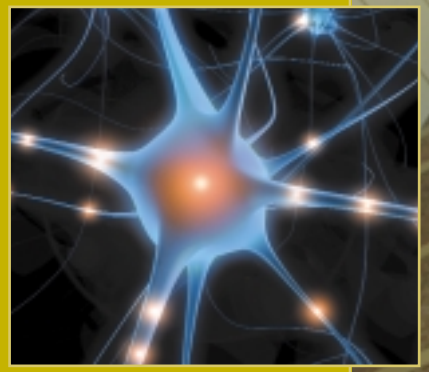
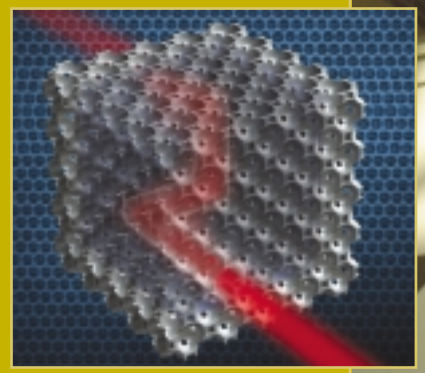
Beckman Institute

FOR ADVANCED SCIENCE AND TECHNOLOGY





ILLINOIS

Annual Report 2007–08

Contents

Evaluation, excellence, and evolution. These three powerful words embody what we strive to accomplish at the Beckman Institute each and every year. This past year was no exception.

In November 2007 we hosted our External Advisory Committee (EAC) for the biannual process of advising Beckman Institute leadership and the campus administration on the state of the Beckman Institute, its research programs, opportunities for new directions, and other issues. The EAC was presented with overviews of our research initiatives and was given presentations on planning, operational, and financial aspects. The EAC also spent time engaging in discussions with Beckman leadership, campus administrators, our research initiative co-chairs, faculty and fellows.

I'm pleased to report that the EAC was very favorably impressed with our strong leadership, the focus and top-quality research that is being conducted here, and the support provided by campus administration.

Each year we also maintain close communication with the Beckman Foundation Board. Without their strong support we would not be able to maintain crucial programs such as our Fellows program, our annual equipment competition, and the grant match program. The funds the Beckman Foundation Board provides can be highly leveraged and are invaluable to our annual budget. We are very grateful for their continued support.

Excellence abounds at the Beckman Institute and you can find it around every corner. From faculty to staff to students there are people who are top level performers. A few examples include researcher Jeff Moore who was inducted into the American Academy of Arts & Sciences; Nicholas Fang who received an MIT Technology Review Young Innovator Award; Alejandro Lleras who received an NSF Early Career Award; and Biomedical Imaging Center associate director Tracey Wszalek who received the Campus Award for Performance Excellence.

The merit of our researchers can also be tangibly measured by the grant dollars they attract from major funding agencies and industry partners. One such example is a multi-million dollar MURI grant awarded to Art Kramer, Monica Fabiani, Gabriele Gratton, Wai-Tat Fu, Brad Sutton, Dmitri Williams, and Dan Simons. Another is Klaus Schulten's long-running NIH resource grant which was just renewed for an unprecedented 20th year.

Evolution within our lines of research and our facility is what keeps things fresh and on the cutting edge at the Beckman Institute. In the past year we have embarked on several new projects and acquired several major new instruments.

One of the major projects is the acquisition of a new 3T whole-body magnet. This new magnet will allow further expansion of MRI and fMRI research in areas including cardiac imaging, animal imaging, and neural activity.

The new magnet set into motion another major change at the Beckman Institute: swapping the space Biomedical Imaging Center occupies (located on the south side of campus) with the Integrated Systems Laboratory space in the basement of the Institute. This space swap has been very labor intensive in both the planning and implementation and we are lucky to have such diligent and creative faculty and staff on the project. The new 3T magnet is expected to be delivered in July 2009 with most of the space transitions being completed to coincide with its delivery.

In 2008 we also launched the Carle Foundation Hospital/Beckman Institute Fellows program. This program gives a young scientist the opportunity to spend several years conducting cancer-related translational research. This program is another step toward building a strong relationship with Carle Foundation Hospital. Our collaboration provides scientists and practicing physicians with an important link that can lead to breakthroughs in translational research. We are looking forward to this program expanding and the development of other similar programs in the future.

Another new equipment acquisition was the $1.9M nano-CT instrument which was added to our Imaging Technology Group. This instrument, which performs complex 3-D imaging at previously unattainable length scales, is the first of its kind at a University in the United States. Kudos to Paul Braun, group leader for the 3-D Micro- and Nanosystems group and Ben Grosser, former director of the Imaging Technology Group for securing the highly competitive and prestigious National Science Foundation Major Research Instrumentation (NSF MRI) funding. The nearly $2M award is in the top one percent of all NSF MRI awards ever given.

In discussing the evolution of the Beckman Institute I would also like to mention that a new bioimaging research initiative is now clearly taking shape. A long list of Beckman Institute faculty members and colleagues from outside of the Institute have proposed projects involving bioimaging for advancing medical research in areas including breast cancer research, speech birth defects, and tar-

geted delivery of drugs and other agents at the molecular level. We are looking forward to implementing our plans as we feel the interface between the physical sciences and the life sciences, biological sciences, and social sciences is a very natural area for the Beckman Institute.

An additional new dimension to the Beckman Institute will include an environmental policy initiative that will be led by Jesse Ribot. His work will be dedicated to the pursuit of socially and politically sound solutions to society's mounting environmental dilemmas. For example, many societal changes such as global change are beyond the scope of technical fixes or ordinary legal or economic analyses. This program will emphasize social science research on the causes of environmental change and how we can best address them to create solutions to society's environmental problems.

On a final note, faculty and staff are gearing up to celebrate the Beckman Institute's 20th anniversary in 2009. Plans are well under way for a 20th Anniversary Symposium that will be held October 5-7, 2009. The planning committee is hard at work creating an event that will celebrate the past, yet is also forward looking and will give a glimpse of what the next 20 years might hold for the Beckman Institute.

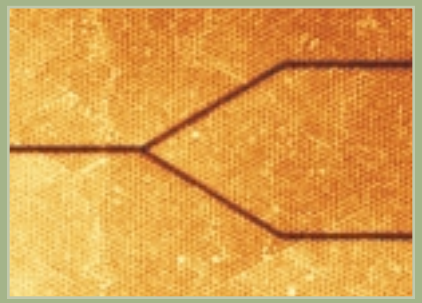
Warm Regards,

Pierre Wiltzius

Pierre Wiltzius, Director

About the **Beckman Institute**

In the spring of 2009 the Beckman Institute will celebrate 20 years of existence as one of the premier interdisciplinary campus research centers in the country. When Beckman officially opened in April of 1989 it was one of the first centers in the country devoted to advancing science and technology through an interdisciplinary approach that brings together researchers from different and sometimes disparate fields to do research in innovative new ways.



Beckman faculty member Paul Braun and Beckman Fellow Stephanie Rinne are the first to achieve optical waveguiding of near-infrared light through features embedded in self-assembled, three-dimensional photonic crystals.

From its origins in casual discussions and formal meetings in the early 1980s to a finely crafted proposal in 1984 that led to Arnold and Mabel Beckman's megagift of $40M a year later, the idea for a new kind of research center on the University of Illinois campus carried with it an interdisciplinary theme. The final proposal to the Beckmans to fund the building of such a center emphasized "the power of interdisciplinary research approaches to complex multifaceted problems" in areas ranging from neuroscience to artificial intelligence to semiconductor physics and electronics.

As it approaches its 20th anniversary, the Beckman Institute continues to be a leading force in those areas and many more, as more than 600 researchers from various fields come together to explore basic science and complex technologies, human biology and computer science, and many more topics in Beckman's limestone, brick, and green glass building that remains as beautiful today as the day it opened.

Twenty years ago, the people behind the Institute foresaw the importance computing would have in the world and today Beckman researchers are breaking new ground with advances in the areas of silicon and photonics, computer simulations, human-computer interfaces, and in applying their discoveries to technology development. Likewise, researchers studying cognition and the brain are using technological advances to understand how the mind works in ways that weren't possible two decades ago when many prominent faculty members from psychology and related disciplines joined Beckman. Today, the breadth of research at Beckman takes place within three broad research themes: Biological Intelligence (BI), Human-Computer Intelligent Interaction (HCII), and Molecular and Electronic Nanostructures (M&ENS).

In 2008 researchers at Beckman have the support of experimental resources that could only be dreamed of 20 years ago, such as a rare immersive virtual reality environment (the Cube), state-of-the-art microscopy equipment (including the only campus-based nano-computed tomography microscope), and a premier magnetic resonance imaging facility. These advanced resources, combined with faculty members who are leaders in their respective fields, ensure that the Beckman tradition of interdisciplinary research is as vibrant, relevant, and forward-looking as it was when the Institute doors first opened nearly two decades ago.

The study of biological intelligence has been an integral part of Beckman Institute history from the earliest discussions about building an interdisciplinary research center on campus to the building's official opening nearly two decades ago to 1994, when the Biological Intelligence (BI) research initiative was created as one of the three core research themes at Beckman.

