2012-2013 ANNUAL REPORT

BECKMAN INSTITUTE
FOR ADVANCED SCIENCE AND TECHNOLOGY

DIRECTOR'S OVERVIEW 2012-13

The Beckman Institute continues to be an exciting place to formulate and conduct interdisciplinary research at the University of Illinois. This was the first full year of operation of our new interdisciplinary Center for Nutrition, Learning, and Memory (CNLM). CNLM is housed in the Beckman Institute, is funded by Abbott Nutrition, and involves collaborations across our campus and with universities in the United Kingdom, France, and Australia. The center funds grants, submitted by our faculty and staff, on basic mechanisms that underlie nutrition effects on brain and cognition, the development of new techniques to measure brain function and structure, computational models of nutritional pathways, and human translational research. The center is unique both for its collaboration with industry and for its cross-species (e.g., mice, birds, pigs, and humans) and cross-method (e.g., metabolomics, microbiome analysis, gene arrays, single and multiple unit physiology, and systems neuroimaging) approaches to studying an important issue related to health. CNLM currently funds grants from 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.

In this past year, the Theoretical and Computational Biophysics Group, led by Klaus Schulten, has constructed molecular simulations that have determined the chemical structure of the HIV capsid, a protein shell that protects the genetic material of the virus and is key to its virulence. Given this new knowledge, the capsid has become an attractive target for new antiretroviral drugs. Stephen Boppart and his colleagues and students in the Biophotonics Imaging Laboratory have continued to develop tools for the more accurate assessment of tumor status for breast cancer surgery, the assessment and staging of lymph nodes, the noninvasive detection and imaging of middle-ear biofilms associated with otitis media, and the detection of retinal changes associated with diabetic retinopathy. Aron Barbey, a relatively new Beckman faculty member in the Cognitive Neuroscience Group, has used the Vietnam veterans lesion database to map the brain circuits that underlie cognitive and emotional intelligence.

Susan Schantz, a world-renowned environmental toxicologist, joined the Beckman Institute this year. Sue is a professor in the Department of Comparative Biosciences. Her research is focused on understanding the influence of environmental toxins on development and functioning of the brain as well as the cognitive implications of toxins. In her research program she employs both animal and human models to examine the impact of toxins. Sue and her colleagues across campus have just been awarded a five-year, $8 million grant to establish the Illinois Children's Environmental Health and Disease Prevention Research Center, jointly funded by the Environmental Protection Agency (USEPA) and the National Institute of Environmental Health Sciences (NIEHS). The research program investigates the health effects of exposure to chemicals widely used in plastics (see related article page 39).

Beckman Institute faculty continue to be recognized for their outstanding scientific achievements both with external funding to pursue their ideas and with a variety of national and international awards received by our faculty, staff, and students. Although the full list of awards is too long to mention in a brief letter (see the awards section starting on page 26 for a more complete list), we mention a few here. Rohit Bhargava was recognized with the Craver Award for his research on spectral chemical imaging. Steve Boppart was honored with the Hans Sigrist Award for his many contributions to the field of diagnostic laser medicine. Steve Drake won his second Mid-America Emmy for his brief documentaries on interdisciplinary science, this year for the video "Sculpting Proteins," featuring Klaus Schulten and his colleagues. Both Tom Huang and John Rogers were named Swanlund Chairs, the highest endowed titles on the Urbana campus. Laxmikant "Sanjay" Kale and Klaus Schulten of the Theoretical and Computational Biophysics Group have been named the recipients of the 2012 IEEE Computer Society Sidney Fernbach Award, "for outstanding contributions to the development of widely used parallel software for large biomolecular systems simulation." Klaus also received the distinguished service award from the Biophysical Society. Joe Lyding has been recognized as a trailblazer in the field of nanotechnology, with the 2012 IEEE Pioneer in Nanotechnology Award for his work that has touched many fields along the nanoscale. Scott White was chosen to receive the prestigious Humboldt Research Award honoring a lifetime of research achievements. Zhi-Pei Liang was invested as a Franklin W. Woeltge Professor of Electrical and Computer Engineering. Clearly, this is an impressive list of awards for our faculty and staff.

With support from the Beckman Foundation, we have also been able to appoint eight new graduate student Fellows and six new postdoctoral Fellows. I encourage you to take a look at a description of their research interests in the report. (See pages 48-52.)

This has been an exciting and productive year for our faculty, staff, and students, and I am looking forward to seeing what the future holds for the Beckman Institute in 2013-2014.

Art Kramer
Director, Beckman Institute for Advanced Science and Technology

THE YEAR IN **REVIEW**

BIOLOGICAL INTELLIGENCE

From an early age, **Aron Barbey** was fascinated by the human mind and how our intellectual abilities emerge from the physical architecture of the brain.

"The brain is a soft, jelly-like lump of flesh that weighs about three pounds," said Barbey. "But it can contemplate the vastness of interstellar space, the meaning of infinity, ask questions about the meaning of its own existence and about the nature of God. The brain is truly the most amazing thing in the world and, for centuries, has motivated considerable research and debate."

Barbey began as a philosophy major in college, so it is no surprise that he is enthralled by big questions about the nature of the human mind. He earned a Ph.D. in psychology from Emory University in 2007 and joined the University of Illinois and the Beckman Institute in fall 2011. Prior to joining the University of Illinois, he worked as a postdoctoral research fellow with the National Institutes of Health. He now directs the Decision Neuroscience Laboratory at Beckman.

His research group investigates the effects of human brain damage on high-level cognitive functions, with particular emphasis on the prefrontal cortex. Studies of patients with brain damage have a long history in the neuroscience of intelligence and provide a direct way to test whether a brain region is necessary for specific intellectual abilities. However, it was only recently that the limited applicability and specificity of small-sample studies of focal brain damage were overcome by Barbey and his colleagues.

In a series of landmark studies, Barbey investigated almost 200 patients with focal brain injuries and mapped the brain systems that underlie a host of high-level cognitive functions, including general intelligence, fluid intelligence, working memory, cognitive flexibility, and emotional intelligence.

The study mapping the neural architecture of general intelligence is considered one of the largest and most comprehensive analyses so far of the brain structures vital to human intelligence. The study enlisted an extraordinary pool of volunteer participants: Vietnam veterans with highly localized brain damage from penetrating head injuries.

The focal brain injuries analyzed in the study allowed the researchers "to draw inferences about how specific brain structures are necessary for performance," Barbey said. "By studying how damage to particular brain regions produces specific forms of cognitive impairment, we can map the architecture of the mind, identifying brain structures that are critically important for specific intellectual abilities."

A second study expanded on those findings to investigate how general intelligence is related to emotional and social aspects of intellectual function—providing the first and largest human lesion study of the brain mechanisms underlying emotional intelligence.

In both studies, researchers pooled data from CT scans of participants' brains to produce a collective, 3D map of the cerebral cortex. They divided this composite brain into 3D units called voxels and then compared the cognitive abilities of patients with damage to a particular voxel or cluster of voxels with those of patients without injuries in those brain regions. This allowed the researchers to identify brain areas essential to specific cognitive abilities, and those that contribute significantly to general intelligence, emotional intelligence, or both.

Barbey found that specific regions in the frontal cortex (behind the forehead) and parietal cortex (top of the brain near the back of the head) were important to both general and emotional intelligence. The findings provide new evidence that human intelligence relies not on one brain region or even the brain as a whole, Barbey said, but involve specific brain areas working together in a coordinated fashion.

"In fact, the particular regions and connections we observed support an emerging body of evidence indicating that executive and social processes critically depend on the brain's ability to integrate information across specific cortical regions," he said.

The new findings will help scientists and clinicians understand and respond to patients with impairments in executive and social brain function, Barbey said, but the

ARON **BARBEY**

WHAT'S THE BEST SCIENCE-RELATED BOOK YOU'VE READ RECENTLY?

How Intelligence Happens by John Duncan. This book reviews recent progress in cognitive neuroscience on the nature of human intelligence and advances the intriguing hypothesis that intelligence emerges from the prefrontal cortex and the property of its neurons to dynamically construct mental representations of a desired goal-state and the means to achieve it.

results also are of broader interest because they illustrate the interdependence of general and emotional intelligence in the healthy mind.

These studies received worldwide attention, but they are only one example of how Barbey's group is using neuroscience evidence to investigate the architecture of the human mind. Barbey also led a collaborative team that received a grant in the first round of funding from the newly created Center for Nutrition, Learning, and Memory for a study on the role of nutrition in executive and social brain function.

"This project is a great example of the integrative, multidisciplinary, and highly collaborative approach to research at the Beckman Institute," Barbey said. "Our project is a large-scale effort that includes collaborations between scientists here at the Beckman Institute and at Carle Foundation Hospital, where we will work with a team of physicians in the Carle Research Institute."

Understanding the nature of the human mind is one of the greatest intellectual quests of all time and requires the combined insights not only of cognitive neuroscientists, psychologists, and clinicians, but thinkers in nearly every intellectual pursuit, said Barbey.

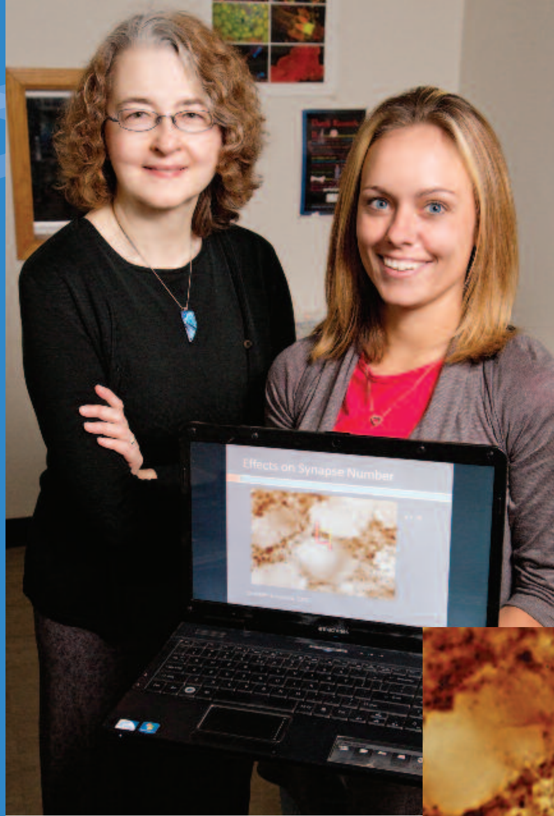
"Indeed, the study of the human mind has benefited from a multidisciplinary approach that investigates how the brain supports the spectrum of mental activities across a broad range of contexts—including how mental capacities emerge through evolution and development, are cultivated through experience, shaped by society and culture, and are altered through psychiatric illness and neurological disease," Barbey said. "As the significance and scope of these issues would suggest, many fundamental questions about the nature of the human mind remain to be explored. We've only just begun to identify and piece together the deep and mysterious constellations of the human mind."

A video about Aron Barbey's study with the Vietnam veterans can be found at beckman.illinois.edu/video/watch/t2AXbFAtX2Y.

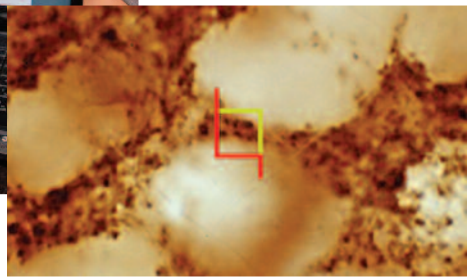
Find more information on the Decision Neuroscience Laboratory at decisionneurosciencelab.org/.

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 included a look at the origin of speech errors, development of a smartphone app to aid first responders, and a study on how prolonged exercise creates more nerve cells.



Below: The researchers looked for a protein marker of synapses (black spots) in the prefrontal cortex, a brain region that governs many abilities known to decline with aging.
Photo by Nioka Chisholm



Treating Aging Losses

A new study of aged female rats by **Janice Juraska** and Nioka Chisholm (above) found that long-term treatment with estrogen and medroxyprogesterone acetate (MPA) increased levels of a protein marker of synapses in the prefrontal cortex, a brain region known to suffer significant losses in aging.

Though studies have been conducted on the effects of hormone therapy to post-menopausal women—suggesting long-term exposure to estrogen and MPA result in an increased risk of stroke and dementia—this new study suggests that starting hormone therapy at the onset of menopause, rather than years or decades after, yields different results.

The study followed middle-aged rats exposed to estrogen alone, to no additional hormones, or to estrogen in combination with MPA for seven months, a time period that more closely corresponds to the experience of women who start hormone therapy at the onset of menopause and continue into old age. The researchers removed the rats' ovaries just prior to the hormone treatment to mimic the changes that occur in humans during menopause.

"Our most important finding is that estrogen in combination with MPA can result in a greater number of synapses in the prefrontal cortex than in animals that are not receiving hormone replacement," Chisholm said. "Estrogen alone marginally increased the synapses, but it took the combination with MPA to actually see the significant effect."

Speech Study Wins Award

Sigmund Freud suggested that speech errors reflected desires and conflicts in the unconscious. Modern studies of how humans process language have shown that Freud was unlikely to be right about the origin of speech errors. But he also suggested that paying attention to what you say would prevent errors. **Nazbanou Nozari** (above) and **Gary Dell** showed that Freud was in fact right about this. Given this benefit, is it a good idea to pay a lot of attention to one word in a sentence if, for example, you are giving a public talk? In three experiments, Nozari and Dell demonstrated that although attending to one word will help you get that word right, it may hurt your ability to get the rest of the sentence right. This is called the benefit and cost of selective attention.

Nozari and Dell's work also shed light on the origin of speech errors: When you make a speech error, you replace a correct sound with an incorrect one. Where does that incorrect sound come from? Some theories of attention predict that the sound would come from the "attended" word. Nozari and Dell showed that this is not true. Instead, the sound comes from other unattended words in the sentence, showing that attention segregates the sounds of the attended word from those of the other words.

Nozari received the American Psychological Association New Investigator Award in 2013 for the paper reporting these results.

Abuse and Harassment Too Common in Field-Based Science

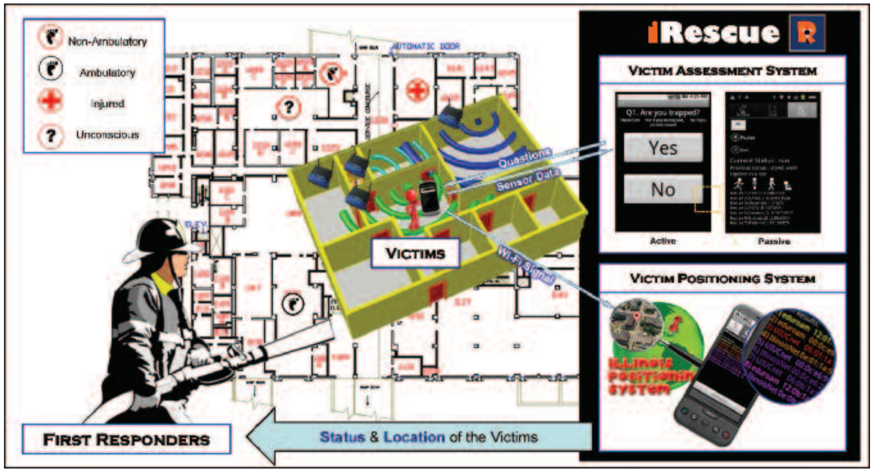
Recent research by **Kate Clancy** found a high incidence of sexual harassment, abuse, and even rape among females in biological anthropology and other field-based sciences.

Of the 124 participants studied so far, nearly 20 percent reported regularly witnessing sexual harassment. Women were far more frequently the target of inappropriate sexual comments—63 percent compared with 39 percent for men. Most troubling, 21 percent of women reported that they had experienced "physical sexual harassment or unwanted sexual contact." Most of the reported abuse happened within the team of researchers, usually perpetrated by someone higher in the professional hierarchy.

"In academia, it is normal for there to be a hierarchy from undergraduate, to graduate student, to postdoc, faculty, and tenured faculty," Clancy said. "And people above you in the hierarchy can have control over your success in your career."

Victims of the harassment may feel they have no choice in stopping the behavior, especially if they are counting on their superiors for future career plans. There are also reports that women are not allowed the same opportunities as their male colleagues.

"We heard many reports of women not being allowed to do certain kinds of fieldwork, being driven or warned away from particular field sites, and being denied access to research materials that were freely given to men (and men who were given access were the ones telling us these things)," Clancy said. "Ultimately, not being able to go to certain field sites, having to change field sites, or not being able to access research materials means women are denied the opportunity to ask certain research questions in our field."



A new app being created by Mark Nelson and his collaborators could aid emergency personnel in more effective rescue missions after a disaster.

Phone App to Aid in Rescue Efforts

Mark Nelson is collaborating with Bill Spencer and Gul Agha to create a smartphone app that will help first responders rescue victims after a disaster.

"Our project focuses on how to quickly and efficiently get useful information to first responders about the status and location of individuals trapped inside buildings," Nelson said. "In general, first responders have no way of sensing the presence of trapped individuals. But today, even in poorer countries, almost everybody carries a cell phone. Cell phones are getting more sophisticated every year, with dozens of onboard sensors (camera, microphone, GPS, gyroscope, accelerometer, etc.), and support for multiple wireless communication protocols (cellular, Wi-Fi, Bluetooth). Our idea is to use individual smartphones inside a building as a distributed wireless sensing network."

After a disaster, the application would be launched and ask questions like "Are you hurt?" or "Are you trapped?" The system can also sense whether the victim is motionless, indicating unconsciousness. All of this information, including the victim's location via GPS, would be sent to emergency personnel, aiding in a quick and efficient rescue operation.

The prototype system is called I-Rescue, short for Illinois Rescue. Researchers envision this app either being individually downloaded or included as a standard feature by smartphone manufacturers.

Insects Show Personality

Shy or fearless? Adventurous or careful? Turns out, bugs have personalities, too.

Gene Robinson led a study that found different behavioral tendencies among insects of the same species. Robinson's study revealed that novelty-seeking honeybees are more likely to scout for nest sites and food. Researchers wanted to know if there were molecular differences in bees that led some to thrill-seeking behavior.

According to the study, there are. Robinson and team took this a step further to find out why these bees were so motivated. They used whole-genome microarray analysis and found thousands of distinct differences in gene activity in the brains of scouting and non-scouting bees.

Robinson and his colleagues studied two novelty-seeking behaviors in honeybees: scouting for nest sites and scouting for food. They found that the nest scouts were three to four times more likely to become food scouts. Their willingness to go the extra mile to seek a nest transcended their desire to scout for food. This, then, became an identifiable personality trait.

"What was most surprising was that some of the same molecular pathways implicated in novelty-seeking behavior in humans also seem to be involved in scouting behavior in bees," Robinson said.

Exercise Prevents Brain Shrinkage

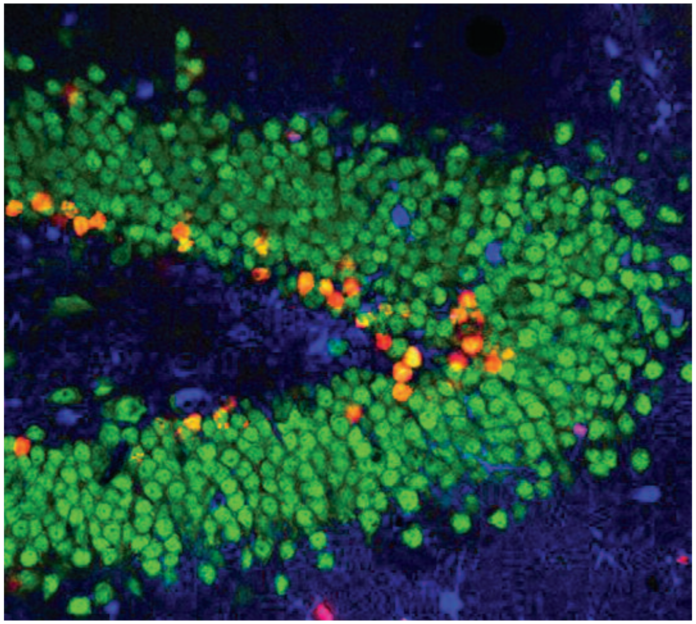
Researchers led by **Justin Rhodes** have shown that exercise protects against brain shrinkage in mice.

The study looked at the results of four different groups of mice. The first group of mice had a cage full of sensory pleasures that included fruit, nuts, cheeses, and flavored water along with colorful beds, tunnels, and balls. The second group was the same with the addition of a running wheel. The third cage was dull with nothing to do and standard kibble to eat. And the fourth only had a running wheel.

After months in the cages, the mice were measured for the number of new nerve cells that were born in an area of the brain that is important for cognition.

"Only one thing had mattered," Rhodes said, "and that's whether they had a running wheel."

Animals that exercised, whether or not they had any other enrichments in their cages, had more new nerve cells than the other mice. Animals that didn't run, no matter how enriched their world was otherwise, did not show a change in how many new nerve cells were born and survived.



Research from Justin Rhodes' lab shows an increase in new nerve cells (highlighted in orange) in the hippocampus (a brain area important for learning and memory) of mice as a result of prolonged exercise.

Though these two bodies are identical in width, a study by Diane Beck showed that people will chose the right image as thinner.

Tallness Creates an Illusion of Thinness

Wearing high heels may be uncomfortable for women, but a study by **Diane Beck** suggests it may make them look thinner. The results showed that tall people are perceived as thinner than a comparably thin short person. When asked to choose between two people of the same narrowness, but one taller than the other, people will often choose the taller person as thinner. The study also showed that thin people are often perceived as taller.

Participants viewed two people and judged which was wider (or taller). On most trials, the stimuli differed in width, but on critical trials they were actually identical in width. When the stimuli have the same width, people should pick at random—there is no correct answer. Yet, people judge the taller one to be skinnier more than 80 percent of the time. They also judged skinnier bodies to be taller more than 70 percent of the time.

The illusion occurs for plain rectangles, but it is exaggerated for the human body. The illusion is unexplained, but one possibility is that it is tapping into culturally valued tall and thin silhouettes. Future research will assess whether patients with body image issues are more prone to this illusion.

Timekeeping in the Brain

Every cell in the body functions on a 24-hour clock that guides the rhythm of our lives. This internal clock emerges from a tiny brain structure called the suprachiasmatic nucleus (SCN) in the hypothalamus.

Martha Gillette and her colleagues discovered that metabolism—the production and flow of chemical energy in the cells—influences timekeeping in the brain.

The new findings alter basic assumptions about how the brain works, Gillette said.

"The fundamental discovery here is that there is an intrinsic oscillation in metabolism in the clock region of the brain that takes place without external intervention. And this change in metabolism determines the excitable state of that part of the brain," she said.

"Basically, the idea has always been that metabolism is serving brain function. What we're showing is metabolism is part of brain function," said Gillette. "Our study implies that changes in cellular metabolic state could be a cause, rather than a result, of neuronal activity."

Power of the Handshake

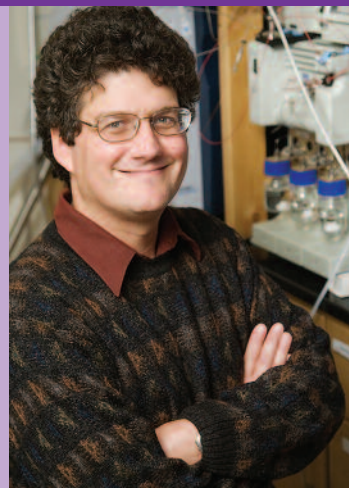
A recent study conducted by **Florin Dolcos** (below right) and his colleagues confirmed what anyone in a successful business already knows: the power of a handshake. Politicians, potential employees, and salesman all know that a handshake creates a positive interaction that projects competence, trustworthiness, and a relationship of positive cooperation.

The research team showed subjects brief video clips of two people meeting in a business interaction. In some of the clips the encounter began with a handshake, and others did not. The clips ended with the parties approaching one another in a collaborative way or separating and displaying avoidance body language, such as crossing arms to discourage further interaction. The subjects then rated each encounter, judging the host's competence and trustworthiness, as well as their own interest in doing business with the hosts. The data showed much higher ratings of all three measures if the encounter was preceded by a handshake. The power of a handshake in boosting trust and partnership was evident regardless of whether the encounters ended positively or negatively, but this effect was stronger for the positive interactions.

These tests were shown to participants while in an MRI, and the scientists found a neural connection to the handshake—a part of the brain called the nucleus accumbens activated when the encounter was preceded by a handshake, and the amygdala brain region activated when the greeting ended positively.

The nucleus accumbens is a central component of the reward pathways that are linked to positive experiences and emotions such as excitement.

Finding the Root Causes of Pain



Working with units of material so small that it would take 50,000 to make up one drop, **Jonathan Sweedler** is developing profiles of the contents of individual brain cells in a search for the root causes of chronic pain, memory loss, and other maladies that affect millions of people.

"Most of our current knowledge about the brain comes from studies in which scientists have been forced to analyze the contents of multiple nerve cells, and, in effect, average the results," Sweedler said.

Sweedler explains that knowledge of the chemistry occurring in individual brain cells would provide the deepest possible insights into the causes of certain diseases, leading to developments in diagnosis and treatment. Until now, scientists have not had the technology to perform this neuron-level research.

Sweedler's group spent much of the past decade developing the technology to analyze the chemicals found in individual cells—a huge feat with a potentially big payoff.

"We are using our new approaches to understand what happens in learning and memory in the healthy brain, and we want to better understand how long-lasting, chronic pain develops," he said.

HUMAN-COMPUTER INTELLIGENT INTERACTION

If one thing can be said about **Fatima Husain**, it's that she has an unwavering passion for asking questions. And once she asks those questions in her research, she makes it her mission to find concrete and quantitative answers.

"Questions, always questions," Husain said. "When I was studying computer science, I wanted to know how real brains worked. When I was doing my Ph.D. in cognitive and neural systems, I wanted to know how speech and hearing worked, and when I was doing my postdoc, I wanted to know what happens when things are disordered. Studying disordered systems in the brain has allowed me to understand the typical order—how do we process sounds? Now there is urgency to the questions: how do I help?"

In her more than five years at the Beckman Institute, Husain has made exponential progress on the research and the documented knowledge of tinnitus, a disorder associated with hearing loss and characterized by a ringing in the ears (or other phantom sounds with no external source). The biggest trigger for tinnitus appears to be hearing loss, but not all people who have hearing loss develop tinnitus.

