2011-2012

# Beckman Institute
FOR ADVANCED SCIENCE AND TECHNOLOGY

Annual Report

# Beckman Institute

The Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign is an interdisciplinary research institute devoted to leading-edge research in the physical sciences, computation, engineering, biology, behavior, cognition, and neuroscience. The Institute's primary mission is to foster interdisciplinary work of the highest quality, transcending many of the limitations inherent in traditional university organizations and structures. The Institute was founded on the premise that reducing the barriers between traditional scientific and technological disciplines can yield research advances that more conventional approaches cannot.

Beckman Institute research is focused around four research themes:

- Biological Intelligence (page 4)
- Human-Computer Intelligent Interaction (page 10)
- Integrative Imaging (page 16)
- Molecular and Electronic Nanostructures (page 22)

The Beckman Institute is also home to three strategic initiatives that seek to unify campus activities in their respective areas:

- HABITS
- Imaging
- Social Dimensions of Environmental Policy

More than 1,500 researchers from more than 40 University of Illinois departments as diverse as psychology, computer science, electrical and computer engineering, and biochemistry, comprising 14 Beckman Institute groups, work within and across these overlapping areas. The building offers more than 200 offices; specialized, cutting edge laboratories and other facilities; and meeting areas.

To assist research efforts, the Beckman Institute provides state-of-the-art resources for faculty, staff, and students, including:

- Biomedical Imaging Center (page 44)
- Illinois Simulator Laboratory (page 46)
- Imaging Technology Group (page 48)

The 313,000-square-foot building was made possible by a generous gift from University of Illinois alumnus and founder of Beckman Instruments, Inc., Arnold O. Beckman, and his wife Mabel M. Beckman, with a supplement from the State of Illinois.

Additionally, the Arnold and Mabel Beckman Foundation provides ongoing financial assistance for various Institute and campus programs. Daily operating expenses of the Institute are covered by the state and its research programs are mainly supported by external funding from the federal government, corporations, and foundations.

# Contents


*The Beckman Institute has always been a place that cultivates new ideas and thrives on research that is on the leading edge. This past year was no exception. Our researchers continued to push the envelope on existing lines of research while also exploring new areas of study.*

*– Art Kramer*

# Cultivating new ideas

From advances in neuroimaging to growing graphene on copper crystals, our annual research highlights are vast and varied and you can read about them within the pages of this book. As the Director of the Institute I am in touch with what is happening throughout the year, but I can't help but be impressed and inspired when I see all of these highlights listed in this annual report. Congratulations to our faculty, staff, and students for doing such an amazing job and keeping the Beckman Institute's place as a world-leader in interdisciplinary research.

I am also proud to say the Beckman Institute was one of the key players in the creation of the Center for Nutrition, Learning, and Memory (CNLM), the first-ever interdisciplinary nutrition and cognition research center. An agreement between Abbott Nutrition and the University of Illinois led to the announcement of a "Grand Challenge" that will award up to $50 million to Illinois researchers over five years. This brings a new funding opportunity to the University and provides Illinois faculty with the opportunity to conduct both basic and translational research on the effects of nutrition on cognition and brain health.

The creation of the CNLM involved four campus units and their directors: the Beckman Institute, the Institute for Genomic Biology, the Division of Nutritional Sciences, and the Neuroscience Program. Grants will be from one to three years and will be administered by the Beckman Institute. The Beckman Institute's very own Neal Cohen is the Illinois director of the Center. His co-director is Keith Garleb of Abbott Nutrition.

The establishment of the CNLM was rapid with the agreement being signed between Abbott Nutrition and the University of Illinois in late October. Illinois hosted workshops for faculty in late November/early December and in early 2012 the first round of proposals were received. The first round of awards were announced on April 16, 2012. The selected awards provide funding for an impressive 13 research projects involving nutrition, the brain, and cognition.

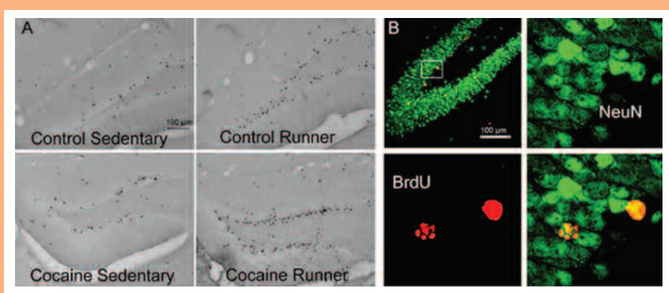
Congratulations to all involved in getting the CNLM up and running! I am very much looking forward to seeing this partnership and new lines of research grow and evolve in the upcoming years. Beckman Institute faculty and staff continue to be recognized for their outstanding scientific achievements, both with external funding to pursue their ideas and with a variety of national and international awards. In the last year, Beckman faculty have brought in millions of dollars in external grant funding (see page 55), published hundreds of peer-reviewed papers, been awarded prestigious prizes, been elected Fellows of several professional societies, and continued to educate and inspire the next generation of students.

Last year we also completed an administrative restructuring with the hiring of two new Associate Directors. Mike Devocelle rejoined the Beckman Institute in August, 2011, as the new Associate Director for Administration. In this role he will oversee the business, grants administration, and HR functions, as well as the building operations staff. Patricia Jones joined the Beckman Institute in March, 2012, as the new Associate Director for Research. In this key position she will be responsible for the advancement of the Institute's research portfolio, as well as the coordination of research efforts with other faculty and research groups across campus.

This has been a very exciting year and I am looking forward to seeing what the future holds for the Beckman Institute in 2012-2013.

# 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. 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 function 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). This past year saw many discoveries and new developments in BioIntel, including advancements in neuroimaging methods, in understanding the brain at the cellular level, and in linguistics.




*Slides show adult hippocampal neurogenesis in mouse models from (A) four different groups and (B) in runner group. Photo courtesy Martina Mustroph.*

## Effects of Exercise in Treating Addiction

Research led by **Justin Rhodes** found that exercise could have beneficial effects for treating drug addiction, or it could strengthen addictive behavior — depending on when the exercise takes place relative to drug-taking. The research used mouse models in experiments employing a running wheel and/or enriched environments to test conditioned place preference (CPP) for cocaine. Rhodes and Matrina Mustroph of his laboratory reported, in a first-ever finding, opposite effects of wheel running on cocaine CPP that depend critically on the timing of the exercise relative to drug conditioning. The researchers found that if the animals exercised *before* the drug conditioning for cocaine, they were better able to learn the association between place and cocaine than sedentary animals. They found an opposite effect when the mice were taught the drug-to-context association and then exercised, as that accelerated the extinction of the drug-to-context preference. The researchers wrote in their paper reporting the research that "the results suggest that exercise could be a useful intervention to facilitate extinction of conditioned drug associations during abstinence. However, the benefit of exercise could be reversed if a relapse episode occurred after running had primed the brain for plasticity."

## Evidence on the Role of MicroRNAs in the Brain

**David Clayton**'s groundbreaking work with zebra finch songbirds as a model organism for understanding learning and memory continued with a new study that gives insight into the role of microRNAs (ribonucleic acid) in the brain. The genetic response of these songbirds to song exposure has been used by Clayton and other researchers for what it tells neuroscience about brain development. Clayton reported this past year on a study that showed, for the first time, that microRNAs (miRNAs) also contribute to the process by which the songbird brain responds to its environment. Clayton and his collaborators found that exposure to a new song induced changing patterns of gene expression in microRNAs, altering their profile in the auditory forebrain. MicroRNAs are part of the 10 percent of DNA that doesn't code for proteins, but are thought to play a role in the regulation of protein production. Clayton and his collaborators wrote about the growing body of evidence that microRNAs play multiple roles in the brain, from development to function: "MicroRNAs are emerging as potential control points in transcriptional networks, and may be particularly important for the evolution of brain and behavior." These results, they reported, show that a "natural perceptual experience, hearing the sound of another bird singing, alters the profile of miRNAs in parts of the songbird brain responsible for auditory perception, integration and memory. Thus miRNAs may have roles in the information processing functions of the brain, in addition to their roles in brain development and evolution."

## Speech Fillers Improve Listener Recall

In research that goes against intuition and what many of us were taught, **Duane Watson** found that "ums", "ahs", and other speech fillers can actually help listeners understand speakers better than fluent speech. Watson and Scott Fraundorf from his laboratory used a story recall task as part of an experiment that tested the mechanisms by which speech fillers affected memory for discourse. They used natural speech instead of "laboratory speech" and controlled for the extra processing time that fillers provide listeners. The experiment required participants to listen to a story that was either completely fluent, or had 'uhs' and 'ums' digitally inserted in different places, or had coughs inserted to control for the timing, so it wasn't just that listeners had more time to respond to a story that included disfluencies. They discovered that the fillers actually facilitated recall for listeners. "The task was for them to listen to it and then tell the story back," Watson said. "We found that they're better at it if uh and um is actually there. So we think that maybe those disfluencies are increasing the person's attention."

## Advances in Neuroimaging Methods

**Monica Fabiani** and **Gabriele Gratton** direct the Cognitive Neuroimaging Laboratory (CNL) at Beckman, where they use a variety of imaging methods to study human brain function. In the past year, they have made several advances in neuroimaging methods that have facilitated research in areas as diverse as human nutrition, child development, and cognitive aging.

They have developed a new optical method for studying arterial stiffness of the brain that provides insight into cognitive decline. Another advance has been made in the reconstruction of optical imaging data for mapping absorption and scattering properties of the human brain. This methodology will enable neuroimaging studies of infants and premature children, as well as studies involving nutrition in research funded by the Center for Nutrition, Learning, and Memory (CNLM). A new imaging approach in collaboration with Beckman colleague **Diane Beck** has allowed the study of functional brain connectivity through a combination of trans-cranial magnetic stimulation (TMS) and optical imaging. Gratton and Fabiani write that this method is "the first brain imaging technology to experimentally manipulate brain activity in a specified area (through TMS), and study consequent changes in activity across different brain areas using methods combining high spatial and temporal resolution (EROS)." In addition, CNLM was instrumental in the creation this past year of the Diffuse Optical Imaging Laboratory (DOIL) located in the Biomedical Imaging Center at Beckman. DOIL is already home to several studies, including CNLM projects, in research involving topics such as cognitive functioning in infants, and visual processing in normal hearing and deaf people.

## Modeling the Category Structure of Speech Prosody

Modulations in our speech such as pitch, intensity, and rhythmic patterns, and the cues they impart to listeners, writes linguistics researcher **Jennifer Cole**, "play an important role in signaling the meaning of a spoken utterance." However, she adds, trying to identify which features of a "continuous acoustic speech signal serve to cue which discrete linguistic features related to meaning poses a serious research challenge, in large part due to the high variability across speakers, speech rate, style, and communicative contexts in the pattern of acoustic cues." So Cole joined with Beckman colleague **Mark Hasegawa-Johnson**, her graduate research assistant Tim Mahrt, and faculty member Margaret Fleck from the Department of Computer Science to create a new statistical modeling method to test prosodic prominence (those modulations used to distinguish information) in conversational speech when it comes to acoustic cues and listener perception. They used a measure called the Bayesian Information Criterion to create a statistical model of audio files from 27 different speakers to try to understand the source of variability between speakers in the patterning of prominence cues. They found, Cole writes, that "prosodic prominence is cued in two distinct patterns, as a discrete contrast and as a gradient, by different acoustic cues. This finding suggests an explanation for the divergent findings from prior work on acoustic cues to prominence, and also suggests new directions for the linguistic model of prominence as it relates to pragmatic and discourse meaning."

PHOTO BY L. BRIAN STAUFFER.

*Beckman researchers Florin Dolcos (left) and Sanda Dolcos.*

## Personality, Gender Affect How We Recollect Memories

How we process emotional memories is related to gender, personality, and the ways in which we regulate our feelings, according to research from **Florin Dolcos**. And those traits can influence not only how we remember, Dolcos found, but also our subsequent emotional state, or mood. Dolcos' study used novel approaches to the topic of how people process their emotion memories by looking at both men and women (previous studies typically look at women) and both positive and negative emotions (most focused on negative feelings), as well as the strategies people use to regulate emotion. Using questionnaires and verbal cues to elicit autobiographical memories, Dolcos and his collaborators found extroverts of both sexes had more positive than negative memories, more men who were high in neuroticism had negative memories than those who were low in neuroticism, and that women high in neuroticism had a tendency to ruminate on the same negative memories. The biggest gender differences found in the study had to do with the effects of the strategies men and women used to recall negative autobiographical memories. In women, as opposed to men, there was a significant association between the attempt to suppress negative memories and their recall, as well as their subsequent lower emotional state. "Depressed people recollect those negative memories and as a result they feel sad," Dolcos said. "And as a result of feeling sad, the tendency is to have more negative memories recollected. It's a kind of a vicious circle."

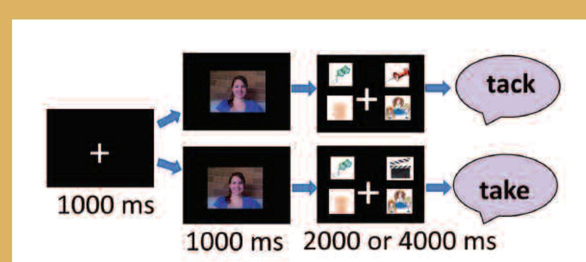
## Individual and Collective Memory Consolidation

**Thomas Anastasio** co- authored a new book, *Individual and Collective Memory*, which focused on consolidation, the process by which individual memories are formed. These memories, according to the book's preview, "provide a version of the past that helps us navigate the present and is critical to individual identity." In the book, Anastasio and his co-authors propose a three-in-one model of memory consolidation that they believe explains both individual and collective memory consolidation phenomena. In individuals, traumatic injury to the brain structure critical to memory, the hippocampus, is known as retrograde amnesia. They extend that concept here to collective memory, where the disruption of what they call the "social hippocampus" can result in collective retrograde amnesia. The book was funded by a Beckman Seed Grant.

## Listeners Make Accommodations for Accents

Accents and dialects may seem to separate people sharing a common language, but we adapt quite well and quickly to differences in speech patterns, according to research from **Sarah Brown-Schmidt**. This past year, Brown-Schmidt and graduate student Alison Trude from her research laboratory reported on work testing whether episodic memory, a form of declarative memory, plays a role in speech perception as it relates to listener adaptions to specific information about the talker. With amnesiacs as participants in a test study of how listeners apply perceptual learning to online speech perception, they found that an episodic memory account may not be suitable for explaining listeners' ability to use talker-specific knowledge when interpreting speech. Rather, their findings point to listeners' ability, as they wrote, to "keep track of a large variety of talker specific information and use this information to guide language processing decisions at multiple levels of analysis" as an explanation for the rapid accommodation for different speech characteristics the study found. The results suggest that "information about talker identity was applied on the basis of knowledge of individual talkers' speech characteristics and not primarily driven by perceptual adjustments made in response to an unfamiliar phoneme sequence. This is consistent with arguments that talker-specific information guides interpretation of all spoken language."

*Sarah Brown-Schmitt (standing) works with graduate student Alison Trude to set a research participant up in their lab. The figure illustrates a task the participant will take part in during the experiment.*



## Understanding the Role of Metabolites and Peptides in the Brain

**Jonathan Sweedler**'s research in the area of neurochemistry is geared toward understanding how signaling molecules work in the nervous system, and support higher order neural processing. In one research line, Sweedler seeks to understand the critical role that metabolites and peptides play in cell function. This past year he reported on an evolving set of tools, such as mass spectrometry-based (MS) methods. Researchers are creating and/or using them to enable the characterization of metabolites and peptides and the assessment of cell-to-cell heterogeneity of single cells, for insights into the chemistry of the brain. "We have developed technologies that allow us to take individual neurons and analyze the metabolites, peptides and thus, many of the cell-to-cell signaling molecules within them," Sweedler wrote. "We are then able to relate this to function and neuronal activity." In one paper, Sweedler and his collaborators reported on the development of an MS system for a new high throughput way of measuring cells one-by-one. In another paper, Sweedler and his collaborators at the University of Illinois described a single-cell capillary electrophoresis (CE) system that was coupled with electrospray ionization (ESI) MS. This method, they wrote, enabled the "simultaneous measurement of a vast array of endogenous compounds in over 50 identified and isolated large neurons from the *Aplysia californica* central nervous system." The marine mollusk is a model organism that has proven valuable for neuroscience studies due to its long-term memory and learning capabilities.

## New Insights into Synaptic Integration

How neurons combine information from their synaptic inputs to generate an output signal is called synaptic integration, a research topic that is a focus of **Lee Cox**. This past year, Cox reported that dendrites of local neurons (interneurons) have an inhibitory effect on other neurons in regulating fast synaptic transmission in the visual thalamus. They also showed, for the first time, that these dendritic interactions can operate independent of global activation. Cox and Shane Crandall from his lab wrote about how the process works: "Local dendritic output is strongly dependent on the activation of AMPA receptors and appears partially dependent on NMDA receptors and voltage-gated L-type calcium channels. Our data also provides insight into the functional organization of dendrodendritic synapses in the visual thalamus." Cox also reported this past year on research involving receptors that modulate the process by which thalamocortical neurons communicate visual information from the retina to the neocortex. They found that these neurons exert "distinct effects in a spatially distributed manner." Their findings, Cox and his collaborators wrote, "provide physiological evidence that (metabotropic glutamate receptors, mGluR) appear to be distributed along the thalamocortical neuron dendrites, whereas mGluR-dependent action occurs on the proximal dendrites/soma of thalamocortical neurons. The differential distribution and activation of mGluR subtypes on interneurons and thalamocortical neurons may serve to shape excitatory synaptic integration and thereby regulate information gating through the thalamus."

*Aron Barbey, Cognitive Neuroscience group.*

## Mapping the Architecture of the Brain

**Aron Barbey** completed a study that mapped the neural architecture of human intelligence, identifying a distinct neural system responsible for key components of general intelligence such as working memory and verbal comprehension. The findings, Barbey said, "suggest that intelligence relies not on one brain region or even the brain as a whole, but involves specific brain structures working together in a coordinated fashion." Using CT scans of test participants with damage to specific, localized areas of the brain as well as a battery of cognitive tests, Barbey and his collaborators were able to identify brain regions crucial to specific intellectual abilities. "We found that general intelligence depends on a remarkably circumscribed neural system," Barbey said. "Several brain regions, and the connections between them, were most important for general intelligence."

# Jennifer Cole

*"You learn one language, that's hard. You learn two languages and a whole new door opens up."*

*– Jennifer Cole*

**Joined Illinois:** 1990

**Department:** Linguistics

**Joined Beckman:** 1994

**Group:** Cognitive Science

**Research Focus:** Prosody, the aspects of speech such as intonation and modulation speakers use to convey speaker's emotions, attitudes and meanings related to content.

# A Talent for Language

Jennifer Cole's parents were university professors who believed in music education for their children, and she counts several musicians among her siblings. Cole followed her parent's path into academia and also inherited, in her own way, the family musical ability.

"I come from a family with a lot of musical talent and, although I had a lot of music training, I am not a musician," Cole said. "But, I would say that my musical upbringing may have something to do with my ability to hear very precisely the detailed qualities of people's speech."

Cole's "good ear" made it easy for her to pick up foreign languages in college and that helped inspire her love of language, and an academic pursuit that eventually led to a Ph.D. at MIT in linguistics. Cole's career choice began as an undergraduate at the University of Michigan when she discovered that she was adept at learning new languages and fascinated by their structure.

"I'm fortunate to be one of the people who can pick up languages by hearing them," Cole said. "Or, give me a grammar book and a few hours and I'll get a pretty good handle on a new language. I noticed that when I got into college. It was effortless for me and fascinating.

"So, you learn one language, that's hard. You learn two languages and a whole new door opens up, revealing patterns and structures that yield insight into every language you learn after that. You begin to see that there are certain organizing principles of language that recur, not exactly in the same guise, but they recur across languages."

Deconstructing and understanding language, specifically spoken language, is what drives Cole's research. She is Professor of Linguistics at the University of Illinois and Co-chair of Beckman's Biological Intelligence research theme. Cole's research interests include language acquisition and processing, computer modeling of speech processing, and the area of prosody, or the elements of speech such as intonation and emphasis that speakers use along with words to communicate meaning.

"My focus is on prosody and how is it that prosody conveys very different kinds of information about the linguistic substance of the speech," Cole said. "But it's also about how speech is influenced by the social identity of the speaker, the speaker's relationship to the hearer, and how listeners decode all of that from the speech signal."

Cole said that prosody, in part, conveys information about punctuation and emphasis, but that acoustic cues is also providing the listener with information about the speaker's identity, gender, geographical origin, education, and other aspects of their personal and social identity.

"The same modulations in pitch and loudness and rhythm are conveying very different kinds of information," Cole said. "And listeners are really sensitive to all of this information."

The fact that these processes are difficult to understand — as well as something speakers aren't even consciously aware of — makes them that much more interesting to Cole.

"It's a mystery," she said. "It's always interesting to me to discover that there are aspects of our behavior which you can observe scientifically, you can even predict them, but which we aren't aware of. Language is like that. It's a tremendous skill and most normally developed adults and children acquire that skill, possess it, master it, and yet we almost never think about it."

Cole has had many collaborations and research projects over the years, with a recent one involving how speakers are influenced by their environment and other speakers.

"One of the interesting findings that's coming out in recent research, including my research, is that the speech that's going on around you in your environment actually influences, immediately and over time, the way that you speak at a level of fine phonetic detail, whether you intend it to or not," she said.

A long-standing research line includes frequent collaborator and Beckman colleague Mark Hasegawa-Johnson, in a project that builds upon studies of human speech to create computational models of prosody for incorporation into automatic speech recognition systems.

"Our original goal was to build better automatic speech recognition systems, but the tools that we've developed along the way have recently given us some new insights into the linguistic structures that underlie the speech as humans are producing it," Cole said.

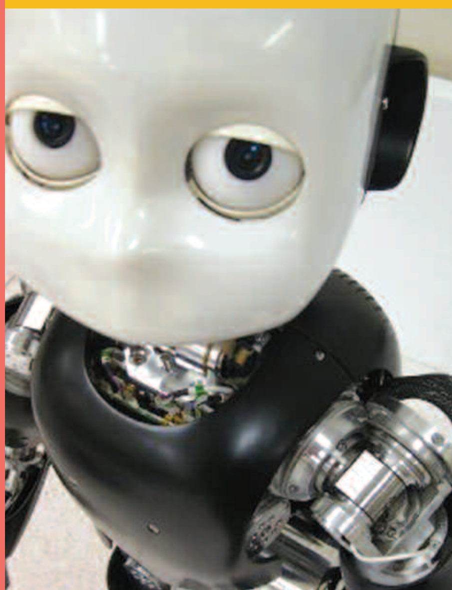
Cole was named Co-chair of the Biological Intelligence research theme a couple of years ago. She accepted the position in order to enhance both her own work and that of others at Beckman.

"I think that there are always more exciting ways that we can enrich our perspective on cognition or biological intelligence, and so I thought I might be able to lend my perspective there," she said. "But I would add that the real excitement is in the opportunity to marry cutting-edge science with cutting-edge technology, to take advantage of technological advances in computing and imaging and other kinds of instrumentation to probe deeper into questions about human intelligence and behavior or, more broadly, biological intelligence and behavior.

"That's pretty much the Beckman vision, I would say. I have the same vision to bring together that science and technology. It's already happening."

# 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 man-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.



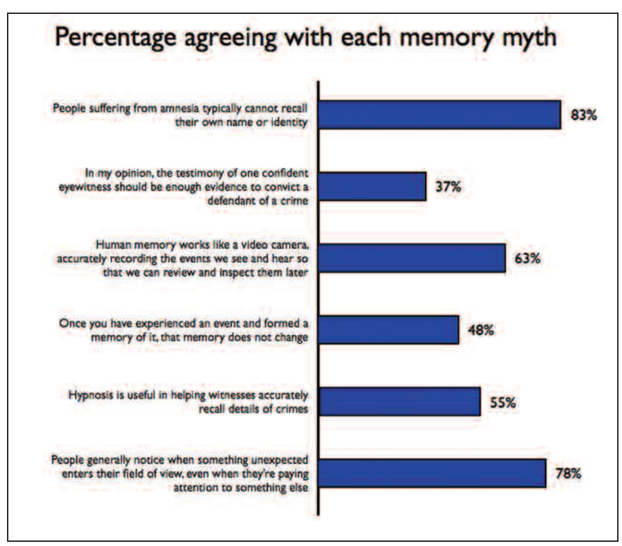
*Bert, the iCub, is a member of Steven Levinson's lab. He is the only robot of his kind being used for language acquisition research.*

## Humanoid Robot Gives Insight into Language Learning

**Stephen Levinson**'s laboratory accomplished something unique in 2012 by showing that a humanoid robot can learn language the way a child does — through real-world experiences. The iCub, acquired by Levinson's lab in 2010, is the only one of these toddler-imitating robots in the world being used for language acquisition research. It stands alone in its experimental use by *learning* a language, rather than being programmed with one. Levinson and graduate student Logan Niehaus reported on the first successful demonstration of the robot's ability to form a model for speech and motor sensory modalities. They wrote that the robot was able to "incrementally build a perceptual model for both the speech and motor sensory modalities" and that "basic linguistic function was then shown to emerge from the interaction between these two perceptual models." Levinson said these first steps in the process were done to "explore the relationship between sensory and motor function in language learning." The researchers used what is called "online learning" in the project. "Online learning refers to algorithms that adapt and learn continuously and in real-time, whenever new data is presented," Niehaus said. "We use these algorithms because they more closely emulate the actual learning capabilities of humans." Levinson and Niehaus wrote that these results are just the first steps in a process of understanding language acquisition through a robot that mimics the ways of a toddler. "This linguistic faculty was further leveraged to allow the robot to learn more complex skills and their labels. These basic representational capabilities will be required for the creation of more advanced models of development which explore the role of motor function, active learning, and social interaction on language acquisition."

## People's Beliefs about Memory at Odds with the Science

Research has shown for years that people's ability to accurately remember events, details, and other aspects of memory are often flawed. Now, a survey reveals that people's faith in the reliability of their own recall abilities is much greater than what the science tells us. As part of research for their popular book, *The Invisible Gorilla, and Other Ways Our Intuitions Deceive Us*, Beckman Institute researcher **Dan Simons** and his co-author and frequent collaborator, Chris Chabris from Union College, commissioned a survey of 1,500 people about their beliefs involving memory. The survey found, as reported in a paper on its results, along with a comparison to expert opinion on the subject, that nearly two-thirds compared human memory to a video camera that records information, while nearly half believed that experiences are encoded in memory and do not change. "People tend to place greater faith in the accuracy, completeness and vividness of their memories than they probably should," Simons said. Those beliefs about memory, Simons and Chabris wrote, are not consistent with what psychologists studying memory have found. But our intuitions, as Simons and Chabris argued in the book, often tell us our memories are accurate. "People rely on their intuitions about how the mind works and their intuitions are often fundamentally wrong," Simons said. "They are wrong for good reasons. Our system wasn't designed to do the things we ask it to do now." The results have obvious implications for real-world outcomes, such as trials that include eyewitness testimony.

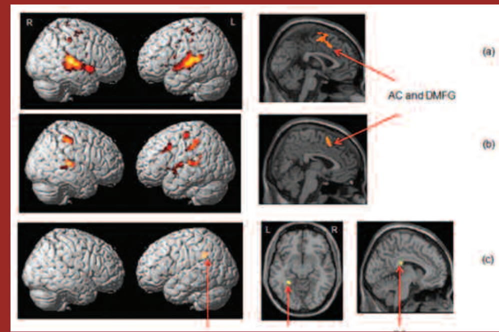



*Dan Simons (above) and his collaborators surveyed people about their beliefs involving memory. The figure above represents some of their results.*

## Power of Positive Thinking for Older Adults

**Elizabeth Stine-Morrow** reported on her research showing that older adults with a positive belief about their cognitive potential, a concept known as self-efficacy, can increase the benefit they get from cognitively enriching activities. Stine-Morrow and Brennan Payne from her lab studied the relationship between self-efficacy beliefs held by older adults prior to starting a program of inductive reasoning training, and how much their skills improved with the training. "This is practically significant," they wrote, "insofar as inductive reasoning has been shown to relate to the proficiency in executing tasks of everyday living among older adults." For this study, 105 older adults from 60 to 94 years of age were assigned to either an inductive reasoning training program or a waitlist control group. The results of the study, they reported, demonstrated that participants' inductive reasoning "showed clear improvements in the treatment group compared to the control. Within the treatment group, initial memory capacity beliefs significantly predicted change in inductive reasoning such that those with higher levels of capacity beliefs showed greater responsiveness to the intervention." They added that the results "indicate that self-referential beliefs about cognitive potential may be an important personal resource in maintaining plasticity in adulthood" and that "older individuals with positive self-referential beliefs may benefit more from engagement in activities that provide opportunities for cognitive enrichment, such as the training intervention, thus increasing the likelihood for an optimal trajectory of cognitive aging."