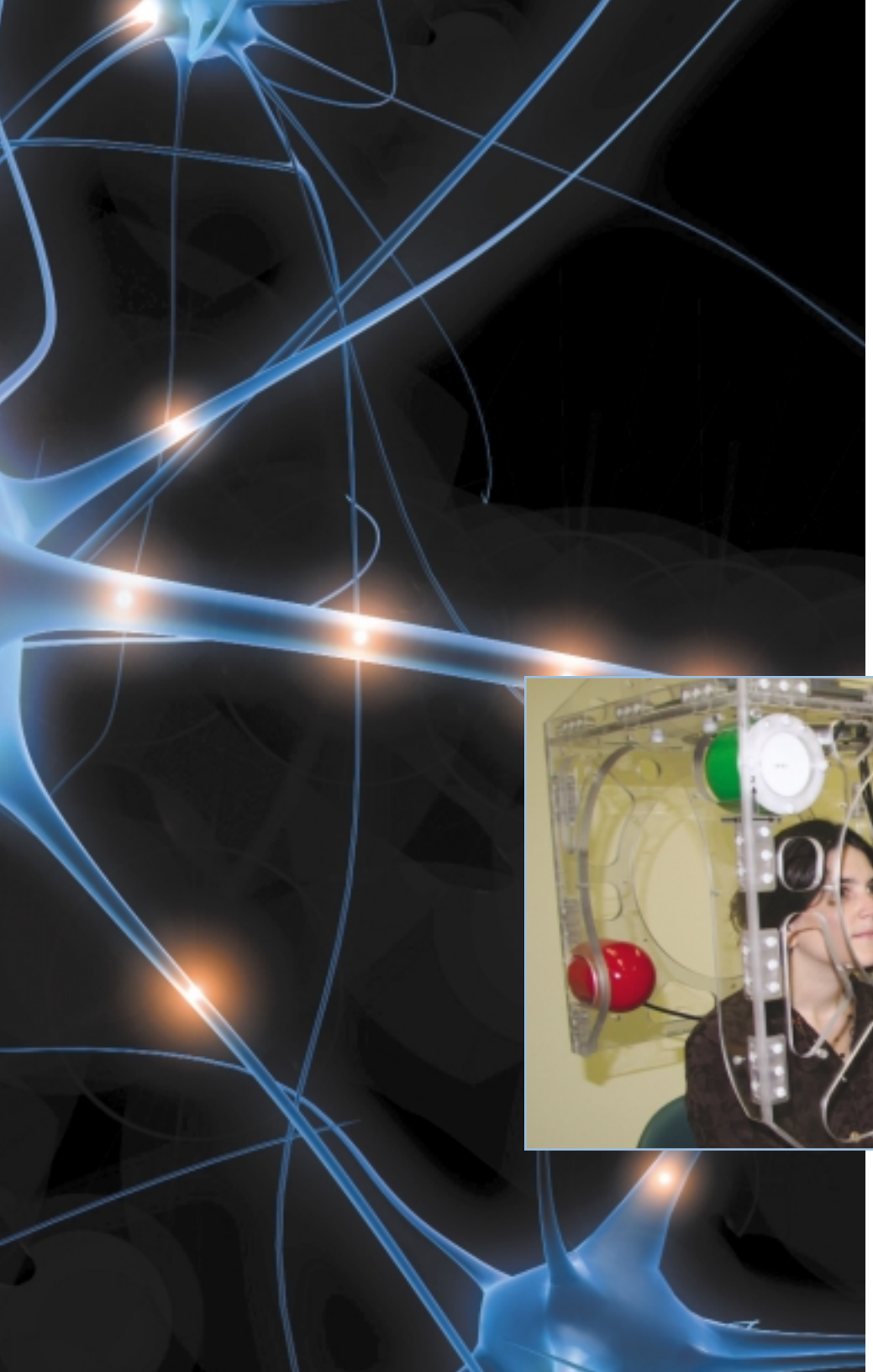
While a professor of psychology at Illinois in the late 1980s, current Biological Intelligence research initiative Co-chair **William Greenough** was a key player in the effort that led to building the Beckman Institute and when it officially opened in 1989, he was appointed as an Associate Director. With faculty members from Psychology like Greenough, **Gary Dell, Brian Ross, William Brewer,** and **Neal Cohen**, as well as researchers from other campus departments interested in the topic like **Bruce Wheeler** and **Douglas Jones** from Engineering and **Kenneth Suslick** from Chemistry as original Beckman faculty appointments, it was clear from the beginning that the study of biological intelligence would be a building block for research at the Institute.

The area of biological intelligence has seen sweeping changes in the past two decades, thanks in part to new discoveries but also increasingly to new insights provided by advanced technologies. Today there are five research groups making up BI, focusing on research lines such as the molecular and cellular workings of brain circuitry, creating computer models of sensory processes, and using advanced technologies that enable newfound insights into higher expressions of intelligence like language acquisition and motivational behaviors.

The work of researchers in BI from the NeuroTech (NT) group, Bioacoustics Research Laboratory (BRL), Bioimaging Science and Technology (BST) group, Cognitive Science (CS) group, and Cognitive Neuroscience (CN) group, provide a comprehensive perspective on biological intelligence that is found in few places in the world.

NeuroTech's efforts range from Greenough's investigations of the cellular mechanisms at work in the nervous system to **Mark Nelson's** studies of electric fish for their sensory processing prowess to **Justin Rhodes**' focus on the causal mechanisms

A 3-D rendering of a neuron cell.
Sebastion Kaulitzki.



underlying detrimental behaviors like alcoholism and drug addiction. Bioacoustics Research Laboratory Director **William O'Brien** contributes advances in the field of ultrasound imaging for better diagnoses and for improved safety.

The Bioimaging Science and Technology group is at the leading edge of developments in imaging techniques, both in improving existing techniques and in creating innovative new methods. BST researchers like **Michael Insana** and **Rohit Bhargava** are improving current Magnetic Resonance Imaging methods while others in the group are creating new technologies, such as **Stephen Boppart's** development of a non-invasive breast imaging technique or **Kenneth Watkin's** project aimed at creating a combat helmet that could relay injury data.

Researchers in the Cognitive Science group look at topics like the ways humans process speech and acquire spoken language (**Jennifer Cole**) or create computational models of those and other cognitive processes (**Gary Dell**).

The lab of Cognitive Neuroscience group members **Gabriele Gratton** and **Monica Fabiani,** also a BI Co-chair, has expanded the capabilities of their optical imaging system called EROS, which measures brain activity in human subjects. EROS can now be used on songbirds, in a collaboration with **David Clayton.** EROS also is being used to study language processing in a project with Dell and **Susan Garnsey.**

Work in the Biological Intelligence research initiative is both translational, leading to numerous applications with current and potential future benefits, and grounded in basic science, as BI researchers increase our understanding of how intelligence works.

Beckman Fellow Sarah Brown-Schmidt tries out the new AG500 3-D articulograph installed at linguistics researcher Chilin Shih's laboratory at the Beckman Institute. The rare electromagnetic articulometer, called EMA, is used to measure physical movements during speech production.

Greenough Lab Discovers Fragile X Syndrome Marker

Biological Intelligence Co-chair **William Greenough, Ivan Jeanne Weiler,** and their laboratory made a significant discovery in the effort to understand and combat Fragile X syndrome (FXS), the most common inherited cause of mental impairment and the most common known cause of autism. In 2008 Greenough and his collaborators reported on using an enzyme called ERK as a marker for measuring the effectiveness of potential drug therapies for treating Fragile X. According to the National Institute of Child Health and Human Development, there are currently no pharmaceutical or other types of cures for Fragile X syndrome. Greenough said their work with ERK could lead to methods for testing the efficacy of drugs aimed at treating FXS, including both newly developed drugs and current drugs, such as the anti-depressant lithium chloride that could be used for treating the disorder. He said it could also prove useful for guiding drug dosage amounts when treating Fragile X patients. "A marker or a reporter that provides feedback as to the efficacy of drug treatment of Fragile X syndrome, I think will be very, very valuable," he said. Fragile X syndrome occurs when the body's cells don't produce the Fragile X Mental Retardation 1 protein (FMRP) which binds the RNA messenger proteins that regulate protein production, synthesis, and translation in the nervous system. The Greenough lab's research found that in Fragile X patients hyperactive enzymes continuously deactivated signals required to translate RNA in a process that eventually leads to maturation of synapses.

Bill Greenough, co-chair for the Biological Intelligence research initiative and group, has been a pioneer in Fragile X research.

New Center for Studying Executive Function

Wendy Heller and **Gregory Miller** from the Cognitive Neuroscience group, **Brad Sutton** from the Bioimaging Science and Technology group, and Beckman's Biomedical Imaging Center are all key players in a new multi-university center for studying executive function. The National Institute of Mental Health Interdisciplinary Behavioral Science Center was created with a $5M grant for the goal, according to the grant, of "significantly increasing the understanding of executive function," which it describes broadly as "the critical cognitive abilities that are used to guide, control, inhibit and monitor behavior." The center's work will be broken down into five projects that examine the influence of executive function on: control processes, learning processes, emotional processes, representations and development, and genetics. Heller is principal investigator and Miller and Sutton are co-PIs on Project III Emotion Processes that will be based at the University of Illinois. The Center is divided into three cores, two of which inolve the Beckman researchers in administrative roles,

Gregory Miller and Wendy Heller from the Cognitive Neuroscience group are co-PIs on a $5 million grant that will set up a center based at the University of Illinois.

NeuroTech researcher Al Feng continues to expand his research in developing high-resolution cochlear implant technology for the hearing impaired. He and his collaborators use the mechanics of frog hearing to help design intelligent hearing aids that boost sound signals of interest.

with Heller as co-PI for the administrative core of the Center while Miller is co-PI for the neuroimaging core, for which Beckman's Biomedical Imaging Center (BIC) is a resource facility. The center will employ several experimental tools, including structural and functional Magnetic Resonance Imaging (fMRI) in support of the effort, with BIC serving as the center's resource for fMRI studies into emotion processes.

Developing High-resolution Cochlear Implant Technology

Albert Feng is leading an interdisciplinary effort involving fellow NeuroTech group members **Richard Kollmar** and **Bruce Wheeler,** and Carle Clinic ear, nose, and throat physician Michael Novak to develop high-resolution cochlear implant technology for the hearing impaired. The research team's goal is to develop connections between cochlear implant devices and the ear's auditory nerve terminals that have higher resolution than what is currently provided by cochlear implant devices. A cochlear implant is an electronic device surgically implanted into the inner ear that stimulates the auditory nerve to give the severely hearing-impaired a sense of sound. Feng said cochlear implant technology, which bypasses the damaged auditory hair cells in the hearing-impaired, is "currently unable to replicate the high quality of sound perceived via a fully intact cochlea. Consequently, recipients may have difficulty with certain real-world tasks, such as understanding speech in a noisy environment or listening to music." So his team is developing a novel biomolecular technology that will allow high-resolution connections to be established between cochlear implant devices and the auditory nerve terminals. Feng said the approach "promises to greatly improve the quality and fidelity of sound that can be transmitted to the brain by the next generation of cochlear implant devices." Feng said the team made advances on its previous research by identifying signaling molecules and receptors in the auditory nerve terminals that are potential targets of pharmacological administration for creating high-resolution auditory connections.

Molecular Biosensors and Nanoscale Biotechnology for Live Cell Imaging

As a member of the Bioimaging Science and Technology group **Peter Wang** studies and manipulates live cells for integration with nanoscale biotechnologies such as cancer-detecting biological sensors. Wang's work has led to several new biosensors based on FRET (fluorescence resonance energy transfer) technologies for the early detection of the molecules that play critical roles in the development of cancer; it has also led to improvements in the sensitivity of second-generation signaling molecule biosensors. Wang's lab is also developing FRET-based probe technology that allows the simultaneous visualization of two signaling events in the same live cell, providing information on molecular hierarchy in time and space. Wang said that these optical sensors have "successfully integrated nanofabrication and FRET technology to control and investigate the microenvironment effect on signaling transduction in live cells." The biosensors being developed are part of a joint effort with the University of Illinois Research Park company iCyt, which integrates an analysis and measuring technique called flow cytometry with a signaling molecule biosensor called MT1-MMP for the detection of circulating tumor cells in cancer patients.