Her most recent research focuses on determining the emotional processing, attentional processing, and intrinsic or resting-state networks of people who experience tinnitus by performing magnetic resonance imaging (MRI) of the brain in the Biomedical Imaging Center (BIC). Her studies look at how and when people pay attention to their tinnitus and how they are cognitively affected when they can't control it or pay attention to anything else.

"When you get stressed out or can't tune [tinnitus] out, it becomes the most dominant sound, and that's really awful. It interferes with communicating with others, it interferes with sleeping. So people use noises to mask it, and in some cases it works, but sometimes it doesn't," Husain said.

When people are unable to mask the sound, it becomes an emotional burden.

"There's depression, anxiety, and the more you become distressed about it, the harder it is to deal with it," said Husain. Accompanying her research on the internal workings of the brain and tinnitus are her studies on interventions to help tinnitus sufferers cope with the condition.

One method that can help is regaining a sense of control, says Husain. "The worst thing for people is that they're unable to control it. When people are successful in every other part of their lives, but they can't stop the sound, it's hard for them," Husain said. "There are no pills you can take and there's no switch to turn off—you literally have no control. So how do we regain the sense of control? How can we make peace with it?"

Helping participants in her study accept that the noise exists and coming to terms with it allows them to gain control over the sound.

Another way to help people understand tinnitus is by pinpointing what is going on in the brain, which Husain tries to do in her research.

"As of now, there isn't a brain scan that anyone can point to and say, 'This person has tinnitus.' We can't determine what level of tinnitus severity people have, or necessarily why they have it. In the next five to 10 years, we want to find a way to say, 'We know what part of the brain is being affected, and here it is.' This helps people gain some of that control," she said.

A pharmaceutical cure to tinnitus would be the obvious answer, but Husain says research still has much to understand about the brain and how the emotional associations of tinnitus will affect the brain, even if drugs relieve the noise production. However, the intention of her research is to understand the nature of tinnitus in depth, so as to learn how to better treat it.

For her next round of research, she intends to look at how exercise might positively affect those with tinnitus.

"We have plenty of outside research about how exercise positively affects cognitive health, and we're getting stories from patients about how exercise has helped them come to terms with their tinnitus. So we'll be studying the correlation between the two and if it pans out, we will actively test exercise as an intervention," Husain said.

As part of her research on tinnitus, Husain also helped create the Initiative on Communication and Aging Research (I-CARE), a Spring 2013 program funded by a Focal Point grant from the Graduate College at the University of Illinois, which created a forum to facilitate the study of aging and communications by bringing together an interdisciplinary group of faculty and graduate students.

The organizers, Christopher Grindrod and Husain, were aided by graduate students Jake Carpenter-Thompson and

FATIMA **HUSAIN**

WHAT'S THE BEST SCIENCE-RELATED BOOK YOU'VE READ RECENTLY?

Actually, I don't like to read science-related books. I read science papers for my day job. By the time the books come out, the research is outdated and diluted for the general public. I read everything else, and I have found that I have greater insight into science or even tinnitus from these outside sources. The books which stand out in the past year are *Tropisms* by Nathalie Sarraute and John Cage's *Silence.* They have made me think of my own research in new ways.

Sara Schmidt, in conducting semi-monthly meetings to discuss the latest research on communications and aging. Other faculty associated with the grant include Dan Morrow, Liz Stine-Morrow, Kara Federmeier, and Raksha Mudar. They also hosted four seminars with world-renowned speakers who lectured on their particular research related to communication and aging. Topics for both the meetings and seminars included how hearing loss, dementia, stroke, Alzheimer's, etc., affect social and health communication in an aging population.

Husain's goals are many. She wants to learn more about the neurological make-up and reason for tinnitus and how better to conduct interventions and impact patients in a beneficial and meaningful way. She knows it will be difficult, however, because of the wide range of experiences with tinnitus.

"The main thing which bedevils understanding neuro-psychiatric populations, including the tinnitus patient population I study, is the great heterogeneity of the population," said Husain. "When you are studying normal populations, you can maintain the illusion that every normal person behaves the same way. You cannot do this when you are studying a disorder. To paraphrase what Tolstoy said of unhappy marriages, every person with tinnitus is unique in his or her own way. My hope is that we develop better imaging and data analytical techniques to discover what is invariant across this vast multitude of differences. When we are able to integrate that information and parse into sub-types, which do vary from the norm for the disorder, we will understand better how to treat it."

The road ahead will undoubtedly be full of questions for Husain, followed by an eager pursuit of the answer. However, the most important goal she hopes to achieve during her lifetime is quite clear.

"I want to contribute ideas that I discovered in my own work—not outside sources but my own research—and I want the new knowledge to contribute to others' lives. I want it to help other people."

Find more information on tinnitus and the Auditory Cognitive Neuroscience Lab, which Fatima Husain leads, at acnlab.com.

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.

Translating Talk Shows

The talk show "Sabah El Doha" interviews rap musicians, reflexologists, city planners, and archaeologists—in Arabic. The hostess, Shaima Alhamadi, begins every show in standard Arabic (the diplomatic language of the Arab world), but most programs diverge rapidly into Qatari Colloquial Arabic, a dialect so different from standard Arabic that it is usually classified as a different language. Giving these interviews to the rest of the world cannot be accomplished by simply running a speech recognizer and machine translation; standard Arabic recognizers fail, as do standard machine-translation algorithms.

Mark Hasegawa-Johnson, (above, third from right) **Roxana Girju**, and Elabbas Benmamoun are now working with faculty at Qatar University in order to develop automatic speech recognition and machine translation algorithms for Qatari Arabic. Their publications to date include acoustic models for Qatari Arabic (adapted from the closest matching standard Arabic models); pronunciation models learned using the small amount of transcribed data; and word-sequence models learned by combining the small amount of available Qatari Arabic with the very large amounts of available standard Arabic.

One team, led by Hasegawa-Johnson, is testing machine-learning models that treat each word of Arabic as the syntactic amalgamation of potentially unlimited sequences of sub-word units, more like an English "phrase" than an English "word." A second team, led by Girju, is testing models that improve machine-translation accuracy by first classifying the role of each Arabic word in its sentence. For example, if a word has never been seen, it may still be possible to translate it—first, by recognizing sub-word sequences that indicate its meaning, and, second, by tagging the way in which its meaning is being used in the sentence.

Exercise and Brain Structure

Exercise increases brain volume, according to **Art Kramer** (below). His study, with **Edward McAuley** and their students, scanned the brains of 120 older adults, half of whom started a program of moderate aerobic exercise—just 45 minutes, three days a week, mostly walking. After a year, the MRI scans showed that for the aerobic group, the volume of a region of the brain called the hippocampus increased. The hippocampus plays an important role in a number of aspects of memory.

What's more, individuals in the control group lost about 1.5 percent of the volume of their hippocampus, adding up to a 3.5 percent difference between individuals who took part in aerobic exercise and those who did not. Further tests showed that individuals who improved the most in cardiorespiratory fitness also showed the largest increases in memory.

These data are consistent with previous animal studies that found that exercise increased the number of new neurons in the hippocampus as well as improvements in spatial memory.

Overconfidence in Bridge Players

Dan Simons concludes that bridge players are overconfident in predicting their performance. The finding that bridge players were overconfident is not surprising—people tend to be overconfident about most of their cognitive abilities. Simons wanted to explore whether the extent of overconfidence varied with the skill level of the players. "Although both weak and strong players were overconfident in their predictions, the weaker players were much more overconfident," Simons said.

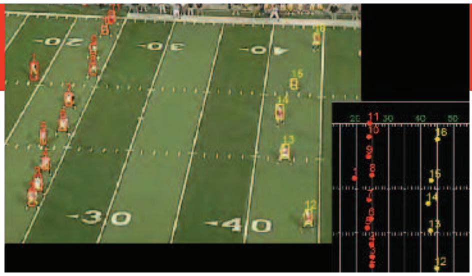
This pattern reflects what is known as the Dunning-Kruger effect: The least skilled players tend to be the most overconfident in rating their ability relative to their peers. Presumably, less skilled people have gaps in their knowledge that make it harder for them to recognize their own relative shortcomings.

Simons' study counters the classic interpretation of this relationship between skill and overconfidence because the players' overconfidence did not result from a lack of knowledge.

"All of the players in my study were experienced and received feedback about their relative performance after every session," Simons said. "So, the Dunning-Kruger effect in my study cannot be attributed to a lack of knowledge of their own abilities or of those of their opponents. Also, our study asked participants to make multiple predictions. That should allow them to calibrate their predictions over time: If you know you over-predicted for the last session, you should temper your optimism for the next one."

This eternal, if unmerited, optimism of bridge players is much like the unjustified optimism that a trip to the slot machines will result in a jackpot, despite repeated evidence to the contrary.

"Weaker players know they are less skilled, but they hold out hope for a good result in any given session. When thinking about their future, people are more likely to imagine positive rather than negative outcomes, and the same principle might apply to anticipated bridge performance," Simons said.



Analyzing Sports Videos More Effectively

"Breaking down film," the process of watching video to formulate strategies in sports, has long been an essential part of athletic training. Traditionally, this type of video analysis has been done manually, but advanced technology created by **Narendra Ahuja** and his computer vision research team at the Advanced Digital Sciences Center (ADSC) could revolutionize the video analysis process, and, subsequently, the way athletes train.

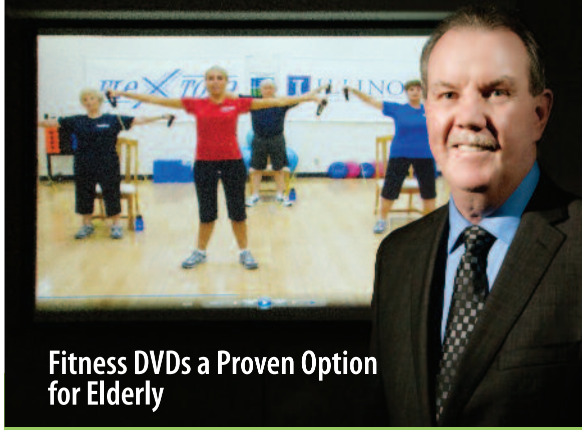
Ahuja and his team look at human actions and interactions in video and have developed a way to analyze these complex movements and patterns automatically. Their system will help coaches and athletes understand large numbers of video clips and quickly and reliably extract statistics from the videos of American football.

"They're tackling fundamental problems that are of key importance when analyzing any sort of video, in particular (video) registration and (object) tracking," said ADSC Director Marianne Winslett. "They're going to make life a lot easier for coaches and athletes."

Ahuja's research team has created an automated prototype, AutoScout, which utilizes advanced computer vision techniques to track objects within, and analyze, sports videos. AutoScout is able to identify what and where the camera is looking at on the field, track athletes during a play, provide statistics for certain plays, and visualize players' motion in 3D.

To accomplish this, ADSC researchers improved the video registration process—the process of mapping a video, which may pan, tilt, or zoom (PTZ) to a coordinate system. They were able to separate out the motion of the object, or athlete in a sports video, from the motion of the camera and then accurately calculate the amount of camera motion.

Photo courtesy of Coordinated Science Laboratory.



Fitness DVDs a Proven Option for Elderly

Exercising at home is a convenient option for many people, especially for adults over the age of 65. In fact, this demographic represents 20 percent of the fitness DVD market. However, until a study conducted by **Edward McAuley** tested the efficacy of a home-based DVD exercise program for older adults, there was little evidence that they worked.

Half of the study's participants used a fitness video designed to improve flexibility, toning, and balance—important abilities to maintain independence and health into older age. The other half watched a video about healthy aging.

At the end of the six months, those who stayed with the fitness program saw "clinically important" improvements in scores on a series of tests of physical function, and, unlike the control group, saw increases in their upper body strength and balance and were able to maintain their previous level of lower body flexibility.

These findings indicate that older adults can achieve fitness at home as effectively as going to classes or the gym, emphasizing that home-based programs are more convenient and can reach a larger audience at a much lower cost, McAuley said.

Research from Dan Morrow finds that photos affect older adults' comprehension of health-related web sites. The image is an example display from the study. Top right is the relevant image. Bottom right is the irrelevant image. The images had varying effects on patient education.

Patient Education Web Site Illustrations

The healthcare industry needs to think carefully about the types of pictures used to illustrate patient education web sites because older adults' comprehension can be negatively affected by irrelevant material, suggests a new study co-written by **Dan Morrow.**

Morrow's research, funded by the National Institutes of Health, used eye-tracking software to measure the attentional processes of 41 older adults while they read passages about hypertension on a computer. Alongside the text in each passage were two pictures: one of a blood vessel (relevant picture), and one of people (irrelevant picture). The participants were then asked to complete a questionnaire based on what they learned, and their resulting knowledge about the risk factors, self-care, and other facets of hypertension that they had learned from the passages varied widely.

The research found that the adults who already had higher levels of health literacy and pre-existing knowledge of hypertension first focused on the text and then used the relevant photo to help consolidate their understanding of the text. However, participants with less knowledge of hypertension spent more time viewing the irrelevant picture and re-reading the text.

Designing effective educational media is becoming increasingly important because the U.S. healthcare system is placing greater responsibility on patients for self-care of chronic illnesses, Morrow said.

Beckman Researchers Contribute to Handbook on Cognitive Engineering

Edited by **Alex Kirlik,** *The Oxford Handbook of Cognitive Engineering* is the first of its kind in the recently and rapidly growing research area of cognitive engineering.

Cognitive engineering is an interdisciplinary approach to the analysis, modeling, and design of engineered systems or workplaces in which humans and technologies jointly operate to achieve system goals. As individuals, teams, and organizations become increasingly reliant on information technology and automation, it is more important than ever for system and workplace design to be maximally informed by state-of-the-art cognitive engineering research.

The book is a collection of more than 60 contributing experts in the field. Six of these authors are University of Illinois faculty: Kirlik, Dan Morrow, Wai-Tat Fu, Christopher Wickens, Anna Ciancolo, and Aaron Benjamin. Throughout the handbook, there is extensive coverage of human factors, human-computer interaction, and the conceptual foundations of cognitive engineering. It addresses cognitive engineering in organizations and communities, as well as individual cognition in topics like attention, decision making, and multi-tasking.

Exercise Can Help Children with ADHD

Just a few minutes of daily exercise can help children with attention deficit hyperactivity disorder (ADHD) perform better academically, according to a new study led by Matthew Pontifex and **Charles Hillman.**

The study shows for the first time that kids with ADHD can better drown out distractions and focus on a task after a single bout of exercise.

In the study, children performed better on two tests (one that replicated standardized testing and another that asked the children to play a simple computer game) following the short bout of exercise compared to when the same children performed those tests after being seated.

"This provides some very early evidence that exercise might be a tool in our nonpharmaceutical treatment of ADHD," Pontifex said.

Though drugs have been highly effective in treating ADHD children, both parents and physicians worry about the side effects and cost of long-term pharmaceutical solutions. Increasing physical exercise in school may lead to better scholastic performance without the risk of drugs, Hillman said.

Regular Breaks Boost Productivity

Though many consider breaks during work to be procrastination, recent research by **Alejandro Lleras** found that regular breaks throughout the day, even just in increments of a few minutes at a time, can improve focus, productivity, and creativity.

"When you do the same thing for a long time, performance falls," Lleras said. "At any point in time you have multiple possible concerns or thoughts you could be having. It's difficult to maintain one particular [focus] for a long period of time. If you break that pattern and force yourself to think of something else very briefly, when you go back to your task you get a refreshed focus."

Lleras says this plays into what we know about the brain's process of habituation. Our minds dull any information that feels constant so that we will be alert to threats. In terms of survival, "it makes sense that there would be a time of expiration for how long we can keep an idea in our mind," he says.

However, when focus is meant to be on work, people are vulnerable to slumps in productivity. After about 40 minutes of focus, attention begins to wane.

To avoid this lapse of productivity and energy, it's important to let the mind escape. The best breaks are "easy to engage and disengage from" or completely unassociated with the task at hand and may include exercise, calling a friend, running an errand, or even taking a nap, Lleras said.

New Technology and Pilots

Tim Bretl has been researching the use of electroencephalography (EEG) connected to brain-machine interfaces (BMIs) to signal movement in aircraft. In other words, the researchers are using “mind-reading” technology to control planes in the sky.

Future pilots might use a tiny sensor surgically implanted in their brain to essentially control the flight with their mind, though Bretl said it is unlikely that systems based on EEGs and similar devices “will give performance that exceeds traditional input devices (e.g., pedals, stick) in an aircraft.”

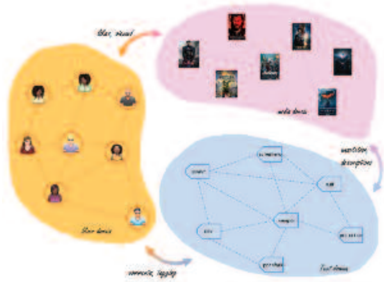
One potential application of this technology is to increase safety without touching controls: EEG-based systems can already measure a subject’s focus and concentration, sending alerts when fatigue begins to dull the mind or concentration wavers.

Because both flight controls and the neural networks and connections in our brains are complex, many improvements to the technology are necessary, but the device may also be a tool used by those with physical disabilities. The device can connect to a computer or machine and transmit a detailed signal to a computer programmed to translate thought into complex action, such as commanding a robotic arm to grip a soda can.

User-Adaptive Recommendation on Social Media Networks

Thomas Huang and his research team are working to curb the information overload of today’s social media sites by more effective content organization.

In the past decade, recommendation systems have become an important necessity to ease user burden from information overload. The e-commerce web sites such as Amazon and Netflix are able to collect item ratings from their customers and analyze these user-to-item preferences to establish recommendations for target users.



An illustration of the heterogeneous social media network that links users, content, and context metadata together.

Among the analysis models, the collaborative filtering (CF) technique has been extremely popular in extracting user and item profiles from the user’s and the crowd’s behaviors toward the preferences. However, with the growing amount of multimedia data uploaded and shared via social media, large amounts of content information are valuable for making recommendations. This might include attaching tags, image content, or social media linkage information, like user-user relationships and user-group memberships.

With such rich user and item information, researchers are able to explore more sophisticated models utilizing the information to construct more precise user profiles and item representations.

INTEGRATIVE IMAGING

When **Stephen Boppart** was growing up in Harvard, Ill., his father, an agricultural engineering graduate from the University of Illinois, would bring home broken motors, engines, and mechanical devices for his son to take apart, figure out what was broken, and then attempt to fix them.

"I wasn't very successful at fixing them," said Boppart, "but I learned to always think about how things work, and how I could solve problems in engineering."

These early experiences proved formative for Boppart's education and research career. He graduated from the U of I in 1990 with a bachelor's in electrical engineering and an option in bioengineering. He completed his master's in electrical and computer engineering (ECE) in 1991, also at Illinois. He cites his master's thesis advisor, former faculty member Bruce Wheeler, as an academic mentor.

"He introduced me to bioengineering research as an undergraduate student and virtually gave me open access to his labs and equipment," said Boppart. "From him, I learned that a lab can be a playground, and that the tinkering I enjoyed as a child could continue the rest of my life in academia, where solutions to engineering challenges could have a significant impact on people's lives."

From 1991 to 1993, at the Air Force Laser Laboratory in San Antonio, Texas, he conducted research on laser-tissue interactions in the eye, helping establish national laser safety standards. At Massachusetts Institute of Technology (MIT), he received his Ph.D. in 1998 in medical and electrical engineering. His doctoral studies included the development of optical coherence tomography (OCT) in the laboratory of Jim Fujimoto, who Boppart also credits as a guide.

"He mentored me to excel in academic research, to develop strategies for success, and to develop independent skills that carried over to managing my own independent lab and research."

As part of a joint program between MIT and Harvard, Boppart completed his M.D. from Harvard Medical School in June 2000.

"I was fascinated by the electrical properties of living cells (neurons), and the analogies between electrical circuits in hardware and in the brain," said Boppart. "At MIT and Harvard, while developing the new optical biomedical imaging technology OCT, I realized that I needed to understand what I was imaging with this technique, and so I combined my interests in optics and imaging with medicine and biology. Now, I continue to focus on how engineering and technology can advance medicine and surgery, as well as enable new fundamental biological discoveries."

At Illinois, Boppart holds appointments in the Departments of Electrical and Computer Engineering and Bioengineering, and is affiliated with the Department of Internal Medicine in the College of Medicine, the Micro- and Nanotechnology Laboratory, and the Institute for Genomic Biology. At the Beckman Institute, Boppart co-chairs, along with Zhi-Pei Liang, the Integrative Imaging theme and heads the Biophotonics Imaging Laboratory. He is also the director of Imaging at Illinois, a campus-wide effort to build community around imaging science, imaging technology, and the application, use, and interpretation of pictures and images.

As part of his research at Beckman, Boppart has helped to translate optical imaging technologies into new clinical tools, such as OCT, an imaging technique useful for medical diagnostics. Improvements include the intraoperative detection and removal of tumors at the cellular level. Similar in operation to ultrasound, OCT works by focusing a beam of near-infrared light (like that used in CD players) noninvasively into tissue and measuring the intensity and position of the resulting reflections.

Working across disciplines is integral to Boppart's work. "My work is truly reflective of what Beckman was intended for," said Boppart. He collaborates with others in fields ranging from chemistry, physics, medicine, biology, physiology, and engineering.

Boppart is also envisioning what the future may hold.

"I believe we can use our advanced optical technologies and imaging methods to answer new questions in neuroscience (neurophotonics), as well as understanding the optics and optical principles employed in natural systems and organisms," said Boppart. "In addition to these new pursuits, I see my current research having a greater impact in human clinical medicine and surgery where we are using label-free optical imaging technologies to detect microscopic cellular and even molecular disease markers during breast cancer surgery, or more effectively screening for early disease in primary care medicine."

STEPHEN **BOPPART**

WHAT'S THE BEST SCIENCE-RELATED BOOK YOU'VE READ RECENTLY?

I suppose a better question for me is "What's the best science-related book on your shelf?" I have a collection of interesting books on my shelves, but can't seem to find the time to read them yet. Some include *The Creative Destruction of Medicine* by Eric Topol; *Technological Medicine: The Changing World of Doctors and Patients* by Stanley Reiser; *The End of Medicine: How Silicon Valley (and Naked Mice) Will Reboot Your Doctor* by Andy Kessler; and *Where Medicine Went Wrong: Rediscovering the Path to Complexity* by Bruce West. I suppose these all follow the theme of how our evolving technology is impacting the field of medicine in both beneficial and harmful ways. And I should say that these sit right alongside the book *Jimmy Buffett and Philosophy*, edited by Erin McKenna and Scott Pratt. I think we have just as much to learn from Jimmy Buffett.

The technologies that Boppart has created use the intrinsic properties of the tissue in the imaging; "label-free" means that no dyes or contrasts are used in the process, lessening the risk of adverse reactions and allowing the technology to be used immediately in a clinical setting.

Boppart, along with colleague P. Scott Carney, has developed a new optical medical imaging technology called Interferometric Synthetic Aperture Microscopy (ISAM), which uses near-infrared light to create high-resolution images of breast cancer cells invading normal tissue. It is the first technology of its kind to be used during surgery to determine whether all of a tumor has been successfully removed. A clinical commercial prototype of the portable, handheld probe and imaging system—built by Diagnostic Photonics, Inc., a start-up company co-founded by Boppart and Carney—is currently in the testing stage at Carle Foundation Hospital in Urbana. The goal is to reduce the high rate of repeat surgeries for those with breast cancer. Diagnostic Photonics was recently awarded a $2.3 million Small Business Innovation Research grant from the National Institutes of Health to begin multi-site clinical trials at Johns Hopkins Hospital in Baltimore, Md., and the Anne Arundel Medical Center in Annapolis, Md. Full FDA approval is expected in 2013 with a product launch expected as early as 2015.

Through research in the Biophotonics Imaging Lab, Boppart has continued to pursue research around other OCT devices, which hold promise in diagnosing and treating various diseases including diabetic retinopathy, chronic ear infections, thyroid cancer, and multiple sclerosis.

"I believe the field of biophotonics and biomedical optics will continue to permeate more and more research areas in the next five to 10 years, including neuroscience, infectious disease, and cancer detection, as well as intravital imaging, where one can image and track the dynamics of single cells in living organisms," Boppart predicts. "Light provides a unique opportunity to probe and image at the molecular and cellular level, which has applications not only for biology, but also for clinical medicine and surgery."

Find more information about Stephen Boppart's lab at biophotonics.illinois.edu, and learn more about Integrative Imaging at beckman.illinois.edu/research/themes/intim.

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, Bioacoustics Research Laboratory (BRL) and Bioimaging Science and Technology (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 research involving the life sciences that could also have real-world outcomes is a pillar of this theme.

Former Football Player Working to Reduce Head Trauma

A former Illinois football player-turned-scientist is working to reduce head trauma in his old sport. Former Illinois running back **Kevin Jackson** (1991-94) is working with a team to design a post-practice head-and-neck cooling helmet that reduces secondary effects and improves the long-term outlook of head trauma victims through repetitive cooling and lowering of brain temperature.

Jackson works with Dr. John Wang, a neurosurgeon at Carle Foundation Hospital, who studies thermal properties of the brain and was developing a cooling helmet for the Department of Defense before meeting Jackson.

Wang became interested in the football applicability after speaking with Jackson.

"I'm not very interested in sports because when I watch it, it's all head trauma to me," Wang said. "Kevin represents a person with an athletic and a Ph.D. background. He has scientific insight to promote long-term well-being within athletics."

The team is using a cooling cap designed by the Welkins Company to cool an injured brain after a trauma. According to its research, "hypothermia is by far the most potent method of neuroprotection in animal studies and has the greatest therapeutic potential."

Left: Kevin Jackson as a member of the University of Illinois football team from 1991–94.

Below: Kevin Jackson and colleagues are designing a post-practice head-and-neck cooling helmet to reduce head trauma.

New Ways of Isolating Cancer Cells

A new method to isolate and grow the most dangerous cancer cells could enable new research into how cancer spreads and, ultimately, how to fight it according to a group of researchers led by **Ning Wang** at Illinois in partnership with the Huazhong University of Science and Technology in China.

