISAS will make 3D pdfs of its objects available on its web site so the public can view the images in lifelike detail.

The photography suite, which features 20 MegaPixel DSLRs and a professional photo and video studio, was added to the Vis Lab in the past year. The Vis Lab also offers a range of highly advanced equipment for

Left: Research staff in the Visualization Laboratory stitched several hundred images of an 800-year-old figurine together to create a 3D interactive image for the Illinois State Archeological Survey (ISAS). In the ISAS archives are hundreds of objects that are not publicly shown. The 3D imaging will allow ISAS to showcase these pieces of history on its web site, so researchers from around the world can have access.

The Sponemann figurine dates to the 12th century A.D. and is associated with the people who created the archaeological site of Cahokia, North America's first city. The 6 x 12″ figurine was excavated by survey crews in the 1980s from a burned temple building a few miles from the current Cahokia State Historical site in Collinsville, Illinois. The figurine is made from an unusual material known as Missouri flintclay from sources just west of St. Louis. The image is of a young woman who likely represents the Corn Mother, a prominent deity in native societies. She is often shown with symbols representative of plants and serpents, all markers of the Underworld that are associated with life renewal and fertility in native cosmology.

imaging and video needs. Users can take advantage of numerous capabilities, including graphics services such as 3D rendering, photography, and image enhancement for journal covers and presentations; scientific research support that includes image analysis, animation, and video production; as well as 2D and 3D object scanning.

Ross said work in 3D has become a focus of the lab, as evidenced by many students, faculty, and groups like ISAS that use the multiple 3D modalities available. The staff of the Vis Lab assist in updating software and meet the specific design and simulation needs of the researchers.

Steve Boppart, a Beckman faculty member and director of Imaging at Illinois, is a frequent user of the Vis Lab. Boppart understands the vital role the lab plays in ensuring users meet their research goals.

"Our Vis Lab plays an essential role in research, and in sharing our results with our scientific communities, with our colleagues across disciplines, and with the general public. By turning seemingly complex information into visual forms, it becomes possible to express the meaning, importance, and beauty of the work," Boppart said. "In doing this, the staff and users in our Visualization Lab have the power to inspire a sense of wonder, and to motivate us to keep asking the questions that drive our paths forward toward discovery and innovation. Data without visualization is simply like paint without the painting."

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A student working in the Vis Lab in 1999.

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.