New Grant for Studying Production and Perception of Phonological Sequences

Cognitive Science group members **Gary Dell, Cynthia Fisher,** and **Jennifer Cole** secured a new grant for studying the role experience plays in the production and perception of phonological sequences. The project seeks to understand the adaptability of an aspect of the phonological processing system called phonotactic constraints, which are language-specific generalizations about how words are pronounced. Their research is guided by the assumption that language learning is an ongoing, changing process that, as they write, "adapts to recent experience, while continuing to reflect the accumulated experience of a lifetime of speaking and listening. We sometimes articulate this assumption like this: language learning never stops." An example of this type of constraint is the sound "ng" which in English is a sound that can never begin a word, but in Vietnamese it can. Their research has shown that constraints such as these can be altered by experience and that a large amount of change is possible. The work has also provided insight into the learning mechanisms behind the changes. The project integrates concepts and methods from linguistics, psychology, computer science, and neuroscience and combines experimental studies of speech production errors and studies of speech perception in both adult and child subjects with neurally plausible computational models of learning.

New Partnership for Quantitative Ultrasound Imaging of the Breast

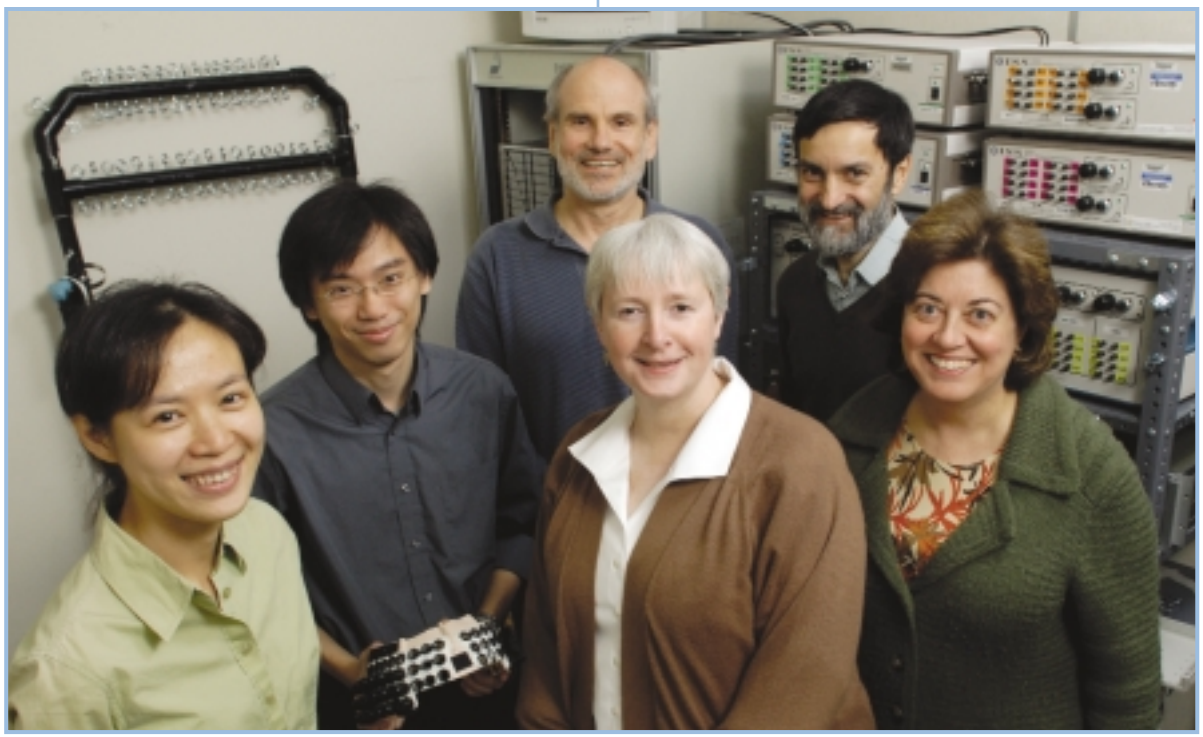
This past year **William O'Brien** and **Michael Oelze** of the Bioacoustics Research Laboratory joined with researchers from the University of Wisconsin to earn a 5-year, $5.2M Bioengineering Research Partnership grant award for their project "Quantitative Ultrasonic Imaging of the Breast." The goal of the Partnership award, funded by the National Institutes of Health's National Cancer Institute, is to, as the proposal states, "develop, unify, refine and implement a fundamentally new approach to quantitative ultrasound (QUS) imaging of biological tissues and mammary tumors by the quantification of tissue microstructure through acoustic backscatter. The overall hypothesis is that a set of QUS parameters can significantly improve breast lesion differentiation /classification, that is, diagnose the lesion noninvasively." While imaging methods like Magnetic Resonance Imaging (MRI) use a qualitative approach to discern properties in tissue, the ultrasound imaging technique is quantitative, estimating properties of the microstructure of breast tissue from the ultrasonic backscatter. In addition to the advantages the method offers by being non-invasive (reducing the need for an invasive biopsy), their technique would also be portable and produce images less expensively and faster than current cancer detection methods such as MRI. The research so far has shown that it is possible to distinguish different types of cancer, such as benign tumors from malignant tumors, using their techniques.

Ultrasound-induced Tissue Damage Assessment

The Bioacoustics Research Laboratory (BRL) earned a Merit Award designation in 2006 and continued funding this past year from the National Institute of Biomedical Imaging and Bioengineering (NIBIB) for its research into ultrasound-induced tissue damage assessment, a project that looks at issues such as whether the effects of diagnostic ultrasound exams are harmful. BRL group leader William O'Brien has been a leading researcher in the area of ultrasound-tissue interaction, especially as it relates to quantitative ultrasound imaging. The current project involves looking at potentially significant ultrasound (US)-induced biological effects, specifically a non-clinical investigation of whether the application of ultrasound contrast agents (UCAs) in humans adversely affects the vasculature. Currently there is no data on this topic, causing concerns as to the effects of UCAs. BRL's investigation of whether the interaction of ultrasound with ultrasound contrast agents is a significant medical problem in humans should provide both medical personnel and patients much-needed information. If the interaction is found to be a risk, doctors can assess and monitor the risk; if US diagnostics are found not to pose a risk, a clinical concern will be eliminated. The knowledge gained from this project should also prove valuable for the Food and Drug Administration (FDA) in the approval process for newly developed UCAs, as the FDA seeks more information on the effectiveness and safety of these potentially beneficial agents.

Evaluation of Acoustic Propagation Paths into the Human Head

A grant to the Bioacoustics Research Laboratory (BRL) from the Air Force Office of Scientific Research was renewed for research that seeks to understand the reception and propagation paths of very high-amplitude airborne sound levels toward designing an advanced hearing protector device. The research looks at the acoustic propagation paths of high-amplitude airborne sound levels of about 150 decibels travelling to the inner ear by soft and hard tissue. According to the grant, the project uses well-known and documented computational methods to develop "an acoustic propagation model that will model propagated acoustic signals around and inside the human head," taking into consideration "the effects of diffraction of sound around the human head, and the direction from which the sound has traveled from the acoustic source to the human head." The grant to BRL is for three years.



A paper by faculty members and graduate students from the Beckman Institute published by the *Proceedings of the National Academy of Sciences* reported on the successful application of a fast optical imaging technique to language processing. From left to right: Chia-Lin Lee, Chun-Yu Tse, Gary Dell, Susan Garnsey, Gabriele Gratton, Monica Fabiani.

Beckman Researchers Develop New Tool for Language Studies

A collaboration between **Gabriele Gratton, Monica Fabiani,** and **Susan M. Garnsey** of the Cognitive Neuroscience group, **Gary Dell** from Cognitive Science, Beckman Graduate Fellow **Chun-Yu Tse**, and graduate student **Chia-Lin Lee** led to the creation of an important new method for studying how the brain processes language. Using the Event-Related Optical Signal (EROS) optical imaging technique developed by Fabiani and Gratton, the researchers applied, for the first time ever, a rapid, functional brain imaging method to the study of neuronal interactions within and between the left temporal and frontal cortex in regions of the brain associated with language processing. EROS is unique in that it gives both spatial and temporal information on how the brain processes language, providing a dynamic picture of interactions during this process. The EROS system, which uses near infrared light to identify and measure changes in the light scattering and absorption properties of neurons, allowed the researchers to identify changes in neuronal activity related to language processing while providing spatial and temporal resolutions on the order of a few millimeters and milliseconds, respectively. The results of a study using EROS correlated with simultaneously collected ERP results, thereby validating the use of this optical imaging technique for studying language processing. The researchers said EROS is especially valuable for studying the relative timing of aspects of language comprehension since it can measure neuronal activity as the dynamics of language processing are happening in real time.

Discovering Clues to Brain Function in the Songs of Birds

David Clayton doesn't quite know how to describe himself, at least when it comes to his scientific calling. Clayton's work in the areas of biology, neuroscience, and genomics is so blurred that he doesn't make distinctions between them in his research.

"They really are intertwined," Clayton said. "That's why I always have a hard time when people ask me what kind of "ist" I am. I identify as much with neurobiology as anything and I started my career coming out of molecular biology.

"As I got deeper in the brain stuff I went through a good 10 years or more where it was much more neurobiology, neuroanatomy, neurophysiology. Then with this genomic era I've kind of come back to where maybe now I'm a genome biologist."

Clayton said his area of study might best be understood through the word neurogenomics.

"It's kind of a pretentious term but it's an attempt to capture the idea that the brain and the genome are the two big control systems in our bodies and certainly in all animals," Clayton said. "Those are traditionally studied as two separate things, but biology doesn't know the difference. It's all one organism, right? So that's what really interests me: how these two things interact, how the genome contributes to brain function and controls how the brain develops."

However fluid his research boundaries are, Clayton's focus on a particular subject of study, the zebra finch songbird, has been laser-like. Clayton has been a leading researcher in the field, publishing a 1992 paper that showed hearing a song of the same species activated transcription in the brain, a seminal finding that ignited a long line of research. His status is such that in 2005 it was Clayton who authored a successful white paper proposal to the National Human Genome Research Institute (NHGRI) to sequence the whole genome of the zebra finch. The sequencing effort is slated to be completed this year.