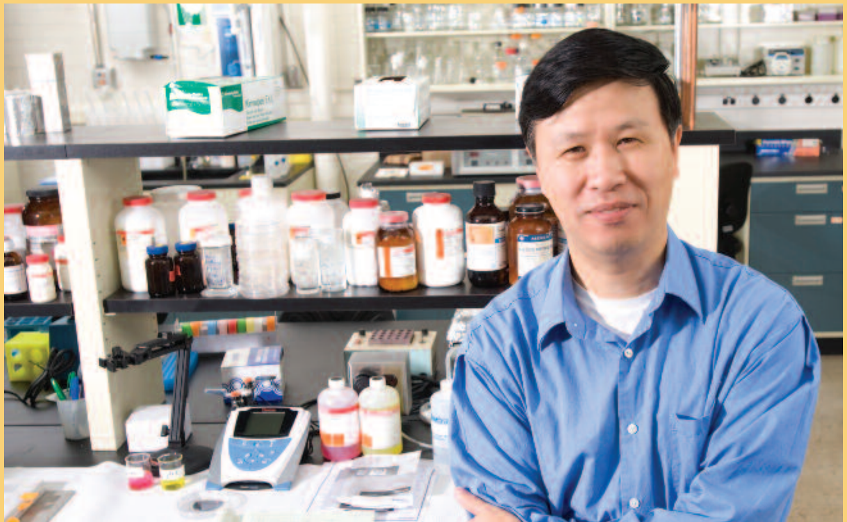
Wang's group had previously found that stem cells grow better in a soft gel than on a rigid plate. They wondered if this principle would also apply to cancer-spreading cells, since they share other qualities of stem cells. So they suspended single cells of mouse melanoma, a type of skin cancer, in soft gel made of fibrin, a fiber-like protein found throughout the body. They cultured the cells into colonies and compared them with those grown on a stiff, flat surface, the traditional method used by cancer researchers.

After five days, the soft gels were riddled with spheres of soft cells, many more colonies than grew on the harder surface. In addition, the cells were softer and grew in spherical clumps—unusual for most cancer cells, but signature characteristics of stem cells.

"Starting from single cells, by day five, you have more cells in the soft substrate proliferating," Wang said. "This is exactly the opposite from most cancer cells, which prefer a stiffer substrate. But these cells like to grow in the soft environment. Why is this important? Because they turn into tumors."

The researchers found that the cells grown in the 3D soft fibrin were much more efficient at causing tumors in mice than cells prepared traditionally. In fact, injecting as few as 10 cells from a culture grown in a soft gel was sufficient to induce tumors in a large percentage of mice, while 10,000 cells from a traditional culture are needed to achieve results with the same incidence of cancer. This suggests that, while a traditional culture of cells has only a few capable of starting new tumors, the soft substrate method is capable of isolating these cells and promoting the growth and multiplication of these cells in culture.

Now, the researchers will continue exploring the molecular mechanisms that make these tumor-seeding cells so good at surviving in distant organs and so efficient at seeding tumors. They hope that knowledge will contribute to treatments to stop the spread of cancer.



The Bioacoustics Research Laboratory is discovering new techniques for improved ultrasounds used for cancer diagnoses and treatment. From left to right: Marianne Gauthier, Aiguo Han, Daniel King, Brendon Smith, Olivia Coiado, Rita Miller, Rami Abu-habsah, Bill O'Brien, and John Erdman. Photo by Dan O'Brien.

Improving Cancer Diagnoses and Treatment through Advanced Ultrasounds

Under the direction of **Bill O'Brien**, the Bioacoustics Research Laboratory (BRL) employs ultrasound to improve cancer diagnoses and treatment, as well as uncover techniques that improve ultrasound imaging generally.

The use of ultrasound in clinical medicine is exceptionally diverse, from diagnostic to therapeutic applications. Diagnostic ultrasound is used in virtually every aspect of clinical medicine from diagnosing heart problems, to assessing the risk of osteoporosis via bone mineral density measures, to assessing the well-being of a fetus in utero. Further, therapeutic modalities of ultrasound are used to break up kidney stones and treat noncancerous uterine fibroids. Research conducted in the BRL since the 1940s has impacted each of these areas, and current research activities are looking toward future healthcare needs.

Intravenous administration of microbubble contrast agents can improve ultrasound image clarity. While useful for imaging the cardiovascular system, concerns have been raised regarding the safety of these agents. Researchers in O'Brien's lab exposed mice to ultrasound with an intravenous infusion of ultrasound contrast agents, which did not affect clinically relevant cardiovascular biomarkers or the progression of cardiovascular disease, suggesting that the procedure is safe.

Angiogenesis is characterized by the development of new blood vessels supplying cancer tumors with nutrients and oxygen. Loading drugs into nanoparticles attached at the surface of microbubbles has the potential of providing a higher therapy dose to the tumor, while minimizing the systemic dose and side effects of the treatment. Researchers in the lab recently succeeded in developing and optimizing a protocol to produce nanoparticle-loaded microbubbles exhibiting stable properties, that is, such microbubbles remain intact over an extended period of time.

To help with the drug delivery through the microbubbles, researchers are also looking at the material properties of the bubbles themselves, demonstrating experimentally that using different shell materials has significant effects on thresholds for when the microbubble oscillates or collapses. These results provide a better understanding of what is important to consider in theoretical models and impacts the localized drug delivery to the tumor site with the intended goal to reduce or prevent new blood vessel growth, that is, starve the tumor from receiving nutrients and oxygen.

Carving Delicate Features onto Semiconductor Wafers

Gabriel Popescu and **Lynford Goddard** have led a team that has a new low-cost method to carve delicate features onto semiconductor wafers using light—and to watch as it happens.

Chip makers and semiconductor researchers need to precisely control the dimensions of their devices. The dimensions of the components affect performance, speed, error rate, and time to failure.

Semiconductors are commonly shaped by etching with chemicals. Etching errors, such as residual layers, can affect the ability to further process and etch, as well as hamper device performance. Thus, researchers use time-consuming and costly processes to ensure precise etching—for some applications, to within a scant few nanometers.

The researchers' new technique can monitor a semiconductor's surface as it is etched, in real time, with nanometer resolution. It uses a special type of microscope that uses two beams of light to precisely measure topography.

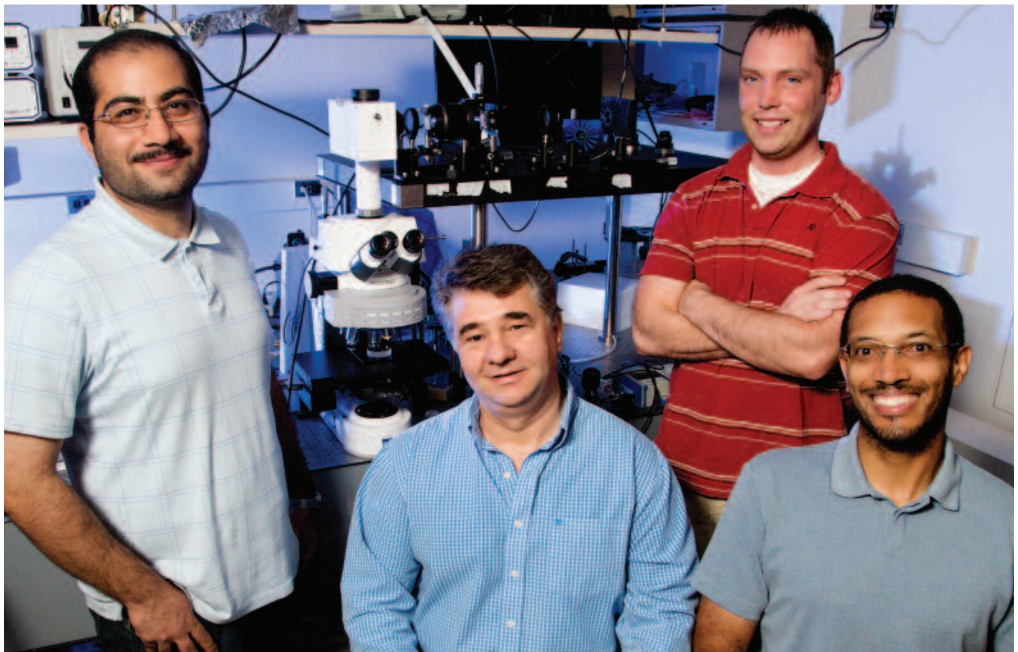
"The idea is that the height of the structure can be determined from the phase of the light as it travels different distances before reflecting off the different surfaces," said Goddard. "Looking at the change in height, you figure out the etch rate. What this allows us to do is monitor it while it's etching. It allows us to figure out the etch rate both across time and across space, because we can determine the rate at every location within the semiconductor wafer that's in our field of view."

The new method is faster, lower in cost, and less noisy than the widely used methods of atomic force microscopy (AFM) or scanning tunneling microscopy, which cannot monitor etching in progress but only compare before and after measurements. In addition, the new method is purely optical, so there is no contact with the semiconductor surface, and the researchers can monitor the whole wafer at once instead of point-by-point.

"I would say the main advantage of our optical technique is that it requires no contact," Popescu said. "We're just sending light, reflected off the sample, as opposed to an AFM where you need to come with a probe close to the sample."

The researchers envision this technology applied beyond etching, to real-time monitoring of other processes in materials science and life science—for example, watching carbon nanotubes self-assemble or error monitoring during large-scale computer chip manufacturing. It could help chip manufacturers reduce costs and processing time by ensuring that equipment stays calibrated.

Graduate students Chris Edwards and Amir Arbabi were also co-authors of the paper, which was published Sept. 28 in the journal *Light: Science and Applications.*



Amir Arbabi, Gabriel Popescu, Chris Edwards, and Lynford Goddard use a special microscope to simultaneously etch tiny features in semiconductor wafers and monitor the process in real time.

New Tool to Diagnose Breast Cancer

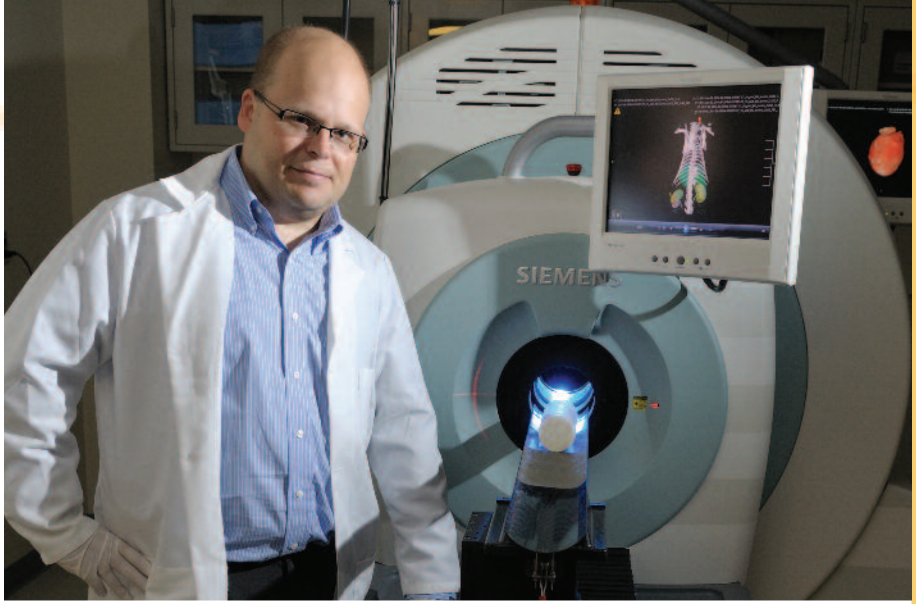
Michael Insana is serving as co-principal investigator on a $2.2 million grant from the National Cancer Institute to develop an ultrasonic imaging technique that diagnoses breast cancer with more accuracy, and, potentially, less physical trauma.

The joint research effort between researchers at the Beckman Institute and the Mayo Clinic in Rochester, Minn., focuses on a method called SAVE (Sub-Hertz Analysis of Viscoelasticity), which measures how slightly compressed breast tissue reacts as it slowly relaxes from the applied pressure.

"This imaging method detects small structural changes in the tissue that are specific to cancerous tumors," explained Insana.

Preliminary studies show that this method can distinguish between cancerous and noncancerous breast masses, which raises the possibility of regularly tracking changes in suspicious breast masses at a low cost and with fewer biopsies. The aim of the project is to translate this laboratory finding into a viable clinical tool through the patient study to be conducted at the Mayo Clinic during the grant period.

The work is part of the Mayo-Illinois Alliance for Technology-Based Healthcare, which was founded in 2010 to advance research and clinical treatment options.



Detector Inserts Developed for PET Imaging

Ling-Jian Meng and **Wawrzyniec Dobrucki** (above) are using newly developed detector inserts for positron emission tomography (PET) imaging toward creation of a novel imaging modality for small animal models.

Meng has a research focus on developing new nuclear imaging techniques such as sensors based on room temperature detectors. Dobrucki has research interests in multimodal imaging and, particularly, imaging strategies for assessing angiogenesis in animal models for studies of disease. This project is developing novel semiconductor detector technology for ultrahigh resolution small-animal PET imaging.

Dobrucki works with the multimodal microPET/SPECT/CT scanner in the Molecular Imaging Laboratory (MIL), which combines nuclear imaging modalities, x-ray computed tomography (CT), single photon emission CT (SPECT), and positron emission tomography (PET). The PET modality can image resolutions of two millimeters which, Dobrucki said, is not good enough for imaging specimens such as heart tissue from a mouse. Meng said the use of small-pixel semiconductor detectors will provide high resolution for samples from small animal models.

"I would say that the target resolution we would like to achieve in PET images is between 0.3 and 0.5 millimeter, which is regarded as ultrahigh resolution in PET imaging," Meng said. He added that his group is developing "proof-of-concept detection systems for preliminary imaging studies, which would also allow a direct comparison against a state-of-art commercial PET system currently installed at MIL."

Meng said the semiconductor-based PET detection system could also be used inside MRI scanners for simultaneous dual-modality PET/MRI studies. That would enable images from the two modalities to be superimposed, providing visualization of anatomical (MRI) and functional (PET) features of samples.

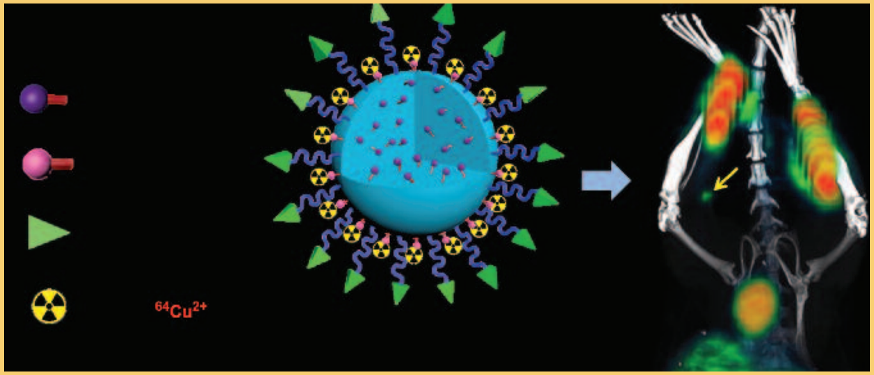
Dobrucki said the first phase in the project was to develop a small ring detector and "test it using phantoms to see how it works, acquire the performance of the system. Now we are moving this to imaging and using tissue."

The project has been supported by the Department of Energy (DOE) and the National Institute of Biomedical Imaging and Bioengineering (NIBIB).

A New Diagnostic Probe Can Efficiently Detect Cancer Metastasis

Because 90 percent of human cancer deaths are caused by cancer metastasis (the spread of cancer cells from the original place of the tumor to elsewhere in the body), it is critical to achieve early diagnosis in order to improve treatment and increase the chance of survival. However, there are currently no efficient, noninvasive diagnostic methods for the detection of cancer metastasis. **Jianjun Cheng**, along with his collaborators Timothy Fan, **William Helferich**, and **Wawrzyniec Dobrucki**, recently developed a novel diagnostic probe for the detection of cancer metastasis: silica-based nanoconjugates (NCs) that monodisperse at an extremely small size (20 nanometers). The silica NC was surface-modified with aptamer, a nucleic acid cancer-targeting ligand, which can identify and bind to metastatic cancer cells specifically. When the cancer cells spread from the original location to the closest lymph node, typically the first site reached by the metastatic cancer cells, the small and modified silica NC can efficiently accumulate in this lymph node and give off a diagnostic signal.

Using this silica NC could potentially realize early diagnosis of cancer metastasis and increase the survival of cancer patients. The silica NC is a dual-functional imaging probe because it integrates two diagnostic methods: positron emission tomography (PET) and fluorescence optical imaging. The PET imaging shows where the metastatic tumors are in the body. During surgical removal of the identified tumors, the NC can serve as a bright fluorescent marker to allow the doctor to easily see the tumors. By combining these two diagnostic methods, this ultra-small silica NC has great potential to improve the efficiency of both cancer metastasis detection and resection in clinical settings.



A 3D PET/CT image shows that the silica nanoconjugates (NCs) can target the metastatic cancer in lymph nodes in mice.

MOLECULAR AND ELECTRONIC NANOSTRUCTURES

Nancy Sottos was one of the lucky ones. Right after she received her Ph.D. in mechanical engineering in 1991 from the University of Delaware, she was asked to teach at the University of Illinois, and shortly after, began pursuing research at the Beckman Institute. Nowadays, a career in research and teaching is difficult to do without a postdoctoral fellowship, but Sottos' passion for and excellence in collaborative research, Beckman's staple requirement, was evident.

For her graduate studies, she worked with a team in a center for composite materials at the University of Delaware, so "it's not a surprise I wound up in a collaborative team. That's initially how I was trained to do research," Sottos said.

It wasn't long after she arrived at U of I that she started talking with Scott White about combining their efforts to work with autonomous materials. They quickly recruited Jeff Moore, and together, they created the Autonomous Materials Systems Group in 2001, one of the longest-standing groups at Beckman, which Sottos says sits at the intersection of materials, chemistry, and mechanics.

"In this group we're focused around some central themes," Sottos said. "We're inspired by biological systems and all the functions of it, in either plants or animals, and we're trying to reproduce these functions synthetically. We're trying to develop materials systems capable of self-healing, self-sensing, and self-cooling responses."

One application of self-cooling and self-healing concepts is through batteries, an integral part of many ubiquitous gadgets, such as laptops, cell phones, and battery-powered cars.

"Batteries have significant reliability and safety issues," explained Sottos. "Nobody wants a heavy battery or one that's too large, especially in cell phones or electric cars. The way to make them smaller is to increase the density and capacity of the battery in order to store more energy. But as the energy density increases, they become unreliable and have greater potential for mechanical failures. A more serious issue is when they overheat, which is called 'thermal runaway.'"

Thermal runaway has become a rather infamous problem in airplane mechanical issues. In planes, the lithium-ion batteries overheat, causing irreversible damage and requiring planes to make emergency landings.

Sottos' group is looking at materials to shut down this problem of thermal runaway autonomously. One way is through an approach that creates a microcapsule of polymers that are triggered to melt when a battery reaches a specific temperature. When the polymers melt, they block the flow of ions, and the process that is causing the battery to "run away thermally" is shut down autonomously.

More recently, the group has been working on cooling concepts for the casing of a battery in order to keep the battery cool all the time, so shutting down the battery isn't necessary. This would maintain optimal battery performance, instead of waiting for the battery to malfunction.

"We've also been trying to solve the issue of losing capacity in batteries," Sottos said. "For example, after two years or so, laptop battery capacity fades, which especially makes an impact in an electric car. If the battery capacity fades in a car, it can't go as many miles. So we're working on autonomous materials to influence the chemistry and the mechanical reliability throughout the life of the battery. Self-contained components will release additives or try to restore conductivity where it's been lost as the battery goes through its charge and discharge cycles."

Sottos is able to conduct this complex research in labs she shares with White and Moore. Moore's group works with the chemical side of the research, she says, like synthesizing polymers and healing chemistries. White's group focuses on the processing of polymers and composites with the healing chemistries. In Sottos' group, they specialize in the characterization of the various functions of polymers with capsules and vascular networks, as well as molecularly changing the architecture of the polymer or composite to enhance the healing or cooling response.

Her lab has facilitated her research, but she knows it's been a team effort with White and Moore. Their successful and long-lasting

NANCY **SOTTOS**

WHAT'S THE BEST SCIENCE-RELATED BOOK YOU'VE READ RECENTLY?

I mostly read fiction in my free time. I just finished reading Margaret Atwood's book *The Year of the Flood*, which is sort of science-fiction.

collaboration has been integral in jointly contributing to the advancement of autonomous materials.

"Not only are the lab facilities unique to Beckman, but the proximity to my collaborators and my student researchers is really important," said Sottos. "Our research program has also received great support from Beckman for grants. Finally, having access to the Microscopy Suite and the Visualization Lab has been huge. We use these capabilities all the time and the staff are incredibly helpful."

With all of these capabilities, Sottos and her group are looking even further into autonomous materials—one day, she hopes to find the technology to not only repair, but regenerate new materials.

"Right now, things are good. Our group is growing, we have new grant support and many new ideas for autonomous materials," Sottos said. "In the next five to 10 years I hope to be developing (in collaboration with Jeff and Scott) synthetic materials that are capable of regeneration (i.e., able to grow new material or remodel old material). I also hope to keep working on autonomous concepts to create more sustainable materials systems—materials capable of self-healing and self-reporting damage so they can have a longer life cycle."

The success of Sottos and her group will continue to contribute to research in the field. "My goals are to maintain a great group of graduate students and continued success with my collaborators as long as we can. Not anything too lofty—just interesting science."

This commitment to "interesting science," coupled with her collaborative spirit, has made her a success not only at Beckman, but in her groundbreaking and promising research.

Find more information on the Autonomous Materials Systems at autonomic.beckman.illinois.edu. Updated information on Nancy Sottos' research group can be found at sottosgroup.beckman.illinois.edu.

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.

Bugs' Eyes Influence Digital Cameras

John A. Rogers and his collaborators have created the first digital cameras with designs that mimic those of ocular systems found in dragonflies, bees, praying mantises, and other insects. This class of technology offers exceptionally wide-angle fields of view, with low aberrations, high acuity to motion, and nearly infinite depth of field.

Taking cues from Mother Nature, the cameras exploit large arrays of tiny focusing lenses and miniaturized detectors in hemispherical layouts, just like eyes found in arthropods. The devices combine soft, rubbery optics with high-performance silicon electronics and detectors.

"Full 180 degree fields of view with zero aberrations can only be accomplished with image sensors that adopt hemispherical layouts—much different than the planar CCD chips found in commercial cameras," Rogers explained. "When implemented with large arrays of microlenses, each of which couples to an individual photodiode, this type of hemispherical design provides unmatched field of view and other powerful capabilities in imaging. Nature has developed and refined these concepts over the course of billions of years of evolution."

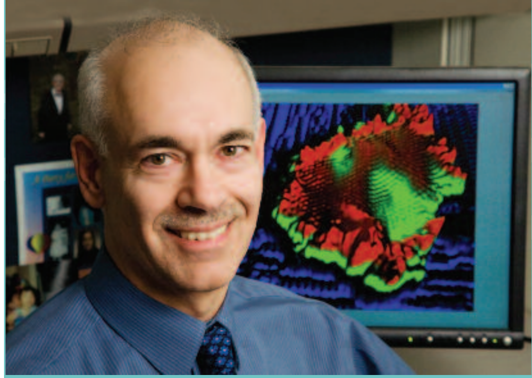
Eyes in arthropods use compound designs, in which arrays of smaller eyes act together to provide image perception. Each small eye, known as an ommatidium, consists of a corneal lens, a crystalline cone, and a light sensitive organ at the base. The entire system is configured to provide exceptional properties in imaging, many of which lie beyond the reach of existing human-made cameras.

The researchers developed new ideas in materials and fabrication strategies, allowing construction of artificial ommatidia in large, interconnected arrays in hemispherical layouts.

The research was funded by the Defense Advanced Research Projects Agency and the National Science Foundation.

The new digital cameras exploit large arrays of tiny focusing lenses and miniaturized detectors in hemispherical layouts, just like eyes found in arthropods.

Photo by John A. Rogers



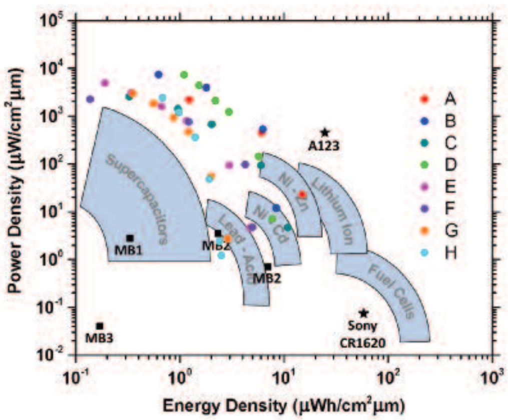
Ions Sharpen Microscope Probe

Scanning probe microscopes provide images of tiny structures with high resolution at the atomic scale. The tip of the probe skims the surface of a sample to measure mechanical, electrical, or chemical properties. Such microscopes are widely used among researchers who work with tiny structures in fields from nanotechnology to cellular biology.

Labs can spend hundreds of thousands of dollars on an elegant instrument, yet the quality of the data depends on the probe. Probes can degrade rapidly with use, wearing down and losing resolution. In such cases, the researcher then has to stop the scan and replace the tip.

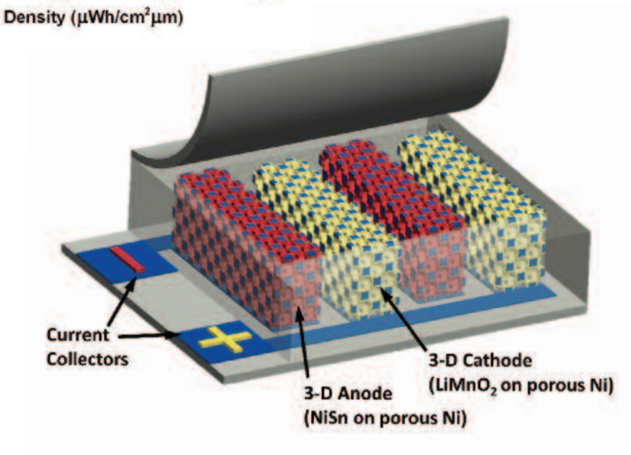
Joseph Lyding's group has developed a new microscope probe-sharpening technique using a stream of ions shot at the tip. The material sputters off as the ions collide with the tip, whittling away the probe. Lyding had the simple, novel idea of applying a matching voltage to the tip to deflect the incoming ions. When a voltage is applied to a sharp object, the electrical field gets stronger as the point narrows. Therefore, ions approaching the sharpest part of the electrified tip are deflected the most.

"This causes the ions to remove the material around that sharp part, not on the sharp part itself, and that makes it sharper," Lyding said. "You preserve the point, and you sharpen what is around it."



Left: This research image displays high-power lithium-ion microbatteries from interdigitated 3D bicontinuous nanoporous electrodes.