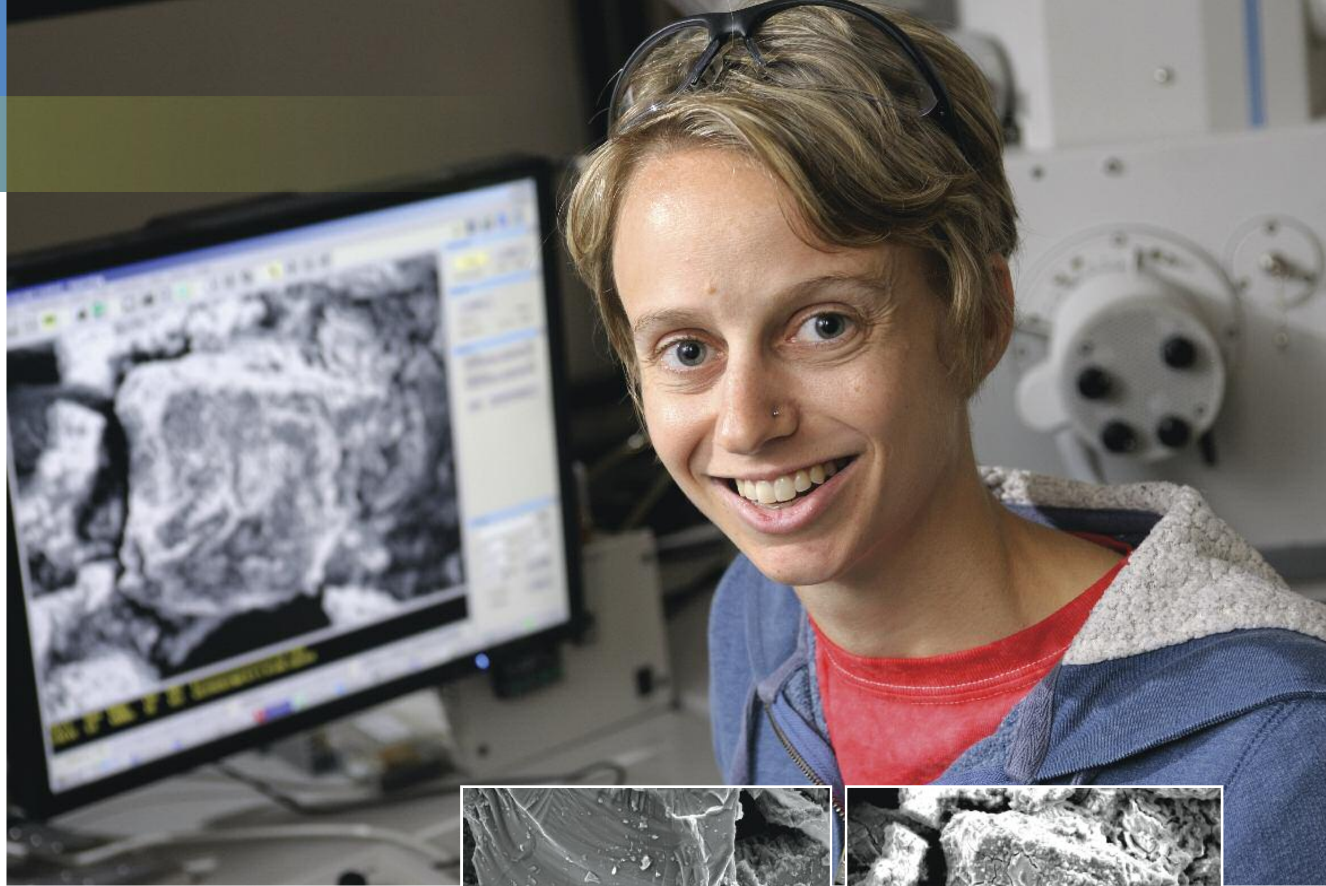
3D Object Scanning
The Vis Lab offers multi-point laser detection to create 3D surface geometry of real-world objects; also used for object measurement and 3D modeling.

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 presentation 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

Researchers come to the Microscopy Suite for a variety of reasons, but they all have a common purpose: to use some of most powerful and state-of-the-art microscopes available. Each instrument housed in the lab in the basement of the Beckman Institute is managed by a knowledgeable staff member who has expertise working with biological samples, biomaterials, and various other materials. The staff are there specifically to aid users in attaining research goals. The four main modes of imaging include light/laser microscopy/spectroscopy, scanned probe microscopy, electron microscopy/energy-dispersive spectroscopy, and x-ray micro- and nano-computed tomography (CT).

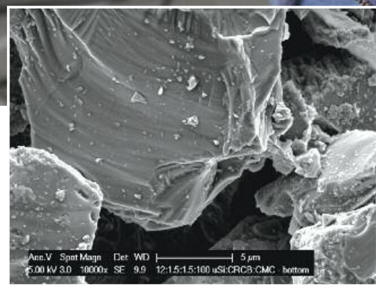
The scanning electron microscope (SEM) is one of the workhorses of the Microscopy Suite, providing high-resolution images at an ultimate resolution of two nanometers (two billionths of a meter). A beam of electrons scans repeatedly across the sample and produces stunningly crisp images of its surface topography and (depending on which detector is used) composition.

Elizabeth Jones, a graduate student working in the Autonomous Materials Systems Group, uses the SEM for her work to improve high-capacity lithium-ion batteries.

Lithium-ion batteries, which power devices like laptops and cell phones, utilize internal electrodes that permit them to charge and discharge. During these cycles the electrodes expand and contract, but—especially with high-capacity lithium-ion batteries—the electrodes may expand too much and then crack, degrading the capacity and lifetime of the battery. Researchers are working to create longer-lasting high-capacity batteries by reducing the strain upon/expansion of the electrodes to prevent cracking.