All of this work has been done by a researcher who began his post-graduate work with no particular scientific or personal interest in birds. Clayton, a professor in the Department of Cell and Developmental Biology and a member of Beckman's NeuroTech group, has a degree in biochemistry and a Ph.D. in molecular cell biology. He also has an interest in neuroscience and psychology going back to his graduate school days; a talk about songbirds by a noted researcher got him interested in avian biology because of the unique insights the birds can provide neuroscience.

"My questions are about the role of genes and gene expression in the brain," Clayton said of his research. "A lot of that is related to how the brain adapts to experience; learning and memory is one flavor of that adaptation. I study the songbirds because they are a useful model organism in many ways; because of the way their brains are put together; because of the way that they learn to sing; and because we are able to analyze their behavior and vocal communication. So we are trying to gain insights that will ultimately be relevant to how the human brain works."

In his white paper to the NHGRI, Clayton wrote of the zebra finch's value as a "powerful biological model to human biology." Once the sequencing is completed, it is hoped the bird will be added to the NIH List of Model Organisms for Biomedical Research.

"A lot of infrastructure was developed with the human genome project," Clayton said. "For a period of years the strategy at the NIH was to focus on other organisms using that sequencing infrastructure, to find other organisms based on their evolutionary relatedness. You can learn a lot about humans by seeing what's changed and what's been conserved in those organisms."

Clayton said songbirds in general are excellent models for studying neuroscience, but the zebra finch is of special interest.

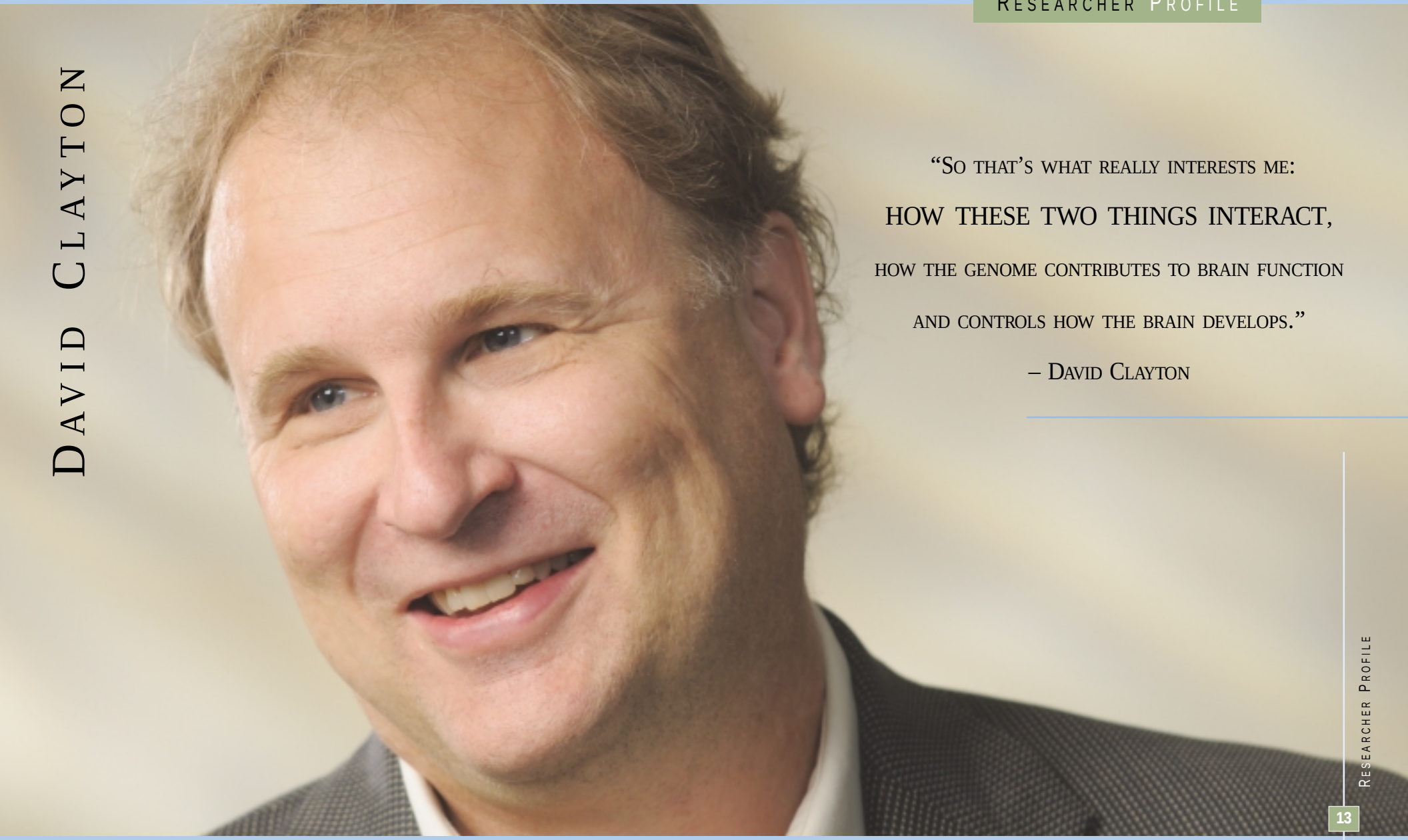
"A zebra finch is a species that learns its song once and only once in its life and it doesn't change after that," Clayton said. "There is this critical period when it is basically an adolescent when he – and only the male learns to sing – hears his tutor and forms a memory of his tutor and then he has to practice over a two-month period. He rehearses and what he ends up with is a good but not a perfect copy, because every bird sings his own unique song, but he ends up with his own little take on his tutor's song. Once he's learned it at 90 days of age, once he's sexually mature, it's like it is set in stone."

Clayton is currently working with Monica Fabiani and Gabriele Gratton of Beckman's Cognitive Neuroscience group, using their EROS optical imaging technology to study the zebra finch's brain activity non-invasively using tiny finch-sized helmets.

Clayton calls the interdisciplinary approach at Beckman and technologies such as EROS housed there as "absolutely essential" for his research.

"I think being at the Beckman has afforded access to the technical and intellectual," he said. "I've had access to people like Monica and Gabriele for example. I think this is a very important big picture kind of thing to be developing and it would not be happening were it not for the Beckman."

David Clayton



"So that's what really interests me:

HOW THESE TWO THINGS INTERACT,

how the genome contributes to brain function

and controls how the brain develops."

– David Clayton

Years before there were cell phones or Photoshopped images or an Internet the general public could use, the idea of including research focused on human-computer interactions was a given as the Beckman Institute came into being nearly 20 years ago.

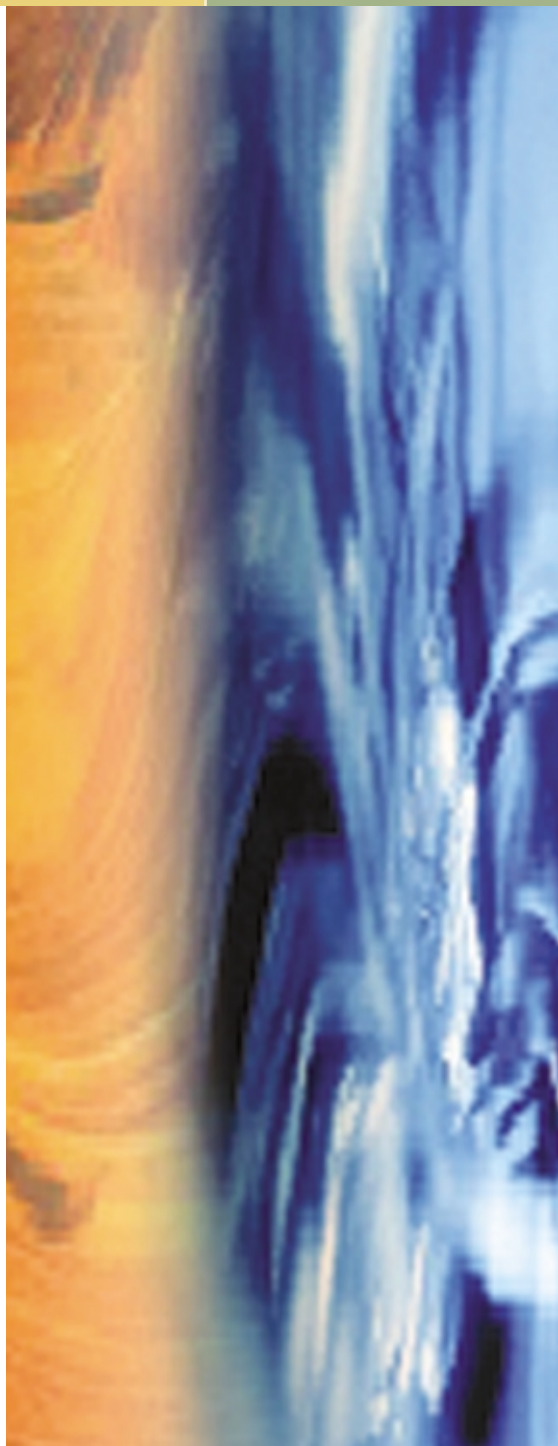
Even in 1988, as the finishing touches were being put on the building and University of Illinois faculty members were accepting appointments to Beckman, the growing importance of computers in people's lives was not only acknowledged but embraced by many faculty members at Illinois. When the Institute officially opened a year later, researchers from the areas of artificial intelligence and robotics, image formation and processing, computer science, perceptual psychology, and neuroscience were included as original faculty members at Beckman.