Bottom: William King and Paul Braun created a super powerful microbattery with applications in radio and electronics.



Microbatteries Pack a Punch

Developed by researchers led by **William P. King** and **Paul V. Braun**, new microbatteries outpower even the best supercapacitors and could drive new applications in radio communications and compact electronics.

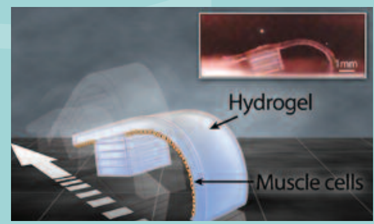
"This is a whole new way to think about batteries," King said. "A battery can deliver far more power than anybody ever thought. In recent decades, electronics have gotten small. And the battery has lagged far behind. This is a microtechnology that could change all of that."

With currently available power sources, users have had to choose between power and energy. For applications that need a lot of power, like broadcasting a radio signal over a long distance, capacitors can release energy very quickly but can only store a small amount. For applications that need a lot of energy, like playing a radio for a long time, fuel cells and batteries can hold a lot of energy but release it or recharge slowly.

The new microbatteries offer both power and energy, and by tweaking the structure a bit, the researchers can tune them over a wide range on the power-versus-energy scale.

The National Science Foundation and the Air Force Office of Scientific Research supported this work.

Bio-Bots Make Tracks in Synthetic Biology



COURTESY OF ELISE A. CORBIN

Designing non-electronic biological machines has been a riddle that scientists at the interface of biology and engineering have struggled to solve. **Rashid Bashir** and his team have been able to develop soft, biocompatible, seven millimeter-long, walking bio-bots using only hydrogel, heart cells, and a 3D printer.

With an altered design, the bio-bots could be customized for specific applications in medicine, energy, or the environment.

"The idea is that, by being able to design with biological structures, we can harness the power of cells and nature to address challenges facing society," said Bashir. "As engineers, we've always built things with hard materials. Yet there are a lot of applications where nature solves a problem in such an elegant way. Can we replicate some of that if we can understand how to put things together with cells?"

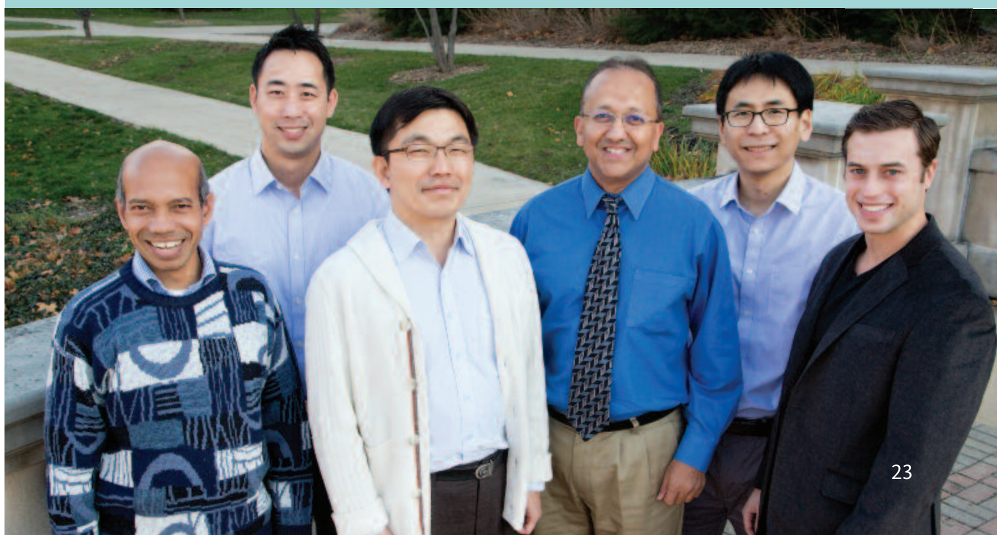
The key to the bio-bots' locomotion is asymmetry. Each bot has one long, thin leg resting on a stout supporting leg. The thin leg is covered with rat cardiac cells. When the heart cells beat, the long leg pulses, propelling the bio-bot forward.

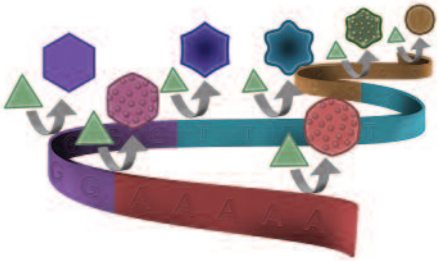
The team used a 3D printing method to make the main body of the bot from hydrogel, a soft gelatin-like polymer. This approach allowed the researchers to quickly alter the design, which will allow them to build and test other configurations.

Bashir envisions the bio-bots being used for drug screening or chemical analysis, since the bots' motion can indicate how the cells are responding to the environment. By integrating cells that respond to certain stimuli, the bio-bots could be used as sensors.

The National Science Foundation supported this work through a Science and Technology Center (Emergent Behavior of Integrated Cellular Systems) grant.

Above: Bio-bots were created with synthetic biology so as to better understand cellular and biological structures.
Below: The team that developed the bio-bots: from left, Taher Saif, Vincent Chan, Hyun Joon Kong, Rashid Bashir, Kidong Park, and Mitchell Collens.





DNA can shape gold nanoparticle growth similarly to the way it shapes protein synthesis, with different letters of the genetic code producing gold circles, stars, and hexagons. Photo courtesy of Li Huey Tan, Zidong Wang, and Yi Lu.

DNA Segments Shape Gold Nanoparticles

DNA holds the genetic code for all sorts of biological molecules and traits. Researchers led by **Yi Lu** have found that DNA's code can similarly shape metallic structures.

The team found that DNA segments can direct the shape of gold nanoparticles—tiny gold crystals that have many applications in medicine, electronics, and catalysis.

"DNA-encoded nanoparticle synthesis can provide us a facile but novel way to produce nanoparticles with predictable shapes and properties," Lu said. "Such a discovery has potential impacts in bio-nanotechnology and applications in our everyday lives such as catalysis, sensing, imaging, and medicine."

Gold nanoparticles have wide applications in both biology and materials science thanks to their unique physicochemical properties. Properties of a gold nanoparticle are largely determined by its shape and size, so it is critical to be able to tailor the properties of a nanoparticle for a specific application.

The National Science Foundation supported this work.

Researchers Help Unlock Structure of HIV Capsid

Until the arrival of petascale supercomputers, no one could piece together the entire HIV capsid—an assemblage of more than 1,300 identical proteins—in atomic-level detail. The simulations that added the missing pieces to the puzzle were conducted during testing of Blue Waters, a new supercomputer at the National Center for Supercomputing Applications at the University of Illinois.

"This is a big structure, one of the biggest structures ever solved," said **Klaus Schulten**, who, with postdoctoral researcher **Juan R. Perilla**, conducted the molecular simulations that integrated data from laboratory experiments performed by colleagues at the University of Pittsburgh and Vanderbilt University. "It was very clear that it would require a huge amount of simulation—the largest simulation ever published—involving 64 million atoms."

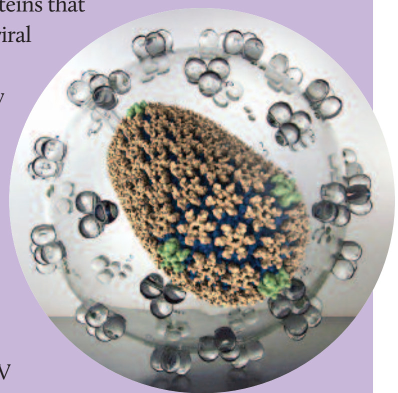
Previous research had established that the HIV capsid contained a number of identical proteins. Scientists knew the proteins were arranged into pentagons and hexagons, and guessed that the pentagons formed the most tightly rounded corners of the capsid shape seen under an electron microscope. But they did not know how many of these protein building blocks were needed or how the pentagons and hexagons fit together to form the capsid.

The Pittsburgh team exposed the building blocks of the capsid to high salt conditions, leading the proteins to assemble into tubes made entirely of hexagons. Further experiments revealed interactions among specific regions of the proteins that were "critical for capsid assembly and stability and for viral infectivity," the researchers report.

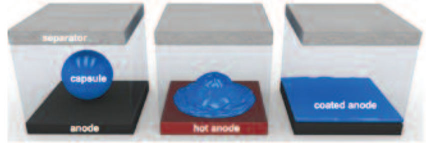
The team also conducted cryo-electron tomography of the complete capsid, slicing it into sections to get a rough idea of its overall shape.

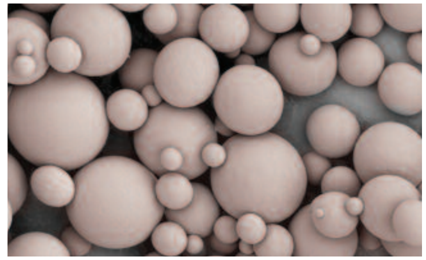
Perilla and Schulten used the data from these experiments and from their own simulations of the interactions between the hexamers and pentamers to conduct a series of large-scale computer simulations that accounted for the structural properties of the capsid's building blocks.

Possessing a chemically detailed structure of the HIV capsid will allow researchers to further investigate how it functions, with implications for pharmacological interventions to disrupt that function.



Top: Klaus Schulten (left) and Juan R. Perilla pieced together the structure of the HIV capsid with the help of Blue Waters, a new supercomputer used at the University of Illinois.
Bottom: Image courtesy of Juan R. Perilla, John Stone, Peijun Zhang, and Klaus Schulten. Glass sculpture by Luke Jerram.



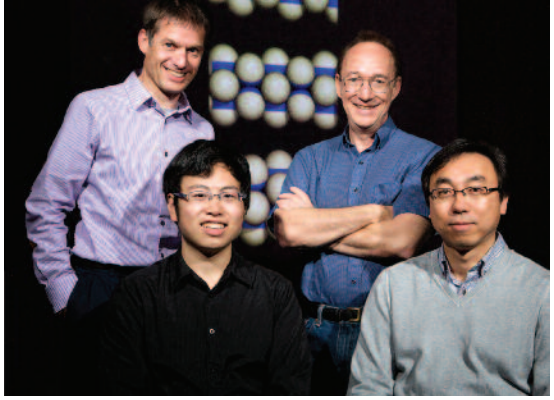


Scott White, Nancy Sottos, and Jeff Moore are developing self-healing materials that will help prevent fire in lithium-ion batteries.

Self-Healing Materials for Lithium-Ion Batteries

In recent years, several major computer manufacturers have made headlines by recalling lithium ion (Li-ion) laptop batteries because of an unfortunate tendency of some of these batteries to burst spontaneously into flames. While rare, spontaneous blazes caused by Li-ion batteries can obviously be quite dangerous. As these batteries proliferate—today they power millions upon millions of devices ranging from smart phones and tablets to small appliances and even hybrid automobiles—the motivation is strong to develop foolproof methods of fire prevention. **Scott White**, **Nancy Sottos**, **Jeff Moore**, and colleagues have proposed a potential new approach to preventing such fires, drawing on one of the more interesting trends in contemporary materials science—the development of "self-healing" materials.

The technique was to coat either the anode layer or separator layer with heat-sensitive "microspheres," or tiny solid capsules, ranging from two to 20 micrometers in diameter. When the battery reached a certain temperature, the microspheres would melt, blocking the pores in the separator through which lithium ions pass and shutting down battery operation.



From left, Erik Luijten, Jing Yan, Steve Granick, and Sung Chul demonstrated tiny spheres that synchronize their movements as they self-assemble into a spinning microtube.

Self-Assembling Structures

Steve Granick and **Erik Luijten** co-led a study demonstrating tiny spheres that synchronize their movements as they self-assemble into a spinning microtube. Such in-motion structures—a blending of mathematics and materials science—could open a new class of technologies with applications in medicine, chemistry, and engineering.

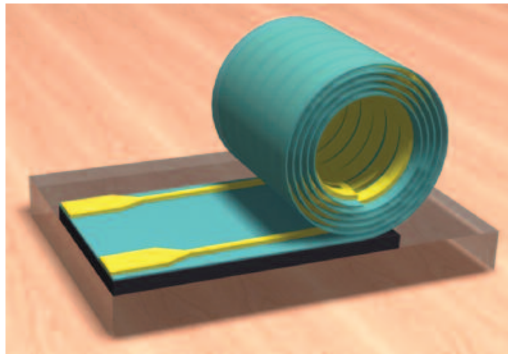
"The world's concept of self-assembly has been to think of static structures—something you would see in a still image," said Granick. "We want shape-shifting structures. Structures where a photograph doesn't tell you what matters. It's like the difference between a photograph and a movie."

The researchers used tiny particles called Janus spheres. One half of each sphere was coated with a magnetic metal. When dispersed in solution and exposed to a rotating magnetic field, each sphere spins at the same frequency but all face a different direction.

As two particles approach one another, they synchronize their motions and begin spinning around a shared center, facing opposite directions. Soon, the pairs and clusters of spheres assemble themselves into a microtube—a long, hollow structure. The entire tube spins, even as each individual sphere continues its motion as well.

The U.S. Army Research Office, the Department of Energy, and the National Science Foundation supported this work.

Miniaturizing Spiral Inductors



Researchers have created an inductor that is more than 100 times smaller than previous models. Photo courtesy of Xiuling Li.

Three-dimensional rolled-up inductors have a footprint more than 100 times smaller than previous models, without sacrificing performance.

Inductors, often seen as the sprawling metal spirals on computer chips, are essential components of integrated circuits. They are necessary to store magnetic energy but take up a lot of space and engineers cannot make them smaller without losing performance.

In addition, the larger the inductor, the more it worsens—an effect called parasitic capacitance, which reduces the operating frequency range. Researchers have developed 3D inductor structures to solve these problems, but the methods are often too complex for manufacturing.

The new inductor design uses techniques **Xiuling Li**'s group developed for making thin films of silicon nitride, merely tens of nanometers in thickness, that roll themselves up into tubes. The research team used 2D processing to pattern metal lines on the film before rolling, creating a spiral inductor.

"We're making 3D structures with 2D processing," Li said. "Instead of spreading this out in a large area to increase inductance, we can have the same inductance but packed into a much smaller area."

Using the self-rolling technique, the inductor can shrink to an area more than 100 times smaller than what a flat spiral would require.

LEDs Illuminate Deep Mysteries of the Brain

Led by **John Rogers** and Michael Bruchas, a professor of anesthesiology at Washington University, researchers have developed ultrathin, flexible optoelectronic devices—including LEDs the size of individual neurons—that are lighting the way for neuroscientists in the field of optogenetics and beyond.

"These materials and device structures open up new ways to integrate semiconductor components directly into the brain," said Rogers. "More generally, the ideas establish a paradigm for delivering sophisticated forms of electronics into the body: ultra-miniaturized devices that are injected into and provide direct interaction with the depths of the tissue."

The researchers demonstrated the first application of their devices in optogenetics, a new area of neuroscience that uses light to stimulate targeted neural pathways in the brain. The procedure involves genetically programming neurons to respond to light. Optogenetics allows researchers to study precise brain functions in isolation in ways that are impossible with electrical stimulation, which affects neurons throughout a broad area, or with drugs, which saturate the whole brain.

Optogenetic experiments with mice illustrate the ability to train complex behaviors without physical reward and to alleviate certain anxiety responses. Yet fundamental insights into the structure and function of the brain that emerge from such studies could have implications for treatment of Alzheimer's, Parkinson's, depression, anxiety, and other neurological disorders.

The newly developed technologies use specially designed powerful LEDs—among the world's smallest, with sizes comparable to single cells—that are injected into the brain to provide direct illumination and precise control. The devices are printed onto the tip end of a thin, flexible plastic ribbon—thinner than a human hair and narrower than the eye of a needle—that can be inserted deep into the brain with very little stress to tissue.

The active devices include not only LEDs but also various sensors and electrodes that are delivered into the brain with a thin, releasable micro-injection needle. The ribbon connects the devices to a wireless antenna and a rectifier circuit that harvests radio frequency energy to power the devices. This module mounts on top of the head and can be unplugged from the ribbon when not in use.

BIOINTEL SELECTED FACULTY AWARDS, PATENTS, GRANTS, AND PUBLICATIONS

Covering July 1, 2012-June 30, 2013

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*
Melissa Littlefield, *Kinesiology and Community Health*
Torrey M. Loucks, *Speech and Hearing Science*
Gregory A. Miller, *Psychology*
Richard S. Powers, *English*
Sung Soo Shin, *Art and Design*
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*
Cynthia L. Fisher, *Psychology*
Jose Mestre, *Educational Psychology*
Jerome L. Packard, *East Asian Languages and Cultures*
Michelle Perry, *Educational Psychology*
Brian H. Ross, *Psychology*
Chilin Shih, *East Asian Languages and Cultures*
Annie Tremblay, *French*
Jonathan Waskan, *Philosophy*
Duane G. Watson, *Psychology*

Neurotech
Thomas J. Anastasio, *Molecular and Integrative Physiology*
Stephanie S. Ceman, *Cell and Developmental Biology*
David F. Clayton, *Cell and Developmental Biology*
C. Lee Cox, *Molecular and Integrative Physiology*
Albert S. Feng, *Molecular and Integrative Physiology*
Roberto Galvez, *Psychology*
Martha L. Gillette, *Cell and Developmental Biology*
Rhanor Gillette, *Molecular and Integrative Physiology*
William T. Greenough, *Psychology*
Janice M. Juraska, *Psychology*
Daniel Llano, *Medical Molecular Integrative Physiology*
Mark E. Nelson, *Molecular and Integrative Physiology*
Justin S. Rhodes, *Psychology*
Gene E. Robinson, *Entomology*
Edward J. Roy, *Psychology*
M. Taher Saif, *Mechanical Science and Engineering*
Susan Schantz, *Comparative Biosciences*
Jonathan V. Sweedler, *Chemistry*

SELECTED HONORS AND AWARDS

Neal Cohen
Fellow of the American Association for the Advancement of Science (AAAS) 2012.

Florin Dolcos
Frontiers Popularity Award for editing the special research topic "The Impact of Emotion on Cognition—Dissociating between Enhancing and Impairing Effects?" 2013.

Kara Federmeier
University of Illinois Scholar 2012.

N. Nozari (with **G. S. Dell**, co-author)
APA Division 3 New Investigator award for paper published in the *Journal of Experimental Psychology: Learning, Memory, and Cognition* 2013.

INVENTION DISCLOSURES

Faculty members from the Biological Intelligence research theme were inventors on one invention disclosures (.6% of the 181 invention disclosures filed by campus) during FY2013.

GRANTS AWARDED

($4,054,995)

Gabriele Gratton, **Monica Fabiani**, and **Brad Sutton**, NIH, "Multi-distance Diffuse Optical Imaging to Study Human Brain Anatomy and Function," 8/7/2012 – 5/31/2014, $932,241.

Jennifer Cole and Erin Rusaw, NSF, "Doctoral Dissertation Research: Modeling Temporal Coordination in Speech Production Using an Artificial Central Pattern Generator Neural Network," 8/1/2012 – 1/31/2014, $5,298.

Jonathan Sweedler and **Stanislav Rubakhin**, NIH, "Glia Classifications via Single Cell Metabolomics," 9/1/2012 – 8/31/2014, $418,994.

Diane Beck, **Gabriele Gratton**, **Monica Fabiani**, and Kyle Mathewson, NIH, "Investigating Frontoparietal and Occipitotemporal Contributions to Awareness," 3/1/2013 – 2/28/2017, $1,500,981.

Neal Cohen, Abbott Nutrition, "The Role of Neurotransmitters in Obesity, Food-Choice and Memory-Related Processes," 5/16/2013 – 5/15/2014, $159,178.

Jonathan Sweedler, **Stanislav Rubakhin**, and **Justin Rhodes**, Abbott Nutrition, "Cognitive Nutrients and the Brain: Production of Isotopically Labeled Nutrients and Development of Animal Models," 5/16/2013 – 5/15/2016, $892,104.

Charles Cox and **Jonathan Sweedler**, NIH, "Synaptic Phenotype Development and Plasticity in the Fragile X Mouse," 7/1/2013 – 6/30/2014, $146,199.

SELECTED PUBLICATIONS

Anastasio, T. J., Exploring the Contribution of Estrogen to Amyloid-Beta Regulation: A Novel Multifactorial Computational Modeling Approach. *Frontiers in Pharmacology* **2013**, *4*, 16.

Baldassano, C.; **Beck, D. M.**; Fei-Fei, L., Differential Connectivity within the Parahippocampal Place Area. *Neuroimage* **2013**, *75*, 228-237.

Barbey, A. K.; Koenigs, M.; Grafman, J., Dorsolateral Prefrontal Contributions to Human Working Memory. *Cortex* **2013**, *49*, (5), 1195-1205.

Beckman faculty names are in bold-face type.

Benjamin, A. S.; Diaz, M.; Matzen, L. E.; Johnson, B., Tests of the Dryad Theory of the Age-Related Deficit in Memory for Context: Not About Context, and Not About Aging. *Psychology and Aging* **2012**, *27,* (2), 418-428.

Berry, D.; Blair, C.; Ursache, A.; Willoughby, M.; Garrett-Peters, P.; Vernon-Feagans, L.; Bratsch-Hines, M.; Mills-Koonce, R.; Granger, D. A., Child Care and Cortisol across Early Childhood: Context Matters. *Developmental Psychology* **2013**, DOI: http://psycnet.apa.org/psycinfo/2013-21356-001/.

Brown-Schmidt, S., Beyond Common and Privileged: Gradient Representations of Common Ground in Real-Time Language Use. *Language and Cognitive Processes* **2012**, *27,* (1), 62-89.

Chiu, Y.-C.; Dolcos, S.; **Gonsalves, B. D.**; **Cohen, N. J.**, On Opposing Effects of Emotion on Contextual or Relational Memory. *Frontiers in Psychology* **2013**, *4,* 103.

Christianson, K.; **Mestre, J. P.**; Luke, S. G., Practice Makes (Nearly) Perfect: Solving "Students-and-Professors"-Type Algebra Word Problems. *Applied Cognitive Psychology* **2012**, *26,* (5), 810-822.

Clint, E. K.; Sober, E.; Garland, T.; **Rhodes, J. S.**, Male Superiority in Spatial Navigation: Adaptation or Side Effect? *Quarterly Review of Biology* **2012**, *87,* (4), 289-313.

Coronel, J. C.; Duff, M. C.; Warren, D. E.; **Federmeier, K. D.**; **Gonsalves, B. D.**; Tranel, D.; **Cohen, N. J.**, Remembering and Voting: Theory and Evidence from Amnesic Patients. *American Journal of Political Science* **2012**, *56,* (4), 837-848.

Croushore, C. A.; **Sweedler, J. V.**, Microfluidic Systems for Studying Neurotransmitters and Neurotransmission. *Lab on a Chip* **2013**, *13,* (9), 1666-1676.

Dabe, E. C.; Majdak, P.; Bhattacharya, T. K.; Miller, D. S.; **Rhodes, J. S.**, Chronic D-Amphetamine Administered from Childhood to Adulthood Dose-Dependently Increases the Survival of New Neurons in the Hippocampus of Male C57bl/6j Mice. *Neuroscience* **2013**, *231,* 125-135.

Docktor, J. L.; **Mestre, J. P.**; **Ross, B. H.**, Impact of a Short Intervention on Novices' Categorization Criteria. *Physical Review Special Topics-Physics Education Research* **2012**, *8,* (2).

Dolcos, S.; Sung, K.; Argo, J. J.; Flor-Henry, S.; **Dolcos, F.**, The Power of a Handshake: Neural Correlates of Evaluative Judgments in Observed Social Interactions. *Journal of Cognitive Neuroscience* **2012**, *24,* (12), 2292-2305.

Galvan, A. M.; **Galvez, R.**, Neocortical Vasculature Abnormalities in the Fragile X Mental Retardation Syndrome. *Brain Research* **2012**, *1471,* 155-161.

Govindaiah, G.; Wang, T. F.; Gillette, M. U.; **Cox, C. L.**, Activity-Dependent Regulation of Retinogeniculate Signaling by Metabotropic Glutamate Receptors. *Journal of Neuroscience* **2012**, *32,* (37), 12820-12831.

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

Kim, M.; **Ceman, S.**, Fragile X Mental Retardation Protein: Past, Present and Future. *Current Protein & Peptide Science* **2012**, *13,* (4), 358-371.

Lee, H.; Voss, M. W.; Prakash, R. S.; Boot, W. R.; Vo, L. T. K.; Basak, C.; VanPatter, M.; **Gratton, G.**; **Fabiani, M.**; **Kramer, A. F.**, Videogame Training Strategy-Induced Change in Brain Function During a Complex Visuomotor Task. *Behavioural Brain Research* **2012**, *232,* (2), 348-357.

Lee, J. V.; Maclin, E. L.; Low, K. A.; **Gratton, G.**; **Fabiani, M.**; **Clayton, D. F.**, Noninvasive Diffusive Optical Imaging of the Auditory Response to Birdsong in the Zebra Finch. *Journal of Comparative Physiology A-Neuroethology Sensory Neural and Behavioral Physiology* **2013**, *199,* (3), 227-238.

Llano, D. A.; Turner, J.; Caspary, D. M., Diminished Cortical Inhibition in an Aging Mouse Model of Chronic Tinnitus. *Journal of Neuroscience* **2012**, *32,* (46), 16141-16148.

Mahrt, T.; **Cole, J.**; Fleck, M.; **Hasegawa-Johnson, M.**, Modeling Speaker Variation in Cues to Prominence Using the Bayesian Information Criterion, *Proceedings of Speech Prosody 2012*, Shanghai, **2012**.

Neese, S. L.; Bandara, S. B.; **Schantz, S. L.**, Working Memory in Bisphenol-A Treated Middle-Aged Ovariectomized Rats. *Neurotoxicology and Teratology* **2013**, *35,* 46-53.

Nemes, P.; Rubakhin, S. S.; Aerts, J. T.; **Sweedler, J. V.**, Qualitative and Quantitative Metabolomic Investigation of Single Neurons by Capillary Electrophoresis Electrospray Ionization Mass Spectrometry. *Nature Protocols* **2013**, *8,* (4), 783-799.

Parks, N. A.; **Beck, D. M.**; **Kramer, A. F.**, Enhancement and Suppression in the Visual Field under Perceptual Load. *Frontiers in Psychology* **2013**, *4:275,* DOI: 10.3389/fpsyg.2013.00275.