*Elizabeth Stine-Morrow, Human Perception and Performance group.*




*Fatima Husain of the Human Perception and Performance group uses auditory stimuli and fMRI to measure brain response in those with hearing loss, tinnitus, and normal hearing.*

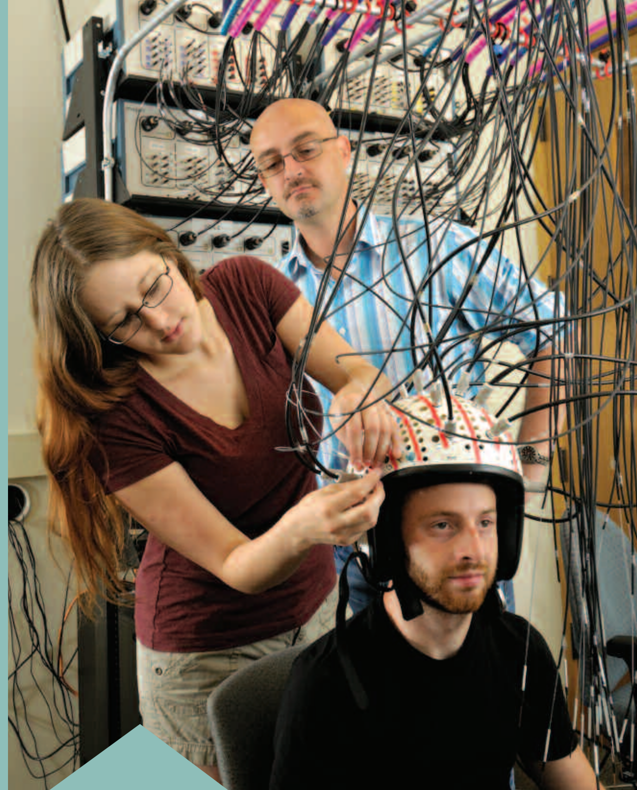
## Neural Differences Found for Tinnitus, Hearing Loss

**Fatima Husain** used a novel research approach to studies of hearing loss and discovered that the brain is capable of doing something that sufferers from tinnitus cannot do: ignore the ringing sound. By including test subjects who had hearing loss but who did not have tinnitus, Husain discovered what appears to be key differences in the neural bases of tinnitus and the larger disorder of hearing loss. It is estimated that tinnitus affects about 50 million Americans, but less than half of hearing impaired people suffer from the disorder, commonly known as ringing in the ears, or "head noise." Husain used auditory stimuli and functional Magnetic Resonance Imaging (fMRI) to measure the brain's responses in those with hearing loss (HL), tinnitus (TIN), and normal hearing (NH). The study found that the HL group performed as well on discrimination tasks as the NH group, but the fMRI revealed that their brains had to work harder and were stimulated in more areas than the NH group; thus, there were clear differences in the responses in those groups and the tinnitus group. Husain said the responses of the tinnitus group show that the brain in those with the disorder is able to ignore the head noise signal, compared to those with hearing loss alone, in discrimination tasks. "So when the brain has an internal noise, the tinnitus, that is distracting it from doing other tasks, it is dividing attention. It ignores the distracting internal sound, while still maintaining attention to the external sound," Husain said. The results, the researchers wrote in the paper reporting the study, "may represent a key difference in the neural bases of chronic tinnitus accompanied by hearing loss relative to hearing loss alone.".

## Self-confidence a Good Tool for Maintaining Exercise Regimen

When it comes to maintaining an exercise routine, believing in yourself and your goals is a critical component of success, according to research from **Ed McAuley**. Taking that finding a step further, McAuley's work also showed ways to boost self-confidence and maintain a successful exercise program. McAuley is a leading researcher in the area of self-efficacy, described as "situation-specific self-confidence." In the case of exercise, McAuley said, self-efficacy means a conviction that a person has a mastery over their physical abilities and belief in their ability to achieve exercise goals. McAuley led a collaboration which included Beckman Institute Director **Art Kramer** that tested whether boosting self-efficacy through certain strategies and use of specific cognitive abilities improved older adults' ability to stay with an exercise program. McAuley said that almost half of the people who start an exercise program quit in the first six months and much of that can be attributed to a lack of self-efficacy. For this project, McAuley performed cognitive tests on men and women in their 60s and early 70s and asked about goal-setting, time management, and other "self-regulatory" behaviors. The results showed that two cognitive abilities, being able to multitask and to inhibit undesirable responses, contributed greatly to exercise regimen adherence by increasing self-efficacy. They also found that self-regulatory strategies, like goal-setting, increased subjects' participation in the program because they also boosted self-efficacy. "We can potentially use this information to identify who might be poor adherers to an exercise program," McAuley said. "And then offer those people an array of different coping skills and strategies to inhibit or overcome bad behaviors."

*Ed McAuley, Human Perception and Performance group.*

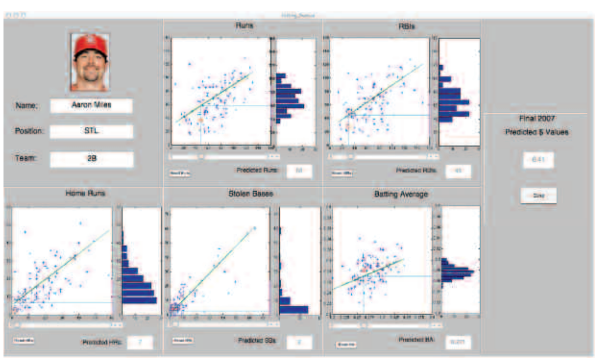


*Matthew Dye oversees graduate student Jenessa Seymour in the Diffuse Optical Imaging Laboratory. They are demonstrating the system on George Kartheiser, a visiting research assistant who is deaf.*

## Studying Cross-modal Plasticity in Profoundly Deaf Adults

When humans lose a sense such as hearing, cross-modal plasticity enables the brain to adapt and reorganize, and even strengthen other senses. Speech and hearing researcher **Matt Dye** studies cross-modal plasticity toward understanding, as he writes, "the effects of deafness on visual functions at the behavioral and neural levels, and to explore the implications for learning in K-12 and higher education settings." In order to understand cross-modal plasticity in people who have lost the ability to hear, Dye is using the Diffuse Optical Imaging Laboratory (DOIL) at Beckman to study visual processing in normal and profoundly deaf adults. He is working with Beckman colleagues **Gabriele Gratton** and **Monica Fabiani**, using the DOIL in a collaboration with the NSF-funded Science of Learning Center at Gallaudet, a university for deaf and hard of hearing students in Washington, D.C. "This imaging project is allowing us to really look at different competing hypotheses about what changes in deaf individuals," Dye said. "Our collaboration uses optical imaging to measure event-related optical signals in the cortex in a spatial visual attention task. By testing both deaf and hearing adults, we are trying to identify the cortical areas that change as a result of early profound deafness, resulting in better spatial attention in the visual periphery in deaf adults."

## Improving Long-term Intelligence Predictions



*This figure is from Alex Kirlik's research that had players of fantasy baseball use computer modeling techniques to predict performance of Major League Baseball players.*

**Alex Kirlik** and his former graduate student in the Human Factors Division at Illinois, **Sarah Miller**, are part of a team that is developing ways to improve long-term intelligence predictions. The team, called SPADE (System for Prediction, Aggregation, Display, and Elicitation), is developing software that gives the most weight to forecasts from analysts who have the highest record for accuracy in fields such as economics and world events. The contributions of Kirlik and Miller include using computer modeling to take advantage of the strengths of experts and of algorithms while compensating for their weaknesses. Their work was successfully demonstrated in a research project led by Kirlik that had players of fantasy baseball use computer modeling techniques to predict performance of Major League Baseball players. Kirlik's research has shown the need for including uncertainty into formal models of human judgment. The goal of the SPADE project, according to team leaders from Draper Labs, is to find "the most precise and timely way to crowd-source its predictions amongst its widely dispersed analysts."

## Experience Facilitates Collaboration in Complex Tasks

**Dan Morrow** led a project that looked at the effects of experience and knowledge in problem-solving tasks and found that those factors not only help one person solve a problem in their area of expertise, but also help people to work together in solving complex problems. For the study Morrow and his collaborators used expert flight instructors, student pilots (novices), and non-pilots. They were asked to work alone or in pairs in problem-solving tasks involving an aviation scenario that had different degrees of difficulty. The researchers discovered that pairs of experts — when they were faced with a challenging problem — produced greater success than experts working alone, and also found more constructive interactions than for pairs of non-experts who worked together. "The findings suggest the importance of knowledge about the task for collaborative benefits," Morrow said. "Experts may more effectively work together than novices do because they share knowledge that helps them build up shared task representations that support joint problem solving." In the paper reporting the results, the researchers wrote that a dyad's "prior knowledge and experience enables them to benefit from both knowledge-based problem solving processes (e.g., elaboration, explanation, and error correction) and collaborative skills (e.g., creating common ground, maintaining joint attention to the task). The results support the hypothesis that individual learner and task structure combine to create a zone of proximal facilitation in which participants can go beyond what they could do individually."

*Research from Dan Morrow finds that experts work better in pairs than working alone when faced with a challenging problem.*

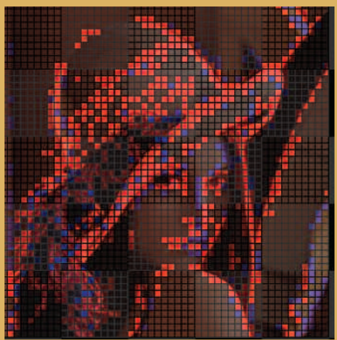

*Beckman faculty member Tim Bretl of the Artificial Intelligence group. Photo courtesy of the Coordinated Science Laboratory.*

## Enabling Robots to Manipulate Flexible Items

Teaching robots to perform certain tasks that humans do easily every day has been a challenge for researchers in the field of robotics. **Tim Bretl** has found a mathematical solution to one of those challenging tasks for robots: manipulating flexible objects. Objects that are flexible, or deformable, have proven difficult to describe mathematically—due to their changeable shape, orientation, etc.—for the program guiding the robot's actions. Bretl addressed the problem by modeling the shape of a flexible object as the solution to an optimal control problem and, by studying the geometry of that problem, was able to describe all possible shapes of the object and develop an algorithm for manipulation planning. Potential uses are many, such as in industry where robots handle rigid objects with ease in manufacturing products but can't manipulate flexible items. Another area is in medicine, for example in robotic surgery, where flexible items are common. "The beauty of this work is that while the analysis was really hard, the results are actually really easy to apply," Bretl said. "There's definitely more that needs to be done, but we have provided a solid foundation for future efforts." Bretl's paper on the research was chosen out of a record 2,032 submissions for the Best Manipulation Paper Award at the IEEE International Conference on Robotics and Automation.

## Novel Algorithms Power Photo Collections, Super-resolution Images

**Tom Huang** has been a leader in developing recognition software for identifying characteristics such as gender and emotion in an image. Now Huang and his research group have developed a way to recognize events in photo collections or online photo communities. Photos are often grouped into albums according to a particular event, such as a holiday gathering, making interpreting the many varied characteristics within an album much more difficult than with a single image. Huang's group developed a new model called Compositional Object Pattern, which uses a novel mining algorithm to characterize object level patterns in the album based on the relative frequencies of discriminative patterns. This method, as the researchers wrote in their paper reporting the results, allowed them to "mine frequent object patterns in the training set, and then rank them by their discriminating power. The album feature is then set as the frequencies of these frequent and discriminative patterns, called Compositional Object Pattern Frequency (COPF). We show with experimental results that our algorithm is capable of recognizing holidays with accuracy higher than the baseline method." This past year Huang's group also developed a single image super-resolution algorithm that has applications in photo upscaling, editing, and printing. Huang and his collaborators described the process: "The algorithm first trains two coupled over-complete dictionaries for low and high resolution image patches jointly. Then for each low resolution image patch from the input image, we find its sparse representation (in terms of the low resolution dictionary), which is applied with the high resolution dictionary to produce the corresponding high resolution image patch. Compared with previous super-resolution algorithms, our approach is mathematically sound and achieves state-of-the-art results."



*This figure shows a comparison of patch-wise SR reconstruction accuracy between sparse recovery and bicubic interpolation. Red = patches where sparse recovery beats bicubic interpolation; Blue = patches where bicubic interpolation is superior; and Gray = the two perform on par with each other.*

## Cross-training for Improving Automatic Speech Recognition Technology

Comparing automatic speech recognition (ASR) technology to an athlete using cross-training, **Mark Hasegawa-Johnson** writes that ASR can also benefit from training on tasks other than those for which it was designed. Hasegawa-Johnson and graduate student Po-Sen Huang applied the concept to ASR technology for automatically recognizing Levantine Arabic speech. One of Hasegawa-Johnson's current research lines involves developing ASR for Arabic dialects like Levantine, a challenging problem since the dialects don't have a standard written form. To try to improve the accuracy of the ASR technology, the researchers added Standard Arabic to the training data for the Levantine ASR training data since Standard Arabic shares 70 percent of its vocabulary with Levantine. They discovered that, as Hasegawa-Johnson writes, "a small amount of out-of-task t raining data actually improved performance: the best accuracy was achieved when (we) combined about five hours of in-task training data (Levantine Arabic) with about fifteen minutes of out-of-task training data (Standard Arabic). In other words, cross-training, with an in-task/out-of-task ratio of about twenty to one, improved the accuracy of the speech recognizer." Hasegawa-Johnson said cross-training adds relevant outliers that include data which might not be part of the in-task training data, but might very well be part of a real-world task situation. "A learner with cross-training is therefore more robust to small unexpected variations," Hasegawa-Johnson writes, "and therefore tends to be more accurate in real-world problems."

PROFILE

# Mark Hasegawa-Johnson

*"This atmosphere is indirectly responsible for almost everything I've done and directly responsible for several big grants that I've won. It's nice not to have such barriers."*

*– Mark Hasegawa-Johnson*

**Joined Illinois:** 1999
**Department:** Electrical and Computer Engineering
**Joined Beckman:** 1999
**Group:** Artificial Intelligence
**Research Focus:** Creating new algorithms and applying knowledge from linguistics and psychology in order to understand human speech and for development of automatic speech recognition (ASR) and other technologies.

# Engineering Better Communication

As a researcher in the area of signal processing, Mark Hasegawa-Johnson works with algorithms, software, and other nonmaterial tools of the computer engineer. But his research is aimed at a very tangible human outcome: improving how we communicate.

That includes communication between people and with their computers, as well as computer-aided exchanges between humans.

"I like to think of my research as progressing technology that enables people to do things they want to do," Hasegawa-Johnson said. "There are an uncounted number of opportunities on the human scale."

Hasegawa-Johnson has been a leader in developing automatic speech recognition (ASR) software for the applications people have become accustomed to, such as when they call a customer service line. His work is also focused on developing technology to improve communication in areas that are less well-known and in need of technology advances.

"A lot of my work on speech in particular has moved in the direction of speech as an enabling technology," he said.

One such research line is developing technology that would make it possible to communicate in a country where the speaker is not fluent in the native language.

"The technology can make it possible to travel anywhere in the world and talk to anyone," Hasegawa-Johnson said.

Hasegawa-Johnson is also working to develop ASR for Arabic dialects, and to empower those with speech disabilities.

"We're working on automatic speech recognition in dialects that don't have speech technology because they don't have a standard written form," he said. "We're also working on a spoken language interface for people with disabilities that make it very difficult for them to use a keyboard. It could be an aid so they can participate at the full level of their mental ability in any job they want to hold."

Research in that area is applying some of the same successful methods developed for speech recognizers toward helping people suffering from speech dysfunctions like dysarthria, a motor speech disorder caused by brain injuries from stroke or cerebral palsy that affect the muscles involved in speaking.

Hasegawa-Johnson is principal investigator on a recent University of Illinois Interdisciplinary Innovation Initiative grant to advance what he calls augmentative communication for those with speech disabilities. The project is starting with a tablet PC prototype, with a goal of enabling those with dysarthria to experience more of the ebb and flow of normal conversation.

"What we're working on now is trying to build these tablet computers that basically act as a third party in the conversation, where the tablet recognizes the person you are talking to, if it's somebody you've talked to frequently," Hasegawa-Johnson said. "It recognizes each voice and tries to predict in that context what they would want to say to the other person. They can then choose among the options it gives them using touch or a few keywords that it is able to recognize from their speech.

"We want to try to avoid just stopping the conversation dead while the person types it out."

Hasegawa-Johnson does research in both speech and non-speech areas. He has collaborated often with Beckman colleagues Thomas Huang (on topics involving signal processing in image and audio technology) and Jennifer Cole (on projects surrounding linguistics). His contributions include developing new algorithms for ASR and language learning software, as well as building mathematical models for aiding linguistics research, for example, in the study of speech landmarks and the dynamics of speech fluency.

Hasegawa-Johnson has many current projects, including as co-leader of a research line developing technology that enables the visualization of large amounts of audio data. The projects involving technology for people with speech disabilities and ASR for Arabic dialects are both difficult challenges, but could ultimately be rewarding for millions.

"The problem is bringing the technologies to bear in ways that make those things possible," Hasegawa-Johnson said. "But these are all things I think that are within reach on the scale of 10 years, or possibly sooner."

Hasegawa-Johnson's longest collaboration at Beckman has been with Cole, a linguistics researcher from the Biological Intelligence research theme.

"I learned about her research through some of her presentations here at Beckman," Hasegawa-Johnson said. "The ideals and the atmosphere in Beckman encourage interdisciplinary research. I'm inclined to work with people from other colleges, so it makes it much easier to find people who are also inclined that way.

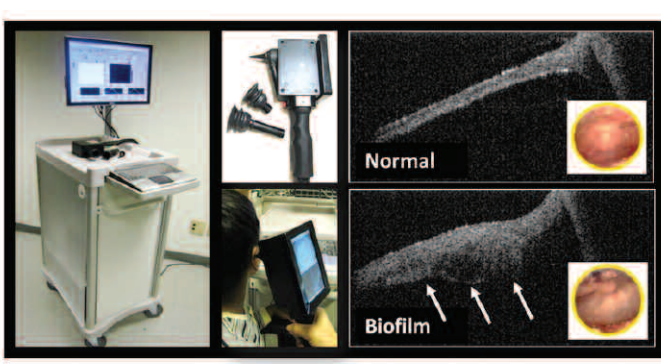
"This atmosphere is indirectly responsible for almost everything I've done and directly responsible for several big grants that I've won. It's nice not to have such barriers."

# HIGHLIGHTS

The **Integrative Imaging (IntIm)** research theme brings together people and technologies to create advances in imaging science that have real-world impact in both research and clinical settings. Research in Integrative Imaging is divided into two groups, the **Bioacoustics Research Laboratory (BRL)** and the **Bioimaging Science and Technology group (BST)**. Their research efforts include those who are working to design and engineer new imaging instruments and methods as well as to optimize current techniques, those for whom imaging is an integral part of doing scientific research, and some who are engaged in both efforts. They are improving methods such as ultrasound and magnetic resonance imaging, creating new methods based on technologies like computed tomography and optical imaging, and applying the instruments and techniques for important biomedical purposes. Some of the medical applications are at the clinical trial stage, where minimally invasive breast cancer screenings and cooling helmets for head trauma are being tested at Carle Foundation Hospital in Urbana. Basic research involving the life sciences that could also have real-world outcomes is a pillar of this theme, including topics such as understanding the morphology of speech and the impact of exercise on the body.

## Multipurpose Imaging Device Proves Effective for Diagnosing Ear Infections

**Stephen Boppart**'s development of a multipurpose medical diagnostic device for non-invasive imaging use by primary care physicians was successfully demonstrated in diagnosing ear infections, a special area of need when it comes to children. Ear infections are the most common condition treated by pediatricians, but biofilms of bacteria that build up behind the eardrum can make diagnosis difficult, and even lead to hearing loss and/or surgery. The imaging technology developed by Boppart is based on optical coherence tomography, a non-invasive method that uses light to render high-resolution, three-dimensional images of tissue. Medical personnel use an otoscope to probe the eardrum; Boppart's device is used like an otoscope, but with the ability to send light into the ear canal and see any biofilm behind the eardrum. "We send the light into the ear canal, and it scatters and reflects from the tympanic membrane and the biofilm behind it," said Cac Nguyen of Boppart's research group. "We measure the reflection, and with the reference light we can get the structure in depth." The prototype device, which can be fitted with multiple tips that enable it to be used for other purposes such as for eye exams, was successfully demonstrated for the first time in a clinical setting at Carle Foundation Hospital in Urbana. "All the sites that a primary-care physician would look at, we can now look at with this more advanced imaging," Boppart said. "With OCT, we are bringing to the primary-care clinic high-resolution 3-D digital imaging, and being able to look at many different tissue structures in real-time, non-invasively, and in depth."



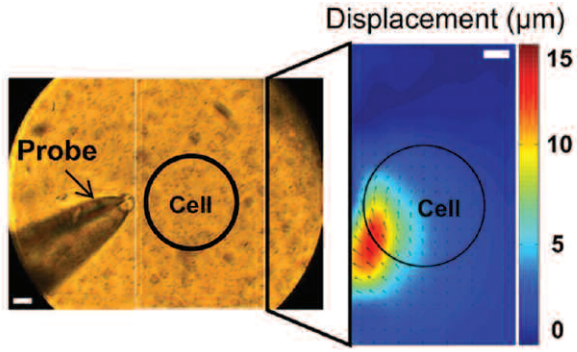

*Stephen Boppart and his collaborators tested a prototype of a new device that can see biofilms behind the eardrum.*


*Still image taken from a video of fast dynamic imaging of speech using PSF.*

## Advancing MRI for Imaging of Speech Function

**Brad Sutton**, **Zhi-Pei Liang**, and their research groups teamed up to develop a method for improving magnetic resonance imaging (MRI) of speech function. The research efforts of both Liang and Sutton are aimed at advancing MRI capabilities, with part of Liang's work dedicated to improving cardiac imaging, while Sutton has a focus on improving speech imaging. They collaborated to combine Liang's image reconstruction algorithms for undersampled data used in cardiac imaging with Sutton's fast acquisition techniques toward the goal of improving speech imaging. The result was faster acquisition and reconstruction of MRI images and, therefore, improved visualization of human speech function. The technique is especially useful for studying the facial birth defect of cleft palate, an area of focus for Sutton. "In our previous work we were able to achieve something like 20 frames per second with a single midsagittal slice," Sutton said. "So we can see the tongue move, see the soft palate, which is split in cleft palate, and see it move in healthy adults. But now, with the methods we are collaborating on with Zhi-Pei Liang, we can get five slices at 20 frames per second. So we can start to see what's happening in multiple planes and really visualize three-dimensional movements."

## Using the Body's Cells for Biosensing




*The left image shows the probe and gel substrate with 1 μm beads embedded. The right images show a typical displacement (in μm).*

**Yingxiao (Peter) Wang**'s approach to developing biosensors is to get the body's own cells to do the sensing work, for example through mechanotransduction, the cellular process that converts mechanical signals into biochemical responses. By manipulating large proteins in live cells Wang is able to create biosensors for use in disease detection and basic science research. In 2012 Wang reported on a collaboration with Taher Saif that used live cell imaging to gain molecular-scale insight into the previously mysterious subcellular process of how mechanical force regulates calcium signaling in the body. The method combines mechanical stimulation with genetically-encoded biosensors that enable live cell imaging. The genetically-encoded biosensors are based on a molecular interaction — called fluorescence resonance energy transfer (FRET) — between dye molecules that enables live cell imaging for the visualization and quantification of crucial molecular signals at subcellular levels. For this research, they created a novel probe device for mechanical stimulation of the cells and used the FRET biosensors to measure the results. The researchers focused on intracellular signaling of calcium ions because their concentration has been shown, as they write, to "play crucial roles in a variety of physiological consequences and is sensitive to mechanical cues." Wang said that the results have implications for those working in fields such as vascular biology and those seeking to use advanced molecular imaging techniques. In another project, Wang and his collaborators used a FRET-based biosensor toward gaining understanding of the focal adhesion kinase (FAK) protein that plays a critical role in many processes at the cell membrane. They developed a FRET-based FAK biosensor that was able to, as they wrote, "visualize FAK activity at different membrane microdomains" with "high spatiotemporal resolution in live cells." This enabled them to show that FAK is activated with "with distinct activation mechanisms in response to different physiological stimuli."

## The Optical Imaging Picture Gets Clearer

Using optical techniques for minimally invasive or non-invasive imaging of tissue holds great promise for medicine — if the images rendered are clear at all depths. **Stephen Boppart** develops optical coherence tomography imaging (OCT) systems for medical applications such as disease diagnosis and surgical probes. Boppart and Beckman colleague **Scott Carney,** a leader in developing algorithms that advance imaging methods, teamed up to create a fast, inexpensive technique that computationally corrects for aberrations in a tomogram. These aberrations, which result in blobs or streaks in images, appear worse at higher resolutions, hampering accurate diagnoses. In tomographic imaging, 3-D models are computed from sectional images from a scan. The method developed by Carney and Boppart scans a tissue sample with an interferometric microscope and uses algorithms based on Fourier optics principles to correct for aberrations post-acquisition, then reconstructs images that provide high resolution at all depths. They call the technique computational adaptive optics, and say it can be used on any computer, for example at a clinic, and for any type of interferometric imaging, including OCT. "The effectiveness is striking," Boppart said. "Because of the aberrations of the human eye, when you look at the retina without adaptive optics, you just see variations of light and dark areas that represent the rods and cones. But when you use adaptive optics, you see the rods and cones as distinct objects."

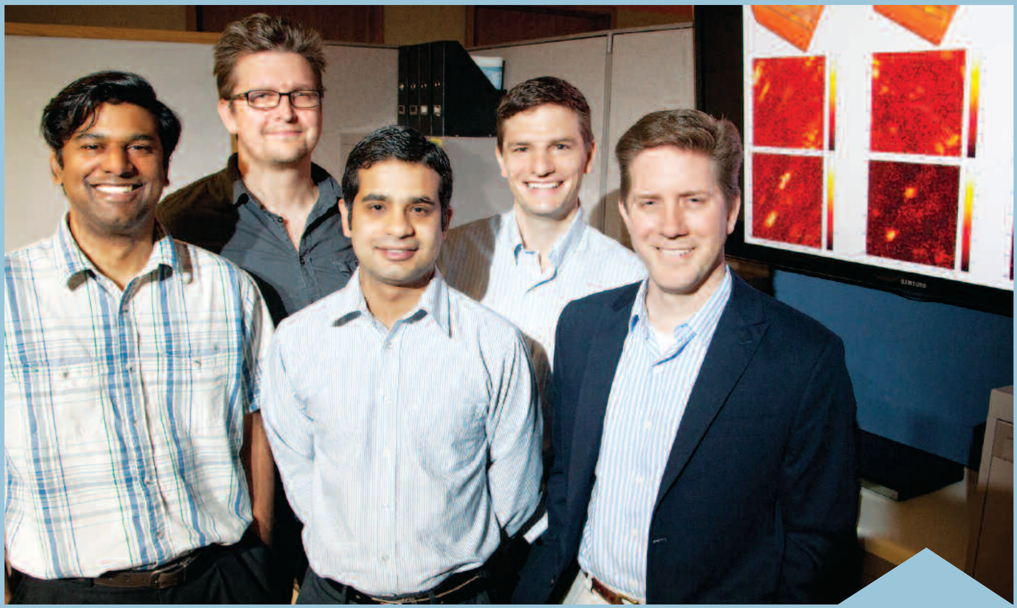
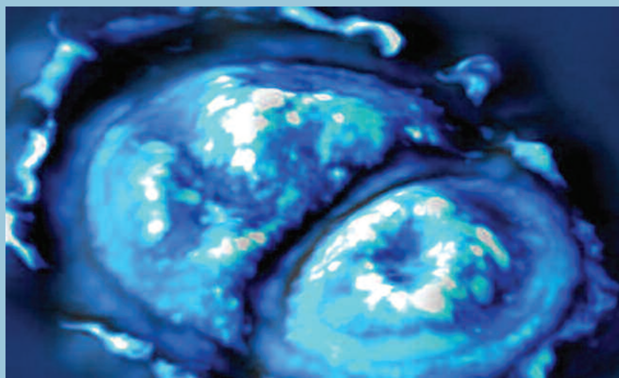


PHOTO BY L. BRIAN STAUFFER.