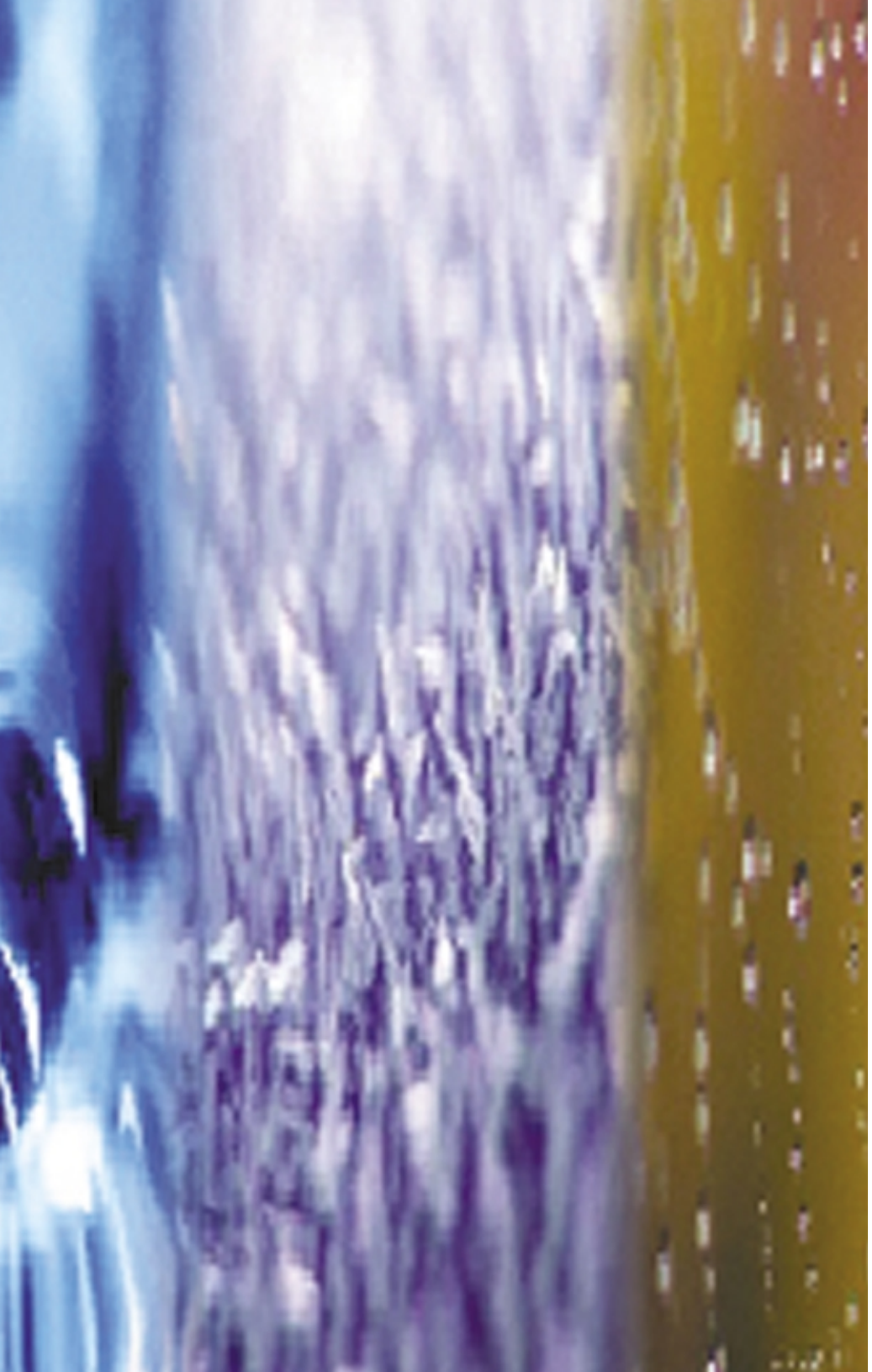
When the Human-Computer Intelligent Interaction research initiative was created in 1994 as one of the Beckman's three main research themes, efforts in computer-related areas were brought together under a broad umbrella with the mission of understanding and enhancing the human-computer interface for the benefit of science and for future applications. Today researchers in the HCII groups of Artificial Intelligence (AI), Image Formation and Processing (IFP) and Human Perception and Performance (HPP) continue to be leaders in a wide range of human-technology interfaces.

Several original faculty members remain on the cutting edge of research topics, including HCII Co-chair **Art Kramer**, who is conducting research on driver and pedestrian distraction, visual search and attention in laboratory and real-world environments, and cognitive and fitness training on human performance and brain function, and robotics researcher **Seth Hutchinson**, a leader in using mathematics to solve issues involving robot sensing, planning and control. Another original Beckman researcher, AI member **Narendra Ahuja**, is a leader in many human-computer topics, including detecting and analyzing visual and auditory signals for computer vision and other applications.

HCII Co-chair **Tom Huang**, a faculty member at Beckman since 1990 and a pioneer of computer vision and signal processing research, is breaking new ground in the areas of gender

Liz Stine-Morrow's research focuses on cognition and the capacity for learning throughout our lifespan.





Beckman researcher Deana McDonagh uses mood boards to extend the product design process. They are often used both in establishing and agreeing on a product's initial ambience with a client.

and emotion recognition software for computer and cell phone applications. Researchers in **Stephen Levinson**'s lab are teaching robots the meaning of words.

Much of the research in HCII involves developing technology that benefits humans, such as AI member **Mark Hasegawa-Johnson's** project to develop speech recognition programs for people with cerebral palsy or **Todd Coleman's** work to design novel, non-invasive brain-machine interface applications that could, for example, aid someone with a prosthetic limb. HPP member **Deana McDonagh** started an industrial design class that worked with students with disabilities to create aids designed specifically for their needs.

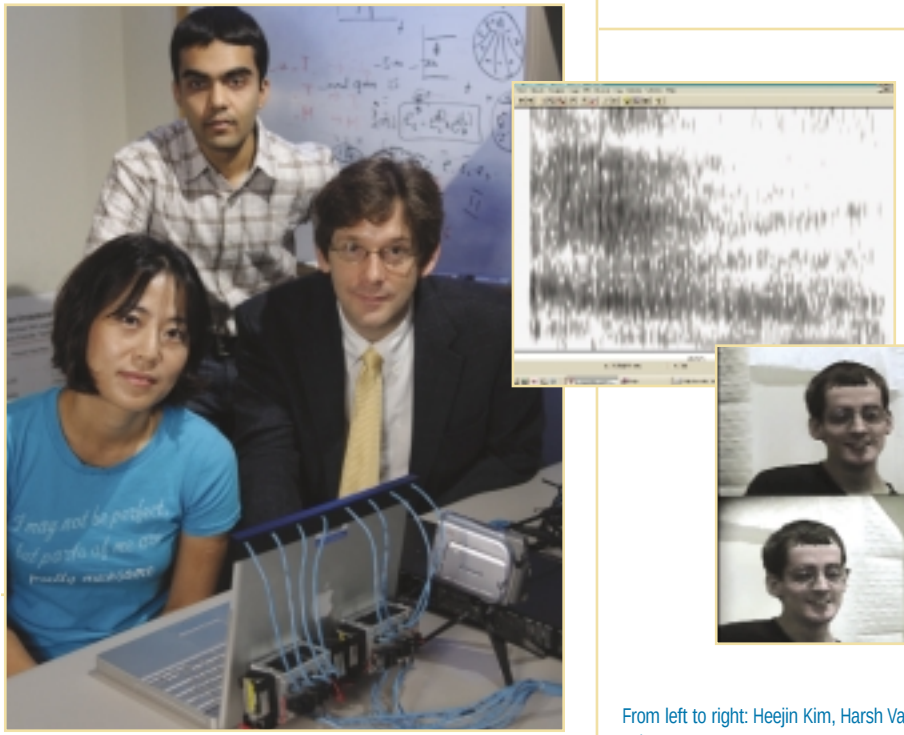
The boundaries of HCII research include developing interventions to help older adults, such as **Dan Morrow's** project that is developing a cognitive aid to assist older adults take their medication properly, or **Elizabeth Stine-Morrow's** Senior Odyssey project that is both a research experiment and intervention program for older adults.

Research in HCII also includes the use of advanced technology for research purposes. HPP group member **Alejandro Lleras** used eye-tracking equipment and computers to run a groundbreaking experiment that demonstrated that directed eye movement could be used for problem-solving and showing that eye movement is not just a function of cognition but can actually affect our cognitive processes. **Frances Wang** from HPP uses the Cube, Beckman's six-sided immersive virtual reality environment, to explore human spatial cognition and visual perception in order to understand how people navigate in their worlds.

The researchers in the Human-Computer Intelligent Interaction research initiative are working to enhance human-machine interfaces and to develop new technology that improves people's lives.

Superhuman Speech Interface for Those with Cerebral Palsy

Mark Hasegawa-Johnson, whose research with the Artificial Intelligence group focuses on speech production and recognition by humans and computers, is leading a project that is helping improve verbal communication for those with cerebral palsy. Hasegawa-Johnson and his collaborators have developed an automatic speech recognizer for people with cerebral palsy that was able to correctly understand 90 percent of a particular subject's words. Researchers recorded 16 volunteer subjects with cerebal palsy (CP) as they read a series of isolated words and found that listeners unfamiliar with the subjects understood them only about a third of the time. However, based on input from the CP subjects, the researchers were able to greatly improve those numbers by giving the speech recognizer the same advantages as listeners who were very familiar with the subjects, such as family members or close friends. The speech recognizer was trained specifically for each individual to recognize utterances from a fixed 55-word vocabulary; its 90 percent success rate proved much more accurate than a human transcriber. In addition, the group developed a prototype of a computer game that enables the subjects to score the speech recognizers. If a sufficiently successful interface is established between the user and the recognizer, further prototypes will be developed.



(Left Inset) A model from the speech interface developed by Mark Hasegawa-Johnson and his collaborators.

(Below) A screen capture showing a user of the automatic speech recognizer for talkers with cerebral palsy.

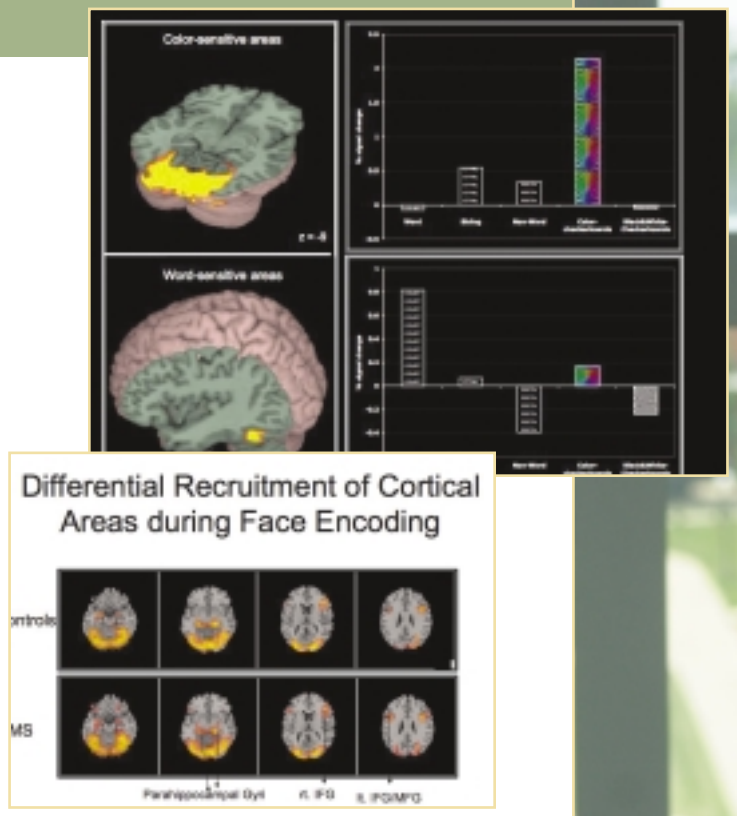
From left to right: Heejin Kim, Harsh Vardhan Sharma, and Mark Hasegawa-Johnson.