Pisani, S. L.; Neese, S. L.; Doerge, D. R.; Helferich, W. G.; **Schantz, S. L.**; Korol, D. L., Acute Genistein Treatment Mimics the Effects of Estradiol by Enhancing Place Learning and Impairing Response Learning in Young Adult Female Rats. *Hormones and Behavior* **2012**, *62,* (4), 491-499.

Slater, B. J.; Willis, A. M.; **Llano, D. A.**, Evidence for Layer-Specific Differences in Auditory Corticocollicular Neurons. *Neuroscience* **2013**, *229,* 144-154.

Warren, D. E.; Duff, M. C.; Jensen, U.; Tranel, D.; **Cohen, N. J.**, Hiding in Plain View: Lesions of the Medial Temporal Lobe Impair Online Representation. *Hippocampus* **2012**, *22,* (7), 1577-1588.

Yuan, S.; **Fisher, C.**; Snedeker, J., Counting the Nouns: Simple Structural Cues to Verb Meaning. *Child Development* **2012**, *83,* (4), 1382-1399.

HCII SELECTED FACULTY AWARDS, PATENTS, GRANTS, AND PUBLICATIONS

Covering July 1, 2012-June 30, 2013

FACULTY

(name followed by home department)

Artificial Intelligence

Narendra Ahuja, *Electrical and Computer Engineering*
Jont Allen, *Electrical and Computer Engineering*
Eyal Amir, *Computer Science*
Richard Berlin, *Surgery*
Timothy W. Bretl, *Aerospace Engineering*
Gerald F. DeJong, *Computer Science*
Roxana Girju, *Linguistics*
Mark A. Hasegawa-Johnson, *Electrical and Computer Engineering*
Seth A. Hutchinson, *Electrical and Computer Engineering*
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 K. Shosted, *Linguistics*
Paris Smaragdis, *Computer Science*
Karen White, *Internal Medicine*

Human Perception and Performance

Matthew Dye, *Speech and Hearing Science*
Wai-Tat Fu, *Computer Science*
Charles H. Hillman, *Kinesiology and Community Health*
Derek W. Hoiem, *Computer Science*
Fatima T. Husain, *Speech and Hearing Science*
David E. Irwin, *Psychology*
Alex Kirlik, *Computer Science*
Arthur F. Kramer, *Psychology*
Charissa Lansing, *Speech and Hearing Science*
Alejandro Lleras, *Psychology*
Edward McAuley, *Kinesiology and Community Health*
Deana C. McDonagh, *Industrial Design*
Daniel G. Morrow, *Educational Psychology*
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*

Image Formation and Processing

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

SELECTED HONORS AND AWARDS

George Francis
Broadrick-Allen Award, U of I Campus Honors Program 2012.

Wai-Tat Fu
Fellow, Hanse-Wissenschaftskolleg Institute of Advanced Study, Delmenhorst, Germany 2012.

Mark Hasegawa-Johnson
Elected to Board of Officers of the International Speech Communication Association 2013.

Thomas Huang
- Swanlund Chair 2012.
- Co-author, Best Paper, KDD BigMine Workshop, Beijing, PRC 2012.

Charissa R. Lansing
Fellow, American Speech Language Hearing Association 2013.

Steven Lavalle
University of Illinois Scholar 2012.

Stephen Levinson
(with L. Niehaus), Paper of Excellence Award, IEEE International Conference on Development and Learning—Epigenetic Robotics (ICDL-EPIROB) 2012.

Pierre Moulin
(with Bingbing Ni and Yong Pei), Human Activities Recognition and Localization competition winner, in conjunction with ICPR 2012.

Elizabeth Stine-Morrow
Spitze-Mather Faculty Award for Excellence, College of Education 2012.

INVENTION DISCLOSURES

Faculty members from Human-Computer Intelligent Interaction research theme were inventors on one invention disclosure (0.6% of the 181 invention disclosures filed by campus) during FY2013.

SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the Human-Computer Intelligent Interaction research theme were inventors on the following two patent applications (1% of the 192 patent applications filed by campus) and two patents issued (2.8% of the 72 patents issued to campus) during FY2013.

Yasutaka Furukawa and **Jean Ponce**, "Match, Expand, and Filter Technique for Multi-View Steropsis," patent issued December 11, 2012, patent number 8,331,615.

Ron Carbonari, John Gaspar, Henry Kaczmarski, **Arthur Kramer**, Kyle Mathewson, Whitney Street, and Matthew Windsor, "Providing a Conversation Partner Views of the Driving Scene Mitigates Cell Phone-Related Driver Distraction," patent filed February 20, 2013, application number 61/767,040.

Yi Ma, Andrew Wagner, John Wright, and Allen Yang, "Recognition via High-Dimensional Data Classification," patent issued March 26, 2013, patent number 8,406,525.

GRANTS AWARDED

($2,078,786)

Douglas Jones and Aadeel Akhtar, TERC-NSF, "2012 Online IGERT Video and Poster Competition," 7/1/2012 – 6/30/2013, $2,000.

Heejin Kim, NIH, "Effects of Familiarization on Dysarthric Speech Intelligibility: Acoustic Correlates of Perceptual Learning," 9/26/2012 – 8/31/2015, $455,254.

Stephen Levinson, Sandia, "Computational Models of Neurals Dynamics," 10/1/2012 – 8/31/2013, $21,532.

Elizabeth Stine-Morrow, **Kara Federmeier**, Carolyn Anderson, **Neal Cohen**, and Sarah Grison Sullivan, U.S. Department of Education, "A Process View of Reading Among Adult Literacy Learners," 7/1/2013 – 6/30/2017, $1,600,000.

Beckman faculty names are in bold-face type.

SELECTED PUBLICATIONS

Akce, A.; Johnson, M.; Dantsker, O.; **Bretl, T.**, A Brain-Machine Interface to Navigate a Mobile Robot in a Planar Workspace: Enabling Humans to Fly Simulated Aircraft with EEG. *IEEE Transactions on Neural Systems and Rehabilitation Engineering* **2013**, *21,* (2), 306-318.

Cao, L. L.; Jin, X.; Yin, Z. J.; Del Pozo, A.; Luo, J. B.; Han, J. W.; **Huang, T. S.**, Rank Compete: Simultaneous Ranking and Clustering of Information Networks. *Neurocomputing* **2012**, *95,* 98-104.

Chaddock-Heyman, L.; Erickson, K. I.; Voss, M. W.; Knecht, A. M.; Pontifex, M. B.; Castelli, D. M.; **Hillman, C. H.**; **Kramer, A. F.**, The Effects of Physical Activity on Functional MRI Activation Associated with Cognitive Control in Children: A Randomized Controlled Intervention. *Frontiers in Human Neuroscience* **2013**, *7*.

Chang, M. W.; Ratinov, L.; **Roth, D.**, Structured Learning with Constrained Conditional Models. *Machine Learning* **2012**, *88,* (3), 399-431.

Fraccone, G. C.; Valenzuela-Vega, R.; Siddique, S.; Volovoi, V.; **Kirlik, A.**, Nested Modeling of Hazards in the National Airspace System. *Journal of Aircraft* **2013**, *50,* (2), 370-377.

Fu, W. T.; Lee, H.; Boot, W. R.; **Kramer, A. F.**, Bridging across Cognitive Training and Brain Plasticity: A Neurally Inspired Computational Model of Interactive Skill Learning. *Wiley Interdisciplinary Reviews-Cognitive Science* **2013**, *4,* (2), 225-236.

Gilbert, J. L.; **Lansing, C. R.**; **Garnsey, S. M.**, Seeing Facial Motion Affects Auditory Processing in Noise. *Attention Perception & Psychophysics* **2012**, *74,* (8), 1761-1781.

Huang, T. S., Can the World-Wide Web Bridge the Semantic Gap? *Image and Vision Computing* **2012**, *30,* (8), 463-464.

Husain, F. T.; Patkin, D. J.; Kim, J.; Braun, A. R.; Horwitz, B., Dissociating Neural Correlates of Meaningful Emblems from Meaningless Gestures in Deaf Signers and Hearing Non-Signers. *Brain Research* **2012**, *Oct 10,* (1478), 24-35.

Insel, K. C.; Einstein, G. O.; **Morrow, D. G.**; Hepworth, J. T., A Multifaceted Prospective Memory Intervention to Improve Medication Adherence: Design of a Randomized Control Trial. *Contemporary Clinical Trials* **2013**, *34,* (1), 45-52.

Jackson, J. J.; Hill, P. L.; Payne, B. R.; Roberts, B. W.; **Stine-Morrow, E. A. L.**, Can an Old Dog Learn (and Want to Experience) New Tricks? Cognitive Training Increases Openness to Experience in Older Adults. *Psychology and Aging* **2012**, *27,* (2), 286-292.

Jun, D.; **Jones, D. L.**, Cascading Signal-Model Complexity for Energy-Aware Detection. *IEEE Journal on Emerging Topics in Circuits and Systems* **2013**, *3,* (1), 65-74.

Laasonen, M.; Salomaa, J.; Cousineau, D.; Leppamaki, S.; Tani, P.; Hokkanen, L.; **Dye, M.**, Project Dyadd: Visual Attention in Adult Dyslexia and ADHD. *Brain and Cognition* **2012**, *80,* (3), 311-327.

Lee, J. D.; **Kirlik, A.** *The Oxford Handbook of Cognitive Engineering*; Oxford University Press: New York, **2013**.

Levinson, S.; Davis, D.; Slimon, S.; Huang, J. Articulatory Speech Synthesis from the Fluid Dynamics of the Vocal Apparatus (Synthesis Lectures on Speech and Audio Processing); Morgan & Claypool Publishers, **July 2013**.

Li, F. P.; Trevino, A.; Menon, A.; **Allen, J. B.**, A Psychoacoustic Method for Studying the Necessary and Sufficient Perceptual Cues of American English Fricative Consonants in Noise. *Journal of the Acoustical Society of America* **2012**, *132,* (4), 2663-2675.

Mathewson, K. E.; Prudhomme, C.; **Fabiani, M.**; **Beck, D. M.**; **Lleras, A.**; **Gratton, G.**, Making Waves in the Stream of Consciousness: Entraining Oscillations in EEG Alpha and Fluctuations in Visual Awareness with Rhythmic Visual Stimulation. *Journal of Cognitive Neuroscience* **2012**, *24,* (12), 2321-2333.

Mathur, S.; Poole, M. S.; Pena-Mora, F.; **Hasegawa-Johnson, M.**; Contractor, N., Detecting Interaction Links in a Collaborating Group Using Manually Annotated Data. *Social Networks* **2012**, *34,* (4), 515-526.

Mereu, S.; **Lleras, A.**, Feelings of Control Restore Distorted Time Perception of Emotionally Charged Events. *Consciousness and Cognition* **2013**, *22,* (1), 306-314.

Mir, M.; Babacan, S. D.; Bednarz, M.; **Do, M. N.**; Golding, I.; **Popescu, G.**, Visualizing Escherichia Coli Sub-Cellular Structure Using Sparse Deconvolution Spatial Light Interference Tomography. *Plos One* **2012**, *7,* (6).

Motl, R. W.; Pilutti, L. A.; Sandroff, B. M.; Klaren, R.; Balantrapu, S.; **McAuley, E.**; Sosnoff, J. J.; Fernhall, B., Rationale and Design of a Randomized Controlled, Clinical Trial Investigating a Comprehensive Exercise Stimulus for Improving Mobility Disability Outcomes in Persons with Multiple Sclerosis. *Contemporary Clinical Trials* **2013**, *35,* (1), 151-158.

Nam, H.; Mitra, V.; Tiede, M.; **Hasegawa-Johnson, M.**; Espy-Wilson, C.; Saltzman, E.; Goldstein, L., A Procedure for Estimating Gestural Scores from Speech Acoustics. *Journal of the Acoustical Society of America* **2012**, *132,* (6), 3980-3989.

Neihus, L.; **Levinson, S.** Online Learning and Integration of Complex Action and Word Lexicons for Language Grounding, 2012 IEEE International Conference on Development and Learning—Epigenetic Robotics (ICDL-EPIROB), San Diego, CA, **November 2012**, 1-6.

Nguyen, V. A.; Min, D. B.; **Do, M. N.**, Efficient Techniques for Depth Video Compression Using Weighted Mode Filtering. *IEEE Transactions on Circuits and Systems for Video Technology* **2013**, *23,* (2), 189-202.

Pathak, M. A.; Raj, B.; Rane, S.; **Smaragdis, P.**, Privacy-Preserving Speech Processing. *IEEE Signal Processing Magazine* **2013**, *30,* (2), 62-74.

Sampaio, C.; **Wang, R. F.**, The Locus of the Categorical Bias in Spatial Memories. *Journal of Cognitive Psychology* **2012**, *24,* (7), 781-788.

Thomas, J.; **McDonagh, D.**, Empathic Design: Research Strategies. *Australasian Medical Journal* **2013**, *6,* (1), 1-6.

Yang, Q. X.; **Ahuja, N.**, Stereo Matching Using Epipolar Distance Transform. *IEEE Transactions on Image Processing* **2012**, *21,* (10), 4410-4419.

Zhang, H. C.; Zhang, Y. N.; **Huang, T. S.**, Simultaneous Discriminative Projection and Dictionary Learning for Sparse Representation Based Classification. *Pattern Recognition* **2013**, *46,* (1), 346-354.

Zhang, T. Z.; Ghanem, B.; Liu, S.; **Ahuja, N.**, Robust Visual Tracking via Structured Multi-Task Sparse Learning. *International Journal of Computer Vision* **2013**, *101,* (2), 367-383.

Covering July 1, 2012-June 30, 2013

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*

Bioimaging Science and Technology
Ryan Bailey, *Chemistry*
Rohit Bhargava, *Bioengineering*
Marni Boppart, *Kinesiology and Community Health*
Stephen Boppart, *Electrical and Computer Engineering*
P. Scott Carney, *Electrical and Computer Engineering*
Jianjun Cheng, *Materials Science and Engineering*
Larry Di Girolamo, *Atmospheric Science*
Ryan Dilger, *Animal Sciences*
Lynford Goddard, *Electrical and Computer Engineering*
Princess Imoukhuede, *Bioengineering*
Michael Insana, *Bioengineering*
Jianming Jin, *Electrical and Computer Engineering*
Aaron Johnson, *Speech and Hearing Science*
John Katzenellenbogen, *Chemistry*
David Kuehn, *Speech and Hearing Science*
Zhi-Pei Liang, *Electrical and Computer Engineering*
Ling J. Meng, *Nuclear, Plasma, and Radiological Engineering*
William C. Olivero, *Surgery*
Gabriel Popescu, *Electrical and Computer Engineering*
Partha Ray, *Surgery*
Martin Starzewski, *Mechanical Science and Engineering*
Kenneth S. Suslick, *Chemistry*
Brad Sutton, *Bioengineering*
Kimani Toussaint, *Mechanical Science and Engineering*
Amy J. Wagoner Johnson, *Mechanical Science and Engineering*
John Wang, *Surgery*
Michelle Wang, *Statistics*
Ning Wang, *Mechanical Science and Engineering*
Yingxiao Wang, *Bioengineering*
Yongmei Wang, *Statistics*
Kenneth L. Watkin, *Speech and Hearing Science*
Sheng Zhong, *Bioengineering*

SELECTED HONORS AND AWARDS

Ryan C. Bailey
- Selected one of the "35 Innovators under 35" by MIT Technology Review 2012.
- Arthur F. Findeis Award for Achievements by a Young Analytical Scientist, Division of Analytical Chemistry, American Chemical Society 2013.

Rohit Bhargava
- Craver Award 2013.
- Federation of Analytical Chemistry and Spectroscopy Societies (FACSS) Innovation Award 2012.

Jianjun Cheng
Willett Faculty Scholar award 2013.

Michael F. Insana
Donald Biggar Willett Professor of Engineering 2013.

Aaron M. Johnson
Sataloff Award for Young Investigators from the Voice Foundation 2013.

Zhi-Pei Liang
Invested as a Franklin W. Woeltge Professor of Electrical and Computer Engineering 2013.

Michael Oelze
Fulbright Scholar Award to Paris, France, 2013.

Gabriel Popescu
(with Shamira Sridharan) 2nd Place Poster Award, Engineering Conferences International's Advances in Optics for Biotechnology, Medicine, and Surgery XIII Conference, Lake Tahoe, Calif., 2013.

Kenneth Suslick
Wilsmore Fellow, University of Melbourne, 2013.

Amy Wagoner Johnson
Campus Award for Excellence in Advising Undergraduate Research 2013.

INVENTION DISCLOSURES

Faculty members from the Integrative Imaging research theme were inventors on 15 invention disclosures (8.3% of the 181 invention disclosures filed by campus) during FY2013.

SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the Integrative Imaging research theme were inventors on 14 of the following patent applications (7.3% of the 192 patent applications filed by campus) and six patents issued (8.3% of the 72 patents issued to campus) during FY2013.

Stephen Boppart, Daniel Marks, Simon Schlachter, and Adam Zysk, "Group Refractive Index Reconstruction with Broadband Interferometric Confocal Microscopy," patent issued July 10, 2012, patent number 8,218,152.

Basanta Bhaduri, Hoa Pham, and **Gabriel Popescu**, "Diffraction Phase Microscopy with White Light," patent filed September 21, 2012, application number 61/704,005.

Tae Kim and **Gabriel Popescu**, "Phase Derivative Microscopy," patent filed September 25, 2012, application number 61/705,377.

Paul Carney, Rainer Hillenbrand, and Martin Schnell, "Optical Nanoholography," patent filed September 25, 2012, application number 61/705,296.

Amir Arbabi, Chris Edwards, **Lynford Goddard**, and **Gabriel Popescu**, "Optically Monitoring and Controlling Nanoscale Topography," patent filed September 28, 2012, application number 13/630,286.

Stephen Boppart, Joseph Geddes, and Daniel Marks, "Matched Pulse Stimulated Raman Scattering," patent issued October 30, 2012, patent number 8,300,388.

Rohit Bhargava, **Paul Carney**, David Mayerich, and Thomas van Dijk, "Coherent Optical Mapping of Particles," patent filed November 2, 2012, application number 13/667,287.

Stephen Boppart and Haohua Tu, "Optical Frequency Up-Conversion of Femtosecond Pulses into Targeted Single Bands in the Visible and Ultraviolet," patent issued November 6, 2012, patent number 8,305,682.

Paul Carney, Brynmor Davis, **Kimani Toussaint**, and Santosh Tripathi, "Second-Order Nonlinear Susceptibility of a Nanoparticule Using Coherent Confocal

Beckman faculty names are in bold-face type.

Microscopy," patent issued December 18, 2012, patent number 8,334,976.

Gabriel Popescu and Zhuo Wang, "Spatial Light Interference Tomography," patent filed December 27, 2012, application number 13/727,875.

Stephen Boppart, Vasilica Crecea, and Jongsick Kim, "Real-Time Biomechanical Dosimetry using Optical Coherence Elastography," patent filed January 11, 2013, application number 13/739,075.

Sevket Babacan, Mustafa Mir, **Gabriel Popescu**, and Zhuo Wang, "Sparse Deconvolution Spatial Light Microscopy in Two and Three Dimensions," patent filed February 25, 2013, application number 13/775,887.

Huafeng Ding, **Gabriel Popescu**, and Zhuo Wang, "Scattering Parameters of Tissue from Quantative Phase Imaging," patent filed February 25, 2013, application number 13/775,788.

Tae Kim and **Gabriel Popescu**, "Phase Derivative Microscopy," patent filed February 25, 2013, application number 13/776,037.

Rohit Bhargava, "Stain-Free Histopathology by Chemical Imaging," patent filed March 15, 2013, application number 61/794,171.

Michael Insana, Marko Orescanin, and Kathleen Toohey, "Techniques to Evaluated Mechanical Properties of a Biological Material," patent issued March 19, 2013, patent number 8,398,550.

Stephen Boppart and Youbo Zhao, "Optical Parametric Amplification of Weak Signals for Imaging Biological Tissue," patent filed May 9, 2013, application number 61/821,642.

Stephen Boppart, "Apparatus and Method for Measuring a Characteristic of a Composition Reactive to a Magnetic Field," patent issued May 21, 2013, patent number 8,447,373.

Rohit Bhargava, **Paul Carney**, David Mayerich, and Thomas van Dijk, "Infrared Microspectroscopy for Intact Spheres," patent filed May 31, 2013, application number 61/829,252.

Steven Adie, **Stephen Boppart**, and **Paul Carney**, "Computational Adaptive Optics for Interferometric Synthetic Aperture Microscopy," patent filed June 21, 2013, application number 13/996,838.

GRANTS AWARDED

($3,688,409)

Yinxiao Wang and Huimin Zhao, NIH, "A Systematic Approach to Engineer Fyn Kinase Biosensor," 9/21/2012 – 7/31/2014, $425,265.

John Erdman and **Jonathan Sweedler**, Abbott Nutrition, "Cognitive Nutrients and the Brain: Production of Isotopically Labeled Nutrients and Development of Animal Models," 5/16/2013 – 5/15/2016, $1,171,000.

Brad Sutton, **Zhi-Pei Liang**, and Ryan Larsen, Abbott Nutrition, "Developing Advanced MRI Methods for Detecting the Impact of Nutrients on Infant Brain Development," 5/16/2013 – 5/15/2016, $1,672,000.

Manabu Nakamura, **John Erdman**, and Elizabeth Jeffery, Abbott Nutrition, "Protection of Biomolecules by Dietary Nutrients and Exacerbation of Oxidative Stress by Impaired Nutrient Supply," 5/16/2013 – 5/15/2014, $320,144.

Stephen Boppart, "Biophotonics Imaging Lab Pilot Projects for GlaxoSmithKline," 5/24/2013 – 11/23/2013, $100,000.

SELECTED PUBLICATIONS

Abouimrane, A.; Odom, S. A.; Tavassol, H.; Schulmerich, M. V.; Wu, H. M.; **Bhargava, R.**; Gewirth, A. A.; **Moore, J. S.**; Amine, K., 3-Hexylthiophene as a Stabilizing Additive for High Voltage Cathodes in Lithium-Ion Batteries. *Journal of the Electrochemical Society* **2013**, *160*, (2), A268-A271.

Adie, S. G.; Shemonski, N. D.; Graf, B. W.; Ahmad, A.; **Carney, P. S.**; **Boppart, S. A.**, Guide-Star-Based Computational Adaptive Optics for Broadband Interferometric Tomography. *Applied Physics Letters* **2012**, *101*, (22).

Ahmad, A.; Shemonski, N. D.; Adie, S. G.; Kim, H.; Hwu, W.-M.; **Carney, P. S.**; **Boppart, S. A.**, Real-Time *in vivo* Computed Optical Interferometric Tomography. *Nature Photonics* **2013**, *7*, 444-448.

Bhaduri, B.; Wickland, D.; Wang, R.; Chan, V.; **Bashir, R.**; **Popescu, G.**, Cardiomyocyte Imaging Using Real-Time Spatial Light Interference Microscopy (Slim). *Plos One* **2013**, *8*, (2).

Borrelli, M. J.; **O'Brien, W. D.**; Hamilton, E.; **Oelze, M. L.**; Wu, J.; Bernock, L. J.; Tung, S.; Rokadia, H.; Culp, W. C., Influences of Microbubble Diameter and Ultrasonic Parameters on *in vitro* Sonothrombolysis Efficacy. *Journal of Vascular and Interventional Radiology* **2012**, *23,* (12), 1677-1684.

Boulos, S. P.; Prigozhin, M. B.; Liu, Y.; Wirth, A. J.; **Boppart, S. A.**; **Gruebele, M.**; Murphy, C. J., The Gold Nanorod-Biology Interface: From Proteins to Cells to Tissue. *Current Physical Chemistry* **2013**, *3,* 128-135.

Buiochi, E. B.; Miller, R. J.; Hartman, E.; Buiochi, F.; Bassani, R. A.; Costa, E. T.; **O'Brien, W. D.**, Transthoracic Cardiac Ultrasonic Stimulation Induces a Negative Chronotropic Effect. *IEEE Transactions on Ultrasonics Ferroelectrics and Frequency Control* **2012**, *59,* (12), 2655-2661.

Cameron, A. J.; Milner, D. J.; Lee, J. S.; **Cheng, J.**; Fang, N. X.; **Jasiuk, I. M.**, Employing the Biology of Successful Fracture Repair to Heal Critical Size Bone Defects. *Current Topics in Microbiology and Immunology* **2013**, *367,* 113-132.

Cely, I.; Yiv, S.; Yin, Q.; Shahidzadeh, A.; Tang, L.; **Cheng, J.**; Uckun, F. M., Targeting Mantle Cell Lymphoma with Anti-SYK Nanoparticles. *Journal of Analytical Oncology* **2012**, *1,* 1-8.

Conlon, L. E.; King, R. D.; Moran, N. E.; **Erdman, J. W.**, Coconut Oil Enhances Tomato Carotenoid Tissue Accumulation Compared to Safflower Oil in the Mongolian Gerbil (Meriones Unguiculatus). *Journal of Agricultural and Food Chemistry* **2012**, *60,* (34), 8386-8394.

Dilger, R. N.; Bryant-Angeoni, K.; Payne, R. L.; Lemme, A.; Parsons, C. M., Dietary Guanidino Acetic Acid is an Efficacious Replacement for Arginine for Young Chicks. *Poultry Science* **2013**, *92,* (1), 171-177.

Elmore, M. R. P.; **Dilger, R. N.**; Johnson, R. W., Place and Direction Learning in a Spatial T-Maze Task by Neonatal Piglets. *Animal Cognition* **2012**, *15,* (4), 667-676.

Flannigan, D. J.; **Suslick, K. S.**, Temperature Nonequilibration During Single-Bubble Sonoluminescence. *Journal of Physical Chemistry Letters* **2012**, *3,* (17), 2401-2404.

Gabrielson, N. P.; Lu, H.; Yin, L. C.; Kim, K. H.; **Cheng, J. J.**, A Cell-Penetrating Helical Polymer for siRNA Delivery to Mammalian Cells. *Molecular Therapy* **2012**, *20,* (8), 1599-1609.

Gai, J. D.; Obeid, N.; Holtrop, J. L.; Wu, X. L.; Lam, F.; Fu, M. J.; Haldar, J. P.; Hwu, W. M. W.; **Liang, Z. P.**; **Sutton, B. P.**, More Impatient: A Gridding-Accelerated Toeplitz-Based Strategy for Non-Cartesian High-Resolution 3D MRI on GPUs. *Journal of Parallel and Distributed Computing* **2013**, *73,* (5), 686-697.