*From left, postdoctoral researcher Steven Adie, professor Scott Carney, graduate students Adeel Ahmad and Benedikt Graf, and professor Stephen Boppart.*



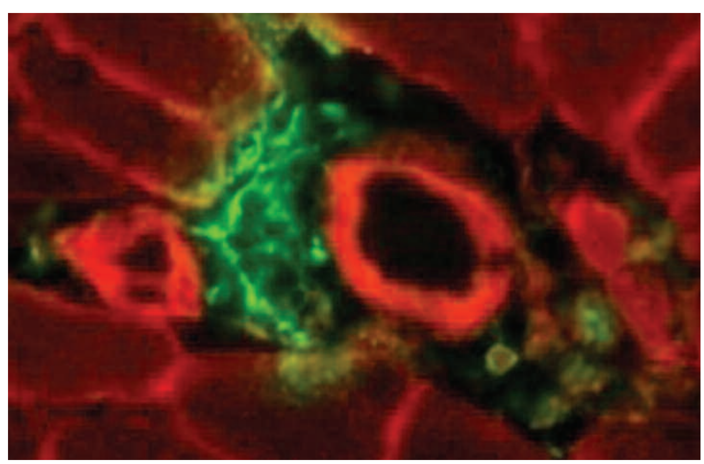
*The SLIM method is capable of measuring mass with a sensitivity of one femtogram, or one thousandth of the mass of a cubic micron of water.*

## SLIM Technique Proves a Success for Stain-free Imaging and Measuring Cell Growth

**Gabriel Popescu** designed a broadband interferometric microscopy technique known as SLIM (Spatial Light Interference Microscopy) as an add-on module to a commercial phase contrast microscope. SLIM, which combines phase contrast microscopy and holography, enables fast nanoscale imaging of cell structures and tissue interactions, and also provides quantitative information on the sample. This past year, the versatility of SLIM was demonstrated in two different applications through its ability to measure single cell growth and as a stain-free imaging method for cancer diagnosis. In the latter project, SLIM's use of light waves allowed researchers to examine more than 1,200 biopsies without using the standard histological method of staining tissue samples and associated lab work. They were able to visualize cells with high resolution and high contrast, at scales that revealed prostate tumors and breast calcifications. Popescu said the method allows for earlier detection and treatment of cancer. "Ideally, we would like to detect cancer at the single-cell level," he said. "So we can find a cell that looks abnormal and do everything so much earlier where the process is still reversible. We know that the disease starts at the nanoscale, at the molecular level, and we think we have the proper tool to catch these early events." That tool was also proven effective in measuring single cell growth, an important biological process which has proven difficult to quantify with other microscopy methods. Using SLIM, Popescu and his collaborators were able to measure the dry mass of many individual adherent cells in samples ranging from bacteria to mammalian cells, in various conditions, and at multiple scales and times. Mustafa Mir of Popescu's research group was first author on the paper. "By using a fluorescence reporter in conjunction with this novel optical technique, we were also able to differentiate how the cells regulate their growth in different stages of their lifecycle," Mir said. "Aside from the basic science interest, this technology could have broader implications in understanding the effects of cancer treatments and other forms of therapy on the fundamental process of cell growth."

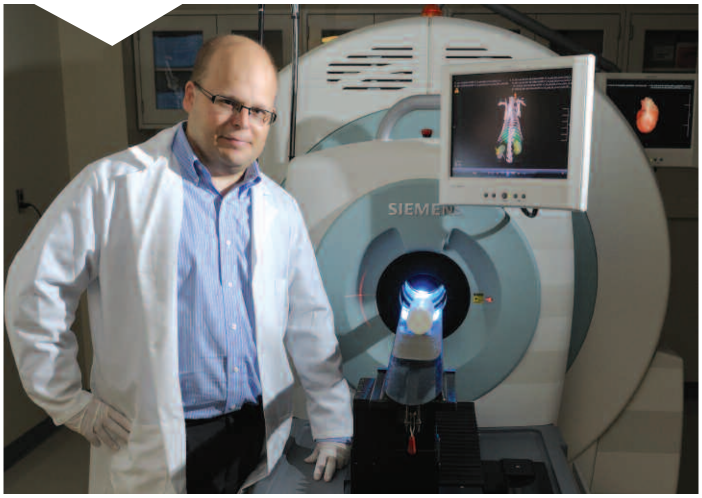
## Exercise Triggers Stem Cell Accumulation in Muscle

**Marni Boppart** directs the Molecular Muscle Physiology Laboratory at Beckman, in research that, she says, is "dedicated to exploring new methods or therapeutics that have the potential to prevent or treat skeletal muscle atrophy." This past year, Boppart reported on her findings that showed, for the first time ever, that just one exercise session in mice leads to an accumulation of what are called muscle-derived mesenchymal stem cells (or mMSCs) that play a role in the regeneration response to injury or disease in skeletal muscle. It is a discovery that could provide insight into the link between exercise and whole body health. Mesenchymal stem cells are found throughout the body and can differentiate into a variety of cell types, including for enhancement of tissue regeneration. In addition to that role, they can indirectly facilitate tissue healing, as was found in this study. Boppart said they were able to show that "mMSCs are not directly contributing to muscle growth, but do in fact secrete a variety of different factors that positively impact muscle growth. The cells usually respond to injury but in the case of exercise what we think, and this is a very novel phenotype for these cells, is that they secrete the factors specifically in response to mechanical strain. We are very excited because this work is an important step towards developing effective interventions that can prevent the loss of muscle that occurs with aging and disease." Boppart's lab is now examining the direct therapeutic value of the MSC population in the prevention of sarcopenia and working with international collaborators to identify MSCs in human skeletal muscle following exercise. "Overall, this work has the potential to transform our current beliefs regarding exercise-induced skeletal muscle adaptation and the way that we treat musculoskeletal and age-specific disorders," she said.



*Mesenchymal stem cells (green florescence) are found in several locations in skeletal muscle, including around blood vessels following exercise.*

## Technology Created for Small Sample Multimodal Imaging




*Wawrzyniec Dobrucki is shown with the Micro PET/SPECT/CT scanner in the Molecular Imaging Laboratory in the Beckman Institute's Biomedical Imaging Center.*

**Ling-Jian Meng** and **Wawrzyniec Dobrucki** are using newly-developed detector inserts for positron emission tomography (PET) imaging and for magnetic resonance imaging (MRI) toward creation of a novel imaging modality. Meng has a research focus on developing new nuclear imaging techniques such as sensors based on room temperature detectors. Dobrucki directs the Molecular Imaging Laboratory (MIL) in Beckman's Biomedical Imaging Center (BIC), with research interests in multimodal imaging and, particularly, imaging strategies for assessing angiogenesis in animal models for studies of disease. They teamed up on a project that is developing novel semiconductor detector technology for ultrahigh resolution small-animal PET imaging. Dobrucki works with the MIL's multimodal microPET/SPECT/CT scanner, which renders PET image resolutions of 2 mm which, he 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 0.5mm, 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." As for their roles, Dobrucki said that Meng is "developing the hardware and I'm developing the applications and agent radio tracer we will use with them." 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, and to determine the performance of the system. Now we are moving this to imaging and using tissue." Meng is also applying the technology toward developing an MRI-compatible SPECT system, which he expects to be completed this fall.

## A Non-invasive Method for Studying Brain Trauma

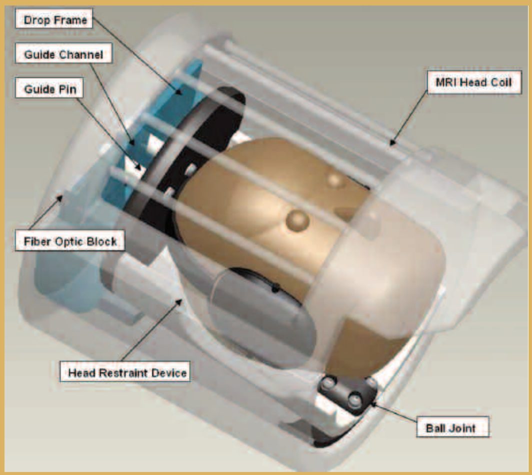



*Figure illustrates the 3-D head model of brain impact.*

Studying the effects of even mild impacts on the brain has been challenging because of the difficulty of direct observation and in replicating brain trauma in artificial or animal models. A research team led by **Martin Ostoja-Starzewski** created unique methods to study the topic in a new way. They used magnetic resonance imaging (MRI) to assess, *in vivo*, the deformation field resulting from a mild impact while also creating a (finite element, FE) computer simulation of a patient-specific 3-D head model of brain impact to make predictions about the MRI data. Ostoja-Starzewski's research at Beckman is focused on MRI-based studies of head trauma; fellow team member **Brad Sutton** works on advancing MRI methods. Together they and their collaborators were able to look at brain injury mechanisms in a new way, using advanced MRI techniques to non-invasively study *in vivo* loading conditions during impact. Volunteers took part in head drop experiments with mild impact, which can, the researchers wrote, provide "some insight into the deformation patters of the brain under more severe impact." The results from the two methods were correlated, proving the FE model successful as a predictor. "To our knowledge, this study is the first attempt where the deformation field obtained by MRI-based assessment is correlated with the prediction of a corresponding FE model, and it is also the first validation of a FE brain injury model on *in vivo* human brain deformation data." They add that this validation "using *in vivo* brain deformation data under mild impact in this study provides us more confidence of using our proposed FE model as an effective predictive tool for future brain injury research."

# Brad Sutton

*"I like coming up with ways to measure these biomarkers that relate underlying physiology to differences in the way the body and brain perform."*

*– Brad Sutton*

**Joined Illinois:** 2003
**Department:** Bioengineering
**Joined Beckman:** 2003
**Group:** Bioimaging Science and Technology
**Research Focus:** Advancing magnetic resonance imaging methods for medical and scientific research applications.

# A Passion for Imaging Science . . .

Brad Sutton's research is making advances in magnetic resonance imaging (MRI) methods for a broad range of biomedical and scientific applications. His perspective on the critical role those images play in 21st Century medicine, however, is singular.

"Seeing *is* believing," Sutton said. "If we can visualize a process and monitor it, that's a really important tool for learning what's going on in physiology. But being able to see something happen is not the same as being able to visualize all the causes of everything that's happening.

"This is why it's so important that imaging science continues to develop. MRI in particular continues to evolve as we find new pieces of information in our data that give us a window into cellular processes that we didn't have before."

This year Sutton earned a tenured faculty position in the Department of Bioengineering, and got new lab space and his very own office at the Beckman Institute. Those might be called the finishing touches to an academic career built on his passion for imaging science, and its function as a pillar of modern medicine.

"What I like most about doing this is, you're trying to make these very fine, detailed, quantitative measurements and often your first try is not successful," Sutton said. "I like coming up with ways to measure these biomarkers that relate underlying physiology to differences in the way the body and brain perform. The hope is that many of these measures will have an impact on healthcare in the future."

Sutton's interest in imaging science and bioengineering began during a two-week period in high school when he shadowed a radiologist.

"During that process I got to see a lot of what clinical and interventional medicine is, and really saw the need for being able to image and measure things without actually going in and taking a sample," Sutton said.

The interest blossomed into a passion for imaging science in graduate school when he had ample access to an MRI scanner.

"That is where my real motivation came from: hey, there is a machine, this MRI scanner, where I can actually go look at all this different physiology," Sutton said.

Sutton's research is based on developing magnetic resonance imaging (MRI) methods, using algorithms and graphics processing units, among other tools, to improve data acquisition, processing speed, and image resolution. The advances in magnetic resonance imaging are being applied to an ever-widening assortment of biological structures and physiological functions in research projects and biomedicine.

As a professor in Bioengineering, Sutton is also helping to prepare the next generation of imaging scientists, ones he hopes will have the same drive he has to contribute to his chosen field.

"The students in our department have a good opportunity to become the future leaders in this area, so we're trying to give them experience with real-world systems, real-world data, so they will be able to learn new systems and design them," Sutton said.

Sutton earned his undergraduate degree in engineering at the University of Illinois and a Ph.D. at the University of Michigan in biomedical engineering. He then spent nearly three years as a chief MRI engineer at Beckman's Biomedical Imaging Center (BIC) before joining the Department of Bioengineering as a faculty member in 2006. He was granted tenure and became an Associate Professor in August, 2012.

One of Sutton's research projects involves MR imaging of speech morphology and structure, with a particular interest in the facial birth defect of cleft palate. In one advance, Sutton and Beckman colleague Zhi-Pei Liang have applied novel computational methods to MR imaging of speech function. The reconstructed, three-dimensional images and resulting video have given an unprecedented, dynamic look into functional anatomy during speech.

Sutton also has research lines that include studying age-related demyelination in motor pathways and imaging microvascular blood flow with MRI. He hopes his students can find the same kind of passion for imaging science that he developed as a graduate student with an MRI scanner at his disposal.

"We're really trying to achieve that here, where we're trying to open the system up for the students," Sutton said. "If I think about what created that really strong MRI interest for me, it was that level of access. You think about 'here is some interesting physiology signal, can I go see it?'

"We want to encourage our students to be innovative. They can identify important physiological changes in aging, for example, and then go to the scanner and see if they can develop methods to measure it. I would like to be able to create that environment here for these students."

# HIGHLIGHTS

**The Molecular and Electronic Nanostructures (M&ENS)** research theme brings together scientists from disciplines as diverse as biology and engineering, and 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,** and **Nanoelectronics and Nanomaterials**. Within these groups, M&ENS researchers develop and use computational tools for simulating biological processes and for designing nanosystems, fashion nanoelectronics for applications in biomedicine and consumer products, and construct autonomous multifunctional materials systems. They have created breakthrough technologies and discoveries that will power future electronics, serve as healthcare monitors and healing tools, and self-heal damaged systems.

## Autonomic Restoration of an Electrical Circuit

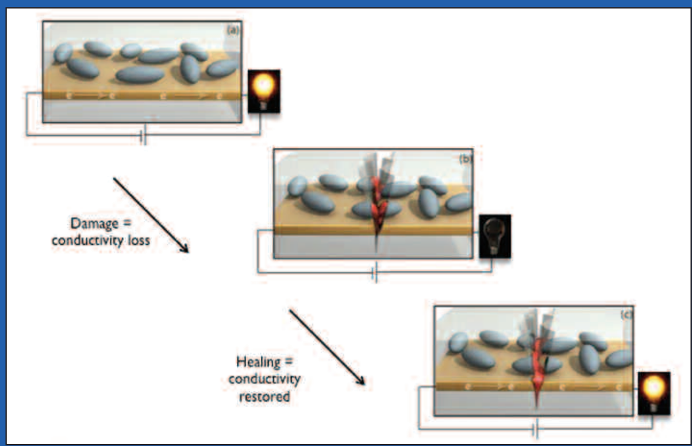
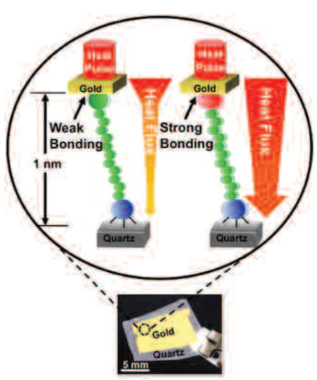



*Figure illustrates research taking place on self-healing circuits. Success in this area could lead to increased longevity and device reliability.*

One of the first steps in a research line devoted to creating longer lasting and safer batteries and electronics technology was taken when researchers **Jeff Moore, Scott White,** and **Nancy Sottos** reported on the restoration of electrical conductivity to a mechanically damaged circuit. Damage to an electrical circuit in electronics and the batteries that power them and other products is often unseen and not repairable, leading to waste and extra costs. "Normally you just replace the whole chip," Sottos said. "It's true for a battery too. You can't pull a battery apart and try to find the source of the failure." To add a self-healing component to electronics, the researchers tried a self- healing approach they had used for polymers by employing a microencapsulated conductive material — in this case gallium-indium (Ga–In) liquid metal. When ruptured upon damage, the material was released, filling the crack, and restoring 99 percent of conductivity to 90 percent of the samples within 40 microseconds, and only in the area of damage. "It simplifies the system," Moore said. "Rather than having to build in redundancies or to build in a sensory diagnostics system, this material is designed to take care of the problem itself." The researchers wrote about the potential applications: "Self-healing circuits will lead to increased longevity and device reliability in adverse mechanical environments, enabling new applications in microelectronics, advanced batteries, and electrical systems."

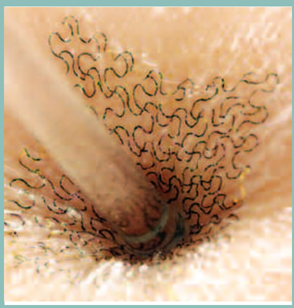
## Controlling Heat Flow across an Interface




*Graphic by Paul Braun's group illustrating the "molecular sandwich."*

**Paul Braun** led a collaboration which included Beckman colleague **Nancy Sottos** and **David Cahill** from the Department of Materials Science and Engineering that demonstrated atomic-scale manipulation of heat flow across an interface between two materials. They applied a measurement technique Cahill developed that uses laser pulses of one trillionth of a second to accurately analyze heat flow with nanometer-depth resolution. The process involves depositing a single layer of molecules on a quartz surface to create what Braun calls a "molecular sandwich". They then transfer-print an extremely thin gold film on top, apply a heat pulse to the gold layer, and then measure how it traveled through the sandwich to the quartz at the bottom. Through manipulation of the composition of the molecules in contact with the gold layer, they were able to observe changes in heat transfer and show that stronger bonding between the molecules and the gold layer resulted in a doubling of the amount of heat flow.

## Electronic Tattoos Created for Health Monitoring



*The circuits filamentary serpentine shape allows them to bend, twist, scrunch, and stretch while maintaining functionality.*

**John Rogers** was a leader of a multi-university collaboration that fabricated an ultrathin flexible patch, or "electronic tattoo" as it was dubbed, for, among other applications, use as an unobtrusive epidermal health monitor. The patch could be used to monitor brain or muscle activity — as is done with, respectively, EEG and EMG methods. It is a thin sheet of water-soluble plastic that, unlike those methods, is mechanically invisible to the person wearing it. Rogers has been a pioneer in developing flexible and stretchable electronics for a wide variety of uses, including consumer products. The electronic tattoo employs some of the same materials, such as silicon, as other stretchable silicon technologies Rogers had created, but he and his collaborators had to overcome fabrication issues that come with applying the system to skin. "Our previous stretchable electronic devices are not well-matched to the mechanophysiology of the skin," Rogers said. "In particular, the skin is extremely soft, by comparison, and its surface can be rough, with significant microscopic texture. These features demanded different kinds of approaches and design principles." So they fabricated tiny wires with a wavy, snakelike shape that allowed them to bend and twist when they were mounted on thin, soft rubber sheets, while also remaining functional. Proof-of-concept of the system was shown by mounting electronic components such as LEDs and sensors on the rubbery substrate. "We threw everything in our bag of tricks onto that platform, and then added a few other new ideas on top of those, to show that we could make it work," Rogers said. The success of the system, the researchers wrote, enables "intimate, mechanically 'invisible', tight and reliable attachment of high-performance electronic functionality with the surface of the skin in ways that bypass limitations of previous approaches."

## Growing Graphene on Copper Crystals

Faculty members **Joseph Lyding** and **Eric Pop** and their collaborators identified copper crystal structures that are optimal for use as a substrate for growing high-quality graphene, the kind needed for future electronics based on the one-atom thick sheet of carbon. "Graphene is a very important material," Lyding said. "The future of electronics may depend on it. The quality of its production is one of the key unsolved problems in nanotechnology. This is a step in the direction of solving that problem." Copper is seen as an ideal substrate for growing graphene because it is cost-effective when it comes to manufacturing, and promotes single-layer graphene growth. Understanding how graphene grows is key to integrating it successfully into manufacturing methods. In this

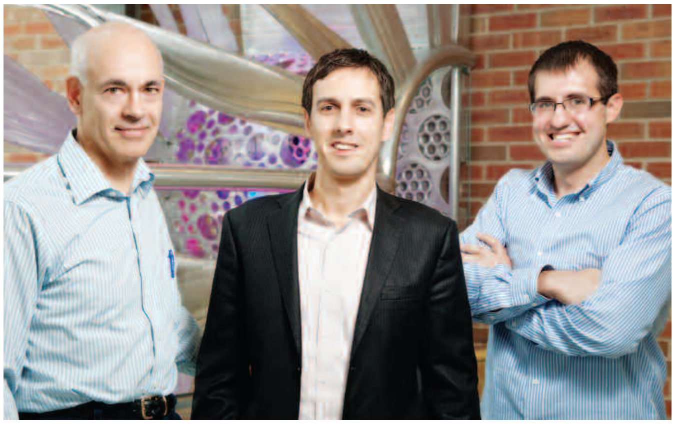


PHOTO BY L. BRIAN STAUFFER.

*Joe Lyding, Eric Pop, and graduate student Josh Wood.*

project, they grew graphene on polycrystalline copper (Cu) and used a suite of imaging methods including scanning electron microscopy (SEM), Raman spectroscopy, and atomic force microscopy (AFM), in making observations of the results. They found that the copper's crystal structure was most important for high-quality graphene growth. "The question is, how do you optimize it while still maintaining cost effectiveness for technological applications?" Pop said. "As a community, we're still writing the cookbook for graphene. We're constantly refining our techniques, trying out new recipes. As with any technology in its infancy, we are still exploring what works and what doesn't."

In another discovery involving graphene, Pop led a project which found that *more* imperfections in graphene used for chemical sensing actually improved the sensitivity of the sensor. They found that the response of graphene chemiresistors used in gas sensors depends on the types and geometry of their defects. "What we determined is that the gases we were sensing tend to bind to the defects," Pop said. "Surface defects in graphene are either point-, wrinkle-, or line-like. We found that the points do not matter very much and the lines are most likely where the sensing happens."

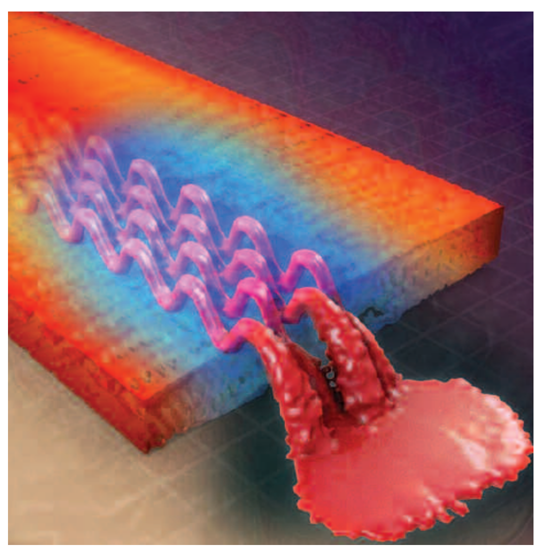
*Image by Li Huey Tan, Yu Xiang, and Yi Lu.*

## DNA Sensors Used to Make Glucose Meter a Multifunctional Testing Tool

**Yi Lu** took a common healthcare product, the personal glucose meter used by people with diabetes to test glucose levels in blood, and applied functional DNA sensors to create a new diagnostic device that could change healthcare testing worldwide. As Lu wrote in the paper reporting the method, "Portable, low-cost and quantitative detection of a broad range of targets at home and in the field has the potential to revolutionize medical diagnostics and environmental monitoring." A personal glucose meter, or PGM, is just such a device but it can only test for glucose. Lu has been a pioneer in using DNA for sensing targets such as lead in paint. In this project he used functional DNA sensors that bind to specific targets but which have mainly been used in expensive laboratory systems. In this new method, Lu employed "functional-DNA-conjugated invertase to link glucose detection to the detection of other targets, and use the concentration of glucose to quantify the other targets of interest present in the samples." The targets, Lu wrote, can "range from recreational drugs such as cocaine to important biological cofactors such as adenosine, as well as disease markers and toxic metal ions (for example, uranium)." Lu said the method "significantly expands the range of targets the glucose monitor can detect. It is simple enough for someone to use at home, without the high costs and long waiting period of going to the clinics or sending samples to professional labs."

## Vascular Composites Created for Multiple Applications

**Nancy Sottos, Scott White,** and **Jeff Moore** had the methods employed by both manufacturers and nature in mind with their development of vascularized structural composites. Synthetic composites, the researchers and their collaborators wrote in reporting their results, "possess high strength-to-weight ratios but lack the dynamic functionality of their natural counterparts" such as bone tissue, that also rely on vascularized networks which "enable a plurality of biological function in both soft and hard tissue" and "exemplify natural materials that are lightweight, high-strength, and capable of mass and energy transport." They answered this industry challenge by creating sacrificial fibers that degrade after fabrication, leaving hollow vascular tunnels for transport of aqueous solutions, organic solvents, and liquid metals. The technology could be used for a variety of applications in materials, from self-healing to self-cooling. Introducing these sacrificial fibers into woven glass fiber preforms, they wrote, enables the "seamless fabrication of 3D microvascular composites that are both strong and multifunctional. The hollow channels produced are high-fidelity inverse replicas of the original fiber's diameter and trajectory. The method has yielded microvascular fiber-reinforced composites with channels over one meter in length that can be subsequently filled with a variety of liquids including aqueous solutions, organic solvents, and liquid metals." They report on using commercially available materials in the process that satisfies manufacturing criteria such as strength, flexibility, and thermal variations. "There have been vascular materials fabricated previously, including things that we've done, but this paper demonstrated that you can approach the manufacturing with a concept that is vastly superior in terms of scalability and commercial viability," White said. "We have a vascularized structural material that can do almost anything."



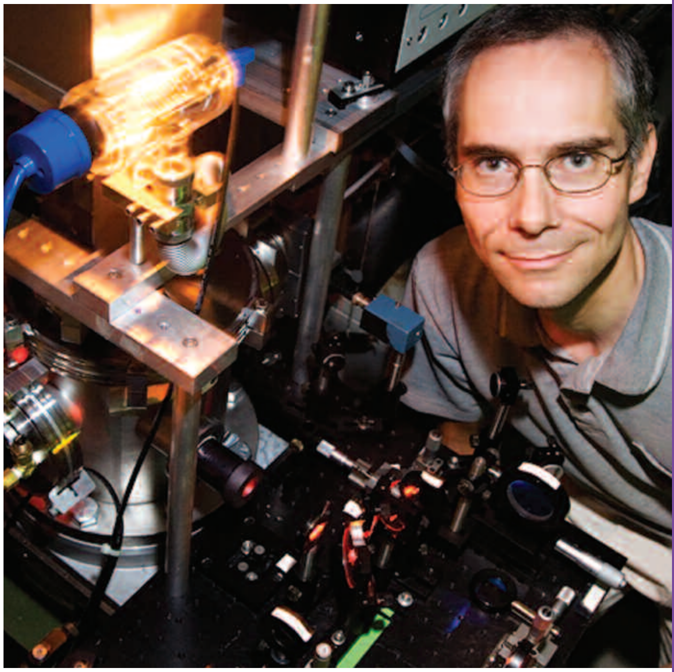
*Researchers developed a class of sacrificial fibers that degrade after composite fabrication, leaving hollow vascular tunnels that can transport liquids or gases through the composite. Image by Piyush Thakre, Alex Jerez, Ryan Durdle, and Jeremy Miller.*

## First Optoelectronically Active 3-D Photonic Crystal

**Paul Braun** led a project that demonstrated the first optoelectronically active 3-D photonic crystal, a discovery that has implications for solar cell and laser technologies, among other applications. "We've discovered a way to change the three-dimensional structure of a well-established semiconductor material to enable new optical properties while maintaining its very attractive electrical properties," Braun said. Researchers have been able to make 3-D photonic crystals that direct light (called optically active) but up until now they have not been able to turn light into electricity or vice versa (electronically active). The photonic crystal produced by Braun and his collaborators including **John Rogers** has both properties. To accomplish it they deposited a single-crystal semiconductor, gallium arsenide (GaAs), through the gaps of a template of tiny spheres to create an intricate three-dimensional structure. To demonstrate the method's optoelectronic capability the group built the first working 3-D photonic crystal LED. The next step is to optimize the technology for a variety of applications by using other semiconductor materials or specific wavelengths.