"People are looking at using high-capacity materials in batteries for electric vehicles to extend the range of electric vehicles," said Jones. "If you have a high-capacity electrode material, you can make the battery smaller and it will last just as long as current batteries. Or, if the high-capacity battery is the same size, it'll last a lot longer."

Electrodes are the conductors through which electricity enters and leaves lithium-ion batteries; thus they are the driving force behind the batteries' power. They have three main components: active material particles, a conductive additive to fill in the interstitial regions between the active material particles, and a polymer that binds the first two materials together.



Jones' work focuses on designing an electrode for which expansion and contraction are minimized, and cracking is thus minimized as well. In order to find the most effective combination, she creates new electrodes with different ratios of the three main components. That's where the SEM comes in.

"I use the SEM to see what the electrodes look like after I create a new one. They're only around 90 microns thick (a micron is a millionth of a meter), so I need to use the SEM to characterize the dispersion of the different materials in the electrodes," Jones said. "I've worked with several different ratios of materials, and also tried different active materials. It's a continual process of trial and error, and the SEM is fundamental in understanding how the materials mix together."

This is just one project of hundreds, at any given time, that benefit from the capabilities of the Microscopy Suite, which has been a Beckman Institute core facility since the

Left: Elizabeth Jones, a graduate student in the Autonomous Materials Systems Group, uses the scanning electron microscope (SEM) to characterize the homogeneity of electrodes used in high-capacity lithium-ion batteries. During charge and discharge cycles of the batteries, the electrodes expand and contract; if they expand too much, they crack and diminish the integrity of the battery. Jones is perfecting an electrode that delivers high-capacity energy without cracking. The two smaller images, as seen through the SEM, show a pristine silicon composite electrode (left), and one that has cracked as a result of the large volume expansion and contraction that silicon undergoes during charging and discharging cycles (right).

late 1990s. In the last year, the Microscopy Suite has undergone significant expansion in terms of both physical space and capabilities. The fluorescence microscope has been completely updated with a new instrument, software, and computer; many of the instruments have had control computers upgraded; and two of the microCT systems have been given new computers, new RAID arrays, 360-degree capability, and load-cell capability, among other improvements. A new ultramicrotome has been delivered and set up in completely remodeled space that also houses several other instruments and microscopes.

Additionally, biosafety level 2 (BL-2) space is being created to facilitate live-cell imaging. Because some live cells may only be imaged under BL-2 conditions, this new space will house the cell and tissue culture facility that incorporates two new systems: a FRET (fluorescence resonance energy transfer) microscope and BioSLIM (biological spatial light interference microscopy) with TIRF (total internal reflectance fluorescence) imaging capability in opposition, permitting a novel form of correlative microscopy.

"We keep updating and growing to meet the needs of our users," said lab manager Scott Robinson, who has been a member of the staff since 1998. "The caliber of work that researchers perform, and that we are able to support, continues to amaze me."

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Former ITG director Bridget Carragher, pictured with one of the first confocal microscopes from Zeiss, circa 1997.

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 Near-IR 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 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 FELLOWS PROGRAM

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.

2014 Postdoctoral Fellows

Jason Patrick

Patrick'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 will focus on the development of authentic biomimetic materials that inherit the evolutionary advantages of dynamic, natural counterparts. He plans to work with a truly multidisciplinary team at Beckman: 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, Lee 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. Lee plans to work with Rohit Bhargava in the Bioimaging Science and Technology Group, and Jeffrey Moore in the Autonomous Materials Systems Group. His initial research plan is to synthesize imaging probes that may help elucidate the sequence of protein signaling in breast cancer progression.