Graf, B. W.; Bower, A.; Chaney, E. J.; Marjanovic, M.; Adie, S. G.; DeLiso, M.; Valero, M. C.; **Boppart, M. D.**; **Boppart, S. A.**, *In vivo* Multimodal Microscopy for Detecting Bone-Marrow-Derived Cell Contribution to Skin Regeneration. *Journal of Biophotonics* **2013**, DOI: 10.1002/jbio.201200240.

Johnson, C. L.; McGarry, M. D.; Gharibans, A. A.; Weaver, J. B.; Paulsen, K. D.; **Wang, H.**, Local Mechanical Properties of White Matter Structures in the Human Brain. *NeuroImage* **2013**, *79,* 145-152.

Joumaa, H.; **Ostoja-Starzewski, M.**; Demmie, P. N., Elastodynamics in Micropolar Fractal Solids. *Mathematics and Mechanics of Solids* **2012**, DOI: 10.1177/1081286512454557.

Kim, T.; Sridharan, S.; **Popescu, G.**, Gradient Field Microscopy Allows Label-Free Disease Diagnosis. *Laser Focus World* **2012**, *48,* (8), 41.

Kwon, B.; Jiang, J.; Schulmerich, M.; **Bhargava, R.**; Liu, G.; **King, W.**, Bimaterial Microcantilevers with Black Silicon Nanocone Arrays. *Sensors and Actuators A* **2013**, *199,* 143-148.

McGarry, M. D. J.; Van Houten, E. E. W.; Johnson, C. L.; **Georgiadis, J. G.**; **Sutton, B. P.**; Weaver, J. B.; Paulsen, K. D., Multiresolution MR Elastography Using Nonlinear Inversion. *Medical Physics* **2012**, *39,* (10), 6388-6396.

Moreno-Torres, J. G.; Llora, X.; Goldberg, D. E.; **Bhargava, R.**, Repairing Fractures between Data Using Genetic Programming-Based Feature Extraction: A Case Study in Cancer Diagnosis. *Information Sciences* **2013**, *222,* 805-823.

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.

Nguyen, N. Q.; Abbey, C. K.; **Insana, M. F.**, Objective Assessment of Sonographic: Quality II Acquisition Information Spectrum. *IEEE Transactions on Medical Imaging* **2013**, *32,* (4), 691-698.

Odom, S. A.; Tyler, T. P.; Caruso, M. M.; Ritchey, J. A.; Schulmerich, M. V.; Robinson, S. J.; **Bhargava, R.**; **Sottos, N. R.**; **White, S. R.**; Hersam, M. C.; **Moore, J. S.**, Autonomic Restoration of Electrical Conductivity Using Polymer-Stabilized Carbon Nanotube and Graphene Microcapsules. *Applied Physics Letters* **2012**, *101,* (4).

Pham, H. V.; Bhaduri, B.; Tangella, K.; Best-Popescu, C.; **Popescu, G.**, Real Time Blood Testing Using Quantitative Phase Imaging. *Plos One* **2013**, *8,* (2).

Rytych, J. L.; Elmore, M. R. P.; Burton, M. D.; Conrad, M. S.; Donovan, S. M.; **Dilger, R. N.**; Johnson, R. W., Early Life Iron Deficiency Impairs Spatial Cognition in Neonatal Piglets. *Journal of Nutrition* **2012**, *142,* (11), 2050-2056.

Tang, L.; Gabrielson, N. P.; Uckun, F. M.; Fan, T. M.; **Cheng, J. J.**, Size-Dependent Tumor Penetration and *in vivo* Efficacy of Monodisperse Drug-Silica Nanoconjugates. *Molecular Pharmaceutics* **2013**, *10,* (3), 883-892.

Wang, B.; Moon, S. J.; **Olivero, W.**; **Wang, H.**, Cortical Blindness as a Rare Presentation of Cerebral Venous Thrombosis. *Journal of Surgical Case Reports* **2013**, *5,* DOI: 10.1093/jscr/rjt035.

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

Covering July 1, 2012-June 30, 2013

FACULTY

(name followed by home department)

3D Micro- and Nanosystems

Rashid Bashir, *Electrical and Computer Engineering*
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*
Mark A. Shannon, *Mechanical 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*

Computational Multiscale Nanosystems

Narayana R. Aluru, *Mechanical Science and Engineering*
Andreas 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*
Matthew Gilbert, *Electrical and Computer Engineering*
Gregory Girolami, *Chemistry*
Martin 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*
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*
Zan Luthey-Schulten, *Chemistry*
Klaus J. Schulten, *Physics*
John Stack, *Physics*
Emadeddin Tajkhorshid, *Pharmacology*

SELECTED HONORS AND AWARDS

Rashid Bashir
IEEE Engineering in Medicine and Biology Society (EMBS) Technical Achievement Award 2012.

Prashant K. Jain
Selected one of the "35 Innovators under 35" by MIT Technology Review 2012.

Martin Gruebele
National Academy of Sciences 2013.

Laxmikant "Sanjay" Kale
IEEE Computer Society Sidney Fernbach Award 2012.

Joseph W. Lyding
IEEE Pioneer in Nanotechnology Award 2012.

John Rogers
Swanlund Chair 2012.

Klaus Schulten
- IEEE Computer Society Sidney Fernbach Award 2012.
- Biophysical Society's Distinguished Service Award 2013.

Stephen Sligar
Swanlund Chair 2012.

Scott R. White
Humboldt Research Award 2013.

INVENTION DISCLOSURES

Faculty members from the Molecular and Electronic Nanostructures research theme were inventors on three invention disclosures (1.7% of the 181 invention disclosures filed by campus) during FY2013.

SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the M&ENS research theme were inventors on 10 of the following patent applications (5.2% of the 192 patent applications filed by campus) and 14 patents issued (19.4% of the 72 patents issued to campus) during FY2013.

Andrew Carlson, Won Mook Choi, Yonggang Huang, Hanqing Jiang, Dahl-Young Khang, Heung Cho Ko, Keon Jae Lee, 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 July 10, 2012, patent number 8,217,381.

Paul Braun, James Coleman, Victor Elarde, Erik Nelson, and Varun Verma, "Porous Device for Optical and Electronic Applications and Method of Fabricating the Porous Device," patent issued July 17, 2012, patent number 8,222,988.

Yi Lu and Yu Xiang, "Detection and Quantification of Analytes," patent filed August 3, 2012, application number 61/679,226.

Douglas Davis, **Jeffrey Moore**, Stephanie Potisek, **Nancy Sottos**, and **Scott White**, "Self-Assessing Mechanochromic Materials," patent issued August 7, 2012, patent number 8,236,914.

Beckman faculty names are in bold-face type.

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

Paul Braun, Xindi Yu, and Hui Zhang, "Porous Battery Electrode for a Rechargeable Battery and Method of Making the Electrode," patent issued August 7, 2012, patent number 8,237,538.

Joseph Lyding, Larry Markoski, and **Jeffrey Moore**, "High Efficiency Fuel Cell with Laminar Flow," patent filed September 11, 2012, application number 13/610,500.

Joseph Lyding, Larry Markoski, and **Jeffrey Moore**, "Electrochemical Cells Comprising Laminar Flow Induced Dynamic Conducting Interfaces, Electronic Devices Comprising Such Cells, and Methods Employing Same," patent issued October 9, 2012, patent number 8,283,090.

Placid Ferreira, Wen Huang, and **Xiuling Li**, "Electrical Component," patent filed October 11, 2012, application number 61/712,360.

Hefei Dong, **Jeffrey Moore**, Stephen Pety, **Nancy Sottos**, and **Scott White**, "Partially Degradable Fibers and Microvascular Materials Formed from the Fibers," patent filed December 1, 2012, application number 61/708,149.

Yi Lu and Zidong Wang, "Nucleic Acid-Mediated Shape Control of Nanoparticles," patent filed December 17, 2012, application number 13/717,535.

Kevin Hart, Brett Krull, **Jeffrey Moore**, Jason Patrick, **Nancy Sottos**, and **Scott White**, "Self-Healing Composite Materials and Micro-Vascular Composites for Forming the Materials," patent filed December 20, 2012, application number 13/721,801.

Seong Kang, Coskun Kocabas, Jang-Ung Park, **John Rogers**, and **Moonsub Shim**, "Methods of Making Spatially Aligned Nanotubes and Nanotube Arrays," patent issued February 5, 2013, patent number 8,367,035.

Juewen Lui and **Yi Lu**, "Nucleic Acid Based Fluorescent Sensor for Mercury Detection," patent issued February 5, 2013, patent number 8,367,416.

John Georgiadis, Curtis Johnson, and **Brad Sutton**, "Spiral Magnetic Resonance Elastography Pulse Sequence," patent filed February 18, 2013, application number 61/765,919.

Benjamin Blaiszik, Christopher Britt, Mary Caruso, James Henderson, **Jeffrey Moore**, **Nancy Sottos**, **Scott White**, and Gerald Wilson, "Systems for Self-Healing Composite Materials," patent issued February 26, 2013, patent number 8,383,697.

Jonathan Felts, **William King**, Kevin Kjoller, and Craig Prater, "Microcantilever with Reduced Second Harmonic While in Contact with a Surface and Nano Scale Infrared Spectrometer," patent issued March 5, 2013, patent number 8,387,443.

Dahl-Young Khang, Heung Cho Ko, Keon Jae Lee, Shawn Mach, Matthew Meitl, Etienne Menard, Ralph Nuzzo, **John Rogers**, Yugang Sun, and Zhengtao Zhu, "Printable Semiconductor Structures and Related Methods of Making and Assembling," patent issued March 12, 2013, patent number 8,394,706.

Juewen Liu and **Yi Lu**, "Nucleic Acid Based Fluorescent Sensor for Copper Detection," patent issued April 2, 2013, patent number 8,409,800.

Yi Lu, Abhijit Mishra, Gerard Wong, and Mehmet Veysel Yigit, "Amphiphilic Substances and Functionalized Lipid Vesicles Including the Same," patent issued April 9, 2013, patent number 8,415,461.

Jean-Pierre Leburton, "Graphene Quantum Point Contact Transistor for DNA Sensing," patent filed April 18, 2013, application number 61/813,220.

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 May 14, 2013, patent number 8,440,546.

John Carlisle, Won Mook Choi, Dae-Hyeong Kim, Matthew Meitl, Etienne Menard, and **John Rogers**, "Printable Flexible and Stretchable Diamond for Thermal Management," patent issued June 25, 2013, patent number 7,470,701.

Juewen Lui and **Yi Lu**, "Aptamer-Based Colorimetric Sensor Systems," patent issued June 25, 2013, patent number 8,470,532.

GRANTS AWARDED

$14,050,092

Jean-Pierre Leburton and **Rashid Bashir Aleksei Aksimentiev**, Oxford Nanopore Technology, "Multi-Layer Solid State Membranes with Nanochannels for Bio-Molecule Manipulation and Sensing," 6/22/2013 – 6/21/2014, $262,208.

Klaus Schulten, **Aleksei Aksimentiev**, **Laxmikant Kale**, **Zaida Luthey-Schulten**, and **Emadeddin Tajkhorshid**, NIH, "Center for Macromolecular Modeling and Bioinformatics," 8/1/2012 – 7/31/2017, $10,010,394.

Umberto Ravaioli, Ting Lu, **Aleksei Aksimentiev**, and **Catherine Murphy**, NSF, "Network for Computational Nanotechnology-NanoBIO Node," 9/1/2012 – 8/31/2017, $3,500,000.

Nancy Sottos and **Scott White**, Bridgestone, "Self-Healing Materials for Automobile Tires: Phase 1 Capsule Survival," 1/1/2013 – 12/31/2013, $75,000.

Narayan Aluru, Lawrence Livermore National Laboratory, "Unraveling the Physics of Nanofluidic Phenomena at the Single-Molecule Level," 1/30/2013 – 9/30/2015, $202,490.

SELECTED PUBLICATIONS

Ashtekar, S.; **Lyding, J.**; **Gruebele, M.**, Temperature-Dependent Two-State Dynamics of Individual Cooperatively Rearranging Regions on a Glass Surface. *Physical Review Letters* **2012**, *109,* (16).

Banerjee, S.; Shim, J.; Rivera, J.; Jin, X. Z.; Estrada, D.; Solovyeva, V.; You, X.; Pak, J.; **Pop, E.**; **Aluru, N.**; **Bashir, R.**, Electrochemistry at the Edge of a Single Graphene Layer in a Nanopore. *ACS Nano* **2013**, *7,* (1), 834-843.

Chandler, D. E.; Penin, F.; **Schulten, K.**; Chipot, C., The p7 Protein of Hepatitis C Virus Forms Structurally Plastic, Minimalist Ion Channels. *Plos Computational Biology* **2012**, *8,* (9).

Chen, K.; Goh, L.; He, G.; **Kenis, P. J. A.**; Zukoski, C. F.; Braatz, R. D., Identification of Nucleation Rates in Droplet-Based Microfluidic Systems. *Chemical Engineering Science* **2012**, *77,* 235-241.

DeSousa, J.; **Leburton, J. P.**, Self-Consistent Quantum Mechanical Analysis of Nanocrystal Flash Memory Operation *Nonvolatile Memories: Materials, Devices and Applications.* Tseng, T. Y., Sze, S. M., Eds. American Scientific Publishers, **2012**; Vol. 1, 1-12.

Diesendruck, C. E.; Steinberg, B. D.; Sugai, N.; Silberstein, M. N.; **Sottos, N. R.**; **White, S. R.**; **Braun, P. V.**; **Moore, J. S.**, Proton-Coupled Mechanochemical Transduction: A Mechanogenerated Add. *Journal of the American Chemical Society* **2012**, *134,* (30), 12446-12449.

Do, J.-W.; Estrada, D.; Xie, X.; Chang, N. N.; **Girolami, G. S.**; **Rogers, J. A.**; **Pop, E.**; **Lyding, J. W.**, Nanosoldering Carbon Nanotube Junctions with Metal Via Local Chemical Vapor Deposition for Improved Device Performance. *Proceedings of 12th IEEE Conference on Nanotechnology* **2012** 1.

Estrada, Z. J.; Dellabetta, B.; **Ravaioli, U.**; Gilbert, M. J., Phonon-Limited Transport in Graphene Pseudospintronic Devices. *IEEE Electron Device Letters* **2012**, *33,* (10), 1465-1467.

Farver, O.; Marshall, N. M.; Wherland, S.; **Lu, Y.**; Pecht, I., Designed Azurins Show Lower Reorganization Free Energies for Intra-Protein Electron Transfer. *Proceedings of the National Academy of Sciences of the United States of America* **2013**, *110,* 10536–10540.

Girolami, G. S., Osmium Weighs In. *Nature Chemistry* **2012**, *4,* (11), 954-954.

Guo, M. H.; Xu, Y. F.; **Gruebele, M.**, Temperature Dependence of Protein Folding Kinetics in Living Cells. *Proceedings of the National Academy of Sciences of the United States of America* **2012**, *109,* (44), 17863-17867.

Hwang, S. W.; Tao, H.; Kim, D. H.; Cheng, H. Y.; Song, J. K.; Rill, E.; Brenckle, M. A.; Panilaitis, B.; Won, S. M.; Kim, Y. S.; Song, Y. M.; Yu, K. J.; Ameen, A.; Li, R.; Su, Y. W.; Yang, M. M.; Kaplan, D. L.; Zakin, M. R.; Slepian, M. J.; Huang, Y. G.; Omenetto, F. G.; **Rogers, J. A.**, A Physically Transient Form of Silicon Electronics. *Science* **2012**, *337,* (6102), 1640-1644.

Jin, S. H.; Dunham, S. N.; Song, J. Z.; Xie, X.; Kim, J. H.; Lu, C. F.; Islam, A.; Du, F.; Kim, J.; Felts, J.; Li, Y. H.; Xiong, F.; Wahab, M. A.; Menon, M.; Cho, E.; Grosse, K. L.; Lee, D. J.; Chung, H. U.; **Pop, E.**; Alam, M. A.; **King, W. P.**; Huang, Y. G.; **Rogers, J. A.**, Using Nanoscale Thermocapillary Flows to Create Arrays of Purely Semiconducting Single-Walled Carbon Nanotubes. *Nature Nanotechnology* **2013**, *8,* (5), 347-355.

Kim, T. I.; McCall, J. G.; Jung, Y. H.; Huang, X.; Siuda, E. R.; Li, Y. H.; Song, J. Z.; Song, Y. M.; Pao, H. A.; Kim, R. H.; Lu, C. F.; Lee, S. D.; Song, I. S.; Shin, G.; Al-Hasani, R.; Kim, S.; Tan, M. P.; Huang, Y. G.; Omenetto, F. G.; **Rogers, J. A.**; Bruchas, M. R., Injectable, Cellular-Scale Optoelectronics with Applications for Wireless Optogenetics. *Science* **2013**, *340,* (6129), 211-216.

Lai, Y.; Diao, J. J.; Liu, Y. X.; Ishitsuka, Y.; Su, Z. L.; **Schulten, K.**; Ha, T.; Shin, Y. K., Fusion Pore Formation and Expansion Induced by Ca2+ and Synaptotagmin 1. *Proceedings of the National Academy of Sciences of the United States of America* **2013**, *110,* (4), 1333-1338.

Leckband, D., Formin' Cables under Stress. *Nature Cell Biology* **2013**, *15,* (4), 345-346.

Levin, E. J.; Cao, Y.; Enkavi, G.; Quick, M.; Pan, Y. P.; **Tajkhorshid, E.**; Zhou, M., Structure and Permeation Mechanism of a Mammalian Urea Transporter. *Proceedings of the National Academy of Sciences of the United States of America* **2012**, *109,* (28), 11194-11199.

Li, L.; Palencia, A.; Lukk, T.; Li, Z.; **Luthey-Schulten, Z. A.**; Cusack, S.; Martinis, S. A.; Boniecki, M. T., Leucyl-tRNA Synthetase Editing Domain Functions as a Molecular Rheostat to Control Codon Ambiguity in Mycoplasma Pathogens. *Proceedings of the National Academy of Sciences of the United States of America* **2013**, *110,* (10), 3817-3822.

Li, Y. H.; Liu, H.; Rata, I.; **Jakobsson, E.**, Building a Knowledge-Based Statistical Potential by Capturing High-Order Inter-Residue Interactions and Its Applications in Protein Secondary Structure Assessment. *Journal of Chemical Information and Modeling* **2013**, *53,* (2), 500-508.

Martin, P. P.; **Rockett, A. A.**; **Lyding, J.**, Growth Mechanism and Surface Atomic Structure of AgInSe2. *Journal of Vacuum Science & Technology A* **2012**, *30,* (4).

Meng, Q. L.; Shivamoggi, V.; Hughes, T. L.; **Gilbert, M. J.**; Vishveshwara, S., Fractional Spin Josephson Effect and Electrically Controlled Magnetization in Quantum Spin Hall Edges. *Physical Review B* **2012**, *86,* (16).

Ochoa, J. S.; **Cangellaris, A. C.**, Expedient Electromagnetic Analysis of the Impact of Statistical Disorder in Periodic Waveguides. *IEEE Transactions on Microwave Theory and Techniques* **2012**, *60,* (12), 3919-3926.

Odom, S. A.; Tyler, T. P.; Caruso, M. M.; Ritchey, J. A.; Schulmerich, M. V.; Robinson, S. J.; **Bhargava, R.**; **Sottos, N. R.**; **White, S. R.**; Hersam, M. C.; **Moore, J. S.**, Autonomic Restoration of Electrical Conductivity Using Polymer-Stabilized Carbon Nanotube and Graphene Microcapsules. *Applied Physics Letters* **2012**, *101,* (4).

Pirro, L.; Girdhar, A.; Leblebici, Y.; **Leburton, J. P.**, Impact Ionization and Carrier Multiplication in Graphene. *Journal of Applied Physics* **2012**, *112,* (9).

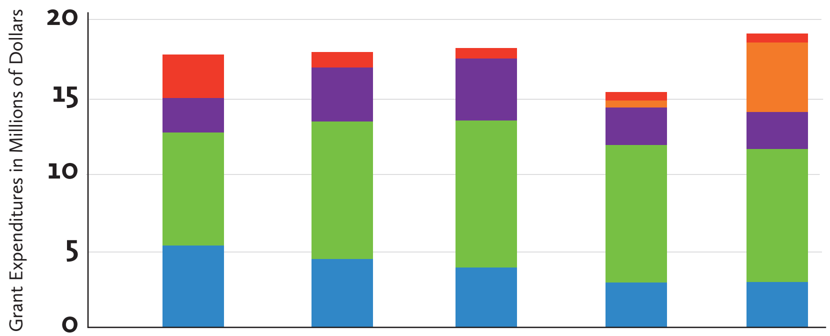
Sanghi, T.; **Aluru, N. R.**, A Combined Quasi-Continuum/Langevin Equation Approach to Study the Self-Diffusion Dynamics of Confined Fluids. *Journal of Chemical Physics* **2013**, *138,* (12).

Wang, Z. D.; Bharathi, M. S.; Hariharaputran, R.; Xing, H.; Tang, L. H.; Li, J. H.; Zhang, Y. W.; **Lu, Y.**, pH-Dependent Evolution of Five-Star Gold Nanostructures: An Experimental and Computational Study. *ACS Nano* **2013**, *7,* (3), 2258-2265.

Yagnamurthy, S.; Chen, Q.; Chen, C. G.; **Chasiotis, I.**, Erosion Yield of Epoxy-Silica Nanocomposites at the Lower Earth Orbit Environment of the International Space Station. *Journal of Composite Materials* **2013**, *47,* (1), 107-117.

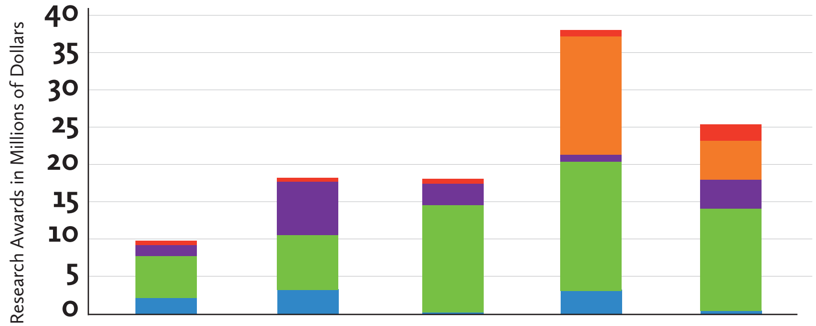
Yoo, J.; **Aksimentiev, A.**, Competitive Binding of Cations to Duplex DNA Revealed through Molecular Dynamics Simulations. *Journal of Physical Chemistry B* **2012**, *116,* (43), 12946-12954.

Grant Expenditures by Funding Source[1]



	FY09	FY10	FY11	FY12	FY13
DOD	$5,238,196	$4,358,155	$3,869,004	$3,200,338	$3,426,205
NIH	$7,518,406	$9,072,558	$9,705,827	$8,665,427	$8,208,039
NSF	$2,310,613	$3,403,358	$4,050,734	$2,482,559	$2,565,483
Abbott[2]	$-	$-	$-	$484,248	4,206,240.51
Other	$2,578,214	$1,075,980	$770,525	$575,790	$667,454
Total	**$17,645,429**	**$17,910,050**	**$18,396,090**	**$15,408,362**	**$19,073,422**

Research Awards by Funding Source[3]



	FY09	FY10	FY11	FY12	FY13
DOD	$2,115,780	$2,831,689	$3,001	$3,107,121	$2,317
NIH	$5,234,846	$7,488,077	$13,879,105	$17,245,588	$14,121,116
NSF	$1,693,264	$6,747,793	$2,578,574	$876,173	$3,507,298
Abbott	$-	$-	$-	$15,246,982	$5,272,426
Other	$666,790	$683,834	$894,094	$757,369	$2,324,885
Total	**$9,710,680**	**$17,751,393**	**$17,354,774**	**$37,233,233**	**$25,228,042**

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, and the College of Liberal Arts and Sciences.

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

Scientific exploration at the Beckman Institute is constantly evolving, as a reflection of current trends and in anticipation of future lines of research. As part of these efforts, the Beckman Institute has formalized three campus-wide strategic initiatives that could eventually become full-fledged research themes.

HABITS

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.
- The Cancer theme 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 members Kara Federmeier and Rohit Bhargava.

Imaging at Illinois

The Beckman Institute is home to the campus-wide Imaging at Illinois initiative, led by Integrative Imaging research theme co-chair Stephen Boppart. 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 and sustained contributions in imaging. Imaging and the visualization of images are pervasive elements in our data-rich lives, and the Imaging at Illinois initiative has built a campus-wide, 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.

Social Dimensions of Environmental Policy (SDEP)

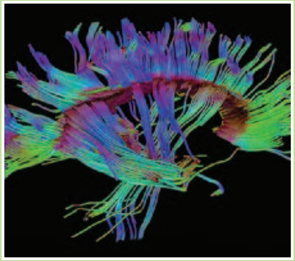
The Social Dimensions of Environmental Policy (SDEP) strategic initiative aims to understand the social and political-economic forces shaping just and sustainable environmental policy, while seeking to improve management of the earth's environment through research on social and policy dimensions of sustainability. 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.

Center for Nutrition, Learning, and Memory



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

The Center for Nutrition, Learning, and Memory partners with two world-renowned Urbana campus research facilities, the Beckman Institute for Advanced Science and Technology and the 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.

Fourteen proposals were funded in the first year of the "Grand Challenge," an award established jointly by Abbott and the University of Illinois to provide up to $50 million to Illinois researchers, over five years. Seven projects have been awarded for 2013, with a total of nearly $8 million:

- The Role of Neurotransmitters in Obesity, Food-Choice, and Memory-Related Processes
- Controlled Trials in "At Risk" Humans to Establish the Cognitive Benefits of a Nutrient Mixture and Underlying Mechanisms of Action
- Cognitive Nutrients and the Brain: Production of Isotopically Labeled Nutrients and Development of Animal Models
- Protection of Biomolecules by Dietary Nutrients and Exacerbation of Oxidative Stress by Impaired Nutrient Supply
- Developing Advanced MRI Methods for Detecting the Impact of Nutrients on Infant Brain Development
- Visualizing Diet-Modified Brain Chemistry with Multifaceted Chemical Imaging
- Functional Characterization of Cognitive Nutrients during Human Neural Development

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.