*Paul Braun and his team demonstrated the first optoelectronically active 3-D photonic crystal.*

PHOTO BY L. BRIAN STAUFFER.



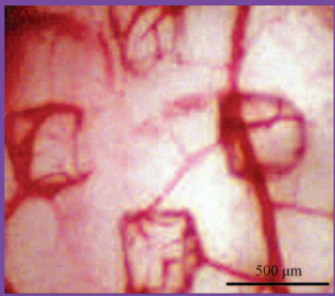
*Martin Gruebele led a group that directly observed two state dynamics in glassy silicon for the first time.*

## Researchers Show that, Yes, Amorphous Silicon is a Glass

**Martin Gruebele** studies one of the oldest — and least understood — materials known to man: glass, an amorphous (or non-crystalline) solid material. On the other hand, amorphous silicon (a-Si) is well-known for its properties useful in applications such as electronics. But what was not known about the semiconductor was whether it should be classified as a glass since it shares some characteristics of glasses but cannot be created by rapid cooling of the liquid phase like conventional glasses. Gruebele joined with Beckman colleague **Joe Lyding**, using the advanced scanning tunneling microscope (STM) created by Lyding, to answer that question. They used the STM to take sub nanometer-resolution images of a-Si created through ion bombardment and vapor growth and pieced them together to form a time-lapse video. They observed a signature property of glass called two-state dynamics, where clusters of atoms hop between two positions. "This is the first time that this type of two-state hopping has been imaged in a-Si," Gruebele said. "It's been predicted by theory and people have inferred it indirectly from other measurements, but this is the first time we're been able to visualize it." The video proved that amorphous silicon is a glass, but in manufacturing it is doped with hydrogen to improve performance. When the researchers introduced hydrogen it quenched the two-state model. In reporting the discovery, the researchers wrote that "our results provide direct evidence for glasslike dynamics on pure a-Si surfaces and its absence on H-passivated surfaces." Gruebele believes the glassy nature of a-Si is worthy of further investigation. "We really need to revisit what the properties of a-Si are," he said. "There could yet be surprises in the way it functions and the kind of things that we might be able to do with it."

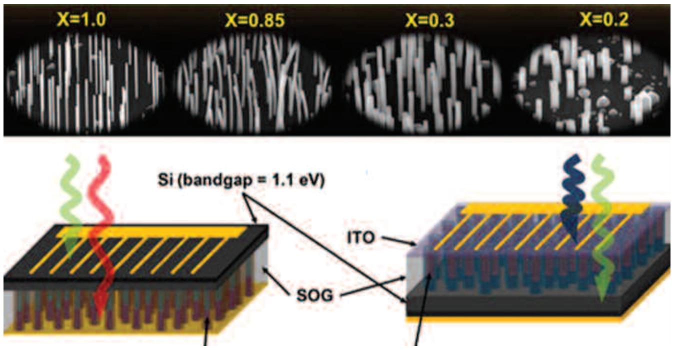
## Bandage for Blood Vessel Growth

**Rashid Bashir** was co-leader of an interdisciplinary, multi-university project that created a bandage which stimulates and directs blood vessel growth on the surface of a wound. The bandage contains living cells that promote and guide blood vessel growth. Using what the researchers call a microvascular stamp, the bandage can pattern functional blood vessels at a never-before-seen scale. "The ability to pattern functional blood vessels at this scale in living tissue has not been demonstrated before," Bashir said. "We can now write features in blood vessels." An advantage of the stamp is that cells release growth factors in a more sustained, targeted manner than other methods. Potential applications include guiding blood vessel growth around a blocked artery and increasing the development of vascular tissues with poor blood flow. This new approach is the first ever to incorporate live cells in a stamp. The project included researchers from three different departments at Illinois in collaboration with MIT and Georgia Tech.




*After the "microvascular stamp" is removed its pattern is revealed in the pattern of blood vessels.*

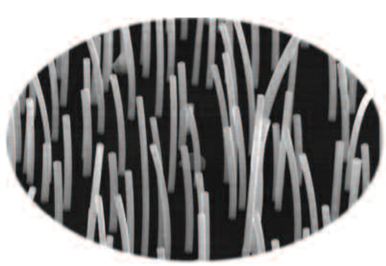
*Photo courtesy of the Micro and Nanotechnology Lab.*




*InGaAs: Solar cells (bottom) made with arrays of nanowires. Engineers can tune the performance by using nanowires of differing composition and thickness. Graphic by Xiuling Li.*

## Advances in Semiconductor Production Methods

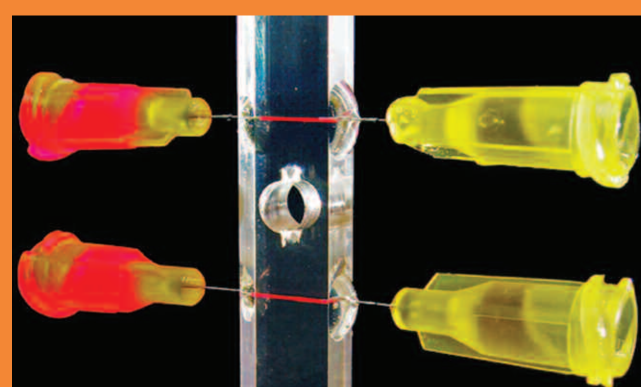
**Xiuling Li** had discoveries in two different areas of semiconductor technology that should improve their manufacture, as well as that of the electronics devices they power. In one research line, Li created a method for etching semiconductors used in optoelectronic devices like solar cells and light-emitting diodes (LEDs). Li used metal-assisted chemical etching to pattern arrays in the semiconductor gallium arsenide, used in many optoelectronics, to create three-dimensional structures for the manufacturing of chips. She used a patterning technique pioneered by Beckman colleague **John Rogers**, joining with him to optimize what is called a soft lithography method for patterning that reduces costs. In another project that also included Rogers, Li and her collaborators created a method for growing semiconductor nanowires on silicon wafers that could improve the manufacturing of solar cells, among other optoelectronic products. Instead of the usual method of depositing a thin film over a silicon wafer (which can cause defects), the new method is based on growing a densely packed array of nanowires, composed of strands of the III-V semiconductor indium gallium arsenide, up vertically from the silicon wafer. Li said the technique is compatible with current manufacturing methods. "This work represents the first report on ternary semiconductor nanowire arrays grown on silicon substrates, that are truly epitaxial, controllable in size and doping, high aspect ratio, non-tapered, and broadly tunable in energy for practical device integration," she said.



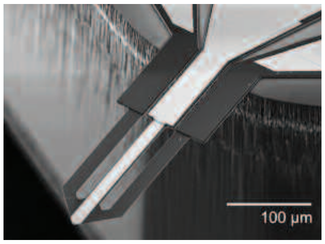
*Xiuling Li's group developed a method for growing semiconductor nanowires on silicon wafers that holds promise for advanced device applications, including solar cells.*

## Pressurized Vascular Systems for Self-healing Materials

One method for self-healing developed by researchers in the Autonomous Materials Systems (AMS) group involves using microvascular systems for self-repair of materials damage, such as cracks in a coating applied to a building or bridge. Typically these systems have relied on capillary force for transport of the healing agents that repair the damage. This past year, **Nancy Sottos** and **Scott White** of AMS demonstrated that an active pumping capability for pressurized delivery of liquid healing agents in microvascular systems significantly improves the degree of healing compared with capillary force methods. The advance was inspired by nature, the researchers wrote: "Fluid flow in these natural vascular systems is typically driven by a pressure gradient induced by the pumping action of a heart, even in primitive invertebrates such as earthworms." To achieve active pumping the researchers experimented with an external "pump" composed of two computer-controlled pressure boxes that allowed for more precise control over the flow of the healing agents, which were fed into two parallel microchannels. They found that active pumping improves the degree of mechanical recovery, and that a continuous flow of healing agents from dynamic pumping extends the repeatability of the self-healing response. Sottos said the study was a first step toward integrating active pumping into microvascular systems. "This set-up could be used with any microvascular network, including the structural composites reported on recently," Sottos said. "In future materials, it would be ideal to have the pumping integrated in the materials itself."



*Vascular epoxy specimen containing two pairs of microchannels (280 microns in diameter) positioned to intersect cracks and release liquid healing agents into regions of damage. Each microchannel contains either a liquid resin (dyed red) or a liquid hardener (dyed blue), which react to form a polymer adhesive upon mixing. Inlets inserted into each microchannel enable connection of the microchannels to external pumps. Specimen height: is 40 mm.*




*Electrothermal cantilever with nanometer-scale electrode tip integrated onto a microheater.*

## First Nanoscale Probe Created for Electronic Measurements

**William King** developed a heated atomic force microscope (AFM) cantilever tip that provides a new way to measure and control electronics. Tips with integrated heaters are used in industry for a wide variety of products and in research labs to study topics such as nanoscale heat flow. The probe developed by King and his collaborators is the first to use a heated nanoscale tip for electronic measurements. "We have developed a new kind of electro-thermal nanoprobe," King said. "Our electro-thermal nanoprobe can independently control voltage and temperature at a nanometer-scale point contact. It can also measure the temperature-dependent voltage at a nanometer-scale point contact." The probe can be used to measure properties of materials such as thermoelectrics and semiconductors at the nanoscale. King has pioneered using AFM for technology such as a "soldering iron" for nanolithography. This tip was different in that there are three electrical paths to the cantilever tip, two carrying heating current, with the third enabling nanoscale electrical measurement. The two electrical paths are separated by a diode junction fabricated into the tip. King said the probes can be used with any atomic force microscope.

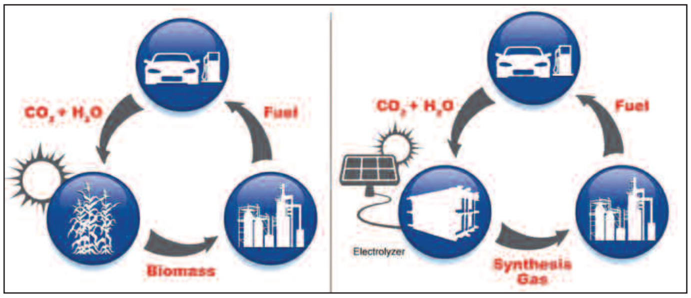
## Solving a Blood Clotting Mystery Using Computer Simulation

*Researchers on the study were (from left): Emad Tajkhorshid, Chad Rienstra, Mary Clay, Rebecca Davis-Harrison, Zenmei Ohkubo, Narjes Tavoosi, Mark Arcario, Taras Pogorelov and James Morrissey. Photo by L. Brian Stauffer.*

**Emad Tajkhorshid** creates dynamic computer simulations of biological processes to gain insights into how nature works at the atomic scale. These simulations — which render "movies" of molecular scales processes such as protein binding — are created with advanced software and large computer arrays in a research area called computational biology. They have provided insights, often for the first time, into workings that have escaped the understanding of scientists using conventional experiments and imaging methods. Tajkhorshid's contribution to a project studying the chemical interactions involved in blood clotting once again provided a never-before-seen view, this time into a chemical interaction that is as critical to blood clotting as that process is to the human body when it comes to response to injury. The computer simulation was able to simulate the interactions of molecules, showing how lipids link to the cell domain in an intricate process that had not been visualized before. "The simulations were a break-through for us," said Professor of Biochemistry James Morrissey, a co-leader of the study with Tajkhorshid. "They provided a detailed view of how things might come together during membrane binding of coagulation factors. This is the first real insight at an atomic level of how most of the blood-clotting proteins interact with membranes, an interaction that's known to be essential to blood clotting. "

## Ionic Liquid Catalyst a Step toward Reducing Fuel Production Costs

A joint effort between industry and the University of Illinois produced a catalyst that greatly reduces the energy requirements of artificial photosynthesis, in a step toward reducing costs and energy in fuel production. Led by **Paul Kenis** and his research group, the collaboration with startup company Dioxide Materials created a catalyst technology that reduces atmospheric carbon dioxide while producing fuel. In artificial photosynthesis, carbon dioxide gas is converted into carbon-based chemicals such as fuels that are usually derived from petroleum. It is an alternative to biofuels, which require transfer of biomass to a refinery. But the process is also energy intensive in the conversion of carbon dioxide into carbon monoxide, the initial step in the fuel manufacturing process. In this project the researchers used an ionic liquid catalyst to mediate the conversion, stabilizing the process and reducing the energy required to drive it. "More work is needed, but this research brings us a significant step closer to reducing our dependence on fossil fuels while simultaneously reducing $CO_2$ emissions that are linked to unwanted climate change," Kenis said.




*Graphics show biofuel production (left) compared to fuel produced via artificial synthesis. Crops takes in $CO_2$, water and sunlight to create biomass, which then is transferred to a refinery to create fuel. In the artificial photosynthesis route, a solar collector or windmill collects energy that powers an electrolyzer, which converts $CO_2$ to a synthesis gas that is piped to a refinery to create fuel. Graphic by Dioxide Materials.*

*Paul Kenis. Photo by L. Brian Stauffer*

# Scott White

*"Jeff (Moore) and Nancy (Sottos) and I are a team. Whatever success I've had is directly attributed to their contributions on that team and we make it work that way."*

*– Scott White*

**Joined Illinois:** 1990
**Department:** Aerospace Engineering
**Joined Beckman:** 2001
**Group:** Autonomous Materials Systems
**Research Focus:** Self-healing materials that autonomically respond to damage such as cracks with healing agents that restore functionality to the system.

# The Power of Persistence

Scott White shares a characteristic with many of his fellow engineers: a seemingly inborn desire to take things apart and see how they work. That also requires persistence, a trait of a more select club White also belongs to, that of the successful scientist/entrepreneur.

The former attribute was revealed around the age of 5 when White dissected whatever caught his attention in his father's garage. The latter quality is what made White a driving force in creating a research line that has now gone worldwide and led to technology that could help prevent everything from bridge collapse to electric vehicle battery failure.

In the 1990s White, a faculty member in the Department of Aerospace Engineering, persuaded a reluctant member of the Department of Chemistry, Jeff Moore, to join a fledgling research collaboration into self-healing materials. White was working with Nancy Sottos from the Department of Materials Science and Engineering on the novel research line and they realized early on that Moore's expertise in chemistry was vital for the project to move forward. Moore wasn't interested but White was persistent, and he eventually joined the team.

"He would say no and I would just come back," White said of their original meetings. "I think, as Jeff would say, I'm a very stubborn guy. As Nancy would say, if I convince myself of something, then I won't give it up. I just don't take no for an answer very well if I believe in it. If I invest myself in something, I'm not going to easily be dissuaded or pointed in a new direction."

What resulted from their collaboration was a new research area into self-healing, or autonomous, materials that is now being pursued by scientists around the world. The three went on to help form the Beckman Institute's Autonomous Materials Systems group, which White now leads.

Their work has broadened from capsules that rupture and release a healing agent in response to damage of a material, to autonomous microvascular systems and, recently, to self-healing for electrical storage systems, with a focus on batteries for electrical vehicles. Their ongoing collaboration is one of the longer and more successful ones on campus, and distinctive in that it involves three core members instead of two.

"Jeff and Nancy and I are a team," White said. "Whatever success I've had is directly attributed to their contributions on that team and we make it work that way. It's pretty unique and I think I've yet to see another group that emulates that. I'm very thankful that we've found each other."

White was also persistent when it came to taking autonomous technology to the real world, after being rebuffed by large corporations he first approached with the research. He saw self-healing as a way to prevent catastrophic events like the Minnesota interstate bridge collapse, believing the technology could be used in coatings to prevent small cracks from turning into larger structural damage.

When industry didn't listen, White led a drive to create a start-up company, Autonomic Materials, Inc. (AMI), that is now working with Fortune 500 companies to develop products to be released within the next year or two.

Self-healing is research that is sharply different from White's original work when he joined the University of Illinois in 1990 with a Ph.D. in engineering and mechanics from Penn State and a focus on composite materials. When that first paper on self-healing came out in *Nature* in 2001, it received worldwide attention and White's career took an immediate turn.

"It changed almost overnight," he said. "If you look at the portfolio of the research I was involved with before that and afterwards, it has changed completely. The kind of research that I did for my Ph.D. is no longer represented in our group. Now it's all focused on self-healing systems, microvascular systems, and battery technologies.

"More importantly, it really opened my eyes to doing exceptional work that has far reaching impact. So, basically, that's what I'm motivated by now. I'm not really interested in doing incremental work that just continues to optimize some particular aspect of the research. I really want to make a huge impact and spend the amount of time I have left in my career doing the kind of research that has transformative effects."

White envisions a research future that includes not just self-healing but a new line built around regeneration of materials systems. If it can be made to work, it's a good bet White will make it happen and have another new research line.

"I don't like the status quo and I think a lot of times we get comfortable with what we're doing," he said. "But you don't make transformative and impactful things by being comfortable."

# Strategic Initiatives

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 seeks to integrate robust, long-term research lines such as the Beckman-led studies of the beneficial effects of exercise on cognitive aging with the goal of promoting health and wellness throughout our lives. 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 concerns the effects cognitive and emotional health play in healthcare decisions such as choices made in determining medical treatments. Bioimaging seeks to take advantage of the world-renowned strength in imaging science at Beckman and the University of Illinois toward advancing research involving topics like brain changes associated with cognition and emotional states, development of biomarkers for disease, and development of computational models. HABITS is led by Beckman faculty Kara Federmeier and Rohit Bhargava.

## Strategic Initiative on Imaging

The Beckman Institute is home to the Strategic Initiative on Imaging, led by Integrative Imaging research theme co-chair Stephen Boppart. This initiative is focusing campus efforts in developing and using imaging technologies for scientific, industry, and biomedical applications. It serves to bring together people, knowledge, and resources in an area in which the University of Illinois has been a leader. Illinois imaging researchers have played key roles in advancing mature modalities like magnetic resonance imaging (developed by Nobel Prize winner Paul Lauterbur, founder of Beckman's Biomedical Imaging Center, BIC) and ultrasound, as well as advancing current, cutting-edge techniques and devices, such as those involving optical imaging. The Strategic Initiative on Imaging includes more than 100 faculty members from many different departments on campus, either developing new imaging techniques, using imaging in research, and some who do both. They come from fields as diverse as astronomy, biology, the arts, and computation. Resources supporting these efforts include, among others, BIC and Beckman's other core facilities, the Illinois Simulator Laboratory and the Imaging Technology Group, and the National Center for Supercomputing Applications.

## Social Dimensions of Environmental Policy (SDEP)

The Social Dimensions of Environmental Policy (SDEP) strategic initiative has a mission of understanding the social and political-economic forces shaping just and sustainable environmental policy, while seeking to improve management of earth's environment through research on social and policy dimensions of sustainability. SDEP does social-science research involving the causes of environmental change, the causes of social problems related to the environment, and the making, implementation, and effects of policy solutions on society and the environment, with a goal of contributing to sound solutions to environmental issues. SDEP houses two research programs. The Program on Democracy and Environmental Policy does 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 responses to global environmental change. The Social Dimensions of Environmental Policy (SDEP) strategic initiative is led by Beckman Institute faculty member Jesse Ribot.


BECKMAN
UNIVERSITY OF ILLINOIS

# BioIntel Selected Faculty Awards, Patents, Grants, and Publications

*Covering July 1, 2011 – June 30, 2012*

## BIOLOGICAL INTELLIGENCE FACULTY

*(name followed by home department)*

**Cognitive Neuroscience**

Aron Barbey, *Applied Health Sciences*
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, *Applied Health Sciences*
Torrey M. Loucks, *Speech and Hearing Science*
Gregory A. Miller, *Psychology*
Richard S. Powers, *English*
Sharon Y. Tettegah, *Curriculum and Instruction*

**Cognitive Science**

Aaron S. Benjamin, *Psychology*
J K. Bock, *Psychology*
Sarah Brown-Schmidt, *Psychology*
Kiel Christianson, *Educational Psychology*
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*
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, *Molecular and Integrative Physiology*
Mark E. Nelson, *Molecular and Integrative Physiology*
Justin S. Rhodes, *Psychology*
Gene E. Robinson, *Entomology*
Edward J. Roy, *Psychology*
Taher Saif, *Mechanical Science and Engineering*
Jonathan V. Sweedler, *Chemistry*

## BIOINTEL SELECTED HONORS AND AWARDS

Florin Dolcos

- Best Paper Award from the Journal of Cognitive Psychology, 2011

Kara Federmeier

- Fellow, Association for Psychological Science, 2012

J Kathryn Bock

- Election to Society of Experimental Psychologists, 2011

Gary Dell

- Fellow, Society of Experimental Psychologists, 2012

Jonathan Sweedler

- Director, School of Chemical Sciences, effective August 2012
- Ralph N. Adams Award, The Pittsburgh Conference, 2012
- Fellow, American Chemical Society, 2011

## BIOINTEL INVENTION DISCLOSURES

Faculty members from the Biological Intelligence research theme were inventors on one invention disclosure (0.4% of the 223 invention disclosures filed by campus) during FY2012.

## BIOINTEL SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the Biological Intelligence research theme were inventors on the following patent filed (0.5% of the 192 patents issued to campus) during FY2012 (Beckman Institute BioIntel faculty members are listed in bold):

**Monica Fabiani**, **Gabriele Gratton**, Kathy Low and Edward Maclin, "Non-Invasive Optical Imaging for Measuring Pulse and Arterial Elasticity in the Brain," Patent filed April 26, 2012, Application Number 13/504,401.

## BIOINTEL GRANTS AWARDED

**($11,345,978)**

**Gabriele Gratton**, Ed Maclin and **Monica Fabiani**, NIH/ISS, "Opticortex: A Full-Head Non-Invasive Functional Optical Brain Imaging Device," 7/1/2010 – 6/30/2012, $116,688.

**Rachel Kohman**, NIH, "Therapeutic Interventions for Brain-Immune Interactions During Cognitive Aging," 7/1/2011 – 6/30/2016, $172,422.

**Neal Cohen** and **Joel Voss**, NIH/Boston University, "Neuropsychological Analysis of PFC-MTL Functional Interactions in Humans," 9/6/2011 – 6/30/2016, $1,228,859.

**Neal Cohen**, **Arthur Kramer** and **Gene Robinson**, Abbott Laboratories, "Grand Challenge-Admin/Web Development," 11/1/2011 – 12/31/2016, $1,782,626.

**Lee Cox** and **Deepa Venkitaramani**, University of Indiana, "Recovery of Cellular Function in Fragile X Syndrome by Acamprostate Treatment," 1/1/2012 – 6/30/2012, $10,000.

**Gabriele Gratton, Monica Fabiani**, Renee Baillargeon and **Cynthia Fisher**, Abbott Laboratories, "Development of a Methodology for Investigating the Effects of Nutrition on the Maturation of Brain Networks Associated with Memory and Language in Infants," 5/16/2012 – 5/15/2014, $408,229.

Joshua Gulley and **Janice Juraska**, Abbott Laboratores, "The Effects of a Bioactive Nutrient on Cognitive Functioning in an Animal Model of Normal Aging," 5/16/2012 – 5/15/2014, $598,908.

**Aron Barbey**, **Neal Cohen**, Janet Jokela, **Art Kramer**, **Dan Llano**, **Brad Sutton**, **John Wang** and **Gene Robinson**, "Nutritional Intake, Cognitive Function, and Measures of Brain Aging," 5/16/2012 – 5/15/2015, $1,315,148.

**Neal Cohen**, **Art Kramer**, **Charles Hillman**, Renee Baillargeon and **John Wang**, Abbott Laboratories, "Optimizing Assessment Tools for Determining Nutritional Enhancement of Learning and Memory," 5/16/2012 – 5/15/2015, $715,909.

**Gabriel Gratton** and **Monica Fabiani**, Abbott Laboratories, "Cognitive and Brain Development in Premature Infants," 5/16/2012 – 5/15/2015, $1,040,067.

**Justin Rhodes**, Abbott Laboratories, "Mouse Cognition Core Facility," 5/16/2012 – 5/15/2015, $1,519,355.

Jeffrey Woods, Rod Johnson, **Justin Rhodes**, Keith Kelley and Robert McCusker, Abbott Laboratories, "Enhancing Learning and Memory in the Aged: Interactions between Dietary Supplementation and Exercise," 5/16/2012 – 5/15/2015, $1,450,542.

William Helferich, Hong Chen, **Ed Roy**, Taekjip Ha, Rodney Johnson and **Justin Rhodes**, Abbott Laboratories, "Molecular Basis of Cognitive Impairment in 'ChemoBrain' and Nutritional Intervention," 5/16/2012 – 5/15/2015, $987,225.

## BIOINTEL SELECTED PUBLICATIONS

Amaya, K. R.; **Sweedler, J. V.**; **Clayton, D. F.**, Small Molecule Analysis and Imaging of Fatty Acids in the Zebra Finch Song System Using Time-of-Flight-Secondary Ion Mass Spectrometry. *Journal of Neurochemistry* **2011**, *118*, (4), 499-511.

**Anastasio, T. J.**, Data-Driven Modeling of Alzheimer Disease Pathogenesis. *Journal of Theoretical Biology* **2011**, *290,* 60-72.

**Barbey, A. K.**; Colom, R.; Solomon, J.; Krueger, F.; Forbes, C.; Grafman, J., An Integrative Architecture for General Intelligence and Executive Function Revealed by Lesion Mapping. *Brain* **2012**, *135,* 1154-1164.

Blackwell, E.; **Ceman, S.**, A New Regulatory Function of the Region Proximal to the Rgg Box in the Fragile X Mental Retardation Protein. *Journal of Cell Science* **2011**, *124,* (18), 3060-3065.

**Bock, J. K.**, How Much Correction of Syntactic Errors Are There, Anyway? *Language and Linguistics Compass* **2011**, *5,* 322-335.

Brumback Peltz, C. R.; **Gratton, G.**; **Fabiani, M.**, Age-Related Changes in Electrophysiological and Neuropsychological Indices of Working Memory, Attention Control, and Cognitive Flexibility. *Frontiers in Cognition* **2011**, *2,* 190.

Carignan, C.; **Shosted, R.**; **Shih, C. L.**; Rong, P. Y., Compensatory Articulation in American English Nasalized Vowels. *Journal of Phonetics* **2011**, *39,* (4), 668-682.

Chambers, K. E.; Onishi, K. H.; **Fisher, C.**, Representations for Phonotactic Learning in Infancy. *Language Learning and Development* **2011**, *7,* 287-308.

**Christianson, K.**; Luke, S. G., Context Strengthens Initial Misinterpretations of Text. *Scientific Studies of Reading* **2011**, *15,* (2), 136-166.

**Dell, G.**; Kittredge, A., Connectionist Models of Aphasia and Other Language Impairments, In *Handbook of Psycholinguistic and Cognitive Processes: Perspectives in Communication Disorders*; Guendouzi, J., Loncke, F., Williams, M. J., Eds. **2011**, 169-188.

**Dolcos, F.**; Iordan, A. D.; Dolcos, S., Neural Correlates of Emotion-Cognition Interactions: A Review of Evidence from Brain Imaging Investigations. *Journal of Cognitive Psychology* **2011**, *23,* (6), 669-694.

Duff, M. C.; **Brown-Schmidt, S.**, The Hippocampus and the Flexible Use and Processing of Language. *Frontiers in Human Neuroscience* **2012***, 6,* DOI: 10.3389/fnhum.2012.00069.