Gillian Hamilton

Since receiving her Ph.D. in behavioral neuroscience from the University of Delaware in 2012, Hamilton has been working 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. Her research at the Beckman will be done in conjunction with Justin 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

Wrobel'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 plans to develop a platform for imaging prostate cancer tissues using IR spectroscopy with very high spatial resolution. He plans to work 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

Biggan recently 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 plans to investigate 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 plans to work 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

Ma 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 will devote systematic efforts on optimizing signal excitation, data acquisition, and image reconstruction and post-processing, and applying metabolic imaging to study brain functions. Ma 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

Jyothi 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 initial 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 Medeiros-Ward
Medeiros-Ward 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
Sadowski 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
Singharoy was a graduate student of theoretical chemistry at Indiana University. His research at the 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
Bhat 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. Bhat'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
Deutsch 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. Deutsch'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, Erickson 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
Lucas 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.

Jie Sun
Sun earned a Ph.D. in molecular and integrative physiology in December 2011 from the University of Illinois at Urbana-Champaign. As a Beckman Fellow, Sun works with Eric Jakobsson from the Computational Multiscale Nanosystems Group and collaborates with Peter Wang. Her research is in the area of synthetic biology, with a goal of trying to understand the fundamental principles governing the molecular regulations of signaling transduction in living cells. In her

Fellows project, Sun uses protocells as a synthetic platform to reconstitute cellular functions and understand the biological organization of cell signaling.

Baoxing Xu
Xu completed a Ph.D. in engineering mechanics at Columbia University's Department of Earth and Environmental Engineering. His thesis topic is on the science of nanofluidics and energy conversion. Baoxing's research involves nanofluidics, fabrication and formation of micro/nanofluidic channels, advanced micro/nano-mechanical characterization of materials and structures, mechanical behavior of advanced materials, and stress-driven pattern in biomaterials and biostructures. At Beckman he works with John Rogers from the 3D Micro- and Nanosystems Group, and also has a collaboration with Nancy Sottos and Scott White from the Autonomous Materials Systems Group. His research with Rogers seeks to develop a micro/nanofluidics-integrated soft actuator based on conductive polymers for integration with an epidermal electronics system with medical applications. He works with Sottos and White on integrating the micro/nanofluidic CP actuator inside self-healing materials.

2011

Kyle Mathewson
Mathewson earned a Ph.D. in psychology from the University of Illinois. He has worked for many years in Beckman's Cognitive Neuroimaging Laboratory with Institute researchers Monica Fabiani and Gabriele Gratton. During his time at Illinois and Beckman, Mathewson's research involved cognitive neuroscience, with a focus on attention and awareness in the human visual system. As a Beckman Fellow he is studying the prediction and control of brain states that influence subsequent perception, learning, brain activity, and even consciousness. He takes research outside of traditional laboratory settings, monitoring brain activity during virtual reality situations, in order to predict performance in more ecologically valid environments. Techniques and technology will be developed to monitor and adaptively manipulate these predictive brain states in order to improve cognitive function.

Joseph Toscano
After completing his Ph.D. in cognition and perception at the University of Iowa, Toscano joined the Fellows program to continue his research looking at how the perceptual system uses context information during speech perception. At Beckman he uses computational modeling and neuroimaging methods to investigate continuous cue encoding and categorization during speech processing, to apply his approaches to spoken word recognition, and to examine effects of prosody and audiovisual speech. Toscano works with Susan Garnsey from the Cognitive Neuroscience Group, Sarah Brown-Schmidt and Duane Watson from Cognitive Science, Jont Allen from Artificial Intelligence, and Charissa Lansing from Human Perception and Performance.

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, Kirk Erickson (above), assistant professor in psychology at the University of Pittsburgh, worked with Beckman researchers to develop collaborations investigating links between fitness and cognitive health.

Erickson, who received his Ph.D. from Illinois in 2005, worked in Beckman Director Art Kramer's lab as a graduate student, and they have continued to collaborate throughout the years. Erickson has also collaborated with Beckman researchers Charles Hillman and Edward McAuley. Erickson visited the researchers' labs during his fellowship to compare methods and styles from his lab at Pitt.

Erickson's research has primarily focused on how exercise interventions can positively affect cognitive heath. For example, in one of his studies, older adults were asked to briskly walk, three times a week. This caused a significant increase in hippocampal volume, a region important in memory formation and especially important for older adults, when decreasing hippocampus levels could lead to Alzheimer's and dementia.