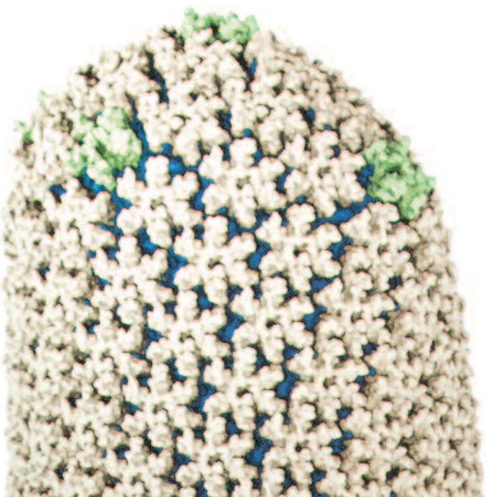
Grants are from one to three years and are administered by the Beckman Institute, with Indirect Cost Recovery earnings to be distributed to colleges and departments that provide research facilities in support of the awarded projects. The co-directors of the CNLM are Neal Cohen (Illinois) and Keith Garleb (Abbott Nutrition). Cohen is a Beckman Institute faculty member, a professor in the Department of Psychology, and the director of the campus Neuroscience Ph.D. Program.

NIH Resource for Macromolecular Modeling and Bioinformatics

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

A particular emphasis of the center is to base its development on its own intense research program in biomedicine, thereby evolving its computational tools along with the frontiers of the field. The center engages in collaborations with leading experimental laboratories and carries out a highly popular training program in computational biology both through frequent face-to-face training workshops as well as through widespread online distribution of training material. The center's software is widely used in the biomedical community, and every year increases its user base and sees many thousands of downloads for each new release. Biomedical scientists from the bench to the world's most advanced computer centers utilize the center's software every day, while high school, college, and graduate students utilize training and visualization material provided on the web site to discover for themselves the miracles of living cells.

The center's key strength is a combination of research and development. On the research side, the center is presently engaged in biomedical research on several fronts: fighting coronary diseases by advancing knowledge on cholesterol uptake by high-density lipoproteins and on blood clotting factors; fighting viral infections by resolving the infection process of several viruses in unprecedented detail; furnishing 4th generation DNA sequencing for personalized medicine; and fighting cancer by understanding how DNA methylation changes gene regulation. 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 seeing the action of the ribosome—an important target for new antibiotics—in chemical detail, to providing images of how living cells shape their interior forms.



Illinois Children's Environmental Health and Disease Prevention Research Center

A five-year, $8 million grant has established the Illinois Children's Environmental Health and Disease Prevention Research Center at the Beckman Institute. Directed by Susan Schantz, the research program investigates the health effects of exposure to chemicals widely used in plastics and personal care products. It is jointly funded by the Environmental Protection Agency (USEPA) and the National Institute of Environmental Health Sciences (NIEHS).

A "formative center," established in 2010, focused on exposure to bisphenol A (BPA) and phthalates. BPA is used in shatterproof plastics, dental fillings, electronics, and the lining 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 earlier center was located at the College of Veterinary Medicine, where Schantz is a faculty member. The move to the Beckman Institute will assist in the expansion of the research.

"The Children's Centers initiative supports transdisciplinary research aimed at understanding and identifying the health effects on children of environmental exposures," said Schantz. "We have collaborators at the Beckman, and being able to run into them every day facilitates more collaboration. We're excited about our beautifully remodeled space for infant assessments, and at Beckman we will be closer to the hospitals, where we will be doing some of the research.

"While still focusing on BPA and phthalates, the research going forward will address two additional compounds: triclosan, used in antibacterial products, and parabens, commonly found in cosmetics, sun screens, and shampoos," said Schantz.

"We are also incorporating diet into the study to explore how endocrine disruptors interact with diets high in saturated fat to impact neurological and reproductive function prenatally and during adolescence—two critical developmental periods."

The center encompasses four closely linked research projects: two human cohort studies and two laboratory animal studies.

The central project, called the Illinois Kids Development Study (I-KIDS), follows pregnant women and their babies, measuring the levels of the compounds of interest in maternal urine during pregnancy and collecting data on possible sources of exposure. During the initial phase of the study, 157 mother-infant pairs were enrolled in I-KIDS. Over the next five years the center expects to recruit an additional 500 mothers and their infants.

The babies undergo physical, behavioral, and cognitive tests at birth and at regularly scheduled intervals thereafter. The researchers will also be measuring infant brain activity and they hope this will reveal underlying neurophysiological changes that may be mediating changes in cognition.

The other human study involves a group of adolescents who have been followed since birth. Their exposure to the compounds of interest is being measured through urine samples collected during the adolescent period.

The Illinois Children's Environmental Health and Disease Prevention Research Center staff includes Andrea Aguiar, Kelsey Dzwilewski, Synthia Lane, Director Susan Schantz, Supida Monaikul, and Ann Hart.

The two laboratory rodent studies have been carefully designed to complement the human studies. The rodent studies focus on the prenatal and adolescent periods, as do the human studies. The initial rodent studies evaluated only BPA, but over the next five years phthalates will be included; phthalate exposure in the rodent studies will replicate the pattern of phthalate exposure found in the women participating in the birth cohort study. In addition, the human and the rodent studies are using parallel tests of cognition.

"It is unusual for a basic researcher to have extensive experience in both human and laboratory animal studies," noted Schantz. "Our center benefits greatly in that both I and associate director Jodi Flaws, an Illinois comparative biosciences professor, bring that dual expertise. It has enabled us to develop highly relevant animal models."

The rodent studies will help identify mechanisms of action of the endocrine disruptors in combination with a high-fat diet. Researchers hypothesize that oxidative stress in the gonads and the brain leads to permanent deficits in reproductive and neural function. In previous human and animal studies, phthalates, BPA, and high-fat diet have all been linked to oxidative stress and inflammation.

Based on an article from the U of I College of Veterinary Medicine.

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.

Four modality-specific laboratories make up BIC. The Magnetic Resonance Imaging Laboratory (MRIL) includes BIC's magnets—the whole-body 3T Magnetom Trio MRI scanner, and the 14T (600) MHz Varian NMR system; the Molecular Imaging Laboratory (MIL) is home to a MicroPET/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 (DOI) system for advanced optical imaging, the largest of its kind in the world.

BIC Director Tracey Wszalek noted that the center's user base has continued to grow over the last year as the number of newly funded imaging investigators on campus has increased.

"In addition to providing the tools, techniques, and support needed by current investigators, the center remains committed to the development of new hardware and software tools and applications," said Wszalek. "An example of this kind of development support is seen in the MR elastography package developed by **Brad Sutton** and **John Georgiadis** on the Trio scanner."

BIC studies during the past year included **Chuck Hillman**, **Neal Cohen**, and **Art Kramer**'s "Fit Kids" study, which uses the MRIL to image the structure and activity of the brains of children undergoing an exercise intervention as compared to those in the control group. **Aron Barbey** is also using the MRIL to compare the prefrontal cortices of healthy volunteers and traumatic brain injury patients.

Rod Johnson and **Ryan Dilger** used the MRIL for neuroimaging piglets at ages 2, 4, 8, 12, 16, 20, and 24 weeks in order to characterize neural growth and create a "deformable pig brain atlas" that averages the data from all 16 piglets in the study.

Florin Dolcos has studied emotion-cognition interactions with behavioral measures and functional MRI.

Brad Sutton's MRI research focused on the microvascular blood flow in the brain.

The MIL was used by **Yi Lu** for his study of aptamer-functionalized nanoprobes for targeted imaging of lymph nodes with metastatic tumors and by **Jianjun Cheng** for his study of the biosynthesis of nanoconjugates to be utilized as targeted anticancer drug delivery agents.

Stephen Boppart used the MIL for his study of multimodal microspheres for imaging of atherosclerotic plaques.

Wawrzyniec Dobrucki conducted several studies in the MIL, including "PET-optical imaging of receptors for advanced glycation end-products to understand biopathology of diabetes-related vascular complications" and "serial noninvasive PET-CT imaging of neovascularization (angiogenesis) in diabetic animals following heart infarction."

The DOIL was used in **Matthew Dye**'s neuroimaging studies of the neural substrates of cross-modal plasticity in deaf human subjects.

John Erdman used ultrasound imaging to monitor prostate growth and pelvic lymph nodes in mice with cancer, in order to assess the effects of dietary intervention strategies.

As each BIC laboratory takes on new imaging challenges and projects, the goal of research cross-pollination has been realized.

"It is not uncommon for a project to begin in ultrasound and migrate to the molecular imaging venue or vice versa," said Wszalek. "Studies focused on the advancement of cardiovascular MR imaging in humans are partnering with other modalities to pursue the development of animal models of cardiovascular disease. It is exciting to see new collaborations develop as a result of the variety of available technologies."

The 2012 Siemens Translational Image of the Year award was received by the Molecular Imaging Laboratory (MIL) in the Biomedical Imaging Center (BIC) for "Imaging of Myocardial Angiogenesis Post-Myocardial Infarction." Representative contrast x-ray CT (left in photo) and microPET-CT (right) images visualize the formation of neovasculature after myocardial infarction (PET) in relationship to existing coronary vascular bed (CT). The team that created the winning image included Beckman Institute researchers Iwona Dobrucka (research scientist in the MIL), Matthew Schuelke (bioengineering undergraduate student and American Heart Association Fellow), and Wawrzyniec L. Dobrucki (director of the MIL, pictured above). To visualize the formation of neovasculature, they used a novel PET radiotracer targeted at alpha-v-beta-3 integrin, synthesized and characterized in the lab. This research in cardiovascular imaging was funded by an American Heart Association Scientist Development Grant awarded to Dobrucki.

Biomedical Imaging Center Capabilities

Two new support spaces were added to the center in the last year: a Data Analysis Room containing hardware and software support for image post-processing in all modalities; and a Neuropsychology Laboratory space for performing cognitive assessments pre- and post-MRI scan studies.

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 3T MRI Scanner**
  This magnet is the workhorse 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.
- **3T Trio Mock Magnet**
  The mock magnet looks and sounds like BIC's 3T Trio scanner but does not have a magnetic field. It is used to familiarize and acclimate human research subjects for experiments in the actual magnet, as well as for tours and other educational outreach programs that explain how magnetic resonance imaging works.

Ultrasound Imaging Laboratory (UIL)

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

Molecular Imaging Laboratory (MIL)

- **MicroPET/SPECT/CT**
  A Siemens Inveon triple-modality molecular imaging instrument (microPET/SPECT/CT) scanner 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

The Illinois Simulator Lab (ISL) supports a variety of studies in perceptual psychology, such as distracted driving, the effects of fitness on tasks such as pedestrian street crossing, research in human factors including new concepts for next generation air traffic control and pilot interactions, and extensive biomechanics research conducted by kinesiology and dance professors.

ISL consists of four large laboratories that support a variety of human-in-the-loop simulation studies and human interaction in virtual environments: the driving simulator, flight simulator, motion capture suite, and CAVE, as well as smaller lab spaces for specific research projects. These capabilities allow for a multitude of different studies that keep ISL Director Hank Kaczmarski and his staff very busy. A study funded by the Office of Naval Research (ONR) and led by **Art Kramer** and his colleagues is exclusively taking place at the ISL using the driving simulator. The research team, in collaboration with ISL staff members Kaczmarski, James Crowell, and Ron Carbonari, created the simulator and experiment.

"Our broad aim is to develop and validate a new measure of the useful field of view, which is the area in which an observer can process information without making any eye movement," said John Gaspar, one of the researchers. "The goal is to measure moment-to-moment changes in how broadly drivers can deploy attention in complex tasks. We use eye tracking to determine where drivers are looking, and then present an additional useful field of view task at those locations. For example, we might present patches of black and white lines at different distances from where the subject is looking and have him or her tell us if the lines are leaning left or right. This measures how broadly drivers can identify information (e.g. a pedestrian stepping into the road) in a complex environment.

"We want to assess how cognitive distraction, such as talking on a hands-free phone, and the difficulty of the driving task (e.g. driving in heavy highway traffic vs. driving on a country road) affect where in the visual field drivers are able to identify critical information."

The flight simulator, in the last five years, has been facilitating quite a few projects, some funded by the Federal Aviation Administration (FAA) and NASA. It continues to be a leading-edge capability that brings worldwide attention to the Beckman Institute.

"The flight simulator is involved in projects that have the ability to change lives and have real-world impact," Kaczmarski said. "It will help change safety measures and consequently save lives."

Experiments taking place in ISL's 3D immersive virtual reality environment, the CAVE, continue to include a variety of research areas in psychology. A recent published study looked at the correlation between cognitive alertness and physical fitness in young children, finding that children determined physically fit performed better on cognitive tasks while crossing a busy street than children who were not fit. Treadmills modified for these studies in the CAVE have been adapted to fit subjects ranging from children to older adults.

"So much of what we have done recently is evolutionary," Kaczmarski said. "We started out with one treadmill experiment and that published so well that all of a sudden we are doing five or six projects simultaneously, but based on the same technology. We have to maintain extremely stable environments so that all the research questions can build on previous results.

"But then we have to think of future projects as well. So it's exciting to keep our ongoing projects viable, and think ahead about what's coming up."

Above: The driving simulator tests cognitive distractions.
Right: A recent study in the CAVE looked at the correlation between cognitive alertness and physical fitness.

Illinois Simulator Laboratory capabilities:

The CAVE

A four-sided immersive reality environment operated by the ISL 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, 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

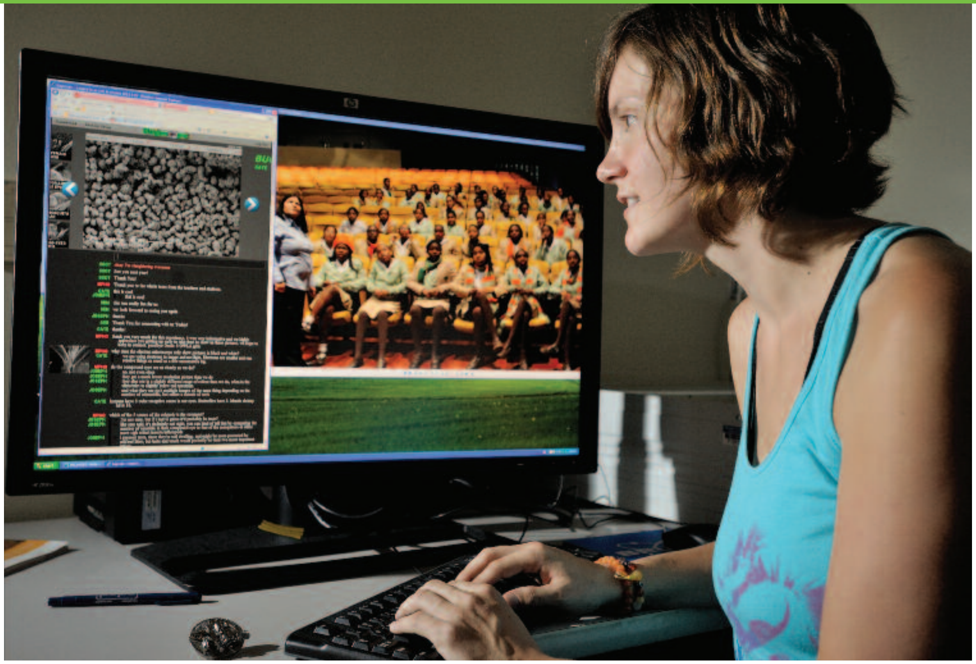
Used extensively by perceptual psychologists examining the way drivers interact with both their environment and the increasingly complex nature of their automobiles, the driving simulator uses a General Motors Saturn automobile that surrounds test subject drivers with eight projected moving images. These 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 store data for later analysis or to connect with other visualization environments for real-time collaborative research.

ImmersaDesks

The ISL houses five 4x6 foot vertical immersive displays called ImmersaDesks, which support monocular and stereo vision, head, eye, and hand tracking, and incorporate surround sound speaker systems. Two of the displays are portable, useful for demonstrating technologies at symposia and workshops, while a horizontal display ImmersaDesk is appropriate for "sand table" style applications.



Bugscope, Beckman's scanning electron microscope (SEM) outreach project, connected with the Oprah Winfrey Leadership Academy (OWLA) for Girls, a school in Henley, South Africa, in June. Like the dozens of other classroom participants each year, the 8th grade class at OWLA obtained highly detailed microscopic views of insects and arthropods such as an ant, wasp, and spider, using the SEM and a web-based interface that permits connections with students around the world.

The Imaging Technology Group (ITG) is a rare and valuable resource for campus researchers because of the technologies and expertise found in its two component facilities, the Microscopy Suite and the Visualization Laboratory.

Microscopy Suite

Researchers from across the University of Illinois campus come to the Microscopy Suite to take advantage of its knowledgeable multidisciplinary staff and state-of-the-art equipment that pushes the limits of microscopy worldwide. The four main modes of imaging include light microscopy, scanned probe microscopy, electron microscopy, and x-ray computed tomography (CT).

About twice a week, however, some of the Microscopy Suite staff, managed by Scott Robinson, take time out from helping researchers to work with the world's aspiring young scientists.

Bugscope, a project started in 1999, is unique because it allows classrooms all over the world to operate the scanning electron microscope (SEM) available at the Beckman Institute and interact with Bugscope team members. And what do they use the microscope for? Well, to look at bugs, of course.

The project enables live interactive control of the SEM through a web browser. Students mail insects to the Microscopy Suite, and staff members create a sample that can be viewed in great detail through an Internet connection. Among other options, teachers can choose to log in from a single computer connected to a projector, or students can log in individually to easily participate in the discussion. The live interface allows all participants to see the latest images coming from the microscope, ask questions via the built-in chat interface, and have the opportunity to control the microscope.

"We absolutely love when students ask a lot of questions," Robinson said. "Sometimes sessions get really crazy, with a million different questions, but we encourage it. We want them to be engaged in what they're seeing."

The Oprah Winfrey Leadership Academy (OWLA) for Girls in Henley, South Africa, recently participated in a Bugscope session. Despite the seven-hour time difference, staff members at Beckman were available to chat live with the 8th grade class.

Because of customs control, the girls were unable to send samples of insects, so the Microscopy Suite provided some. Each sample is unique to each group, and the OWLA girls viewed an ant, mosquito, silverfish (which they said they call a fishmoth), wasp, roly poly, and spider, among other insects/arthropods.

The girls had several questions, such as "Why do we itch when a mosquito bites us?" "How long do insects live?" "Do ants have brains?"

"It's truly inquiry-based learning," Robinson said. "We want the kids to get interested in science as a career, so when we're answering questions, we're always patient and talk to them at their level. I especially love when they ask what we do in our jobs or what schooling we had to do to become scientists. That's when you know they're really enjoying learning."

To prepare a specimen for a sample, the bug is frozen for a few days, allowed to thaw and dry, and then coated in gold-palladium—creating stunningly crisp and detailed electron microscopic images.

The Bugscope Project has conducted more than 800 sessions in nearly 15 years, and staff members continue to share the SEM with classrooms every week. Robinson is glad to provide Bugscope and the other unique and rare services to the campus and elsewhere.

"We are really lucky to have all these different pieces of equipment and we're lucky to have multiple ways of imaging something for someone," he said. "Sometimes it's simple and sometimes it's not, but our mission is to translate what they want done, give them results on a system, and then evaluate how those results came out."

Visualization Laboratory

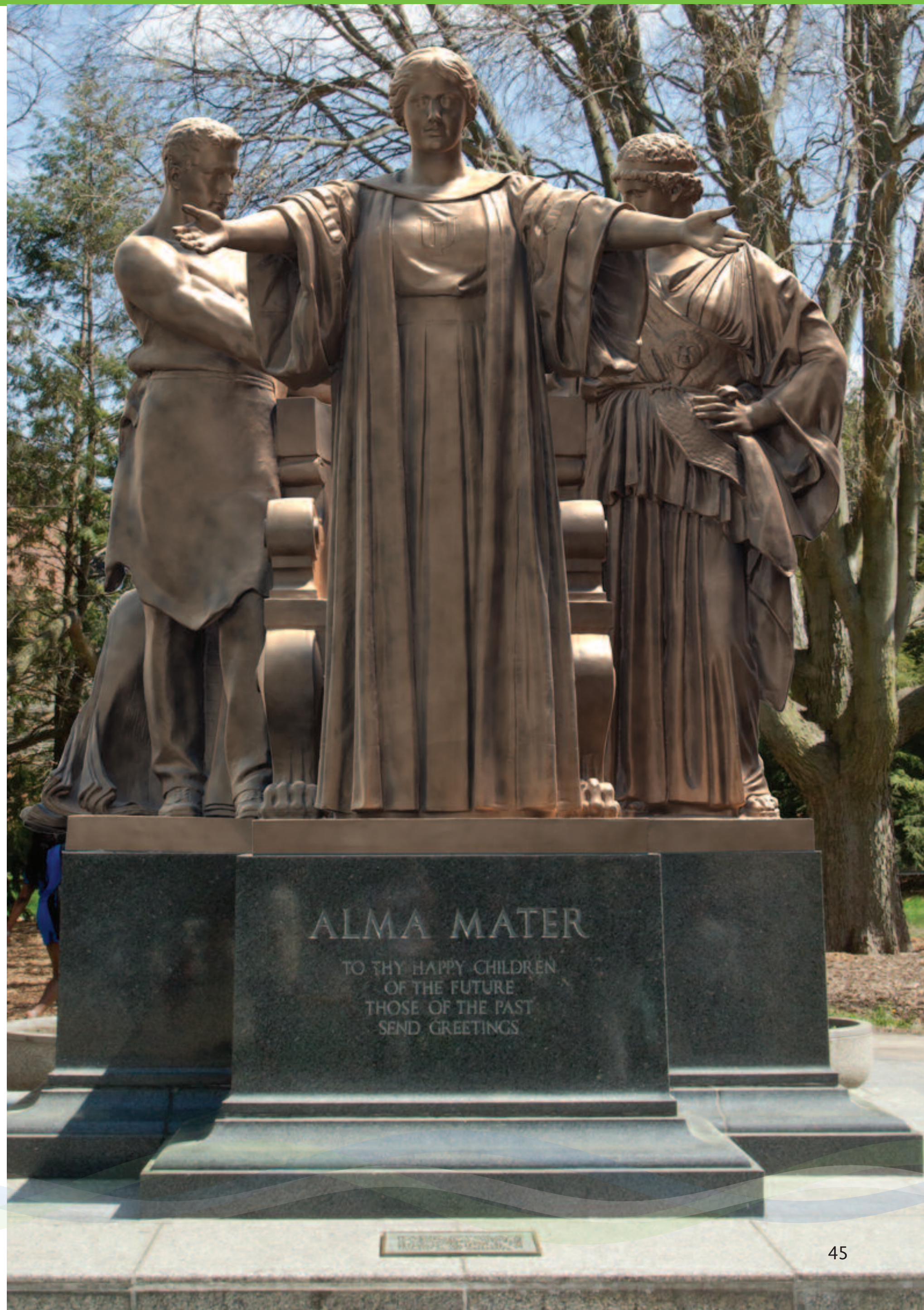
When the iconic Alma Mater statue was removed for restoration this year, University of Illinois students and administration bemoaned the fact that 2013 graduates would miss out on a tradition: a photo taken in commencement garb in front of the statue. In a testament to collaboration and interdisciplinary research, Travis Ross, the manager of the Visualization Laboratory at Beckman, joined artists and programmers from across campus to create virtual Alma, a free augmented reality application for iOS devices that displayed the much-adored sculpture on its pedestal, life-sized, and in real time.

Building the model began with a high-resolution surface scan of the sculpture at the Conservation of Sculpture and Objects Studio in Forest Park, Ill., to create a digital duplicate in painstaking detail. Ross then faced the challenge of taking the two billion points of data from the scan and creating a simplified model that could be processed by a mobile device in real time, while retaining the high-resolution detail in its appearance. Meanwhile, the augmented reality unit at the National Center for Supercomputing Applications (NCSA) and the Institute for Computing in Humanities, Arts and Social Science (I-CHASS) worked to build the application, collaborating with graphic designers in campus Public Affairs and metalworkers in Facilities and Services to create the target, a large poster of the sculpture set on the base, that the app would recognize.

Besides assisting in creating such apps, the Visualization Laboratory (Vis Lab) offers a range of highly advanced equipment for 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. This year, the lab will be adding four powerful new visualization computers and a supercomputer, which will have remote user access.

Ross said work in 3D has become a focus of the lab, as evidenced by many students and faculty who use the multiple 3D modalities in the Vis Lab.

"The Visualization Lab continues to develop and acquire advanced visualization tools to improve user capabilities," said Ross. "One key benefit of the facility is that staff members are involved in the daily work being done by researchers. We listen to their comments and act accordingly, so that tools and technology keep up with the heavy demands of research."



A smartphone app, created in part by Travis Ross of the Visualization Laboratory, virtually recreated the Alma Mater, which was removed for restoration and not present for the traditional commencement photos in 2013. Through the app's lens, this life-size Alma would appear, allowing a photo to be taken with graduates in real time.

Microscopy Suite Capabilities

Micro- and Nano-computed Tomography
The four Micro and Nano-CT 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. New capabilities of the Xradia BioMicro-CT and Micro-CT include software-integrated tensile/compression stage functionality as well as 1x imaging and 360-degree-rotation options on the BioMicro-CT.

Light Microscopy/Spectroscopy
Suite users have access to laser scanning confocal microscopes with standard, two-photon, and multi-photon imaging capabilities; an inverted fluorescence microscope with the ability to create seamless mosaics of images in x, y, and z; a sophisticated upright microscope with fluorescence and differential interference contrast (DIC) imaging, as well as comprehensive stereology and nerve-tracing software packages; a dedicated darkfield/polarized light microscope; and a stereozoom microscope with automated tiling, color-corrected imaging at 120,000 frames per second, and large-diameter lenses to minimize parallax on large samples. In addition, the Suite provides light-scattering particle-sizing systems and instruments capable of a number of different types of spectroscopy, from UV to visible light to NearIR and Raman. Other important capabilities include fluorescence correlation spectroscopy (FCS), fluorescence lifetime imaging microscopy (FLIM), Förster resonant energy transfer (FRET) microscopy, total internal reflectance fluorescence (TIRF) microscopy, and two versions (materials and biology oriented) of spatial light interference microscopy (SLIM).

Scanned Probe Microscopy
This includes atomic force microscopy (AFM), with its multitude of permutations, at 5k x 5k imaging capability; scanning tunneling microscopy (STM); and near-field scanning optical microscopy (NSOM). The Suite also maintains 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. 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. The energy-dispersive spectroscopy (EDS; elemental analysis) system on the ESEM has been upgraded to state of the art, with a hundredfold better collection capability that is especially useful for traditionally difficult samples.