Enhancing Medication Adherence Among Older Patients

Dan Morrow of the Human Performance and Perception group is advancing his work on a cognitive aid that assists older adults with chronic illnesses in their drug-taking regimen. Morrow developed a medications table (called medtable for short) as part of a pharmacy-based intervention program aimed at assisting older patients who are taking multiple medications improve their health literacy and their adherence to medication regimens. The successful results shown in that program led Morrow to focus this past year on making improvements in the medtable. He also completed laboratory studies that confirmed in simulation experiments the efficacy of using a medtable and began a collaboration toward using the medtable in actual clinical settings. Filling out a medtable, which involves consultation between the patient and providers such as a doctor or health care specialist, can have several benefits. It requires useful patient-provider interactions regarding the medication regimen, including times for taking each drug that are both convenient for the patient and that correlate with the drug regimen. It also provides the patient a printout of their medication schedule, which can serve as a useful cognitive aid for older adults who are taking multiple medications. While Morrow believes the medtable can be a useful aid for older patients, he says the aid's real benefits may lie in the patient-provider relationship. "To me the value is not walking away with the printout, it's working with the provider to generate it," Morrow said. "That's what supports your understanding, gives the provider a sense of how well you do understand and a chance to do some education."

Enhancing the Training and Performance of Complex Computer-based Tasks

A project headed by HCII Co-chair **Art Kramer** aimed at increasing understanding of how skills relevant to complex computer-based tasks and environments are learned and transferred is a true interdisciplinary effort that includes a strong collaboration with MIT. A Multidisciplinary University Research Initiative (MURI) grant award from the Office of Naval Research last year funded the project, which capitalizes on research into brain plasticity—the concept that brain circuitry is constantly changing and adjusting due to new knowledge and experiences, and a central theme of much of the cognitive neuroscience work done at Beckman. Much of this previous research has shown that the transfer of skill training has very narrow effects. This new project is based on the work of Beckman researchers and others showing that some forms of training, such as when training strategies emphasize flexible skill coordination in challenging tasks and environments, can have broader transfer of training effects. The project, which features six Beckman Institute researchers in addition to Kramer, is studying and trying to capitalize on those strategies in order to develop a corpus of techniques that can be used to enhance training and transfer of complex computer-based skills. Researchers are using behavioral and neuroimaging methods and human (at Illinois) and non-human primate (MIT) subjects to examine training transfer across both domain-specific and domain-general processes, and for the purpose of identifying brain networks that support such learning and transfer. They will also develop neurally plausible computational models of training and transfer for both individual and team performance. Joining Kramer in these efforts are fellow Beckman faculty members **Dan Simons, Monica Fabiani, Gabriele Gratton, Brad Sutton, Michelle Wang,** and **Wai-Tat Fu.**



Art Kramer, Co-chair for the HCII research initiative and Director of the Biomedical Imaging Center, is leading an interdisciplinary effort that explores how some forms of training, such as when training strategies emphasize flexible skill coordination in challenging tasks and environments, can have broader transfer of training effects.

Senior Odyssey: A Test of the Engagement Hypothesis of Cognitive Aging

Human Perception and Performance group member **Elizabeth Stine-Morrow** began her Senior Odyssey project as a small pilot program and expanded it with a two-year, $90K grant from the National Institute on Aging (NIA) in 2004. The value of the project was recognized in 2007 as Stine-Morrow and her collaborators were awarded a new 5-year, $1.9M grant from the NIA for a five-year Senior Odyssey study. From modest beginnings, Senior Odyssey has now grown into a multi-level research project as well as a community-based cognitive intervention program for older adults. Stine-Morrow said the new grant will allow for a more comprehensive study and for greater outreach to older adults. "We are also working to reach elders who have relatively few planned activities each week; these are seniors who are typically hard to recruit but who might benefit more from engagement," Stine-Morrow said. "Finally, the larger sample size we will be able to recruit with this level of funding will enable us to examine individual differences in change—e.g., what are the characteristics of people who benefit more or less from a program of engagement?" Using the educational enrichment program Odyssey of the Mind, which features creative problem-solving in team-style competitions, as a template, Stine-Morrow developed Senior Odyssey to test the theory that such a program requires participants to operate in what is called a "substantively complex" environment in which "individuals face myriad choices in encountering and resolving ill-defined problems requiring creativity and the development of solutions that need to be implemented, evaluated, and revised."

In Senior Odyssey teams of adults age 60 and over participate in long-term problem solving over a 16-week session and compete in a tournament at the end of the session that is judged by the same criteria as that used in the international Odyssey of the Mind competition. So far, they have completed the first of four cycles testing the Senior Odyssey program's effects on participants, using a wider array of cognitive and psychological measures than in the past. Results from a two-cycle pilot of the study show that, relative to a wait-list control, Odyssey participants show relative gains in speed of processing, inductive reasoning, and divergent thinking.

Artificial Intelligence researcher Narendra Ahuja explores how the complex sensory signals in nature can be used as inspiration for signal processing solutions.

Nature's Complex Sensory Signals Inspire Solutions for Signal Processing

How do animals transform sensory input from the world around them—the visual scenes their eyes take in, the sounds their ears absorb—into useful information? An interdisciplinary research project at the Beckman Institute is looking at the solutions nature provides to that question in order to create algorithms that emulate those biological solutions. Artificial

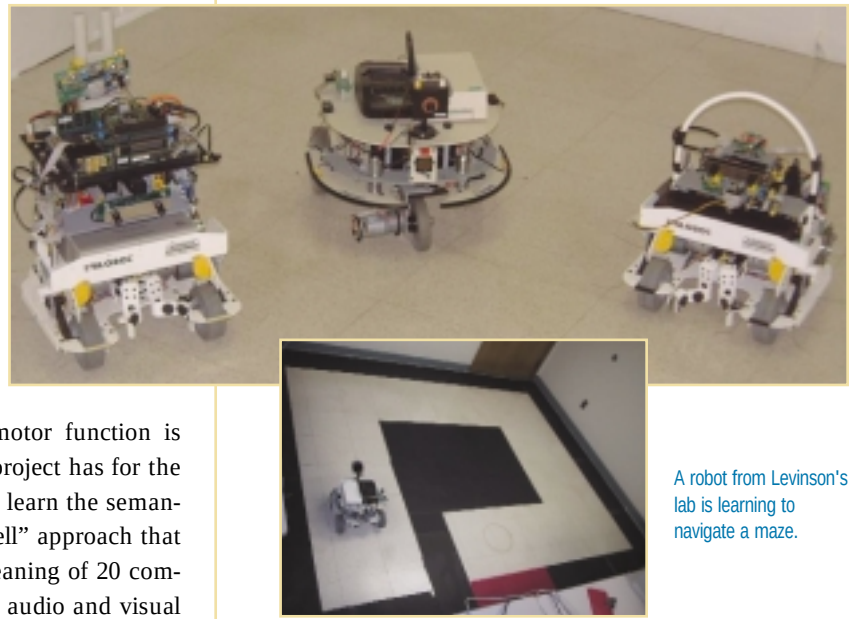
Intelligence group member and project principal investigator **Narendra Ahuja** is contributing his expertise in decoding the computational relationships between images and three-dimensional scenes for human-computer interaction purposes to the effort. Ahuja and members of his Computer Vision and Robotics Laboratory are developing computer vision methods for detecting and localizing hierarchical spatial structures in complex sensory signals. The algorithms they are creating for this project are inspired by fellow Beckman faculty members doing biological signal-processing research on creatures on land and in the water. Collaborator **Al Feng,** who investigates the neural basis of sound pattern recognition in the auditory system of frogs and bats, is contributing knowledge gained from his studies of the acoustic identification and spatial localization of the sounds made by frogs in acoustically complex environments. The other biological inspiration comes from weakly electric fish, a unique creature that inhabits freshwater rivers in South America. **Mark Nelson's** Electrosensory Processing Laboratory studies these fish because they use an electric field for navigation and localizing prey. The project's goal is to gain a better understanding of biological information-processing principles, with a potential for developing novel applications in robotics, or in other areas such as surveillance technology.

Biological inspiration for complex sensory signals is taken from the weakly electric fish, a native inhabitant of the freshwater rivers in South America. Mark Nelson's Electrosensory Processing Laboratory examines the electric field the fish use for navigation.

Teaching the Meaning of Words to a Robot

Robotics researcher **Steve Levinson's** Language Acquisition and Robotics Laboratory has accomplished a pair of firsts in its mission to develop intelligent robots that have the ability to learn natural language. The lab modifies robots and develops and integrates modules for various cognitive processes, such as sensory input processing and speech recognition, with the goal of eventually creating a "mechanical mind." The lab does research on the hypothesis that language is acquired through interaction with the real world and that sensory motor function is essential to this process. A current project has for the first time enabled robots to correctly learn the semantics of verbs through a "show-and-tell" approach that has allowed a robot to learn the meaning of 20 common verbs. The robot received both audio and visual input from a human teacher who demonstrated an action while speaking the word corresponding with that action. The number of different verbs was unknown and the descriptions were highly variable. Using its audio and visual senses, the robot was able to learn the meanings of 20 common verbs such as kick, throw, lift, and wave.

Beckman researcher Steve Levinson's laboratory is teaching its robots the meaning of words using a "show-and-tell" approach.



A robot from Levinson's lab is learning to navigate a maze.

Designing a Way of Life

It was probably as unique an exhibition opening as the Illini Union Art Gallery has ever played host to: Illinois students with disabilities sharing the spotlight with students from an industrial design class, taking as much pride in the collaborative efforts it took to create the assisted living devices on display as in the end products themselves. It was just the result Deana McDonagh was hoping for.

McDonagh, whose unique class pairing the students together led to the exhibition, is an Associate Professor of Industrial Design and member of the Human Performance and Perception group at Beckman. She is also an author, editor, sought-after speaker, and consultant to industry because of her pioneering approach to industrial design. McDonagh's user-centered methods for designing products and environments would make Arnold Beckman proud, thanks to its emphasis on real-world applications that have the potential to improve our lives.

"We're not artists," McDonagh said of designers. "The one thing that I'm an advocate of is that design is not about styling, design is about creating a positive experience for others. That sets us apart from artists; designers are very different creatures. I just want (design) to make a difference, so every piece of my research is about enhancing the quality of life."