Fossat, P.; Turpin, F. R.; Sacchi, S.; Dulong, J.; Shi, T.; Rivet, J. M.; **Sweedler, J. V.**; Pollegioni, L.; Millan, M. J.; Oliet, S. H. R.; Mothet, J. P., Glial D-Serine Gates Nmda Receptors at Excitatory Synapses in Prefrontal Cortex. *Cerebral Cortex* **2012**, *22,* (3), 595-606.

**Galvez, R.**; Nicholson, D. A.; Disterhoft, J. F., Physiological and Anatomical Studies of Associative Learning: Convergence with Learning Studies of W.T. Greenough. *Developmental Psychobiology* **2011**, *53,* (5), 489-504.

Hannula, D. E.; Baym, C. L.; Warren, D. E.; **Cohen, N. J.**, The Eyes Know: Eye Movements as a Veridical Index of Memory. *Psychological Science* **2012**, *23,* (3), 278-287.

Hayes, J. P.; LaBar, K. S.; McCarthy, G.; Selgrade, E.; Nasser, J.; **Dolcos, F.**; Morey, R. A., Reduced Hippocampal and Amygdala Activity Predicts Memory Distortions for Trauma Reminders in Combat-Related PTSD. *Journal of Psychiatric Research* **2011**, *45,* (5), 660-669.

Huang, H. W.; Meyer, A. M.; **Federmeier, K. D.**, A "Concrete View" of Aging: Event Related Potentials Reveal Age-Related Changes in Basic Integrative Processes in Language. *Neuropsychologia* **2012**, *50,* (1), 26-35.

Janes, D. E.; Chapus, C.; Gondo, Y.; **Clayton, D. F.**; Sinha, S.; Blatti, C. A.; Organ, C. L.; Fujita, M. K.; Balakrishnan, C. N.; Edwards, S. V., Reptiles and Mammals Have Differentially Retained Long Conserved Noncoding Sequences from the Amniote Ancestor. *Genome Biology and Evolution* **2011**, *3,* 102-113.

Kohman, R. A.; Rodriguez-Zas, S. L.; Southey, B. R.; Kelley, K. W.; Dantzer, R.; **Rhodes, J. S.**, Voluntary Wheel Running Reverses Age-Induced Changes in Hippocampal Gene Expression. *PLoS One* **2011***, 6,* DOI: 10.1371/journal.pone.0022654.

Kuchinsky, S. E.; **Bock, J. K.**; **Irwin, D. E.**, Reversing the Hands of Time: Changing the Mapping from Seeing to Saying. *Journal of Experimental Psychology: Learning, Memory, and Cognition* **2011**, *37,* 748-756.

Kutas, M.; **Federmeier, K. D.**, Thirty Years and Counting: Finding Meaning in the N400 Component of the Event-Related Brain Potential (ERP), In *Annual Review of Psychology*; Fiske, S. T., Schacter, D. L., Taylor, S. E., Eds. **2011**; Vol. 62, 621-647.

Maclin, E. L.; Mathewson, K. E.; Low, K. A.; Boot, W. R.; **Kramer, A. F.**; **Fabiani, M.**; **Gratton, G.**, Learning to Multitask: Effects of Video Game Practice on Electrophysiological Indices of Attention and Resource Allocation. *Psychophysiology* **2011**, *48,* (9), 1173-1183.

Mathewson, K. E.; **Lleras, A.**; D.M., B.; **Fabiani, M.**; Ro, T.; **Gratton, G.**, Pulsed out of Awareness: EEG Alpha Oscillations Represent a Pulsed Inhibition of Ongoing Cortical Processing. *Frontiers in Perception Science* **2011**, *2,* 99.

**Mestre, J. P.**; Docktor, J. L.; Strand, N. E.; **Ross, B. H.**, Conceptual Problem Solving in Physics, In *Psychology of Learning and Motivation: Cognition in Education*; **Mestre, J. P.**, **Ross, B. H.**, Eds. **2011**; Vol. 55, 269-298.

**Nelson, M. E.**, Electric Fish. *Current Biology* **2011**, *21,* (14), R528-R529.

Parks, N. A.; Maclin, E. L.; Low, K. A.; **Beck, D. M.**; **Fabiani, M.**; **Gratton, G.**, Examining Cortical Dynamics and Connectivity with Simultaneous Single-Pulse Transcranial Magnetic Stimulation and Fast Optical Imaging. *Neuroimage* **2012**, *59,* (3), 2504-2510.

Rubin, R. D.; **Brown-Schmidt, S.**; Duff, M. C.; Tranel, D.; **Cohen, N. J.**, How Do I Remember That I Know You Know That I Know? *Psychological Science* **2011**, *22,* (12), 1574-1582.

Spielberg, J. M.; **Miller, G. A.**; Warren, S. L.; Engels, A. S.; Crocker, L. D.; **Sutton, B. P.**; **Heller, W.**, Trait Motivation Moderates Neural Activation Associated with Goal Pursuit. *Cognitive Affective & Behavioral Neuroscience* **2012**, *12,* (2), 308-322.

Voss, J. L.; Galvan, A.; **Gonsalves, B. D.**, Cortical Regions Recruited for Complex Active-Learning Strategies and Action Planning Exhibit Rapid Reactivation During Memory Retrieval. *Neuropsychologia* **2011**, *49,* (14), 3956-3966.

Voss, J. L.; Warren, D. E.; **Gonsalves, B. D.**; **Federmeier, K. D.**; Tranel, D.; **Cohen, N. J.**, Spontaneous Revisitation During Visual Exploration as a Link among Strategic Behavior, Learning, and the Hippocampus. *Proceedings of the National Academy of Sciences of the United States of America* **2011**, *108,* (31), E402-E409.

Voss, M. W.; Chaddock, L.; Kim, J. S.; Vanpatter, M.; Pontifex, M. B.; Raine, L. B.; **Cohen, N. J.**; **Hillman, C. H.**; **Kramer, A. F.**, Aerobic Fitness Is Associated with Greater Efficiency of the Network Underlying Cognitive Control in Preadolescent Children. *Neuroscience* **2011**, *199,* 166-176.

Walther, D. B.; **Beck, D. M.**; Li, F. F., To Err Is Human: Correlating FMRI Decoding and Behavioral Errors to Probe the Neural Representation of Natural Scene Categories, In *Visual Population Codes: Toward a Common Multivariate Framework for Cell Recording and Functional Imaging*; Kriegeskorte, N., Kreiman, G., Eds. **2012**, 391-415.

Yang, S.; **Cox, C. L.**; **Llano, D. A.**; **Feng, A. S.**, Cell's Intrinsic Biophysical Properties Play a Role in the Systematic Decrease in Time-Locking Ability of Central Auditory Neurons. *Neuroscience* **2012**, *208,* 49-57.

Zombeck, J. A.; DeYoung, E. K.; Brzezinska, W. J.; **Rhodes, J. S.**, Selective Breeding for Increased Home Cage Physical Activity in Collaborative Cross and Hsd:ICR Mice. *Behavior Genetics* **2011**, *41,* (4), 571-582.

# HCII Selected Faculty Awards, Patents, Grants, and Publications

## HCII FACULTY

*(name followed by home department)*

### Artificial Intelligence

Narendra Ahuja, *Electrical and Computer Engineering*
Jont Allen, *Electrical and Computer Engineering*
Eyal Amir, *Computer Science*
Timothy W. Bretl, *Aerospace Engineering*
Gerald F. Dejong, *Computer Science*
Roxanna 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 Portugese*
Dan Roth, *Computer Science*
Ryan K. Shosted, *Linguistics*
Paris Smaragdis, *Computer Science*

### Human Perception and Performance

Matthew Dye, *Speech and Hearing Science*
Wai-Tat Fu, *Human Factors Division*
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, *Human Factors Division*
Arthur F. Kramer, *Psychology*
Charissa Lansing, *Speech and Hearing Science*
Alejandro Lleras, *Psychology*
Edward McAuley, *Kinesiology and Community Health*
Jason McCarley, *Psychology*
Deana C. McDonagh, *Industrial Design*
Daniel G. Morrow, *Human Factors Division*
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*
Yi Ma, *Electrical and Computer Engineering*
Pierre Moulin, *Electrical and Computer Engineering*
Klara Nahrstedt, *Computer Science*

## HCII SELECTED HONORS AND AWARDS

Mark Hasegawa-Johnson

- Fellow, Acoustical Society of America, 2011

Daniel Simons

- Fellow, Association for Psychological Science, 2012

## HCII INVENTION DISCLOSURES

Faculty members from the Human-Computer Intelligent Interaction research theme were inventors on three invention disclosures (1.3% of the 223 invention disclosures filed by campus) during FY2012.

## HCII SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the Human-Computer Intelligent Interaction research theme were inventors on the following two patent applications (1.0% of the 192 patent applications filed by the campus) and two patents issued (2.6% of the 76 patents issued to campus) during FY2012 (Beckman Institute HCII faculty members are listed in bold):

**Minh Do**, Robert Morrison and David Munson, "Synthetic Aperture Focusing Techniques," Patent filed August 31, 2011, Application Number 13/222,770.

**Jont Allen** and Marion Regnier, "Speech and Method for Identifying Perceptual Features," Patent issued October 25, 2011, Patent Number 8,046,218.

Ashvin George and **Yoram Bresler**, "Fast Hierachical Tomography Methods and Apparatus," Patent issued February 21, 2012, Patent Number 8,121,378.

Sevket Babacan, **Minh Do**, Gabriel Popescu and Zhuo Wang, "Sparse Deconvolution Spatial Light Microscopy in Two and Three Dimensions," Patent filed May 31, 2012, Application Number 61/653,460.

## HCII GRANTS AWARDED

**($8,338,256)**

**Arthur Kramer** and **Edward McAuley**, NIH, "Influence of Fitness on Brain and Cognition," 7/15/2010 – 6/30/2015, $10,000.

**Roxanna Girju**, State Farm, "A Text-to-Scene Conversion and Visualization System for Car Accident Reports," 5/16/2011 – 5/15/2012, $94,107.

**Tim Bretl** and **Seth Hutchinson**, NSF, "CPS:Small:Mathematical Computational and Perceptual Foundations for Interactive Cyber-Physical Systems," 8/8/2011 – 8/31/2012, $15,474.

**Mark Hasegawa-Johnson**, **Thomas Huang, Henry Kaczmarski** and **Camille Goudeseune**, NSF, "Fodava-Partner: Visualizing Audio for Anomaly Detection," 9/1/2011 – 8/31/2013, $343,857.

**Arthur Kramer**, ONR/KSU, "A New Measure of the Useful Field of View (UFOV): The Gaze-Contigent Peripheral Blue Detection Task," 10/1/2011 – 9/30/2014, $551,432.

**Matthew Dye**, **Monica Fabiani** and **Gabriele Gratton**, NSF/Gallaudet, "Optical Imaging of Visual Selective Attention in Deaf Adults," 10/1/2011 – 9/30/2013, $164,000.

**Stephen Levinson**, Sandia National Laboratories, "Computational Models of Neurals Dynamics," 1/1/2012 – 8/15/2012, $35,197.

**Arthur Kramer**, **Charles Hillman** and **Neal Cohen**, "Enhancing Children's Cognitive and Brain Health Through Physical Activity Training," 4/1/2012 – 3/31/2017, $3,075,701.

**Erik Johnson**, Borroughs Wellcome Fund, "Developing Localization Algorithms for Extracellular Neural Recordings," 5/16/2012 – 12/31/2012, $5,845.

**Charles Hillman**, **Neal Cohen**, Sharon Donovan and Naiman Khan, Abbott Laboratories, "The Effects of Fortified Nutritional Supplementation on Cognition, Memory, and Achievement," 5/16/2012 – 5/15/2015, $1,547,371.

**Arthur Kramer**, George Fahey, **Eddie McAuley**, **Neal Cohen** and Jeffrey Woods, Abbott Laboratories, "Synergistic Effects of Exercise and Nutrition on Cognition and Brain Health of Older Adults: A Randomized Controlled Trial," 5/16/2012 – 5/15/2015, $2,495,272.

## HCII SELECTED PUBLICATIONS


Babacan, S. D.; Wang, Z.; **Do, M.**; **Popescu, G.**, Cell Imaging Beyond the Diffraction Limit Using Sparse Deconvolution Spatial Light Interference Microscopy. *Biomedical Optics Express* **2011**, *2*, (7), 1815-1827.

Becker, A.; **Bretl, T.**, Motion Planning under Bounded Uncertainty Using Ensemble Control, In *Robotics: Science and Systems Vi*; Matsuoka, Y., Durrant Whyte, H., Neira, J., Eds. **2011**, 299-306.

Bhattacharya, S.; **Hutchinson, S.**, A Cell Decomposition Approach to Visibility-Based Pursuit Evasion among Obstacles. *International Journal of Robotics Research* **2011**, *30*, (14), 1709-1727.

Bielski, L. M.; **Lansing, C. R.**, Utility of the Baddeley and Hitch Model of Short-Term Working Memory to Investigate Spoken Language Understanding: A Tutorial. *Perspectives on Aural Rehabilitation and Its Instrumentation* **2012**, *19,* 25-33.

Bredemeier, K.; **Simons, D. J.**, Working Memory and Inattentional Blindness. *Psychonomic Bulletin & Review* **2012**, *19,* (2), 239-244.

**Bretl, T.**, Minimum-Time Optimal Control of Many Robots That Move in the Same Direction at Different Speeds. *IEEE Transactions on Robotics* **2012**, *28,* (2), 351-363.

Burns, C.; **Wang, R. F.**; Stipanovi, D. M., A Study of Human and Receding Horizon Controller Performance of a Remote Navigation Task with Obstacles and Feedback Delays. *Paladyn: Journal of Behavioral Robotics* **2011**, 2(1), 44-63.

Carignan, C.; **Shosted, R.**; **Shih, C. L.**; Rong, P. Y., Compensatory Articulation in American English Nasalized Vowels. *Journal of Phonetics* **2011**, *39,* (4), 668-682.

Chaddock, L.; Erickson, K. I.; Prakash, R. S.; Voss, M. W.; VanPatter, M.; Pontifex, M. B.; **Hillman, C. H.**; **Kramer, A. F.**, A Functional MRI Investigation of the Association between Childhood Aerobic Fitness and Neurocognitive Control. *Biological Psychology* **2012**, *89,* (1), 260-268.

Chin, J.; **Morrow, D. G.**; **Stine-Morrow, E. A. L.**; Conner-Garcia, T.; Graumlich, J. F.; Murray, M. D., The Process-Knowledge Model of Health Literacy: Evidence from a Componential Analysis of Two Commonly Used Measures. *Journal of Health Communication* **2011**, *16,* 222-241.

Erickson, K. I.; Voss, M. W.; Prakash, R. S.; Basak, C.; Szabo, A.; Chaddock, L.; Kim, J. S.; Heo, S.; Alves, H.; White, S. M.; Wojcicki, T. R.; Mailey, E.; Vieira, V. J.; Martin, S. A.; Pence, B. D.; Woods, J. A.; **McAuley, E.**; **Kramer, A. F.**, Exercise Training Increases Size of Hippocampus and Improves Memory. *Proceedings of the National Academy of Sciences of the United States of America* **2011**, *108,* (7), 3017-3022.

Erickson, K. I.; Weinstein, A. M.; **Sutton, B. P.**; Prakash, R. S.; Voss, M. W.; Chaddock, L.; Szabo, A. N.; Mailey, E. L.; White, S. M.; Wojcicki, T. R.; **McAuley, E.**; **Kramer, A. F.**, Beyond Vascularization: Aerobic Fitness Is Associated with N-Acetylaspartate and Working Memory. *Brain Behavior* **2012**, *2,* (1), 32-41.

**Fu, W. T.**, A Dynamic Context Model of Interactive Behavior. *Cognitive Science* **2011**, *35,* (5), 874-904.

Huang, Y. W.; **Moulin, P.**, On the Saddle-Point Solution and the Large-Coalition Asymptotics of Fingerprinting Games. *IEEE Transactions on Information Forensics and Security* **2012**, *7,* (1), 160-175.

Kannampallil, T. G.; Waicekauskas, K.; **Morrow, D. G.**; Kopren, K. M.; **Fu, W.-T.**, External Tools for Collaborative Medication Scheduling, In *Cognition, Technology & Work*; Springer-Verlag, London, **2011**.

Kapoor, A.; **Allen, J. B.**, Perceptual Effects of Plosive Feature Modification. *Journal of the Acoustical Society of America* **2012**, *131,* (1), 478-491.

Ma, R.; Aghasadeghi, N.; Jarzebowski, J.; **Bretl, T.**; Coleman, T. P., A Stochastic Control Approach to Optimally Designing Hierarchical Flash Sets in P300 Communication Prostheses. *IEEE Transactions on Neural Systems and Rehabilitation Engineering* **2012**, *20,* (1), 102-112.

Mathur, S.; Poole, M. S.; Feniosky, P. M.; **Hasegawa-Johnson, M.**; Contractor, N., Detecting Interaction Links in a Collaborating Group Using Manually Annotated Data. *Social Networks* **2012**, DOI: doi:10.1016/j.socnet.2012.04.002.

**McDonagh, D.**; Formosa, D. *Designing for Everyone, One Person at a Time*, **2011**, 91-100.

Min, D. B.; Lu, J. B.; **Do, M. N.**, Depth Video Enhancement Based on Weighted Mode Filtering. *IEEE Transactions on Image Processing* **2012**, *21,* (3), 1176-1190.

**Morrow, D.**, Expertise and Age Differences in Pilot Decision Making. *Gerontologist* **2011**, *51,* 552-552.

Nguyen, N.; **Jones, D. L.**; Yang, Y. C.; Liu, C., Flow Vision for Autonomous Underwater Vehicles Via an Artificial Lateral Line. *EURASIP Journal on Advances in Signal Processing* **2011**, DOI: 10.1155/2011/806406.

Ozbek, I. Y.; **Hasegawa-Johnson, M.**; Demirekler, M., Estimation of Articulatory Trajectories Based on Gaussian Mixture Model (Gmm) with Audio-Visual Information Fusion and Dynamic Kalman Smoothing. *IEEE Transactions on Audio Speech and Language Processing* **2011**, *19,* (5), 1180-1195.

Payne, B. R.; Jackson, J. J.; Hill, P. L.; Gao, X. F.; Roberts, B. W.; **Stine-Morrow, E. A. L.**, Memory Self-Efficacy Predicts Responsiveness to Inductive Reasoning Training in Older Adults. *Journals of Gerontology Series B-Psychological Sciences and Social Sciences* **2012**, *67,* (1), 27-35.

Pham, H.; Ding, H. F.; Sobh, N.; **Do, M.**; Patel, S.; **Popescu, G.**, Off-Axis Quantitative Phase Imaging Processing Using Cuda: Toward Real-Time Applications. *Biomedical Optics Express* **2011**, *2,* (7), 1781-1793.

Qi, G. J.; Aggarwal, C.; Tian, Q.; Ji, H.; **Huang, T. S.**, Exploring Context and Content Links in Social Media: A Latent Space Method. *IEEE Transactions on Pattern Analysis and Machine Intelligence* **2012**, *34,* (5), 850-862.

**Shosted, R. K.**, An Articulatory-Aerodynamic Approach to Stop Excrescence. *Journal of Phonetics* **2011**, *39,* (4), 660-667.

Shu, X. B.; Gao, C. Y.; **Ahuja, N.**, Aperture Access and Manipulation for Computational Imaging. *Computer Vision and Image Understanding* **2012**, *116,* (2), 222-237.

**Smaragdis, P.**; Raj, B., The Markov Selection Model for Concurrent Speech Recognition. *Neurocomputing* **2012**, *80,* 64-72.

Tang, H.; Chu, S. M.; **Hasegawa-Johnson, M.**; **Huang, T. S.**, Partially Supervised Speaker Clustering. *IEEE Transactions on Pattern Analysis and Machine Intelligence* **2012**, *34,* (5), 959-971.

Wan, X.; **Wang, R. F.**; Crowell, J. A., The effect of landmarks in human path integration. *Acta Psychologica* **2012**, 140(1), 7-12.

Wan, X. A.; Voss, M.; **Lleras, A.**, Age-Related Effects in Inter-Trial Inhibition of Attention. *Aging Neuropsychology and Cognition* **2011**, *18,* (5), 562-576.

Yang, Q. X.; **Ahuja, N.**, Surface Reflectance and Normal Estimation from Photometric Stereo. *Computer Vision and Image Understanding* **2012**, *116,* (7), 793-802.

Yoon, Y. S.; **Allen, J. B.**; Gooler, D. M., Relationship between Consonant Recognition in Noise and Hearing Threshold. *Journal of Speech Language and Hearing Research* **2012**, *55,* (2), 460-473.

Zhuang, X. D.; Zhou, X.; **Hasegawa-Johnson, M. A.**; **Huang, T. S.**, Efficient Object Localization with Variation-Normalized Gaussianized Vectors, In *Intelligent Video Event Analysis and Understanding*; Zhang, J., Shao, L., Zhang, L., Jones, G. A., Eds. **2011**; Vol. 332, 93-109.

# INTIM Selected Faculty Awards, Patents, Grants, and Publications

*Covering July 1, 2011 – June 30, 2012*

## INTEGRATIVE IMAGING FACULTY

*(name followed by home department)*

**Bioacoustics Research Laboratory**

William D. O'Brien, *Electrical and Computer Engineering*
Michael L. Oelze, *Bioengineering*
Douglas Simpson, *Statistics*

**Bioimaging Science and Technology**

Rohit Bhargava, *Bioengineering*
Marni Boppart, *Kinesiology and Community Health*
Stephen Boppart, *Electrical and Computer Engineering*
Scott Carney, *Electrical and Computer Engineering*
Jianjun Cheng, *Materials Science and Engineering*
Lynford Goddard, *Electrical and Computer Engineering*
Princess Imoukhuede, *Bioengineering*
Michael Insana, *Bioengineering*
Jianming Jin, *Electrical and Computer Engineering*
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*
Michelle Wang, *Statistics*
Ning Wang, *Mechanical Science and Engineering*
John Wang, *Surgery*
Yongmei Wang, *Statistics*
Yingxiao Wang, *Bioengineering*
Kenneth L. Watkin, *Speech and Hearing Science*
Sheng Zhong, *Bionengineering*

## INTIM SELECTED HONORS AND AWARDS

Stephen Boppart, *Electrical and Computer Engineering*
- Hans Sigrist Prize, 2012, International prize on selected topic of Diagnostic Laser Medicine
- Bliss Professorship of Engineering, 2011

Michael Insana, *Bioengineering*
- Fellow, Institute of Electrical and Electronics Engineers, 2011

Zhi-Pei Liang, *Electrical and Computer Engineering*
- Elected to the International Academy for Medical and Biological Engineering, 2012
- Otto Schmitt Award, International Federation for Medical and Biological Engineering, 2012

Gabriel Popescu, Electrical and Computer Engineering
- Fellow, Center for Advanced Studies, 2012
- Finalist, Innovation Discovery Award, 2012

Kenneth Suslick, Chemistry
- Associate, UIUC Center for Advanced Study, 2012

## INTIM INVENTION DISCLOSURES

Faculty members from the Integrative Imaging research theme were inventors on 14 invention disclosures (6.3% of the 223 invention disclosures filed by campus) during FY2012.

## INTIM SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the Integrative Imaging research theme were inventors on the following nine patent applications (4.7% of the 192 patent applications filed by the campus) and seven patents issued (9.2% of the 76 patents issued to campus) during FY2012 (Beckman Institute IntIm faculty members are listed in bold):

**Paul Carney**, Rainer Hillenbrand, John Schotland and Jin Sun, "Nanoscale Optical Tomography Based on Volume-Scanning Near-Field Microscopy," Patent issued July 12, 2011, Patent Number 7,978,343.

**Stephen Boppart** and Haohua Tu, "Compression of Polarized Supercontinuum Pulses Generated in Birefringent All NOraml-Dispersion Photonic Crystal Fiber," Patent filed July 15, 2011, Application Number 13/184,025.

**Rohit Bhargava**, F. Pounder and Rohith Reddy, "Automated Detection of Breast Cancer Lesions in Tissue," Patent filed August 31, 2011, Application Number 13/222,623.

**Ling-Jian Meng**, "Ionizing Radiation Sensor," Patent issued September 13, 2011, Patent Number 8,017,917.

**Rohit Bhargava**, Anil Kodali and Xavier Llora, "Tailored Raman Spectroscopic Probes for Ultrasensitive and Highly Multiplexed Assays," Patent filed October 20, 2011, Application Number 13/277,674.

**Paul Carney** and Brynmor Davis, "Robust Determination of the Anisotropic Polarizability of Nanoparticles Using Coherent Confocal Microscopy," Patent issued October 25, 2011, Patent Number 8,045,161.

Huafeng Ding, **Gabriel Popescu** and Zhuo Wang, "Spatial Light Interference Microscopy and Fourier Transform Light Scattering for Cell and Tissue Characterization," Patent filed January 3, 2012, Application Number 13/342,350.

**Gabriel Popescu** and Zhuo Wang, "Spatial Light Interference Tomography," Patent filed January 3, 2012, Application Number 61/582,599.

**Paul Carney**, Brynmor Davis, John Schotland and Jin Sun, "Spectral Near-Field Optical Tomography," Patent issued January 3, 2012, Patent Number 8,089,630.

**Rohit Bhargava**, Jin Kwak and Saurabh Sinha, "Automated Prostate Tissue Referencing for Cancer Detection and Diagnosis," Patent filed January 18, 2012, Application Number 13/353,196.

**Stephen Boppart**, Vasilica Crecea and Jongsick Kim, "Real-Time Biomechanical Dosimetry using Optical Coherence Elastography," Patent filed January 20, 2012, Application Number 61/588,884.

**Stephen Boppart** and Chuanwu Xi, "Device and Method for Imaging the Ear Using Optical Coherence Tomography," Patent issued February 14, 2012, Patent Number 8,115,934.

Huafeng Ding, **Gabriel Popescu** and Zhuo Wang, "Scattering Parameters of Tissue from Quantitative Phase Imaging," Patent filed March 2, 2012, Application Number 61/606,149.

**Gabriel Popescu** and Zhuo Wang, "Spatial Light Interference Microscopy and Fourier Transform Light Scattering for Cell and Tissue Characterization," Patent issued May 22, 2012, Patent Number 8,184,298.

Sevket Babacan, **Minh Do, Gabriel Popescu** and Zhuo Wang, "Sparse Deconvolution Spatial Light Microscopy in Two and Three Dimensions," Patent filed May 31, 2012, Application Number 61/653,460.

Mingxing Ouyang and **Yingxiao Wang**, "Detection of Specific Binding Reactions Using Magnetic Labels," Patent issued June 5, 2012, Patent Number 8,192,947.

## INTIM GRANTS AWARDED

**($2,392,638)**

**Brad Sutton**, NIH, "Cognitive Neuroscience of Aging and Culture," 6/16/2011 – 12/31/2011, $26,349.

**Zhi-Pei Liang**, NIH, "Faster Dynamic MRI with Sparse Sampling," 7/1/2011 – 6/30/2015, $1,392,141.

**Stephen Boppart** and **Woong Gyu Jung**, Samsung, "Imaging Depth and Contrast Enhanced Endoscopic Optical Coherence Tomography at 800nm," 11/14/2011 – 11/13/2012, $105,547.

**Rohit Bhargava**, Dow AgroSciences, LLC, "Non-destructive Chemical Analysis of Whole Grain Components Using Transmission Raman Spectroscopy: A Pilot Study," 12/1/2011-5/31/2012, $5,000.

**Brad Sutton**, NIH/UTD, "Cognitive Neuroscience of Aging and Culture," 1/1/2012 – 5/15/2012, $18,943.

Ryan Larsen, **Brad Sutton**, **Zhi-Pei Liang**, Wenmiao Lu and Tracey Wszalek, Abbott Laborites, "Probing the Effect of Brain Metabolism on Cognitive Function," 5/16/2012 – 5/15/2013, $174,284.

**Marni Boppart** and **Justin Rhodes**, Abbott Laboratories, "Nutritional Enhancement of Cognition through Stem Cells," 5/16/2012 – 5/15/2015, $600,000.

**Brad Sutton** and **David Kuehn**, NIH/East Carolina University, "MRI Analysis of the Valopharyngeal Mechanism Among Different Populations," 6/16/2012 – 5/31/2012, $70,374.