2014 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.

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)
Rubin, 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 has previously been involved in clinical research studies at Carle Foundation Hospital and the University of Iowa Hospital.

Elizabeth Jones is a doctoral candidate in theoretical and applied mechanics in the Department of Mechanical Science and Engineering. Her research looks to advance the reliability and safety of lithium-ion batteries, and to extend their use beyond portable electronics to electric vehicles and renewable energy storage. She proposes to study high-capacity electrode materials, such as silicon and tin, which have up to 10 times the theoretical capacity of commercially used materials (graphite) but are limited by the huge volumetric expansion that occurs during the alloying process with lithium. Jones works with Nancy Sottos and Scott White, of the Autonomous Materials Systems Group, as well as with Paul Braun, from the 3D Micro- and Nanosystems Group.

Taewoo Kim is a Ph.D. student in electrical and computer engineering. His research focuses on building a quantitative phase imaging (QPI) system that can be used for both noninvasive live cell imaging as well as imaging of optogenetic biomachines. His proposed new technique will improve the spatial light interference microscopy (SLIM) with a programmable light source to be more informative by adding spatial and spectral specificity. Kim works primarily with Gabriel Popescu, from Bioimaging Science and Technology Group, and will be co-advised by Rashid Bashir, from 3D Micro- and Nanosystems, and Martha Gillette, from NeuroTech, for this project.

A doctoral student in molecular and integrative physiology, **Itamar Livnat** is developing tools to detect D-amino containing-peptides (DAACP), taking advantage of their unique properties like their resistance to degradation by peptidases. The long-term objective of this work is to identify DAACPs in the mammalian nervous system. He is working with Martha Gillette and Jonathan Sweedler in the NeuroTech Group.

Qian Yin is a Ph.D. student in materials science and engineering. The goal of her proposed research is to develop a novel translational polymeric nanoparticle system that can successfully evade nonspecific uptake *in vivo*, and achieve targeted cancer diagnosis and therapy. By uniquely integrating well-established chemical reaction with a nanoprecipitation technique, Yin can prepare drug/dye/radioisotope-containing nanoparticles with perfectly controlled physicochemical characteristics in large quantities. Yin works with faculty in Bioimaging Science and Technology including Stephen Boppart, Jianjun Cheng, and Wawrzyniec Dobrucki, and Timothy Fan from the College of Veterinary Medicine.

Giang-Chau Ngo is completing her Ph.D. in bioengineering. She is looking at how to develop acquisition and estimation approaches for MRIs to provide a fast and robust method to estimate the parameter that represents brain function. Ngo will work with Brad Sutton, of the Bioimaging Science and Technology Group, and Art Kramer, of the Human Perception and Performance Group.

Peiyun Zhou is a doctoral candidate in educational psychology. Her research into auditory perceptual simulation (APS) bridges the fields of linguistics, psychology, and education, and she hopes to contribute to embodied cognition theory in psychology. APS is performed when readers mentally simulate characteristics of the voice of the character in a text. Zhou will employ two methodologies, event-related brain potentials (ERPs) and eye-tracking, to investigate how to improve morphosyntactic awareness through APS of native and non-native English speech. She is working with Kiel Christianson and Duane Watson of the Cognitive Science Group, Susan Garnsey in the Cognitive Neuroscience Group, and Elizabeth Stine-Morrow from Human Perception and Performance. She also works with Tania Ionin from the Department of Linguistics.

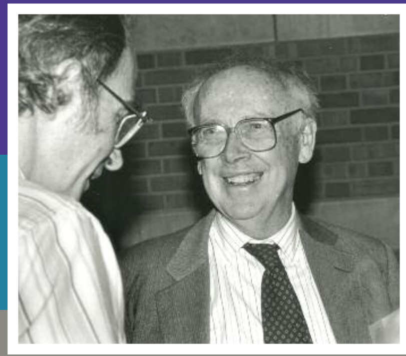
OUTREACH AT THE BECKMAN INSTITUTE

Educating and informing the world about innovative research has been part of the Beckman Institute's mission since its doors opened in 1989. In 1992, James Watson, Nobel Laureate and director of Cold Spring Harbor Laboratory, presented a lecture, "After the Double Helix," as part of the Smith, Hinchman & Gryllis Lecture series (now the SmithGroup Lecture). In a follow-up letter to Beckman Director Ted Brown, Watson noted, "You are to be congratulated on both (the Institute's) super architectural design and the broad ranging collection of highly motivated young scientists who now inhabit it."