The Disability + Relevant Design exhibition at the Illini Art Gallery in the spring of 2008 put a fine point on McDonagh's perspective on researching and teaching industrial design. Her innovative approach—summed up through the term "empathic design research"—relies on the concept that creating a successful product is best accomplished by including not only the users' needs but also the users themselves in the design process. The exhibition was the culmination of a semester-long project in which McDonagh had her industrial design class students work with U. of I. students registered with Disability Resources and Educational Services (DRES) to create prototypes of products that were more user-friendly for the students with disabilities.

The show featured devices such as a tool for drawing and cutting a straight line for people with low vision and a prototype of a chin-pointer (a head-worn aid used for tasks such as typing and pushing buttons) that is already on the path to being patented. As potentially beneficial as the prototypes may turn out to be, for McDonagh it was the process itself that generated the most positive feedback.

"I think it was certainly a showcase that illustrated how design applies technology and responds to people's situations," she said. "I think it was a really nice way to let people know that these products don't just happen; there is a process behind it and we're integrating the user more and more. There's a shift from designing for, to designing with, to designing by, so we all benefit from different perspectives."

The students with disabilities may have benefitted the most from the project, and not just because of the devices created to improve their lives.

"What we found is that they had never really had any experience of the impact of design and to be part of the process and—this is my interpretation—it was very empowering for them," McDonagh said. "They realized that their voice has real authority. They are the experts in their life experience. Well, suddenly, we took their life experience and their feelings, which are very visceral and difficult to communicate, and we actually responded to them."

McDonagh says the empathic design approach tries to take all of a user's needs, including what she says are supra-functional needs like emotional and cultural concerns, into account. In order to do that, she said, an empathic designer has to get a firsthand look at the world from the user's point of view.

"Before the user was always seen as a subject, as the other," McDonagh said. "What my Ph.D. focused on was the designer and the user coming together as collaborators. With empathic design we don't design for, we don't design with somebody in mind; we design collaboratively. I develop design research tools and approaches that enable designers to expand their empathic horizon, so that they can develop and create products that satisfy an authentic need through more intuitive design outcomes."

Using her approach, McDonagh is now working with Beckman colleagues on projects to incorporate empathic design principles with new technologies. A new collaboration with psychology researcher Jason McCarley and Integrated Systems Laboratory Director Hank Kaczmarski is looking to create goggles that will enable designers working on products for the elderly to visualize the world through an older person's eyes, thereby improving product design. It is the type of collaboration McDonagh hopes to have with more Beckman researchers.

"What I would really love is for more scientists and engineers and technologists to welcome that kind of collaboration because design does make a difference," she said.

McDonagh is starting a class in the fall that will have students with disabilities in the class, not just as users but as budding designers themselves.

"We're going to challenge them and get them to design for able-bodied students," McDonagh said. "So they are going to be designed for and they are also going to be part of a design team. What we want to do is harness the creativity of everyone, because we're all creative, we all adapt to our environments. It's really channeling and harnessing that creative energy from what is often a marginalized group of people. And to hear their voice and see it manifest itself into something tangible can only happen on this campus."

Deana McDonagh

"What I would really love is for more scientists and engineers and technologists to welcome that kind of collaboration because DESIGN does make a difference."

– Deana McDonagh

Nano is a popular prefix these days in the worlds of research, technology, and manufacturing but research and technology development at the nanoscale have been a part of the Beckman Institute from the beginning.

Although the Molecular and Electronic Nanostructures (M&ENS) research initiative was formed in 1994, work at the nanoscale (less than 100 nanometers) has taken place at the Institute since 1989 when researchers from University of Illinois departments like Chemistry, Engineering, and Physics joined Beckman as original faculty members.

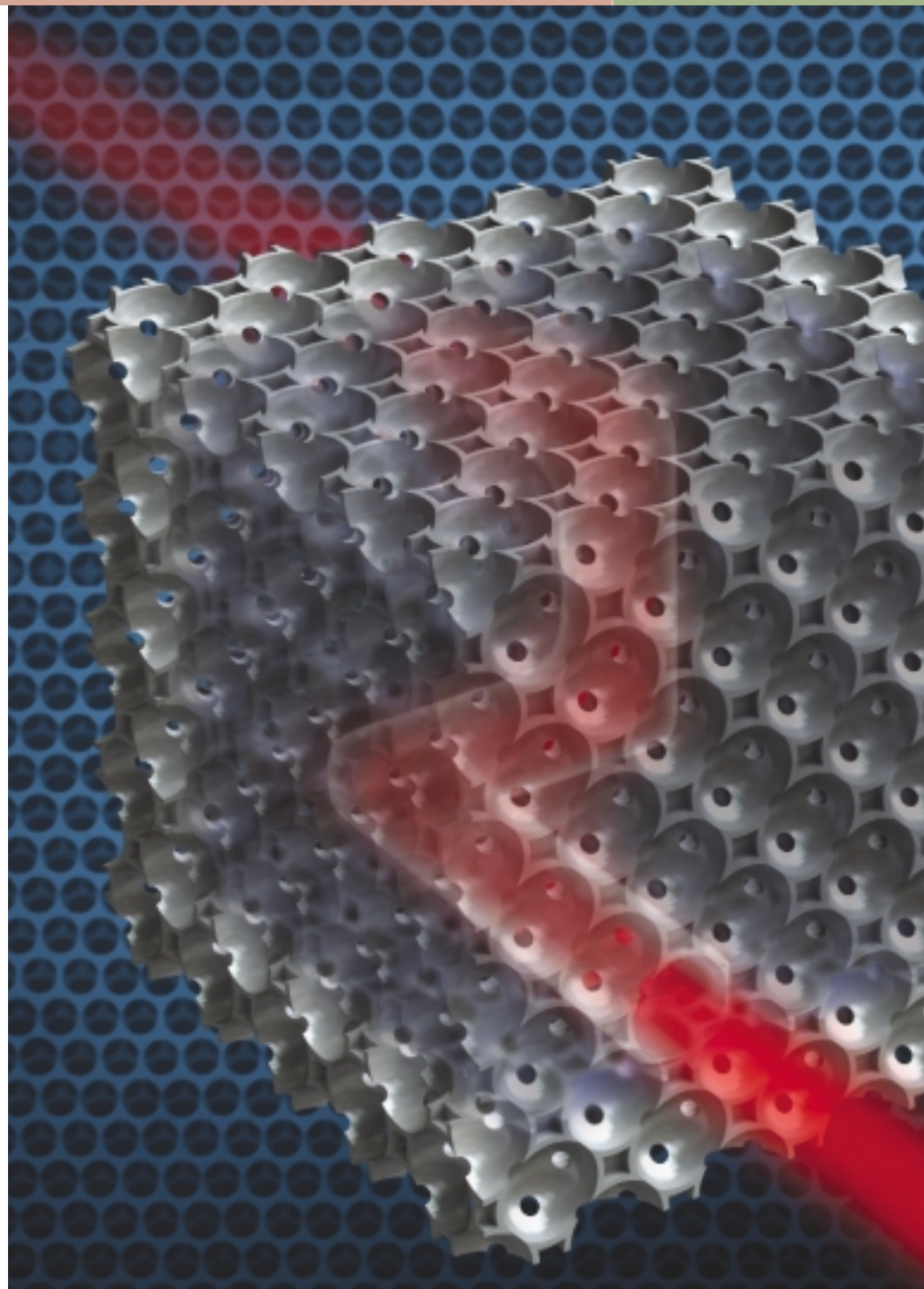
M&ENS researchers have the broad mission of understanding chemical and physical processes involving structures on the nanometer scale and developing nanoscale applications, including advanced software for advancing this research.

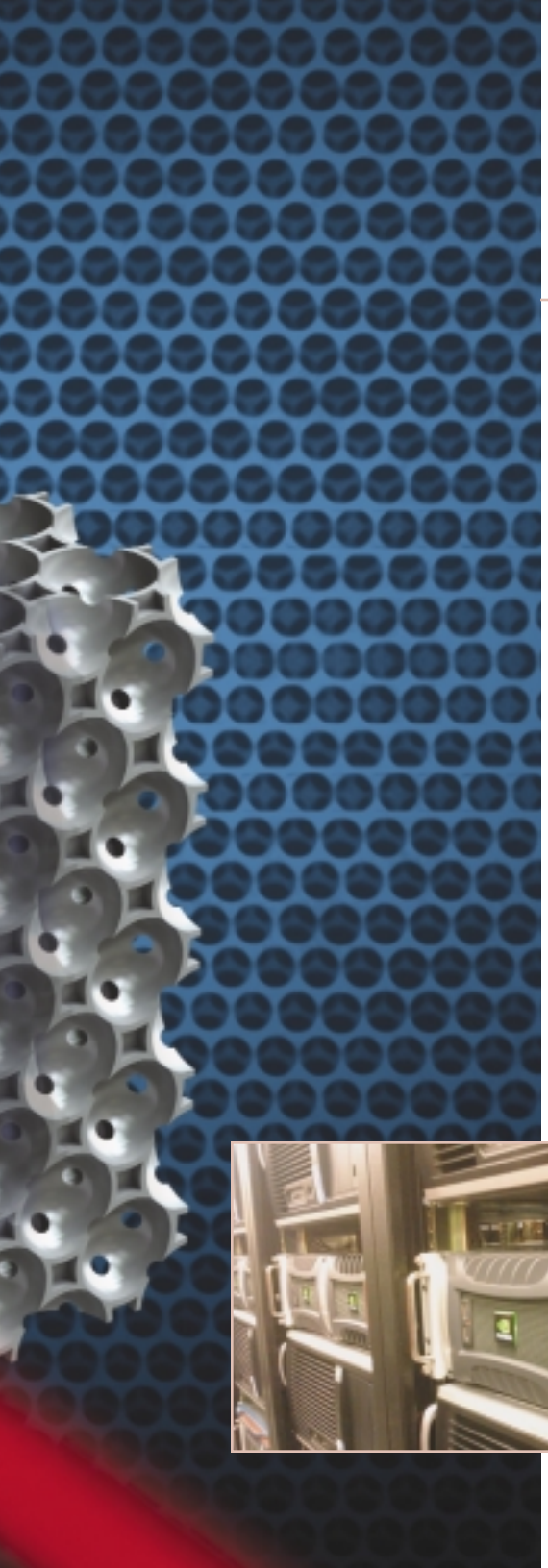
Within this research initiative there are six groups working toward those ends: 3-D Micro- and Nanosystems (3-DMN), Autonomous Materials Systems (AMS), Computational Electronics (CE), Computational Multiscale Nanosystems (CMN), Nanoelectronics (NE), and Theoretical and Computational Biophysics (TCB).