## INTIM SELECTED PUBLICATIONS

Abbey, C. K.; Nguyen, N. Q.; **Insana, M. F.**, Frequency, Bandwidth, and Information Transfer in B-Mode Imaging. *Proceedings of SPIE Medical Imaging: Ultrasonic Imaging, Tomography, and Therapy* **2012**, *8320,* DOI: 10.1117/12.912430.

Adie, S. G.; Graf, B. W.; Ahmad, A.; **Carney, P. S.**; **Boppart, S. A.**, Computational Adaptive Optics for Broadband Optical Interferometric Tomography of Biological Tissue. *Proceedings of the National Academy of Sciences of the United States of America* **2012**, *109,* (19), 7175-7180.

Ament, S. A.; Wang, Y.; Chen, C. C.; Blatti, C. A.; Hong, F.; Liang, Z. Z. S.; Negre, N.; White, K. P.; Rodriguez-Zas, S. L.; Mizzen, C. A.; Sinha, S.; **Zhong, S.**; **Robinson, G. E.**, The Transcription Factor Ultraspiracle Influences Honey Bee Social Behavior and Behavior-Related Gene Expression. *PLoS Genetics* **2012**, *8,* DOI: 10.1371/journal.pgen.1002596.

Bae, Y.; Kuehn, D. P.; **Sutton, B. P.**; Conway, C. A.; Perry, J. L., Three-Dimensional Magnetic Resonance Imaging of Velopharyngeal Structures. *Journal of Speech Language and Hearing Research* **2011**, *54,* (6), 1538-1545.

Benalcazar, W. A.; **Boppart, S. A.**, Nonlinear Interferometric Vibrational Imaging for Fast Label-Free Visualization of Molecular Domains in Skin. *Analytical and Bioanalytical Chemistry* **2011**, *400,* (9), 2817-2825.

Bhaduri, B.; Pham, H.; Mir, M.; **Popescu, G.**, Diffraction Phase Microscopy with White Light. *Optics Letters* **2012**, *37,* (6), 1094-1096.

**Bhargava, R.**, Resolution in Mid-Infrared Imaging: The Theory. *Spectroscopy* **2012**, *27,* (2), 74-74.

Borrelli, M. J.; **O'Brien, W. D.**; Bernock, L. J.; Williams, H. R.; Hamilton, E.; Wu, J. N.; **Oelze, M. L.**; Culp, W. C., Production of Uniformly Sized Serum Albumin and Dextrose Microbubbles. *Ultrasonics Sonochemistry* **2012**, *19,* (1), 198-208.

Carey, J. R.; **Suslick, K. S.**; Hulkower, K. I.; Imlay, J. A.; Imlay, K. R. C.; Ingison, C. K.; Ponder, J. B.; Sen, A.; Wittig, A. E., Rapid Identification of Bacteria with a Disposable Colorimetric Sensor Array. *Journal of the American Chemical Society* **2011**, *133,* 7571-7576.

# INTIM Selected Faculty Awards, Patents, Grants, and Publications

**Carney, P. S.**; Deutsch, B.; Govyadinov, A. A.; Hillenbrand, R., Phase in Nanooptics. *ACS Nano* **2012**, *6,* (1), 8-12.

Chan, L. L.; George, S.; Ahmad, I.; Gosangari, S. L.; Abbasi, A.; **Cunningham, B. T.**; **Watkin, K. L.**, Cytotoxicity Effects of Amoora Rohituka and Chittagonga on Breast and Pancreatic Cancer Cells. *Evidence-Based Complementary and Alternative Medicine* **2011** (Article ID 860605), 8 pages.

Chanda, D.; Shigeta, K.; Truong, T.; Lui, E.; Mihi, A.; Schulmerich, M.; **Braun, P. V.**; **Bhargava, R.**; **Rogers, J. A.**, Coupling of Plasmonic and Optical Cavity Modes in Quasi-Three-Dimensional Plasmonic Crystals. *Nature Communications* **2011**, *2,* DOI: 10.1038/ncomms1487.

Chen, Y.; **Sutton, B.**; Conway, C.; Broglio, S. P.; **Ostoja-Starzewski, M.**, Brain Deformation under Mild Impact: Magnetic Resonance Imaging-Based Assessment and Finite Element Study. *International Journal of Numerical Analysis and Modeling Series B* **2012**, *3,* (1), 20-35.

Cheng, O. Y.; **Sutton, B. P.**, Localized Blood Flow Imaging Using Quantitative Flow-Enhanced Signal Intensity. *Magnetic Resonance in Medicine* **2012**, *67,* (3), 660-668.

Choo, A. L.; Kraft, S. J.; **Olivero, W.**; Ambrose, N. G.; Sharma, H.; Chang, S. E.; **Loucks, T. M.**, Corpus Callosum Differences Associated with Persistent Stuttering in Adults. *Journal of Communication Disorders* **2011**, *44,* (4), 470-477.

Demmie, P. N.; **Ostoja-Starzewski, M.**, Waves in Fractal Media. *Journal of Elasticity* **2011**, *104,* (1-2), 187-204.

Gosangari, S. L.; **Watkin, K. L.**, Enhanced Release of Anticancer Agents from Nanoliposomes in Response to Diagnostic Ultrasound Energy Levels. *Pharmaceutical Development and Technology* **2012**, *17,* 383-388.

Haldar, J. P.; Wang, Z.; **Popescu, G.**; **Liang, Z. P.**, Deconvolved Spatial Light Interference Microscopy for Live Cell Imaging. *IEEE Transactions on Biomedical Engineering* **2011**, *58,* (9), 2489-2497.

John, R.; Nguyen, F. T.; Kolbeck, K. J.; Chaney, E. J.; Marjanovic, M.; **Suslick, K. S.**; **Boppart, S. A.**, Targeted Multifunctional Multimodal Protein-Shell Microspheres as Cancer Imaging Contrast Agents. *Molecular Imaging and Biology* **2012**, *14,* (1), 17-24.

Johnson, C. A.; Miller, R. J.; **O'Brien, W. D.**, Ultrasound Contrast Agents Affect the Angiogenic Response. *Journal of Ultrasound in Medicine* **2011**, *30,* (7), 933-941.

Johnson, C. L.; Chen, D. D.; **Olivero, W. C.**; **Sutton, B. P.**; **Georgiadis, J. G.**, Effect of Off-Frequency Sampling in Magnetic Resonance Elastography. *Magnetic Resonance Imaging* **2012**, *30,* (2), 205-212.

Kong, R.; **Bhargava, R.**, Characterization of Porcine Skin as a Model for Human Skin Studies Using Infrared Spectroscopic Imaging. *Analyst* **2011**, *136,* (11), 2359-2366.

Kwon, B.; Wang, C.; Park, K.; **Bhargava, R.**; **King, W. P.**, Thermomechanical Sensitivity of Microcantilevers in the Mid-Infrared Spectral Region. *Nanoscale and Microscale Thermophysical Engineering* **2011**, *15,* (1), 16-27.

Mahr, D. M.; **Bhargava, R.**; **Insana, M. F.**, Three-Dimensional in Silico Breast Phantoms for Multimodal Image Simulations. *IEEE Transactions on Medical Imaging* **2012**, *31,* (3), 689-697.

Mazzone, P. J.; Wang, X.-F.; Xu, Y.; Mekhail, T.; Beukemann, M. C.; Na, J.; Kemling, J. W.; **Suslick, K. S.**; Sasidhar, M., Exhaled Breath Analysis with a Colorimetric Sensor Array for the Identification and Characterization of Lung Cancer. *Journal of Thoracic Oncology* **2012**, *7,* 137-142.

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 Microscopy. *PLoS One* **2012**, *7,* (6), e38916.

Mir, M.; Wang, Z.; Shen, Z.; Bednarz, M.; **Bashir, R.**; Golding, I.; Prasanth, S. G.; **Popescu, G.**, Optical Measurement of Cycle-Dependent Cell Growth. *Proceedings of the National Academy of Sciences of the United States of America* **2011**, *108,* (32), 13124-13129.

Norato, J. A.; **Johnson, A. J. W.**, A Computational and Cellular Solids Approach to the Stiffness-Based Design of Bone Scaffolds. *Journal of Biomechanical Engineering-Transactions of the ASME* **2011**, *133,* DOI: 10.1115/1.4004994.

Pham, H.; Ding, H. F.; Sobh, N.; **Do, M.**; Patel, S.; **Popescu, G.**, Off-Axis Quantitative Phase Imaging Processing Using Cuda: Toward Real-Time Applications. *Biomedical Optics Express* **2011**, *2,* (7), 1781-1793.

Rivas-Astroza, M.; Xie, D.; Cao, X. Y.; **Zhong, S.**, Mapping Personal Functional Data to Personal Genomes. *Bioinformatics* **2011**, *27,* (24), 3427-3429.

Valero, M. C.; Huntsman, H. D.; Liu, J. M.; Zou, K.; **Boppart, M. D.**, Eccentric Exercise Facilitates Mesenchymal Stem Cell Appearance in Skeletal Muscle. *PLoS One* **2012**, *7,* DOI: 10.1371/journal.pone.0029760.

Wang, H.; **Olivero, W.**; Elkins, W., Traumatic Brain Injury and Hypothermia. *Journal of Neurosurgery* **2012**, *116,* (5), 1159-1160.

Wang, Z.; Marks, D. L.; **Carney, P. S.**; Millet, L. J.; Gillette, M. U.; Mihi, A.; **Braun, P. V.**; Shen, Z.; Prasanth, S. G.; **Popescu, G.**, Spatial Light Interference Tomography (Slit). *Optics Express* **2011**, *19,* (21), 19907-19918.

Yao, J. M.; Le, A. P.; Schulmerich, M. V.; Maria, J.; Lee, T. W.; Gray, S. K.; **Bhargava, R.**; **Rogers, J. A.**; Nuzzo, R. G., Soft Embossing of Nanoscale Optical and Plasmonic Structures in Glass. *ACS Nano* **2011**, *5,* (7), 5763-5774.

Zhao, Y. B.; Graf, B. W.; Chaney, E. J.; Mahmassani, Z.; Antoniadou, E.; DeVolder, R.; Kong, H.; **Boppart, M. D.**; **Boppart, S. A.**, Integrated Multimodal Optical Microscopy for Structural and Functional Imaging of Engineered and Natural Skin. *Journal of Biophotonics* **2012**, *5,* (5-6), 437-448.

# M&ENS Selected Faculty Awards, Patents, Grants, and Publications

## M&ENS 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*
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, *Chemistry*
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 and Engineering*
John G. Georgiadis, *Mechanical Science and Engineering*
Eric Jakobsson, *Molecular and Integrative Pysiology*
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*

**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*
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, *Biochemistry*

## M&ENS SELECTED HONORS AND AWARDS

Ioannis Chasiotis
- ASME Thomas J.R. Hughes Young Investigator Award, 2011
- Hetenyi Best Paper Award by the Society for Experimental Mechanics, 2012

Nancy Sottos
- Fellow, Society of Experimental Mechanics, 2012

Andreas Cangellaris
- IEEE Microwave Theory and Techniques Society Distinguished Educator Award, 2012

Joseph Lyding
- Fellow, IEEE, 2011

Paul Braun
- Ivan Racheff Professorship, University of Illinois

Eric Pop
- Fellow, Center for Advanced Study, 2011
- Outstanding Presentation Award, E\PCOS Symposium, 2011
- Best Paper in Session Award, SRC TechCon (shared with graduate student Feng Xiong), 2011

Iwona Jasiuk
- Fellow, Society of Engineering Science, 2012

Paul Kenis
- University Scholar, University of Illinois President's Office, 2011

William King
- Society of Manufacturing Engineers, "Innovations that will Change Manufacturing," 2011

Yi Lu, Chemistry
- Innovation Discovery Award, Champaign County, IL, 2012

John Rogers
- Selected to Receive the Engineering Council Award for Excellence in Advising at University of Illinois, Urbana-Champaign, 2012
- Wulff Lecturership, Massachusetts Institute of Technology, 2012
- Selected by Nature as one of the top 10 scientists who mattered in 2011
- Nyquist Distinguished Lecturer, Department of Electrical & Computer Engineering, Yale University, 2012
- ASU Distinguished Scholar and Lecturer, Arizona State University, 2011
- Judd Distinguished Lecturer, Department of Electrical & Computer Engineering, University of Utah, 2011

Klaus Schulten
- Fellow, Biophysical Society, 2011

## M&ENS INVENTION DISCLOSURES

Faculty members from the Molecular and Electronic Nanostructures research theme were inventors on 28 invention disclosures (12.6% of the 223 invention disclosures filed by campus) during FY2012.

## M&ENS SELECTED PATENTS AND PATENT APPLICATIONS

Faculty members from the Molecular and Electronic Nanostructures research theme were inventors on the following 12 patent applications (6.3% of the 192 patent applications filed by the campus) and 21 patents issued (27.6% of the 76 patents issued to campus) during FY2012 (Beckman Institute M&ENS faculty members are listed in bold):

Jong-Hyun Ahn, Alfred Baca, Heung Cho Ko, Matthew Meitl, Etienne Menard, Michael Motala, Ralph Nuzzo, Sang Park II, **John Rogers**, Mark Stoykovich, Jongseung Yoon and Chang-Jae Yu, "Optical Systems Fabricated by Printing-Based Assembly," Patent issued July 5, 2011, Patent Number 7,972,875.

**Paul Kenis**, Sarah Perry, Griffin Roberts and Joshua Tice, "Microfluidic Device for Preparing Mixtures," Patent issued July 12, 2011, Patent Number 7,976,789.

**John Rogers**, Feng Hua and Anne Shim, "Nano-molding Process," Patent issued July 12, 2011, Patent Number 7,976,748.

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 July 19, 2011, Patent Number 7,982,296.

**Yi Lu** and Yu Xiang, "Detection and Quantification of Analytes," Patent filed July 22, 2011, Application Number 61/510,578.

**Nicholas Fang**, Placid Ferreira, Keng Hao Hsu, Kyle Jacobs, Anil Kumar and Peter Schultz, "Direct Nanoscale Patterning of Metals Using Polymer Electrolytes," Patent Issued August 16, 2011, Patent Number 7,998,330.

Apratim Dhar, Simon Ebbinghaus, **Martin Gruebele** and Douglas McDonald, "Particle Dynamics Microscopy Using Temperature Jump and Probe Anticorrelation/Correlation Techniques," Patent filed August 16, 2011, Application Number 13/2510,942.

**Paul Kenis, Yi Lu**, Zidong Wang, Ngo Wong and Jieqian Zhang, "Nucleic Acid-Mediated Shape Control of Nanoparticles for Biomedical Applications," Patent filed September 29, 2011, Application Number 13/249,070.

Dahl-Young Khang, Cho Heung Ko, Keon Jae Lee, Shawn Mack, Matthew Meitl, Etienne Menard, Ralph Nuzzo, **John Rogers**, Yugang Sun and Zhengtao Zhu, "Printable Semiconductor Structures and Related Methods of Making and Assembling," Patent filed October 11, 2011, Application Number 13/270,954.

Dahl-Young Khang, Heung Cho Ko, Keon Jae Lee, Shawn Mack, 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 October 18, 2011, Patent Number 8,039,847.

**Yi Lu**, "Fluorescence Based Biosensor," Patent issued October 25, 2011, Patent Number 8,043,802.

**Joseph Lyding** and Scott Schmucker, "Nanometer-Scale Sharpening of Conductor Tips," Patent filed November 9, 2011, Application Number 13/292,714.

Jack Chen, Jonathan Engel and **Chang Liu**, "Artificial Lateral Line," Patent issued November 15, 2011, Patent Number 8,056,419.

Juewen Liu and **Yi Lu**, "Aptamer- and Nucleic Acid Enzyme-Based Systems for Simultaneous Detection of Multiple Analytes," Patent issued November 15, 2011, Patent Number 8,058,415.

Jung Lee, **Yi Lu** and Zidong Wang, "Fluorescent Sensor for Mercury," Patent issued November 22, 2011, Patent Number 8,062,893.

**Joseph Lyding** and Scott Schmucker, "Nanometer-Scale Sharpening of Conductor Tips," Patent issued December 6, 2011, Patent Number 8,070,920.

**Yi Lu** and Zidong Wang, "Nucleic Acid "Genetic Codes" for Abiological Metal Nanostructural Morphologies," Patent filed December 16, 2011, Application Number 61/576,867.

Daniel Therriault, **Jennifer Lewis** and **Scott White**, "Microcapillary Networks," Patent issued January 24, 2012, Patent Number 8,101,139.

Navneet Kumar, Angel Yanguas-Gil, **Gregory Girolami** and John Abelson, "Surface Preparation for Thin Film Growth by Enhanced Nucleation," Patent issued February 7, 2012, Patent Number 8,110,503.

Bryce Ching, Luisa Ciobanu and **Brad Sutton**, "System and Method for Providing Flow-Enhanced Signal Intensity During a Functional MRI Process," Patent issued February 21, 2012, Patent Number 8,121,668.

Richard Masel, Zheng Ni and **Mark Shannon**, "High Gain Selective Metal Organic Framework Preconcentrators," Patent issued February 28, 2012, Patent Number 8,123,834.

Richard Masel, Adarsh Radadia and **Mark Shannon**, "Column Design for Micro Gas Chromatograph," Patent issued February 28, 2012, Patent Number 8,123,841.

Maria Gracheva, **Jean-Pierre Leburton**, **Gregory Timp** and Julien Vidal, "Solid State Device," Patent filed March 22, 2012, Application Number 13/427,442.

**John Rogers**, "A Stretchable Form of Single Crystal Silicon for High Performance Electronics on Rubber Substrates," Patent filed April 6, 2012, Application Number 13/441,618.

**John Rogers**, "Controlled Buckling Structures in Semiconductor Interconnects and Nanomembranes for Stretchable Electronics," Patent filed April 6, 2012, Application Number 13/441,598.

Ling Zang, **Jeffrey Moore**, Tammene Naddo and Wei Zhang, "Flourescent Organic Nanofibrils Based on Arylene-Ethylene Macrocycles as Sensory Materials for Explosives Detection," Patent issued April 10, 2012, Patent Number 8,153,065.

**Yi Lu** and Yu Xiang, "Personal Glucose Meters for Detection and Quantification of a Broad Range of Analytes," Application filed April 12, 2012, Application Number 13/445,635.

Winston Chern, Ik Su Chun, **Nicholas Fang**, Placid Ferreira, Keng Hao Hsu and **Xiuling Li**, "Method of Forming an Array of High Aspect Ratio Semiconductor Nanostructures," Patent filed April 20, 2012, Application Number 13/503,123.

Dewain Garner, Hee-Jung Hwang, **Yi Lu** and Nathan Sieracki, "Temperature Resistant pH (TIP) Buffers for Use at Low Temperatures," Patent issued May 22, 2012, Patent Number 8,183,046.

Maria Gracheva, **Jean-Pierre Leburton**, Gregory Timp and Julien Vidal, "Solid State Device," Patent issued June 5, 2012, Patent Number 8,192,600.

Dae-Hyeong Kim and **John Rogers**, "Flexible and Stretchable Electronic Systems for Epidermal Electronics," Patent filed June 8, 2012, Application Number 13/492,636.

Gil De Aquino Farias, Jeanlex De Sousa, Valder Freire and **Jean-Pierre Leburton**, "Memory Device," Patent issued June 12, 2012, Patent Number 8,199,580.

**Yi Lu** and Jing Li, "Nucleic Acid Enzyme Biosensors for Ions," Patent issued June 26, 2012, Patent Number 8,206,915.

## M&ENS SELECTED GRANTS AWARDED

**($6,723,046)**

**Klaus Schulten**, **Wen-Mei Hwu** and **Laxmikant Kale**, NIH, "Commodity Hardware Acceleration of Popular Modeling Software for Structural Biology, Cell Biology, and Bio-nanotechnology," 7/15/2011 – 4/30/2015, $1,166,791.

**Narayana Aluru**, NSF, "QMHP:Multiscale Analysis of Coupled Electrical Mechanical Systems at Nanoscale," 8/15/2011 – 7/31/2014, $352,842.

**Klaus Schulten** and **James Gumbart**, NIH, "Mechanisms of Membrane Proteins Through In Situ Modeling," 9/1/2011 – 6/30/2015, $1,146,668.

**Eric Jakobsson**, NIH, "Genetically Specific Therapy Against Pathogenic Bacteria," 9/1/2011 – 6/30/2015, $1,248,411.

**Narayan Aluru**, DOD-CERL, "Fundamental Physics of Mass Transport Through Nanoscale Channels," 12/1/2011 – 9/30/2014, $137,620.

**Jeffrey Moore**, American Chemical Society, "Associate Editor of the American Chemical Society," 1/1/2012 – 12/31/2013, $161,821.

**Scott White**, DOD/Army, "US-Europe Workshop on Structural Regeneration and Remodeling," 6/1/2012 – 11/30/2012, $52,008.

**Jean-Pierre Leburton**, **Oleksii Aksimentiev** and **Rashid Bashir**, Oxford Nanopore Technology, "Multi-Layer Solid State Membranes with Nanochannels for Bio-Molecule Manipulation and Sensing," 6/26/2012 – 6/25/2013, $256,885.

**Paul Braun**, DOD-DTRA, "Surface Directed Molecular Transport, Separation, and Concentration," 7/1/2012-6/30/2017, $2,200,000.

## M&ENS SELECTED PUBLICATIONS

Afshar, M.; Sadewasser, S.; Albert, J.; Lehmann, S.; Abou-Ras, D.; Marron, D. F.; **Rockett, A. A.**; Rasanen, E.; Lux-Steiner, M. C., Chalcopyrite Semiconductors for Quantum Well Solar Cells. *Advanced Energy Materials* **2011**, *1*, (6), 1109-1115.

Ambekar, R.; Chittenden, M.; **Jasiuk, I.**; **Toussaint, K. C.**, Quantitative Second-Harmonic Generation Microscopy for Imaging Porcine Cortical Bone: Comparison to SEM and Its Potential to Investigate Age-Related Changes. *Bone* **2012**, *50*, (3), 643-650.

Andreasson-Ochsner, M.; Romano, G.; Hakanson, M.; Smith, M. L.; **Leckband, D. E.**; Textor, M.; Reimhult, E., Single Cell 3-D Platform to Study Ligand Mobility in Cell-Cell Contact. *Lab on a Chip* **2011**, *11*, (17), 2876-2883.

Arpin, K. A.; Pikul, J. H.; **King, W. P.**; Fan, H. Y.; **Braun, P. V.**, Template Directed Assembly of Dynamic Micellar Nanoparticles. *Soft Matter* **2011**, *7*, (21), 10252-10257.

Baginska, M.; Blaiszik, B. J.; Merriman, R. J.; **Sottos, N. R.**; **Moore, J. S.**; **White, S. R.**, Autonomic Shutdown of Lithium-Ion Batteries Using Thermoresponsive Microspheres. *Advanced Energy Materials* **2012**, *2*, (5), 583-590.

Blaiszik, B. J.; Kramer, S. L. B.; Grady, M. E.; McIlroy, D. A.; **Moore, J. S.**; **Sottos, N. R.**; **White, S. R.**, Autonomic Restoration of Electrical Conductivity. *Advanced Materials* **2012**, *24*, (3), 398-+.

Chanda, D.; Shigeta, K.; Gupta, S.; Cain, T.; Carlson, A.; Mihi, A.; Baca, A. J.; Bogart, G. R.; **Braun, P.**; **Rogers, J. A.**, Large-Area Flexible 3D Optical Negative Index Metamaterial Formed by Nanotransfer Printing. *Nature Nanotechnology* **2011**, *6*, (7), 402-407.

Chanda, D.; Shigeta, K.; Truong, T.; Lui, E.; Mihi, A.; Schulmerich, M.; **Braun, P. V.**; **Bhargava, R.**; **Rogers, J. A.**, Coupling of Plasmonic and Optical Cavity Modes in Quasi-Three-Dimensional Plasmonic Crystals. *Nature Communications* **2011**, *2*, DOI: 10.1038/ncomms1487.

Comer, J. R.; Wells, D. B.; **Aksimentiev, A.**, Modeling Nanopores for Sequencing DNA, In *DNA Nanotechnology: Methods and Protocols*; Zuccheri, G., Samori, B., Eds. **2011**; Vol. 749, 317-358.

Daly, S. R.; Kim, D. Y.; **Girolami, G. S.**, Lanthanide N,N-Dimethylaminodiboranates as a New Class of Highly Volatile Chemical Vapor Deposition Precursors. *Inorganic Chemistry* **2012**, *51*, 7050.

Dellabetta, B.; Hughes, T. L.; **Gilbert, M. J.**; Lev, B. L., Imaging Topologically Protected Transport with Quantum Degenerate Gases. *Physical Review B* **2012**, *85*, DOI: 10.1103/PhysRevB.85.205442.

Dhar, A.; **Gruebele, M.**, Fast Relaxation Imaging in Living Cells. *Current Protocols in Protein Science* **2011**, *28*, DOI: 10.1002/0471140864.ps2801s65.

Diamantis, D. J.; **Georgiadis, J. G.**; Goussis, D. A., Two-Phase Modeling of Heat and Mass Transfer in Packed Bed Absorbers: Implications for Process Design. *Journal of Porous Media* **2012**, *15*, (5), 459-473.

Farimani, A. B.; **Aluru, N. R.**, Spatial Diffusion of Water in Carbon Nanotubes: From Fickian to Ballistic Motion. *Journal of Physical Chemistry B* **2011**, *115*, (42), 12145-12149.

Girdhar, A.; **Leburton, J. P.**, Soft Carrier Multiplication by Hot Electrons in Graphene. *Applied Physics Letters* **2011**, *99*, DOI: 10.1063/1.3615286.

Giusi, G.; Iannaccone, G.; Crupi, F.; **Ravaioli, U.**, A Backscattering Model Incorporating the Effective Carrier Temperature in Nano-Mosfet. *IEEE Electron Device Letters* **2011**, *32*, (7), 853-855.

Hamed, E.; **Jasiuk, I.**, Elastic Modeling of Bone at Nanostructural Level. *Materials Science and Engineering R* **2012**, *73*, (3-4), 27-49.

Hamilton, A. R.; **Sottos, N. R.**; **White, S. R.**, Pressurized Vascular Systems for Self- Healing Materials. *Journal of the Royal Society Interface* **2012**, *9*, (70), 1020-1028.

He, K. T.; Wood, J. D.; Doidge, G. P.; **Pop, E.**; **Lyding, J. W.**, Scanning Tunneling Microscopy Study and Nanomanipulation of Graphene-Coated Water on Mica. *Nano Letters* **2012**, *12*, 2665.

He, Y.; **Lu, Y.**, Metal-Ion-Dependent Folding of a Uranyl-Specific Dnazyme: Insight into Function from Fluorescence Resonance Energy Transfer Studies. *Chemistry - A European Journal* **2011**, *17*, 13732-13742.

Jing, Y. H.; **Aluru, N. R.**, Atomistic Simulations on the Mechanical Properties of a Silicon Nanofilm Covered with Graphene. *Computational Materials Science* **2011**, *50*, (10), 3063-3066.

Khalili-Araghi, F.; **Tajkhorshid, E.**; Roux, B.; **Schulten, K.**, Molecular Dynamics Investigation of the Omega-Current in the Kv1.2 Voltage Sensor Domains. *Biophysical Journal* **2012**, *102*, (2), 258-267.

Kim, D. H.; Lu, N. S.; Ma, R.; Kim, Y. S.; Kim, R. H.; Wang, S. D.; Wu, J.; Won, S. M.; Tao, H.; Islam, A.; Yu, K. J.; Kim, T. I.; Chowdhury, R.; Ying, M.; Xu, L. Z.; Li, M.; Chung, H. J.; Keum, H.; McCormick, M.; Liu, P.; Zhang, Y. W.; Omenetto, F. G.; Huang, Y. G.; Coleman, T.; **Rogers, J. A.**, Epidermal Electronics. *Science* **2011**, *333*, (6044), 838-843.