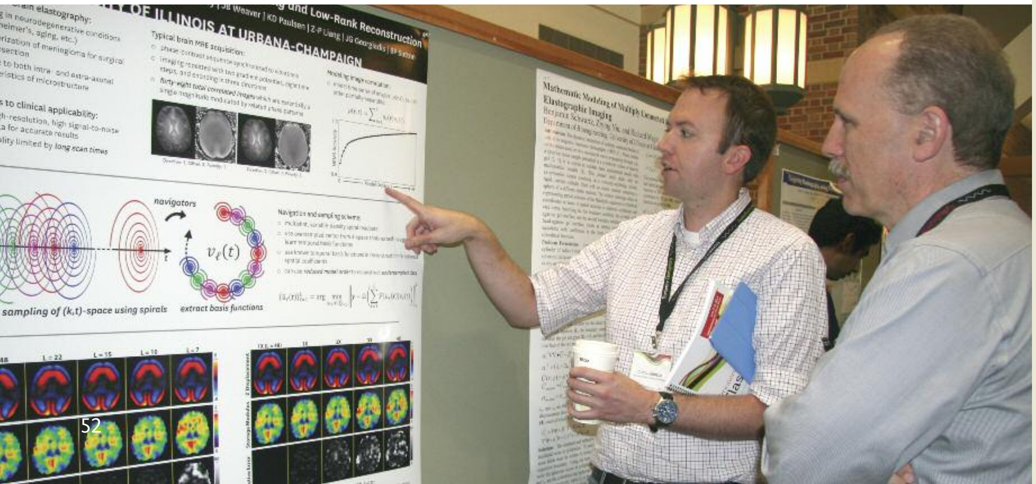
Those "highly motivated young scientists" are excited about sharing their research results to a wide audience. From tours of the Beckman facilities to school groups and international visitors, to lecture series, special events, and workshops, the Beckman Institute opens wide the doors of its architectural wonder to invite the world in.

Speakers series and seminars, including the Director's Seminar Series, spotlight research and labs within Beckman. Last year a Medical Humanities Lecture series, co-sponsored by the Illinois Program for Research in the Humanities, provided insight into humanities- and arts-influenced medical practices. A BRAIN Initiative seminar series focused on "Mapping and Deciphering Brain Activity."

Regular special events include the Thursdays at 12:20 concert series, which brings in musicians from the U of I School of Music to perform in the Beckman Atrium. Individual research groups and Strategic Initiative areas, such as Social Dimensions of Environmental Policy (SDEP), hosted a number of campus-wide events, including a workshop on Advancing Socio-Hydrology, a New Science of People and Water. Symposia and summer schools this year ranged from focusing on nano/biosystems to environmental toxicology, from fluorescence techniques to biophotonics and elastography.


Nobel Laureate James Watson presented the first SmithGroup Lecture at the Beckman Institute in 1992.

Beckman researcher Curtis Johnson (left) explains his research during the Frontiers in Elastography symposium, held June 2014.



Citizen Scientist

Research at the Beckman Institute is made possible by the broad range of skills and expertise of its researchers, which include students, postdocs, faculty members, and, as of 2009, members of the Osher Lifelong Learning Institute (OLLI), a member-driven learning community for people over the age of 50.

The Beckman Institute collaborates with the Institute for Genomic Biology and OLLI to support the Citizen Scientist Program, which invites OLLI members into the labs as research assistants.

OLLI citizen scientists are matched with scientists at the Beckman Institute based on their knowledge, skills, and interests. They volunteer in a lab for several hours every week, oftentimes being delegated their own tasks to manage for the lab.