Sample Preparation Equipment
The wide range of microscopes and spectroscopy equipment requires a comparable range of sample preparation instrumentation, from a critical point dryer to an ultramicrotome to a dual-metal evaporator, which is another example of an instrument that was designed and fabricated in response to requests from numerous researchers.

Visualization Laboratory Capabilities

Graphics Services
The Visualization Laboratory provides assistance with graphics and illustrations, including cover art and other images for journals and presentations. Working from concepts, photos, or other imagery, 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 multiphysics simulation capabilities.

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

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

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

EDUCATIONAL OUTREACH AT THE BECKMAN INSTITUTE

The Beckman Institute is dedicated to interdisciplinary research, with breakthrough discoveries in science and technology constantly emerging from the dedicated researchers who share results with worldwide audiences. Beckman's commitment to the broader community in which this work takes place is demonstrated by the Institute's many educational programs, seminars, and the biennial open house.

The Open House in March 2013 showcased many of the labs and current research at Beckman, and attendees were able to interact with the technology and programs used for research and experiments. Hundreds of visitors took part in the fun and learning, which included Bert, the iCub robot, a drone that could be flown with signals from the pilot's arm, and a 3D display of nature photography from Beckman Senior Fellow Lisa Frank.

Students from campus and across the country attend seminars and summer school programs at Beckman that help promote and advance research in a wide variety of areas. Some of these include the annual Imaging at Illinois: The Next Generation conference, the Principles of Fluorescence Techniques Workshop, the Advanced Microscopy Workshop, and the annual Biophotonics Summer Schools.

Speaker series and seminars, including the Director's Seminar Series at Beckman, are a common way to spotlight research, researchers, or labs within Beckman. The Center for Nutrition, Learning, and Memory (CNLM) sponsored numerous events for researchers and hosted a two-day symposium headlined by *The New York Times* personal health columnist Jane Brody. In addition, architect and gerontologist Victor Regnier spoke on how better living space design can help with long-term care as part of the Smith Group Distinguished Lecture series.

Special events include the Thursdays at 12:20 Concert Series, which brings music provided by U of I School of Music students into the Beckman Atrium. Regular tours are given to school groups, visiting scholars, and special guests.

Finally, the Beckman Institute continues its collaboration with the Osher Lifelong Learning Institute (OLLI) and the Institute for Genomic Biology (IGB) to develop and support the Citizen Scientist Program. This outreach and education program places older adults from the University of Illinois chapter of OLLI in campus research laboratories, where they assist in running experiments and in providing laboratory support. This program has multiple benefits: the researchers benefit from having extra help in the laboratory, the undergraduate and graduate students have the opportunity to interact with senior citizens who have a wealth of life experience and often push the students to provide cogent explanations of their research projects, the Citizen Scientists are motivated and enlightened by University research, and the Citizen Scientists become ambassadors for the state-of-the-art science conducted at the Beckman Institute and elsewhere on campus.

To follow Beckman's events schedule, visit beckman.illinois.edu.

The Beckman Institute 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 Fellows are selected based on evidence of professional promise, capacity for independent work, outstanding achievement, and interdisciplinary research interests that correspond to one or more of the Beckman Institute's research themes.

Applications for the Beckman Institute Fellows program are accepted during the fall semester and the announcement of the selected Fellows is made in late February/early March of the spring semester. Fellows may begin working at the Beckman Institute as early as July of the calendar year they are selected and no later than December 31 of that same year.

2013 Postdoctoral Fellows

Chao Ma

Ma completed his Ph.D. in electrical and computer engineering at the University of Illinois. 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. He is focusing on developing a novel magnetic resonance spectroscopic imaging (MRSI) technique to enable high-resolution metabolic imaging of the brain. Specifically, he devotes systematic efforts on optimizing signal excitation, data acquisition, and image reconstruction and post-processing, and applying metabolic imaging to study brain functions. 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 earned 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 plans on working with Jennifer Cole in the Cognitive Science Group, and Mark Hasegawa-Johnson and Paris Smaragdis in the Artificial Intelligence Group. She is focusing 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 explores 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. Medeiros-Ward plans to work 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 earned her Ph.D. in neuroscience at the University of Illinois. Her research interests are 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 proposed 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 earned his Ph.D. in theoretical chemistry at Indiana University. His research focuses on two modern fields, biophysics of viruses and multiscale simulation. He explores molecular dynamics (MD) simulations, which provide biomedical researchers with a new perspective on the dynamics of cellular processes hitherto inaccessible by observation. His proposed 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.

Kelly Wiggins

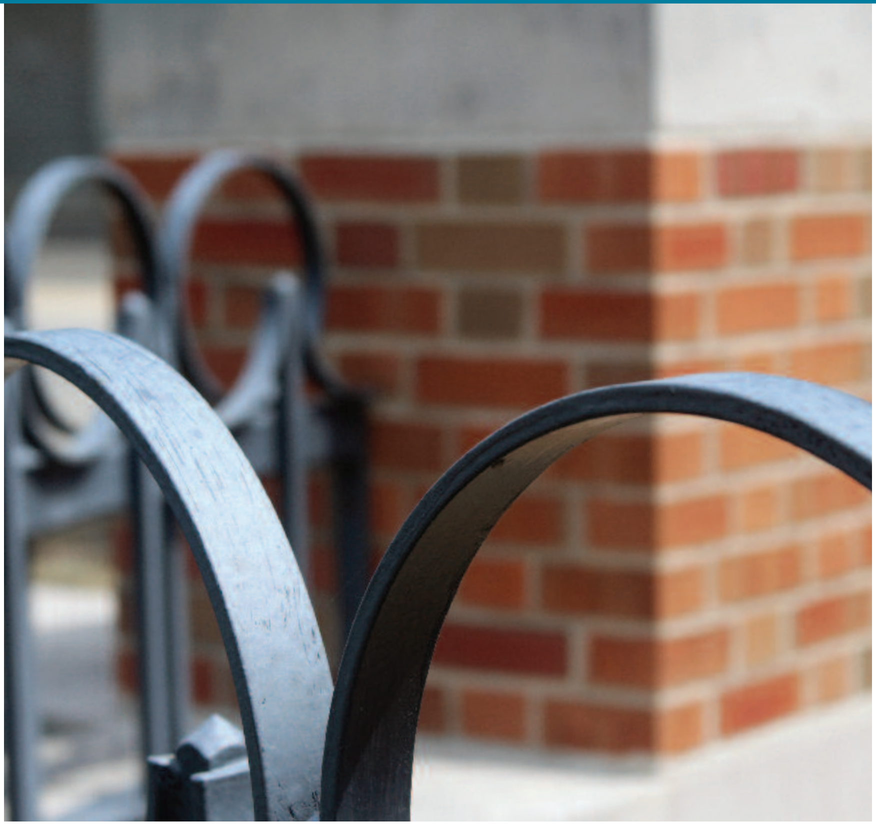
Wiggins received her Ph.D. in chemistry at the University of Texas at Austin. Her interests are in developing new techniques that enable chemical transformations to follow higher energy pathways and facilitate novel reactions. An emerging approach to address this important fundamental challenge is to use mechanical force. In essence, she asks the question: "If one could put his or her hands on a molecule, could it be twisted or stretched in a way that is not possible using traditional methods?" Wiggins plans to build on experience within the Beckman Institute involving mechanically responsive polymer composites, mechanochemistry, and encapsulation, to explore a broad-based, multi-pronged approach to the development of novel "smart" materials capable of responding to energetic stimuli to locally mitigate damage and maintain the structural integrity of the bulk material. She intends to work with Jeffrey Moore, Nancy Sottos, and Scott White in the Autonomous Materials Systems 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. She is using 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 is working with 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. He works with P. Scott Carney and Rohit Bhargava of the Bioimaging Science and Technology Group. Deutsch's project as a Beckman 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. Erickson has used diffuse optical tomography (DOT) toward development of a hand-held based optical imager; 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. Erickson 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. Her research focus is on the neural bases of human memory systems and the changes they undergo during the aging process. She works with Cognitive Neuroscience Group members Neal Cohen and Kara Federmeier and in the Center for Nutrition, Learning, and Memory that Cohen directs. Her research includes 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 from the University of Illinois at Urbana-Champaign. 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. Xu'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 patterns in biomaterials and biostructures. He works with John Rogers from the 3D Micro- and Nanosystems Group and also collaborates 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

Jonathan Fan

Fan is working with John Rogers on new materials systems for electronics and photonics. He was formerly a postdoctoral research associate in the Capasso group at Harvard University. He received his doctorate in applied physics from the Capasso Group in 2010, where he was an NSF Graduate Fellow and did plasmonics research in colloidal systems and in quantum cascade laser waveguide design. He received his B.S. with highest honors in electrical engineering from Princeton in 2004. He has authored or co-authored 21 papers.

Kyle Mathewson

Mathewson earned a Ph.D. in psychology from the University of Illinois. He has worked for more than four 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. He is studying the prediction and control of brain states that influence subsequent perception, learning, brain activity, and even consciousness. He plans to take the 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

Toscano earned his Ph.D. in cognition and perception at the University of Iowa. His research looks at how the perceptual system uses context information during speech perception. He uses computational modeling and neuroimaging methods to investigate continuous cue encoding and categorization during speech processing, applies his approaches to spoken word recognition, and examines 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.

Thomas van Dijk

Van Dijk completed his Ph.D. in physics at Vrije University in Amsterdam. His dissertation focused on theoretical and experimental studies in optical coherence theory, while his main areas of research include computed imaging, inverse problems, statistical optics, and plasmonics. Van Dijk explores the theoretical frontiers in bio-optics, which uses light to study, manipulate, and treat biological samples toward advancing the design of experimental methods and analysis of results. He is concentrating his work on problems in the imaging and diagnosis of disease in order to meet both clinical and research needs. Van Dijk works with Rohit Bhargava and P. Scott Carney from the Bioimaging Science and Technology Group.

2010

Malini Ranganathan

Ranganathan earned a Ph.D. in the Energy and Resources Group at the University of California at Berkeley in 2010. Her dissertation research explores the political ecology of water in the city of Bangalore in India, specifically focusing on the implications of market-oriented reforms for equity at the peri-urban interface. At Beckman, she has investigated the specific social and environmental vulnerabilities—particularly related to water infrastructure—of populations living in fringe areas of developing cities. She aims to substantiate the claim that greater resilience to water-related environmental hazards in peri-urban Manila or Bangalore can, in part, be explained by the existence of neighborhood associations, their relationships with the state, and the wider social and political networks in which they operate. She works with Tom Bassett, Ashwini Chhatre, and Jesse Ribot from SDEP.

Ilia Solov'yov

Solov'yov received a Ph.D. in physics from Frankfurt University in Germany, in 2008 and a Candidate of Science degree in Theoretical Physics from the Ioffe Physical-Technical Institute in St. Petersburg, Russia, in 2009. His current research interests cover a broad range of questions on the structure and dynamics of nanosystems and biomolecules. Specifically his research explores animal magnetoreception in creatures including migratory birds. This work could eventually lead to solutions in protecting airports from birds. He works with Klaus Schulten from the Theoretical and Computational Biophysics Group.

Carle Foundation Hospital—Beckman Institute Fellow

Jongsick Kim

Kim joined Beckman's Biophotonics Imaging Laboratory, headed by Stephen Boppart, after serving as a postdoctoral research associate at the University of Pittsburgh. He earned his Ph.D. at Pittsburgh in bioengineering. As the second Carle–Beckman Fellow, his project involving oncology-related research is titled, "Magnetomotive optical coherence tomography (MM-OCT) image-guided hyperthermia of tumor lesions using targeted magnetic nanoparticles (MNPs)." Kim's goals include demonstrating real-time diagnostic MM-OCT imaging with molecular specific contrast enhancement of tumor and enlarging the role of OCT technology as a diagnostic imaging modality.

2013 Nadine Barrie Smith Memorial Fellow

Giang-Chau Ngo

Ngo, a Ph.D. student in bioengineering, works with Brad Sutton. Her research with Sutton looks to advance magnetic resonance imaging technique. More precisely, she aims to understand the impact of field inhomogeneity on MRI image acquisition and develop a correction method, which should provide a more robust imaging tool and help move toward the grand challenge of understanding how the brain works.

Lisa Frank
Senior Fellows Program

Lisa Frank, a photographic artist, was appointed a Beckman Senior Fellow in July 2012. The Senior Fellows program gives established faculty from other universities the opportunity to do short-term, onsite, interdisciplinary research with other Beckman researchers. Frank's work brought a brand new field of artistic science to Beckman.

At the University of Wisconsin-Madison, Frank focused on creating 2D nature scenes. As she was completing her master of fine arts, she was challenged to take the 2D planes and create an immersive 3D virtual environment using a newly built Cave Automatic Virtual Environment (CAVE).

The Beckman Institute invited her to recreate her 15-minute art exhibition consisting of six explorable artworks using the CAVE found at the Illinois Simulator Laboratory (ISL) at Beckman.

"This exhibition presents the outcome of collaboration between two different disciplines, computer science and the visual arts," Frank said. "I reinterpreted my nationally exhibited artwork using a combination of programming strategies that endow the imaginary settings with a deep sense of spatiality.

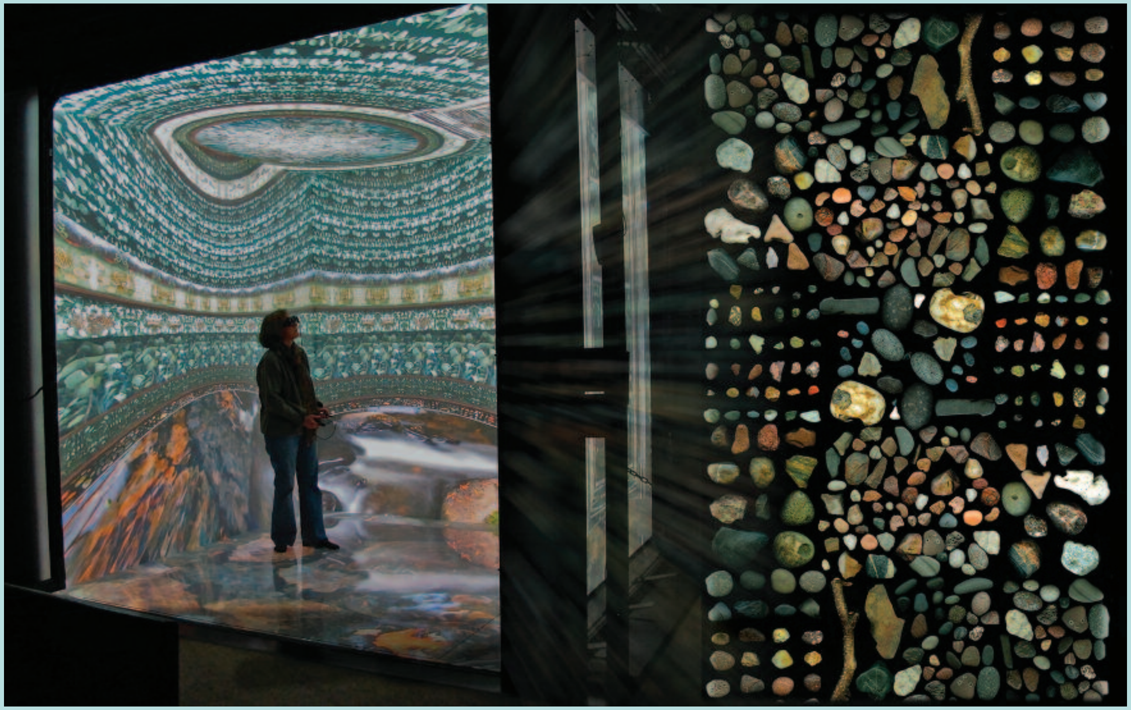
"The process of creating this virtual art exhibition began far away from the CAVE's projection screens. As an artist, I find wonder in nature. Over several years, I have taken thousands of photographs in the natural settings of forests, prairies, and wetlands. Culling through this library, I isolate elements of the photos, regroup them into motifs, and stitch them together. The resulting images are constructed patterns of substantial size and complexity, referencing traditional wallpaper design. In the CAVE, these are reinvented as interior and exterior spaces that become expansive, exploratory worlds, allowing the immersant to consider the wonders of nature from atypical perspectives."

Since completing her yearlong fellowship, she is continuing her work at Beckman with research led by Art Kramer and Ed McAuley. The study will utilize the CAVE and Frank's virtual landscapes, but she is now creating 3D video that participants will walk through.

"We will use a treadmill [within the CAVE] and provide 20 minutes of 3D video of nature scenes, so we will simulate a walk in the woods," Frank said. "Then there will be 20 minutes of an urban environment. We'll be examining the effects of these different virtual environments on different aspects of cognition including memory and attention, as well as the role of physical activity on the beneficial effects of exposure to nature."

The fact that Frank's artwork is being used for scientific research is still hard to believe for the artist.

"If you had asked me three years ago if my artwork would be used for research like this, I would have laughed," Frank said. "It's totally surprising, but in an exciting way. It is great to see my art evolving and also to be able to merge these two disciplines in a way that can help people."



Senior Fellow Lisa Frank incorporates nature photography into an immersive 3D virtual environment.

2013 BECKMAN GRADUATE FELLOWS

The Beckman Graduate Fellows Program, supported by funding from the Arnold and Mabel Beckman Foundation, offers University of Illinois graduate students at the M.A., M.S., or Ph.D. level the opportunity to pursue interdisciplinary research at the Institute. Research projects must involve at least one Beckman faculty member in addition to a second U of I faculty member, and preference is given to those proposals that are interdisciplinary and involve the active participation of two Beckman faculty members from two different groups.

Pauline Baniqued
Baniqued is a Ph.D. student in psychology, with research interests in understanding the neurocognitive mechanisms of executive control, and how these control processes change with age, training, and other interventions. She plans to employ an integrative research approach that takes into account the complex system of interactions among brain regions for optimal cognition and performance, with the aim of shedding light on questions that span the disciplines of psychology and human performance, neuroscience, and public health. Baniqued works with Art Kramer, Monica Fabiani, and Gabriele Gratton.

April Colette
Colette is a Ph.D. candidate in the Department of Geography and Geographic Information Science. Her research interests are broadly related to the human dimensions of environmental change with a specific focus on cities. Her dissertation research explores the complex and multiscalar interplay between the social, political, economic, and technological processes that interact to reproduce vulnerability. By examining how people understand their own vulnerability and what they do to reduce it, Colette's research will help illuminate different types of human adaptive responses to climate-related change, particularly in areas persistently at risk of hazards. Prior to her Ph.D., she earned her M.S. at the London School of Economics and Political Science and worked as a consultant for international development aid agencies. Colette currently works with faculty from two SDEP programs: Jesse Ribot from the Program on Climate and Society, and Ashwini Chhatre from the Program on Democracy and Environment, as well as Robert Olshansky from the Department of Urban and Regional Planning.

Matt Gelber
Gelber is a Ph.D. student in bioengineering. He is developing a 3D printer capable of patterning cells, gels, and polymers with micron-scale resolution. The initial application will be to create 3D microfluidic devices for applications in synthetic and analytical chemistry. Ultimately, the device will be used to construct experimental systems that mimic tissue structure and microenvironment. Gelber hopes to use this research tool to collaborate with investigators across the campus, facilitating their work as he continues to explore new applications of 3D printing. He collaborates with Rohit Bhargava, Martin Gruebele, Jeff Moore, and Narayana Aluru.

Anuj Girdhar
Girdhar is a Ph.D. student in physics. His work, under the supervision of Jean-Pierre Leburton and Klaus Schulten, aims to develop a graphene nanoribbon Quantum Point Contact (QPC) DNA sequencing device. His project aims to be at the forefront of computational engineering, nanoscale device physics, and computational biophysics, while examining the possibilities that interdisciplinary collaboration can achieve.

Michael Odarczenko
Odarczenko is pursuing graduate studies in aerospace engineering. His research goal is to develop multifunctional coatings that are capable of healing damage in response to a variety of environmental triggers, such as change in pH due to corrosion, chemical composition, or bacterial growth. He works with Nancy Sottos and Scott White.

Brennan Payne
Payne is a doctoral student in the Cognitive Science of Teaching and Learning division of educational psychology and a trainee on the NIH-funded language training grant. His research interests address two major questions: 1) How do aging and individual differences impact sentence understanding? (including topics such as eye-movement control during reading and the role of working memory); and 2) How is cognitive enrichment achieved in adulthood? (including topics such as cognitive training). He works with Elizabeth Stine-Morrow, Kara Federmeier, Kiel Christianson, Dan Morrow, and Duane Watson.

Brendon Smith
Smith's research has focused on the biological effects of ultrasound imaging when used with microbubble contrast agents to image blood vessels. He is currently pursuing a Ph.D. in nutritional sciences and is working with John Erdman and William O'Brien. His research at Beckman will utilize ultrasound imaging to determine the ability of the dietary tomato to prevent or delay aging-related chronic disease in rodent models.

Renjie Zhou
Zhou is a Ph.D. candidate in the Department of Electrical and Computer Engineering. He is supervised by Lynford Goddard and Gabriel Popescu and works on finding isolated defects in nine nanometer node semiconductor wafers using quantitative phase microscopy. He plans to inspect wafers with intricate structures, such as ones with non-periodic patterns, silicon 3D structures (e.g. finFET architecture), and high aspect ratio (HAR) structures. His research goal is to develop methods to improve the image resolution and the ability to detect defects from a single frame image capture. He will also work on developing algorithms for reconstruction of the 3D structures of the wafer patterns. The research will bring collaborations with P. Scott Carney, Minh Do, and Zhi-Pei Liang.

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:
Mike Devocelle
Phone: 217-244-8380
Email: mdevocel@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:
Thomas Huang
Phone: 217-244-1638
Email: t-huang1@illinois.edu

Dan Morrow
Phone: 217-300-0915
Email: dgm@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:
Narayana Aluru
Phone: 217-333-1180
Email: aluru@illinois.edu

Nancy Sottos
Phone: 217-333-1041
Email: n-sottos@illinois.edu

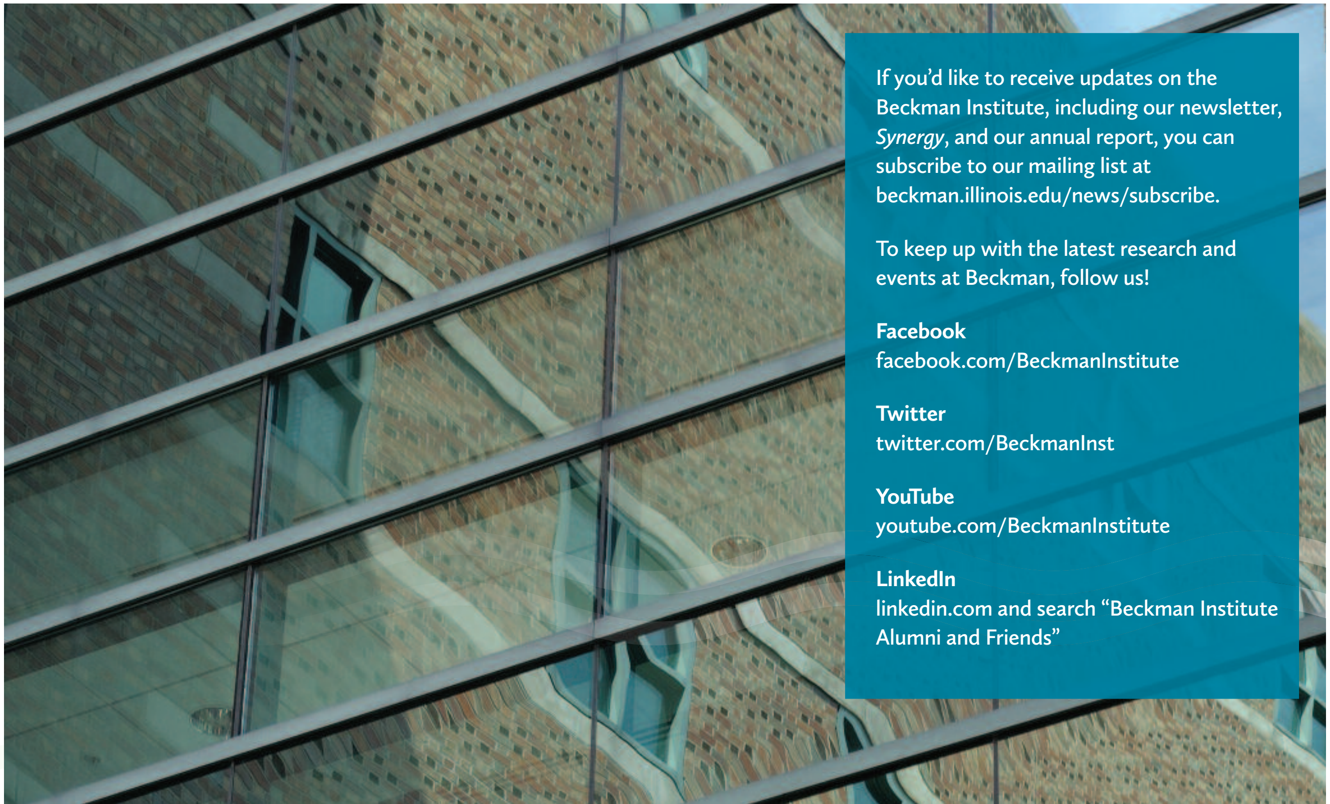
Biomedical Imaging Center
Tracey Wszalek, Director
Phone: 217-333-3149
Email: traceyws@illinois.edu

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

Beckman Institute Annual Report Credits
Project Manager: Maeve Reilly, Director of Communications
Writers: August Cassens, Steve McGaughey, Maeve Reilly, and the University of Illinois News Bureau
Design: Pat Mayer, Urbana, Ill.
Editor: Julie O'Mahoney, Champaign, Ill.
Photography: Unless otherwise noted, photography by L. Brian Stauffer, University of Illinois News Bureau; Thompson-McClellan; Pat Mayer; and the Beckman Institute Communications Office.



If you'd like to receive updates on the Beckman Institute, including our newsletter, *Synergy*, and our annual report, you can subscribe to our mailing list at beckman.illinois.edu/news/subscribe.

To keep up with the latest research and events at Beckman, follow us!

Facebook
facebook.com/BeckmanInstitute

Twitter
twitter.com/BeckmanInst

YouTube
youtube.com/BeckmanInstitute

LinkedIn
linkedin.com and search "Beckman Institute Alumni and Friends"

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