Kim, S.; Su, Y.; Mihi, A.; Lee, S.; Liu, Z.; Bhandakkar, T. K.; Wu, J.; Geddes, J. B.; **Johnson, H. T.**; Zhang, Y. W.; Park, J. K.; **Braun, P. V.**; Huang, Y. G.; **Rogers, J. A.**, Imbricate Scales as a Design Construct for Microsystem Technologies. *Small* **2012**, *8*, (6), 901-906.

Kwon, B.; Schulmerich, M. V.; Elgass, L. J.; Kong, R.; Holton, S. E.; **Bhargava, R.**; **King, W. P.**, Infrared Microspectroscopy Combined with Conventional Atomic Force Microscopy. *Ultramicroscopy* **2012**, *116*, 56-61.

**Leckband, D. E.**, Novel Functions and Binding Mechanisms of Carbohydrate-Binding Proteins Determined by Force Measurements. *Current Protein & Peptide Science* **2011**, *12*, (8), 743-759.

Li, Y. H.; Rata, I.; **Jakobsson, E.**, Sampling Multiple Scoring Functions Can Improve Protein Loop Structure Prediction Accuracy. *Journal of Chemical Information and Modeling* **2011**, *51*, (7), 1656-1666.

Naughton, M. S.; Moradia, A. A.; **Kenis, P. J. A.**, Quantitative Analysis of Single-Electrode Plots to Understand in-Situ Behavior of Individual Electrodes. *Journal of the Electrochemical Society* **2012**, *159*, (6), B761-B769.

Nelson, E. C.; Dias, N. L.; Bassett, K. P.; Dunham, S. N.; Verma, V.; Miyake, M.; **Wiltzius, P.**; **Rogers, J. A.**; Coleman, J. J.; Li, X. L.; **Braun, P. V.**, Epitaxial Growth of Three-Dimensionally Architectured Optoelectronic Devices. *Nature Materials* **2011**, *10*, (9), 676-681.

Ni, C. J.; Aksamija, Z.; Murthy, J. Y.; **Ravaioli, U.**, Coupled Electro-Thermal Simulation of Mosfets. *Journal of Computational Electronics* **2012**, *11*, (1), 93-105.

Noinaj, N.; Easley, N. C.; Oke, M.; Mizuno, N.; Gumbart, J.; Boura, E.; Steere, A. N.; Zak, O.; Aisen, P.; **Tajkhorshid, E.**; Evans, R. W.; Gorringe, A. R.; Mason, A. B.; Steven, A. C.; Buchanan, S. K., Structural Basis for Iron Piracy by Pathogenic Neisseria. *Nature* **2012**, *483*, (7387), 53-U92.

Odom, S. A.; Chayanupatkul, S.; Blaiszik, B. J.; Zhao, O.; Jackson, A. C.; **Braun, P. V.**; **Sottos, N. R.**; **White, S. R.**; **Moore, J. S.**, A Self-Healing Conductive Ink. *Advanced Materials* **2012**, *24*, (19), 2578-2581.

Olbrich, C.; Strumpfer, J.; **Schulten, K.**; Kleinekathofer, U., Theory and Simulation of the Environmental Effects on Fmo Electronic Transitions. *Journal of Physical Chemistry Letters* **2011**, *2*, (14), 1771-1776.

Ong, Z. Y.; **Pop, E.**, Effect of Substrate Modes on Thermal Transport in Supported Graphene. *Physical Review B* **2011**, *84*, (7), 075471.

**Rogers, J. A.**; Lagally, M. G.; Nuzzo, R. G., Synthesis, Assembly and Applications of Semiconductor Nanomembranes. *Nature* **2011**, *477*, (7362), 45-53.

Salehi-Khojin, A.; Estrada, D.; Lin, K. Y.; Ran, K.; Haasch, R. T.; Zuo, J. M.; **Pop, E.**; Masel, R. I., Chemical Sensors Based on Randomly Stacked Graphene Flakes. *Applied Physics Letters* **2012**, *100*, (3), 033111.

Sun, L.; Karanjgaokar, N.; Sun, K.; **Chasiotis, I.**; Carter, W. C.; Dillon, S., High-Strength All-Solid Lithium Ion Electrodes Based on $Li_4ti_5O_{12}$. *Journal of Power Sources* **2011**, *196*, (15), 6507-6511.

Wang, Z.; Marks, D. L.; **Carney, P. S.**; Millet, L. J.; Gillette, M. U.; Mihi, A.; **Braun, P. V.**; Shen, Z.; Prasanth, S. G.; **Popescu, G.**, Spatial Light Interference Tomography (Slit). *Optics Express* **2011**, *19*, (21), 19907-19918.

Xiang, Y.; **Lu, Y.**, Using Personal Glucose Meters and Functional DNA Sensors to Quantify a Variety of Analytical Targets. *Nature Chemistry* **2011**, *3*, 673-703.

# Educational Outreach and Scholarships

The Beckman Institute is dedicated to interdisciplinary research, with breakthrough discoveries in basic science, as well as translational outcomes that have an impact on people through applications such as biomedical devices and research that points the way to maintaining health throughout the lifespan.

Beckman's commitment to the broader community in which this work takes place is demonstrated by the Institute's many educational programs, seminars, and scholarship programs for aiding young scientists.

Over the years more than 5,000 young researchers have benefitted from working at Beckman, and have contributed greatly to its success. There are currently more than 800 students and postdoctoral researchers working at the Institute, performing much of the day-to-day work that leads to great science. There are five scholarship funds set up at Beckman to support these young scientists in all facets of research.

Many of these students, as well as those 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 conference, the Cancer Community at Illinois symposium, and the annual Biophotonics Summer School.

Speaker series and seminars, including the Director's Seminar Series at Beckman, have shone a spotlight on research and researchers at the Institute and will again this coming year. In addition, the Social Dimensions of Environmental Policy strategic initiative has played host to a speaker series at Beckman featuring some of the world's top scientists and thinkers on topics involving the complex relationships between human societies and the environment, and issues such as climate change.

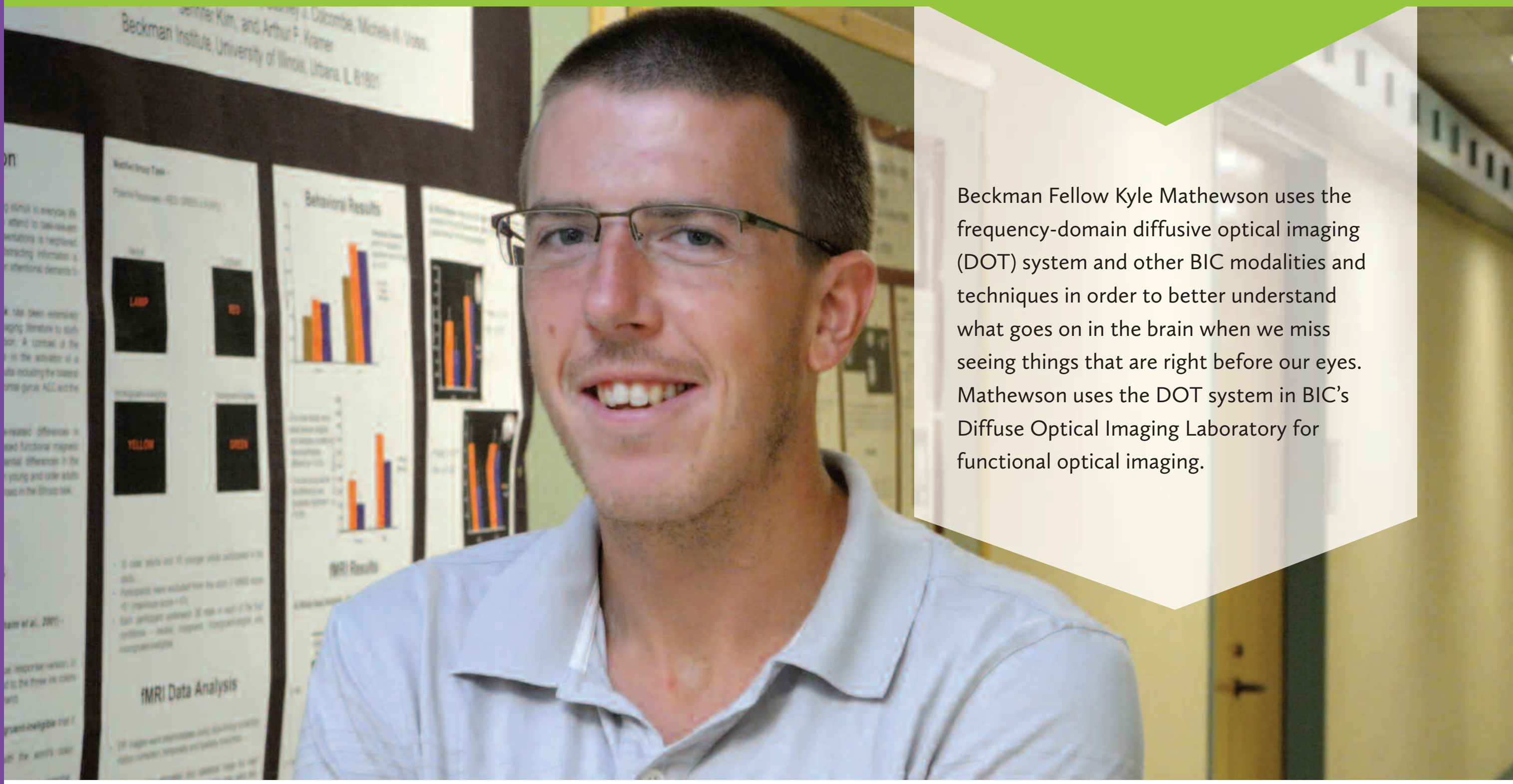
One of the traditional and always popular ways to share Beckman research is through open house events. The biennial Beckman Institute Open House will be held in March of 2013. The 2011 event featured the largest number of exhibits ever for a Beckman Open House, with more than 8,000 visitors taking part in the fun and learning.

Also, this past year Beckman played host to the Cognitive Science and Cognitive Neuroscience Research Expo that gave participants a chance to learn about different labs and research activities in cognitive science and cognitive neuroscience. Fourteen Beckman researchers, including faculty members, Beckman Fellows, and graduate students gave talks at the Expo on topics ranging from speech processing to visual attention.

The Beckman Institute also c ontinues to be involved in the Osher Lifelong Learning Institute's Citizen Scientists program. This promising program works with older adults and places them in campus research laboratories at the Beckman Institute and other locations across campus.

Beckman's educational outreach program Bugscope, operated by the Imaging Technology Group's Microscopy Suite, is now in its 13th year of bringing science into classrooms worldwide in a unique and memorable way. Bugscope gives remote control of an electron microscope via the Internet to students from around the world, reaching more than 250 classrooms since it was started in March of 1999 with a grant from the National Science Foundation. This past year, Bugscope had a first with a session with the American Embassy school in Colombo, Sri Lanka.

# Biomedical Imaging Center



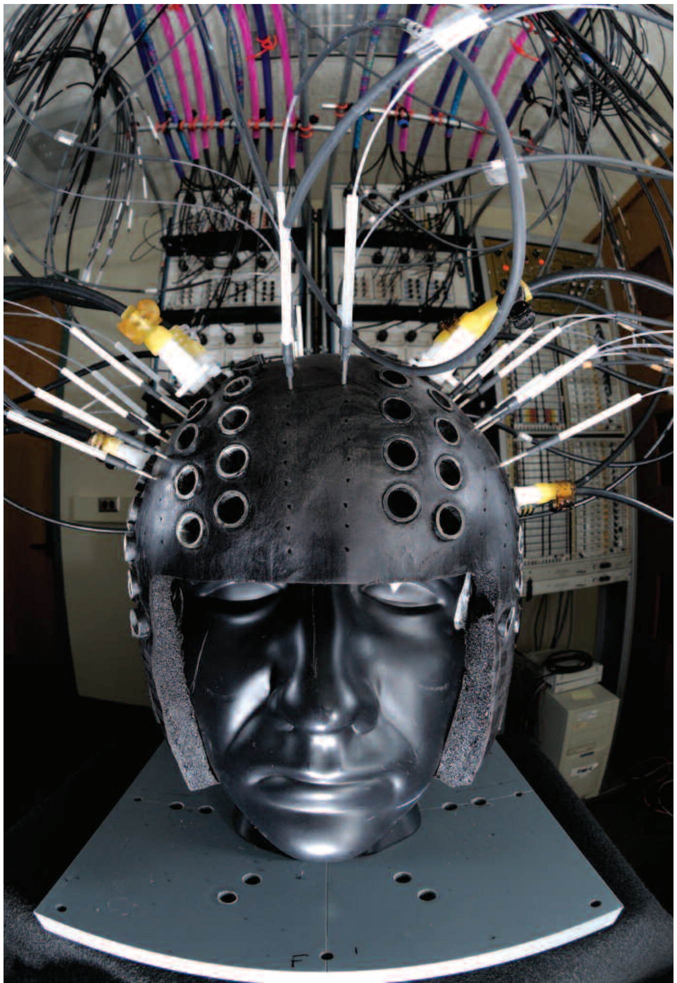

Beckman Fellow Kyle Mathewson uses the frequency-domain diffusive optical imaging (DOT) system and other BIC modalities and techniques in order to better understand what goes on in the brain when we miss seeing things that are right before our eyes. Mathewson uses the DOT system in BIC's Diffuse Optical Imaging Laboratory for functional optical imaging.

After moving into a new home, seeing the addition of new staff, and an expansion of its capabilities into multiple modalities, the Biomedical Imaging Center (BIC) has the pieces and people in place for even greater research opportunities. The growth and changes over the past two years have transformed BIC from a campus facility with state-of-the-art magnetic resonance imaging (MRI) capabilities into a comprehensive center that now includes advanced optical, ultrasound, and molecular imaging modalities. The multiple modalities and larger staff of scientists mean BIC is expanding into new research areas and imaging a wider variety of samples, sometimes using newly-developed techniques.

"What the staff has allowed us to do is to be even more forward thinking," said BIC Director Tracey Wszalek. "I think we've done an incredible job of meeting the need that existed but I think the new staff is allowing us to discover new needs."

That means BIC will still serve users such as neuroscience researchers using functional MRI to study the brain in action, but it will also take advantage of newer imaging modalities and greater research opportunities.

"We will still take all comers but I think that within each modality we will start to focus in on what can that modality do that is unique and still have practical applications," Wszalek said. "In the coming year we will be focusing on identifying and developing those opportunities in an effort to generate new imaging tools and applications."



*A mannequin is fitted with the Frequency-domain Diffusive Optical System in the DOIL lab.*

Biomedical Imaging Center staff (left to right): Holly Tracy, Nancy Dodge, Ryan Larsen, Rochelle Yambert, Boris Odintsov, Tracey Wszalek (Director), Wenmiao Lu, Iwona Dobrucka, Emily Hartman, Wawrzyniec Dobrucki, Edward Maclin.

The array of imaging modalities includes four separate laboratories. The Magnetic Resonance Imaging Laboratory (MRIL) includes BIC's three magnets—the whole-body 3T MAGNETOM Trio MRI scanner, the 14T (600) MHz Varian NMR system, and the 3T Allegra headscanner. That lab is joined by a Micro-PET/SPECT/CT machine for dynamic molecular imaging in the Molecular Imaging Laboratory (MIL), a High Frequency Ultrasound Imaging System in the Ultrasound Imaging Laboratory (UIL), and a frequency-domain diffusive optical imaging (DOT) system for advanced optical imaging in the Diffuse Optical Imaging Laboratory (DOIL).

One of the greater research opportunities involves the new Center for Nutrition, Learning, and Memory, which approved several research proposals that will be using BIC facilities as an integral part of the project.

"CNLM provides us with a new area in which to apply our tools," Wszalek said. "While we have years of experience asking questions about learning and memory, we certainly weren't nutritionists but we recognize that there is great nutrition expertise on this campus and we are eager to see how imaging can be applied to answer questions in that area."

The quartet of labs at BIC are already playing host to a wider variety of research topics than ever before. For example, **Matthew Dye** is leading a team using DOIL to study visual processing in normal and profoundly deaf adults. MIL senior scientist manager Wawrzyniec Dobrucki was part of a project using the microPET/SPECT/CT that reported on agents for multi-target and multimodal cancer imaging and therapy. MRI efforts include a 3-D free-breathing cardiac imaging project that focuses on improving contrast of the myocardial muscle, imaging of speech function (led by **Brad Sutton**), cardiac imaging (**Zhi-Pei Liang**), and temperature mapping of the brain (**John Wang**).

In addition to these projects and in new areas such as the work involving CNLM, Wszalek said there are other research areas where BIC could also play a role.

"We want to also look more broadly at the kinds of science questions that are being asked on this campus and certainly within this building, and then you say 'does imaging have a role to play in that?'" she said.

## Biomedical Imaging Center capabilities

**Magnetic Resonance Imaging Laboratory (MRIL)**

- **600 MHz Varian NMR System**
  Used for micro-imaging and spectroscopic measurements, such as high resolution imaging of very small samples, including biological tissue, as well as liquid and non-living samples.
- **MAGNETOM Allegra 3T MRI Headscanner**
  Primarily used for cognitive studies; also includes capabilities for animal scanning, including scans for clinical analyses.
- **MAGNETOM Trio Whole-body 3T MRI Scanner**
  This magnet is a workhorse for many cognitive and human clinical research studies, as well as being used in animal studies, clinical care scans for animal patients, and imaging many other types of samples.
- **3T Allegra Mock Magnet and 3T Trio Mock Magnet**
  These mock magnets that look and sound like a real MR scanner but do not have a magnetic field, are used to prepare human research subjects for experiments in the actual magnets, as well as for tours and other educational outreach programs to explain how magnetic resonance imaging works.

**Ultrasound Imaging Laboratory (UIL)**

- **High-resolution Ultrasound**
  A Visualsonics Vevo 2100 High Frequency Ultrasound Imaging System was added to the BIC lineup in 2010. The Vevo 2100 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.

**Molecular Imaging Laboratory (MIL)**

- **MicroPET/SPECT/CT**
  A molecular imaging instrument (microPET/SPECT/CT) used for imaging dynamic biological and material systems that was installed in the spring of 2011. The MicroPET/SPECT/CT is used for molecular imaging research in the areas of pre-clinical medical research in cancer and neuroscience; nanomedicine; nanoparticle biodistribution and physiological integration; stem cell tracking and functional integration; nutritional metabolomics; non-destructive 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 resource is an optical tomography imaging method that records event-related optical signals (EROS) from the brain. Using an ISS 128-source, 24-detector Dual-Imagent system from ISS, the 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

John Gaspar takes advantage of ISL's immersive reality environments such as the driving and flight simulators for a project aimed at creating and implementing what Gaspar calls a "contextual measure of the Useful Field of View"—which he describes as the visual field that can be processed without head or eye movements. This measure will enable researchers to study the effects of workload and stress on moment-to-moment changes in the Useful Field of View.

At the Beckman Institute's Illinois Simulator Laboratory (ISL), researchers are testing the concept of virtual surgery, studying behavior in simulated real-world settings like a busy street crossing, and taking a three-dimensional stroll through the inside of the human body. ISL's highly-advanced visualization environments have been critical components for studies involving perceptual psychology for more than 17 years. Today, this Beckman core facility features a wider array of research projects than ever before, including several with biomedical applications.

"We have such a strong perceptual psychology component at the Institute that there is no way to neglect that," said ISL Director Hank Kaczmarski. "That is crucial to us, but we are expanding into biomedical research."

One example is the virtual surgery lab, where Beckman researchers John Rogers and Torrey Loucks are using one of ISL's three Immersadesks as a testbed for developing strategies toward teaching surgery in a virtual environment. Another is happening in the Motion Capture Suite, where Institute researcher Jacob Sosnoff has been studying the motions involved in wheelchair use, and developing technology such as an intelligent flywheel for wheelchairs.

A new project being developed that could have far-reaching possibilities for the medical world is happening in the Cube, ISL's virtual reality environment that features six wall-sized display screens for a truly immersive, three-dimensional experience. Kaczmarski said they are working to incorporate biomedical imagery from magnetic resonance imaging (MRI) and other imaging modalities into a system for performing real-time clinical assessments.

"If we can take CAT scans, MRIs, PET scans and recompose them in this environment, in real time, then you can walk through them. You are actually *inside* of it," he said. "The ultimate goal is to have a patient in an MRI machine, do a very fast low resolution scan, and then a clinician in here would say 'wait a minute there is something funny looking here, let's go back and do a high resolution scan.'"

Experiments involving perceptual psychology continue to be a pillar of research at the Illinois Simulator Laboratory, but that area will also see an expansion into including more biometric measurements like EEG.

"We need all kinds of biometric data to really figure out what's going on," Kaczmarski said. "This is all perceptual psychology research so we want to see what's going on in the brain as people are doing these tasks."

Psychology experiments taking place in ISL's other 3-D immersive virtual reality environments, the CAVE™, continue in a number of research areas. A new multi-university project that will make use of the CAVE, as well as the flight and driving simulators, is looking at the effects of workload and stress on moment-to-moment changes in the visual field that can be processed without head or eye movements. ISL staff is fashioning a system for reducing information overload that will guide the on-screen visual attention of users such as pilots.

"They have way too much information and information that becomes time critical, so you need to get someone to look there when the computer thinks you need to look there," Kaczmarski said.

The CAVE continues to be booked solid for psychology


research projects, including those involving the effects of exercise on cognitive aging, acting training on cognitive aging, and video gaming and cognition. 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 in the future as well. So it's exciting to be able to do those two things at the same time."

## Illinois Simulator Laboratory capabilities:

### The Cube

The Cube is a world-renowned, six-sided virtual reality chamber that provides a completely immersive environment. Used extensively by researchers in the area of perceptual psychology, the Cube is driven by a continuously upgraded cluster of personal computers using an ISL-developed application called Syzygy.

### The CAVE™

The CAVE is a four-sided immersive reality environment operated by the ISL. First constructed in 1995, the CAVE continues to function as a prototyping facility for the Cube and as a research environment in its own right. Several Immersadesks™ (horizontal and vertical stereo video large screen display devices) are located in discrete lab spaces in the new facility, connected to specialized graphics computers, enabling users to quickly develop, test, and remotely demonstrate new applications and modalities of human-computer interaction.

### Flight Simulator

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

### Driving Simulator

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

### Motion Capture Suite

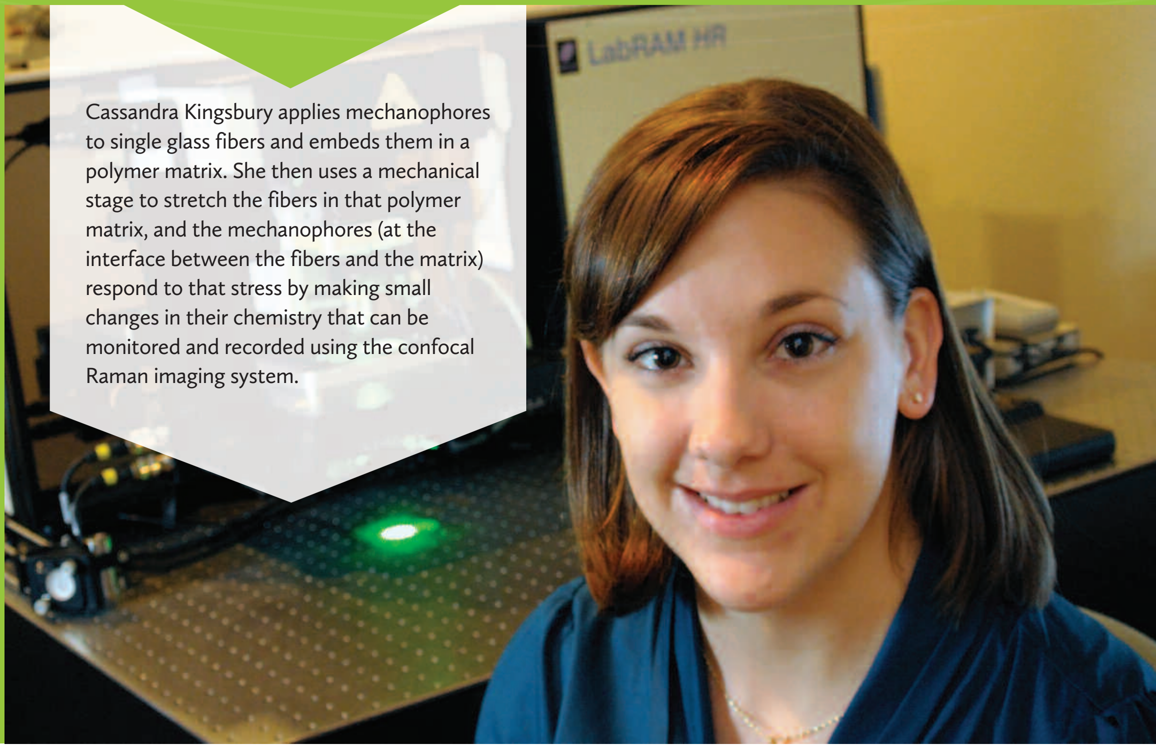
Used by kinesiologists for the analysis of human motion, the Motion Capture Suite features a Motion Analysis ten camera motion capture system, force-feedback plates, video outputs, and gigabit networking that allows researchers to store data for later analysis or to connect with other visualization environments for real-time collaborative research. Additionally, a new University-funded dance project is returning the motion capture system to its earliest research roots.

### Immersadesks

The ISL houses five 4'x6 vertical immersive displays called Immersadesks™ that 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.

# Imaging Technology Group

The Imaging Technology Group (ITG) is a valuable and rare resource for campus researchers because of the technologies and expertise found in its two facilities, the Microscopy Suite and the Visualization Laboratory. ITG offers researchers on the University of Illinois campus a comprehensive array of imaging and microscopy instruments and capabilities for scientific research that are found on few campuses, and in one location, the Beckman Institute.




Cassandra Kingsbury applies mechanophores to single glass fibers and embeds them in a polymer matrix. She then uses a mechanical stage to stretch the fibers in that polymer matrix, and the mechanophores (at the interface between the fibers and the matrix) respond to that stress by making small changes in their chemistry that can be monitored and recorded using the confocal Raman imaging system.

## Microscopy Suite

The Microscopy Suite continues to add to its array of instruments and resources, with technologies and staff members pushing the limits of its four main modes of imaging: light microscopy, scanned probe microscopy, electron microscopy, and x-ray computed tomography (CT).

Last year a new confocal Raman imaging system that provides three-dimensional information on the location of molecules in tissue samples and in materials such as polymers was added to the Microscopy Suite, with its range of options providing a unique capability for this campus. Scott Robinson is manager of the Microscopy Suite.

"The confocal Raman imaging system is up and running and booked almost around the clock," Robinson said. "They're using it in every way possible. It's spread from the graphene people to the hexagonal boron nitride people, to the soybean people, the cancer foci people, and the people who work in the Autonomous Materials Systems (AMS) group."

Cassandra Kingsbury of AMS is using the confocal Raman imaging system to monitor very small changes that occur in the chemistry of mechanophores between the interface of a single glass fiber and a polymer matrix as they are stretched on a mechanical stage. Members of the AMS group are also using the Suite's micro CT instruments for their research into self-healing for batteries, with the help of Leilei Yin, who oversees those instruments.

"We have a big thrust going to get them good images of the batteries using the micro CT," Robinson said. "Leilei has also made it so that you can run a fuel cell in real time in the Bio Micro-CT, and you can collect images while it's running."

This year the Microscopy Suite upgraded the atomic force microscope to state-of-the-art status and acquired a new camera, all thanks to funding from the Beckman Foundation. Robinson said staff member Dianwen Zhang has been able to provide Total Internal Reflectance Fluorescence (TIRF) and Fluorescence Lifetime Imaging Microscopy (FLIM) capabilities to one of the confocal microscopes.

"That's a very powerful technique for both biology and materials people," Robinson said of FLIM. "Dianwen has also made it possible to perform TIRF, and the specialized TIRF camera allows us to take full advantage of that."

## Visualization Laboratory

The Visualization Laboratory is a premier campus support facility thanks to the wide variety of scientific imaging technologies and services it offers researchers and others at the University of Illinois.

The Visualization Laboratory offers highly advanced equipment for imaging, video, and audio needs. Users can take advantage of numerous capabilities, including graphics services such as image enhancement for journal covers and presentations, scientific research support that includes image analysis, animation, and video production, as well as 2-D and 3-D object scanning and printing. This year, the lab added two new higher-end systems called Structure Light for a wider range of 3-D scanning, and four powerful new computers.