"What we appreciate about this program is that it allows our members to explore new areas and make important contributions even after their own careers may be behind them," said Christine Catanzarite, OLLI director. "That's a valuable lesson about the importance of lifelong learning."

Since 2009, the Citizen Scientist Program has grown to include 15 citizen scientists, who are involved in a variety of disciplines and subject areas, from entomology to neurology. Past participants include retired teachers, bankers, gardeners, scientists, and others.

"In a sense, they were all self-selected because they all wanted to do something scientific and be part of the scientific community," said Geena Skariah, who helped manage the fledgling program for two years. "Their personalities may range from very talkative to very friendly to absolutely quiet people, but they all find their own niche in each lab."

Sallie Miller, a retired healthcare industry professional, found her niche at the Beckman Institute volunteering for Susan Schantz, who heads the Illinois Children's Environmental Health and Disease Prevention Research Center, which studies whether chemicals in plastics and personal care products alter child development, cognition, or other behaviors. There are six citizen scientists in the Schantz lab.

Miller assists with calling and recruiting participants and inputting data—a vital task for the center as it's working to test more than 600 mothers and babies. As all scientists know, there's a lot that goes on behind the scenes to make science happen, and Miller makes sure this work gets done.

"I know I could be slowing down," Miller said. "But I like doing this. I was interested to see what they were doing, what they wanted me to do, whether I would enjoy doing it or not. It keeps me active and it keeps my mind sharp. Why wouldn't I take advantage of that?"

BECKMAN INSTITUTE CONTACT INFORMATION

The Beckman Institute for Advanced Science and Technology
University of Illinois at Urbana-Champaign
405 North Mathews Avenue
Urbana, IL 61801
Phone: 217-244-1176
Fax: 217-333-2922
Web: beckman.illinois.edu

Director
Art Kramer
Phone: 217-244-8373
Email: a-kramer@illinois.edu

Associate Director for Administration
Kara Johnson
Phone: 217-244-8380
Email: kjohnsn@illinois.edu

Associate Director for Research
Patty Jones
Phone: 217-300-1784
Email: pmjones5@illinois.edu

Biological Intelligence Research Theme Co-Chairs
Jennifer Cole
Phone: 217-244-3057
Email: jscole@illinois.edu

Mark Nelson
Phone: 217-244-1371
Email: m-nelson@illinois.edu

Human-Computer Intelligent Interaction Research Theme Co-Chairs
Elizabeth Stine-Morrow
Phone: 217-244-2167
Email: eals@illinois.edu

Mark Hasegawa-Johnson
Phone: 217-333-0925
Email: jhasegaw@illinois.edu

Integrative Imaging Research Theme Co-Chairs
Stephen Boppart
Phone: 217-244-7479
Email: boppart@illinois.edu

Zhi-Pei Liang
Phone: 217-244-4023
Email: z-liang@illinois.edu

Molecular and Electronic Nanostructures Research Theme Co-Chairs
Nancy Sottos
Phone: 217-333-1041
Email: n-sottos@illinois.edu

Narayana Aluru
Phone: 217-333-1180
Email: aluru@illinois.edu

Biomedical Imaging Center
Tracey Wszalek, Director
Phone: 217-333-3149
Email: traceyws@illinois.edu

Imaging Technology Group
Scott Robinson, Microscopy Suite
Phone: 217-265-5071
Email: sjrobin@illinois.edu

Travis Ross, Visualization Laboratory
Phone: 217-244-9033
Email: travisr@illinois.edu

Illinois Simulator Laboratory
Hank Kaczmarski, Director
Phone: 217-244-5412
Email: kacmarsk@illinois.edu

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Project Manager: Maeve Reilly, Director of Communications
Writers: August Cassens, Maeve Reilly, Steve McGaughey, Meg Dickinson, Diana Yates, and Liz Ahlberg
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BECKMAN INSTITUTE
FOR ADVANCED SCIENCE AND TECHNOLOGY

University of Illinois at Urbana-Champaign
405 North Mathews Avenue
Urbana, Illinois 61801, U.S.A.
beckman.illinois.edu