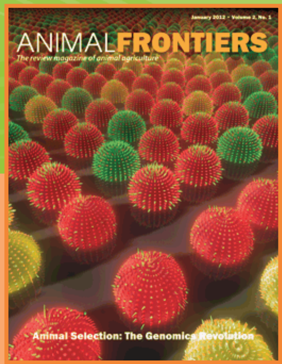
Visualization Laboratory manager Travis Ross said work in 3-D has become a focus of the lab, as evidenced by students from Beckman Institute faculty member Deana McDonagh's design class for people with disabilities who used the 3-D scanner and 3-D printer.

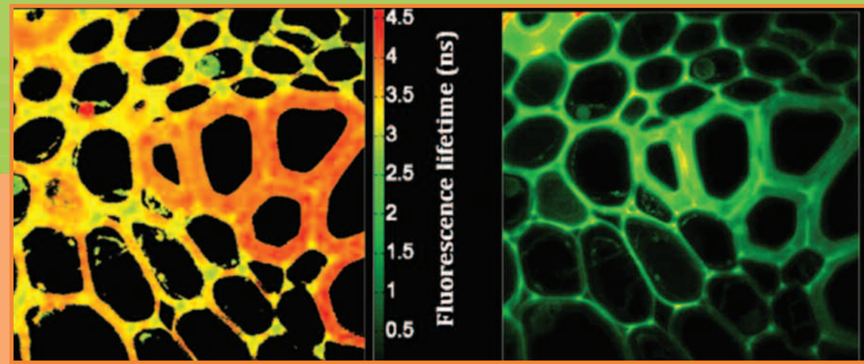
"We became the epicenter of production for her design class," Ross said.

Even with all the technology and capabilities, Ross said the emphasis of the lab is still on providing quality services to users.

"We have good computers, which I think is a key to our lab," he said. "We just want to make sure that first of all, everything is well-structured and everything is well-documented. A new user comes in, and it's clear what they need to do to get their work done.

"This is a really great resource."




## Microscopy Suite Capabilities:

**• Micro- and Nano-computed Tomography**

The four Micro and Nano-CT instruments permit the collection of 3-D x-ray datasets of materials, biomaterials, and biological samples with resolutions ranging from 5 microns to 50 nanometers, with 'hard' or 'soft' x-rays, and with a variety of choices for magnification/field of view. The Skyscan Micro-CT also incorporates a tensile and compression stage.

**• Light Microscopy**

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

**• Scanned Probe Microscopy**

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

**• Electron Microscopy**

The environmental scanning electron microscope (ESEM), with a field-emission electron gun and a large number of optional imaging modalities, is an essential component of the Bugscope project, which has run continuously for more than 13 years. The transmission electron microscope (TEM), for which the Suite has designed and built a variety of specialized holders, has 2-Angstrom resolution and operates at accelerating voltages of up to 200 kV.

**• Sample Preparation Equipment**

The wide range of microscopes and spectroscopy equipment requires a comparable range of sample preparation instrumentation, from 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, the Vis Lab staff members are able to render super high-resolution, professional quality images.

**• Image Analysis**

This capability includes obtaining qualitative and quantitative information from 2-D and 3-D 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: 2-D image, 3-D image, video, and animation, for both analysis and presentation.

**• 3-D Object Scanning**

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

**• 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.

**• Audio Booth**

The lab contains a soundproof audio booth for high-quality, professional audio recording.

**• 3-D Modeling**

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

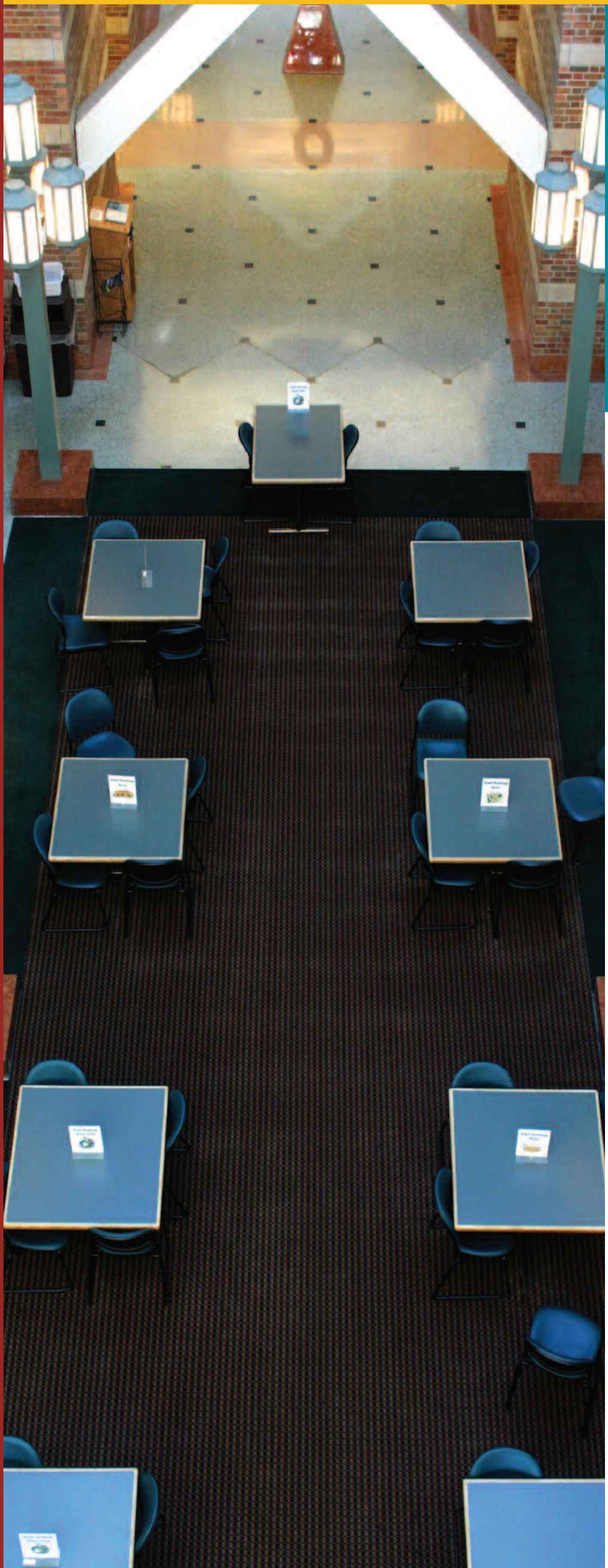
**• Animation and Video Production**

These facilities offer the ability to produce moving image sequences, created as communication resources for scientific presentation and for understanding of 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.

# Beckman Institute Graduate Fellows 2012



The Beckman Graduate Fellows Program offers unique research opportunities for some of the top graduate students at the University of Illinois. The program is supported by funding from the Arnold and Mabel Beckman Foundation and gives U. of I. 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 as well as a second U. of I. faculty member. Preference is given to those proposals that are interdisciplinary and involve the active participation of two Beckman faculty members from two different groups.

**Adrienne Barry**
Adrienne Barry is an M.D./Ph.D. candidate in the Medical Scholars Program and the Department of Biochemistry. She integrates biophysical and molecular imaging techniques to investigate alterations in vascular endothelial cell mechanics that are associated with acute lung injury. The integrity of the endothelial barrier is crucial for maintaining tissue homeostasis and regulating inflammatory responses. Gaining a better understanding of the role of mechanical force in the regulation of endothelial cell-cell junctions could reveal novel therapeutic targets for inflammatory pulmonary disorders. Adrienne works with Beckman Institute faculty members Deborah Leckband and Peter Wang.

**Alexandru Iordan**
Alexandru Iordan is a Ph.D. candidate in Neuroscience with a research interest in the neural circuitries linking the enhancing and impairing effects of emotion on different memory systems. Using an interdisciplinary approach that combines behavioral, brain imaging, eye-tracking, and skin-conductance assessments, Alex will investigate the following issues: 1) the contributions of emotional content and personal significance to the impact of task-irrelevant distracters on working memory, 2) the impact of elevated arousal on relational memory, and 3) the role of sex differences in the neural circuitry underlying the impact of emotion on these cognitive processes. Investigation of these issues is critical for understanding healthy behavior as well as changes in affective disorders, such as post-traumatic stress disorder and depression, where remembering of and focusing on traumatic or distressing memories interferes with proper cognitive functioning. Alex works with Beckman Institute faculty members Florin Dolcos, Neal Cohen, and Alejandro Lleras in his research.

**Curtis Johnson**
Curtis Johnson is a Ph.D. candidate in Mechanical Engineering. His research is at the intersection of medical imaging and biomechanics. Curtis develops techniques for high-resolution magnetic resonance elastography that allow for the mechanical properties of brain

tissue to be estimated non-invasively, and will ultimately provide researchers with a new contrast mechanism for studying the structure and function of the human brain. He is working with Beckman faculty members John Georgiadis, Brad Sutton, William Olivero, and John Wang.

**Fan Lam**

Fan Lam is a Ph.D. student in the Department of Electrical and Computer Engineering. His research is focused on developing advanced data acquisition and reconstruction methods for high-resolution neuroimaging. During his Beckman Fellowship, Fan will focus on developing and implementing a novel method for integrated structural, functional and physiological (metabolic) imaging of the brain. This new method is expected to provide neuroscientists a powerful tool to study structural and functional changes of the aging brain. Fan will work with Beckman faculty members Zhi-Pei Liang, Brad Sutton, and Art Kramer on the project. He will also collaborate with Dr. Norbert Schuff from the Center for Imaging of Neurodegenerative Diseases at the University of California, San Francisco.

**Jim Monti**

Jim Monti is a Ph.D. student in the Department of Psychology studying how the medial temporal lobe memory system is affected by aging, and what lifestyle factors ameliorate or contribute to these age related changes. Specifically, he investigates the role of exercise and nutrition on the structure and function of the medial temporal lobe memory system in older adults, while also examining how one's social network, education level, and body composition factor in to age-related changes in this system. Other areas of research include how a history of head trauma or mild traumatic brain injury interacts with the aging process to possibly produce decrements in memory and brain function later in life, as well as the development of cognitive tasks aimed at dissociating healthy aging from very mild dementia at the earliest possible stage. He works with Beckman faculty members Neal Cohen, Art Kramer and Edward McAuley.

**Martina Mustroph**

Martina Mustroph is a Ph.D. candidate in Neuroscience and an M.D. candidate in the College of Medicine. Martina's research integrates neuroscience and chemistry to investigate brain peptides in the hippocampus and amygdala that influence cocaine-induced conditioned place preference behavior in mice. This work has potential applications in the development of new therapies for drug dependence and addiction. Martina is working with Beckman Institute faculty members Justin Rhodes and Jonathan Sweedler.

**Chaitanya Sathe**

Chaitanya Sathe is a Ph.D. candidate in Electrical Engineering with research interest in graphene based nanopores for DNA sequencing. As a Beckman Graduate Fellow, Sathe will resolve in detail the physical interaction between DNA and graphene membrane through molecular dynamics and semi-empirical electronic structure calculations. The simulations can guide the development of graphene-based nanoelectronic biosensors for detecting and sequencing DNA. He is working with Beckman faculty members Klaus Schulten, Jean-Pierre Leburton and Rashid Bashir.

**John Ben Soileau**

John Ben Soileau is earning his Ph.D. in Sociocultural Anthropology and his research examines different forms environmental governance in Brazil's Amazon region. He has a particular focus on the process of the Environmental Impact Assessment (EIA) and how this process involves social and natural scientists on the one hand, and affected populations on the other. Currently, he is investigating these issues in the context of the Belo Monte hydroelectric complex on the Xingu River in the Brazilian state of Para. This research is part of a long-term ethnographic project that charts the development and implementation of environmental policy during large-scale infrastructural expansion in the greater Amazon region. John Ben is working with Beckman faculty Jesse Ribot, Tom Bassett and A shwini Chhatre. His primary advisor is Andrew Orta from the Department of Anthropology.

**Hang Xing**

Hang Xing is a Ph.D. candidate in Chemistry at Illinois who earned his B.S. and M.S. degrees from Nanjing University. His research focuses on developing a general platform for multi-target and multi-modal cancer imaging and therapy. In his research he will incorporate versatile nucleic acid aptamers as targeting agents with liposomes to recognize several important cancer markers and receptors. By introducing the aptamer-liposome system with correct combinations of different targeting agents and imaging probes, it is possible to improve the specificity and sensitivity of cancer diagnosis and therapy and further establish a well-characterized pre-clinical mouse model for future clinical applications. Hang will be working with Beckman Institute faculty members Stephen Boppart, Jianjun Cheng, and William Helferich.

**Joshua Wood**

Joshua Wood is a Ph.D. candidate in the Department of Electrical and Computer Engineering (ECE). He received his M.S. in ECE at Illinois and his B.S. in Computer Engineering at Valparaiso University. He works with carbon-based nanomaterials, specifically graphene and carbon nanotubes. He investigates better ways to synthesize and control these nanomaterials from the atomic to the electronic device level. He also explores alternative applications for graphene, such as using it as a protective atomic coating for DNA. He is working with Beckman faculty members Joe Lyding, Eric Pop, and Rashid Bashir.

# Beckman Institute Postdoctoral Fellows Program

The Beckman Institute Fellows Program is entering its 20th year of existence. We are proud to have been home to more than 70 postdoctoral scientists who had the rare opportunity to pursue their research goals unburdened by teaching or other work responsibilities. Postdoctoral researchers from across the country and around the world have taken part in the Beckman Institute Fellows Program since 1992.

The Beckman 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.

## Current Beckman Institute Fellows

### 2012 Fellows

**Suma Bhat**

Suma 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. Her research plans as a Beckman Fellow are to use multiple elements of communication, such as speech and gesture, for improving virtual reality applications like video conferencing. Suma's goal is to precisely characterize the efficacy of a new an online presentation tool, and then to design tools for improved human-to-human interactions in a virtual setting. She will work with several Beckman researchers, including Art Kramer, Minh Do, Mark Hasegawa-Johnson, and Tom Huang from the Human-Computer Intelligent Interaction research theme, and Jennifer Cole and Kara Federmeier from the Biological Intelligence research theme.

**Bradley Deutsch**

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

**Sarah Erickson**

After earning a Ph.D. in Biomedical Engineering from Florida International University in 2011, Sarah 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. Sarah has used diffuse optical tomography (DOT) toward development of a hand-held based optical imager; as a Fellow she will explore 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. Sarah will work with Integrative Imaging research theme Co-chair Stephen Boppart, and collaborate with Rohit Bhargava from the Bioimaging Science and Technology group, and Martin Gruebele from the Nanoelectronics and Nanomaterials group.

**Heather Lucas**

Heather Lucas completed her Ph.D. in Psychology at Northwestern University in the summer of 2012. Her research focus is on the neural bases of human memory systems and changes they undergo during the aging process. At Beckman she will work with Cognitive Neuroscience group members Neal Cohen and Kara Federmeier, and with the Center for Nutrition, Learning, and Memory that Cohen directs. Her research aims as a Fellow include identifying early markers of pathological memory decline with age and characterizing the impact of B-vitamin supplementation on cognitive functioning in older adults. The 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**

Jie earned a Ph.D. in Molecular and Integrative Physiology in December of 2011 from the University of Illinois at Urbana-Champaign. She is currently a postdoctoral researcher in Beckman Institute faculty member Peter Wang's research group. As a Beckman Fellow, Jie will be working with Wang, and will collaborate with Eric Jakobsson from the Computational Multiscale Nanosystems group. 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, Jie will use protocells as a synthetic platform to reconstitute cellular functions and understand the biological organization of cell signaling.

**Baoxing Xu**

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

## 2011 Fellows

**Kyle Mathewson**

Kyle earned a Ph.D. in Psychology from the University of Illinois. He has worked for more than three years in Beckman's Cognitive Neuroimaging Laboratory with Institute researchers Monica Fabiani and Gabriele Gratton. During his time at Illinois and Beckman, Kyle's research involved cognitive neuroscience, with a focus on attention and awareness in the human visual system. He plans to spend his time as a Beckman Fellow 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.

**Meredith Silberstein**

Meredith completed a Ph.D. in Mechanical Engineering from the Massachusetts Institute of Technology this spring. Her research interests are in the area of alternative energy harvesting and conversion methods that can perform electrochemical functions while maintaining mechanical integrity. Her work is aimed at developing microstructurally-based models for electro- and/or chemo-mechanically coupled materials that will facilitate system level design and design of new multifunctional composite materials. At Beckman Meredith focuses on mechanochemical transduction in synthetic material design, specifically characterization and development of mechanophores.

**Joseph Toscano**

After completing his Ph.D. in Cognition and Perception at the University of Iowa, Joseph will join the Fellows program to continue his research looking at how the perceptual system uses context information during speech perception. At Beckman he plans to use computational modeling and neuroimaging methods to investigate continuous cue encoding and categorization during speech processing, apply his approaches to spoken word recognition, and examine effects of prosody and audiovisual speech.

**Thomas van Dijk**

Thomas van Dijk earned his Ph.D. in Physics at Vrije University in Amsterdam. His dissertation has a focus 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 is interested in exploring theoretical frontiers in biooptics, which uses light to study, manipulate, and treat biological samples, toward advancing the design of experimental methods and analysis of results. He plans to concentrate his work on problems in the imaging and diagnosis of disease in order to meet both clinical and research needs.

## 2010 Fellows

**S. Derin Babacan**

Derin joined the Beckman Institute from Northwestern University where he completed his Ph.D. work in Electrical Engineering in December 2009. His research interests are focused on problems in image processing, computer vision, and compressive sensing. He is investigating novel Bayesian modeling and inference procedures that effectively utilize complex signal and degradation models that are consistent with the nature of imaging instruments and subjects. These novel methods could potentially advance the state-of-the-art in many imaging applications.

**Simon Fischer-Baum**

Simon earned his Ph.D. in Cognitive Science from Johns Hopkins University in the fall of 2010. He was a William Orr Dingwall Foundation Neurolinguistic Fellow at Johns Hopkins. His research seeks to identify domain-independent principles of cognitive processing, specifically regarding how serial order is represented and processed. This line of research could have implications for many aspects of biological intelligence including more high-level cognitive processes like language and problem solving, and more peripheral processes like perception and motor control.

**Malini Ranganathan**

Malini earned a Ph.D. in the Energy and Resources Group at the University of California at Berkeley. 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 investigates 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.

**Ilia Solov'yov**

Ilia 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.

## 2009 Fellows

**David Mayerich**

David completed his Ph.D. in Computer Science from Texas A&M University. While there he helped develop a prototype microscope capable of quickly imaging large three-dimensional tissue samples. His current research goals are to advance methods for reconstruction and visualization of biomedical data in order to provide an unprecedented understanding of anatomy at the sub-cellular level. He focuses on creating sub-cellular anatomical models of tissue as well as better ways to process and visualize datasets provided by new microscope techniques.

**Nathan Parks**

Nathan completed his Ph.D. in the area of Cognitive and Brain Science at the Georgia Institute of Technology. His research plan concentrates on examining the neural mechanisms of attention, competition, and short-term plasticity within the human visual system. He uses a variety of noninvasive neuro-physiological measures and psychophysical techniques in his investigations.

**Edward Wlotko**

Eddie earned a Ph.D. from the Brain and Cognition Division of the Department of Psychology at the University of Illinois at Urbana-Champaign. His research explores how the two hemispheres of the brain each serve language functions that are necessary for comprehension. At the Beckman Institute, he uses the event-related optical signal

(EROS) system to explore the individual and joint contributions of the cerebral hemispheres to language comprehension, and how those contributions change over the lifespan.

### Carle Foundation Hospital—Beckman Institute Fellow

**Jongsick Kim**

Jongsick joined Beckman's Biophotonics Imaging Laboratory, headed by Institute researcher 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 oncololgy-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.

### 2011 Nadine Barrie Smith Memorial Fellows

**Yue Wang**

Yue is a member of the Ultrasonic Imaging Laboratory at the Beckman Institute where she works with Michael Insana of the Bioimaging Science and Technology group. She is a graduate student in Department of Bioengineering at the University of Illinois. Yue's research is aimed at developing a novel shear wave imaging technique that has the potential to bridge molecular, cellular, and tissue biology, and to support medical diagnoses of cancer. She is also interested in exploring biological sources of mechanical contrast in cancer development.

**Cac Nguyen**

Cac is an Electrical and Computer Engineering major at the University of Illinois and a member of the Institute's Biophotonics Imaging Laboratory, where she works mainly with lab director and Integrative Imaging Co-chair Stephen Boppart. Cac also collaborates with Beckman researcher Jont Allen. Cac's research investigates bacteria biofilm in the middle ear using imaging techniques and acoustic measurements, and she has developed an automatic algorithm for classification of data.

## Postdoctoral Fellows Program Alumni (listed by class)

**2009**
- Nanshu Lu, Ph.D. from Harvard University
- Jeremy Brooks, Ph.D. from University of California, Davis

**2008**
- Agustín Mihi, Ph.D. from University of Seville
- Jacob Eisenstein, Ph.D. from Massachusetts Institute of Technology
- Amy Shih, Ph.D. from University of Illinois
- Joel Voss, Ph.D. from Northwestern University

**2007**
- Derek Hoiem, Ph.D. from Carnegie Mellon University
- Zhi Jiang, Ph.D. from Purdue University
- Severine Lepage, Ph.D. from University of Liège, Belgium
- Jongseung Yoon, Ph.D. from Massachusetts Institute of Technology

**2006**
- Joseph B. Geddes III, Ph.D. from Pennsylvania State University
- Yael Gertner, Ph.D. from University of Pennsylvania
- Ming Hsu, Ph.D. from California Institute of Technology
- Mark Neider, Ph.D. from Stony Brook University
- Stephanie Rinne, Ph.D. from University of Illinois
- Sarah Brown-Schmidt, Ph.D. from University of Rochester
- Dirk Bernhardt-Walther, Ph.D. from California Institute of Technology

**2005**
- Chandramalika Basak, Ph.D. from Syracuse University
- Emma Falk, Ph.D. from Helsinki University
- Silvio Savarese, Ph.D. from CalTech
- Zhihong Zeng, Ph.D from the Chinese Academy of Sciences

**2004**
- Byron McCaughey, Ph.D. from Tulane University
- Michelle Meade, Ph.D. from Washington University, St. Louis
- Timothy Nokes, Ph.D. from University of Illinois, Chicago
- Maxim Raginsky, Ph.D. from Northwestern University

**2003**
- Joshua Ballard, Ph.D. from University of Colorado
- Richard Godijn, Ph.D. from Vrije Universiteit, Amersterdam
- Mathews Jacob, Ph.D. from Swiss Federal Institute of Technology
- Ryan Kershner, Massachusetts Institute of Technology

**2002**
- Tyler Bruns, Ph.D. from University of Illinois
- Stan Colcombe, Ph.D. from University of Illinois
- Diego Diaz, Ph.D. from Cornell University
- Sarah Grison, Ph.D. from the University of Wales
- Cristina Iani, Ph.D. from the University of Bologna

**2001**
- Michael Bevan, Ph.D. from Carnegie Mellon University
- Donald Cannon, Ph.D. from Penn State University
- Christina Grozinger, Ph.D. from Harvard University
- Jesse Spencer-Smith, Ph.D. from Indiana University

**2000**
- John Paul Minda, Ph.D. from SUNY, Buffalo
- Slava Rotkin, Ph.D. from Ioffe Institute, Russia
- Ilya Zharov, Ph.D. from University of Colorado

**1999**
- Dale Barr, Ph.D. from University of Chicago
- Hong Hua, Ph.D. from Beijing Institute of Technology
- Jason McCarley, Ph.D. from University of Louisville
- Lolita Rotkina, Ph.D. from Ioffe Physico-Technical Institute

**1998**
- Michal Balberg, Ph.D. from Hebrew University of Jerusalem
- Gregory DiGirolamo, Ph.D. from University of Oregon

**1997**
- Brendan Frey, Ph.D. from University of Toronto
- Tammy Ivanco, Ph.D. from McMaster University

**1996**
- Srinivas Akella, Ph.D. from Carnegie Mellon University
- Jose Jimenez, Ph.D. from Columbia University
- Chen Liu, Ph.D. from Techinion-Israel Institute of Technology

**1995**
- Prahlad Gupta, Ph.D. from Carnegie Mellon University
- Gregory Zelinsky, Ph.D. from Brown University

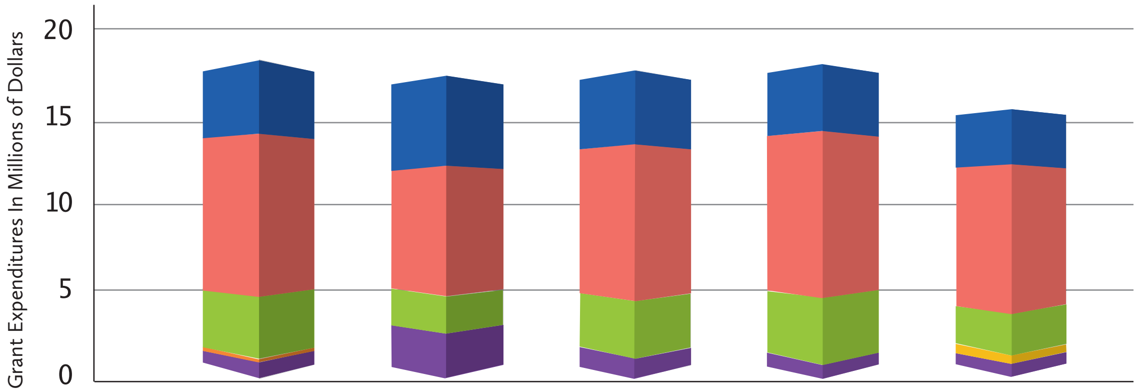
**1994**
- Barbara Church, Ph.D. from Harvard University
- Narayan Srinivasa, Ph.D. from University of Florida

**1993**
- Andreas Herz, Ph.D. from Heidelberg University
- Rejeev Sharman, Ph.D. from University of Maryland

**1992**
- Andrew Nobel, Ph.D. from Stanford University
- Efrat Shimshoni, Ph.D. from The Weizmann Institute of Science

# Beckman Institute Funding 2011-2012

## Research Grant Expenditures by Funding Source[1]




| | FY2008 | FY2009 | FY2010 | FY2011 | FY2012 |
|---|---|---|---|---|---|
| DOD | $4,217,584 | $5,238,196 | $4,358,155 | $3,869,004 | $3,200,338 |
| NIH | $9,444,099 | $7,518,406 | $9,072,558 | $9,705,827 | $8,665,427 |
| NSF | $3,596,633 | $2,310,613 | $3,403,358 | $4,050,734 | $2,482,559 |
| IBHE | $223,626 | $(1,674) | $- | $- | $- |
| Abbott[3] | $- | $- | $- | $- | $484,248 |
| Other | $1,151,309 | $2,578,214 | $1,075,980 | $770,525 | $575,790 |
| **Total** | **$18,633,251** | **$17,643,755** | **$17,910,050** | **$18,396,090** | **$15,408,362** |

## Research Awards by Funding Source[3]

| | FY2008 | FY2009 | FY2010 | FY2011 | FY2012 |
|---|---|---|---|---|---|
| DOD | $7,030,763 | $2,115,780 | $2,831,689 | $3,001 | $3,107,121 |
| NIH | $15,036,128 | $5,234,846 | $7,488,077 | $13,879,105 | $17,245,588 |
| NSF | $4,628,500 | $1,693,264 | $6,747,793 | $2,578,574 | $876,173 |
| Abbott | $- | $- | $- | $- | $15,246,982 |
| Other | $1,917,393 | $666,790 | $683,834 | $894,094 | $757,369 |
| **Total** | **$28,612,784** | **$9,710,680** | **$17,751,393** | **$17,354,774** | **$37,233,233** |

DOD Department of Defense
NIH National Institutes of Health
NSF National Science Foundation
IBHE Illinois Board of Higher Education (grant match funds)
Abbott Abbott Nutrition

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 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.

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**Beckman Institute**
FOR ADVANCED SCIENCE AND TECHNOLOGY

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