The M&ENS mission was codified in 1994 with the creation of research themes but researchers working at the nanoscale were a building block of Beckman research from the start.

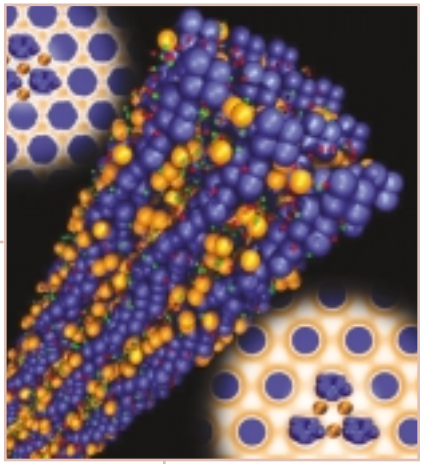
Twenty years ago **Jean-Pierre Leburton,** head of the Computational Electronics group, and **Joseph Lyding,** head of the Nanoelectronics group, were investigating nanoscale topics such as quantum dots and semiconductor physics. Today, Leburton continues to study quantum dots while expanding his research to include projects like the development of a solid-state silicon semiconductor membrane for biosensing applications. Lyding built Illinois' first scanning tunneling microscope (STM) and invented an ultrastable STM while at Beckman – technology he uses today while researching materials like graphene, a sheet of carbon a single atom thick, for possible electronics applications.

Klaus Schulten is a Swanlund Chair in the Department of Physics and original Beckman faculty member whose research has evolved through his TCB group to include a leadership role in developing software for molecular dynamics simulations of biological systems and processes. Schulten and TCB recently enhanced graphics processing units in order to perform a million-atom simulation that matched the computing power of hundreds of traditional processors. Another Beckman original, **Umberto Ravaioli** of the





(Left) This stunning image created for Paul Braun's research group by Beckman's Imaging Technology Group (Stephen Eisenmann) illustrates guiding light around the bend in three-dimensional photonic crystals. The image was used on the January 2008 cover of *Nature Photonics*.



Eric Luijten and Gerard Wong's 2007 *PNAS* paper provided new insights into fighting bacterial infections in cystic fibrosis patients. This image shows a side view and cross-sections of a bundle of F-actin filaments (blue) held together by lysozyme (orange), as predicted by molecular dynamics simulations.

CMN group, also develops tools for simulations in nanostructures, including nanoscale silicon devices that are being used by research groups at major semiconductor companies.

Stephen Sligar (3-DMN) is a Professor of Chemistry and Beckman original faculty member whose discovery this past year of a novel method for detecting molecule binding to Cyrochrome P450s, a family of enzymes that play critical roles in metabolizing compounds like drug compounds, was a first step toward development of a detection assay for possible applications in personalized medicine.

These original faculty members have been joined over the years by new faculty who are pushing the boundaries of nanoscale research.

Scott White, Nancy Sottos, and **Jeff Moore** of the AMS group paved the way for the rapidly growing area of self-healing materials with their seminal 2001 *Nature* article reporting on a novel autonomic, or self-healing, system for healing cracks in a polymeric material. That work is an even stronger research line today with new advances in the technology and commercial applications of the system in the past year.

[INSET] Klaus Schulten's Theoretical and Computational Biophysics group has adapted graphics processing units (GPUs) to NAMD, a widely used parallel molecular dynamics simulation package. GPUs are an attractive option for accelerating scientific computations. Schulten's group presents performance results for a 64-core 64-GPU cluster.

The work of 3-DMN group member **John Rogers** with a wide variety of materials and methods at the nanoscale for electronics and photonic systems applications continues to turn heads not only among his fellow scientists but also in the national media. This past year Rogers' breakthrough method for creating perfectly aligned, parallel arrays of carbon nanotubes (CNTs) was used to make the first-ever transistor radio using CNTs for all the active components.

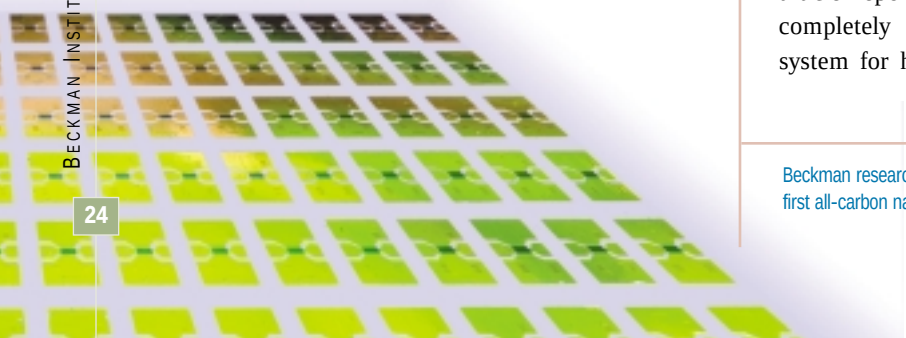
Research in M&ENS continues to grow and evolve with more recent additions. The research of **Ioannis Chasiotis** (AMS) into micro- and nanoscale materials has led to a new method for revealing the mechanical behavior of polymeric and organic nanofibers at timescales ranging from milliseconds to hours. **Emad Tajkhorshid** began his career at Beckman as a postdoctoral researcher for the TCB group but now is a full-time faculty member with his own research group making breakthroughs in computer simulations of biological processes. **Eric Luijten** (AMS) also uses computer simulations, taking the work of experimental researchers like **Gerard Wong** (3-DMN) and adding the element of dynamic computer simulation in order to gain a better understanding of the workings of complex fluids.

Researchers from the 3-DMN group like **Paul Braun**, who studies nanostructures and microstructures with properties useful for optical, electrical and biological applications, **Paul Kenis** (development of microchemical systems through the miniaturization of chemical processes) and **Nicholas Fang** (using nanoscale materials to improve applications like high-resolution ultrasonic imaging) may work with different materials but have the same goal of advancing nanoscale research for real world uses.

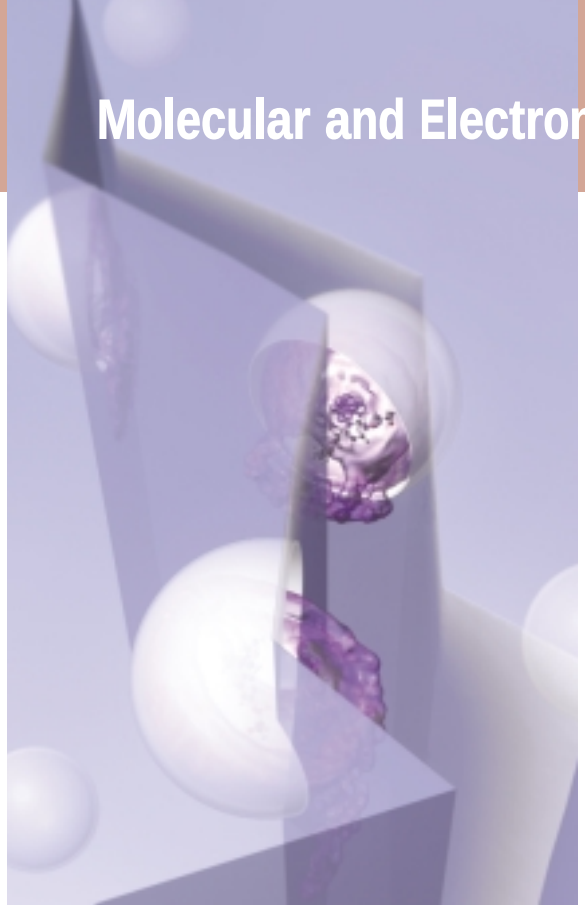
Upholding a tradition of almost 20 years of groundbreaking research, M&ENS researchers are continuing to lead the way in nanoscale research and technology development.

Rogers and Collaborators Create Carbon Nanotube Radio

A team of Beckman Institute researchers led by 3-D Micro and Nanosystems group member **John Rogers** built the world's first all-carbon nanotube (CNT) transistor radio, creating in the process a new type of radio frequency (RF) analog electronics technology. The group used a growth technique developed by Rogers' lab to create perfectly aligned, densely packed, parallel arrays of carbon nanotubes that formed an effective type of semiconductor thin-film material. With properties significantly better than silicon and a high current output, the arrays were used to make high-performance circuits and transistors that hold great potential for analog radio frequency applications in high-speed electronics or other applications. The researchers used CNTs for all of the active components, including the antenna, amplifiers, and filters, and the technology is compatible with current manufacturing methods. Rogers and his collaborators at Illinois and at Northrop Grumman used the technology to fabricate transistor radios, one of which was successfully tested by picking up a traffic report from a radio station in Baltimore. The work was reported in both *Nature Nanotechnology* and *Proceedings of the National Academy of Sciences* and carried by a wide range of national media, including an interview with Rogers on the National Public Radio show *Science Friday.*



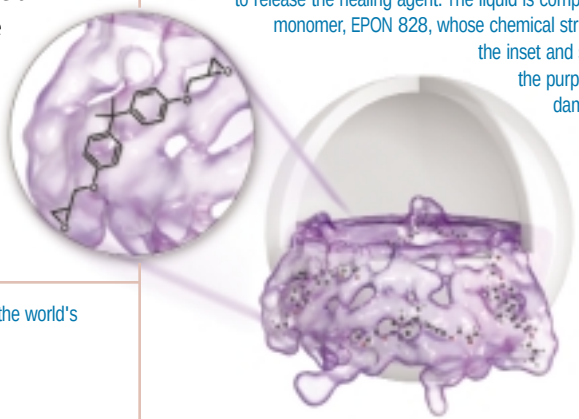
Beckman researcher John Rogers and his collaborators built the world's first all-carbon nanotube (CNT) transistor radio.



This image was featured on the cover of *Advanced Functional Materials*. It accompanied a paper by Mary Caruso, Ben Blaiszik, Scott White, Nancy Sottos, and Jeff Moore. ITG visualization specialists collaborated to create the image.

Development of Catalyst-free Self-healing Polymers

The pioneering work of Autonomous Materials Systems group members **Nancy Sottos, Scott White,** and **Jeff Moore** into self-healing materials continues to yield new discoveries and greater advances in a research line that has already led to commercial applications. Sottos, White, and Moore have been leaders in the area of self-healing materials ever since their 2001 *Nature* article reported for the first time on a completely autonomic, or self-healing, system for healing cracks in a polymeric material. The original proof-of-concept system used a ruthenium-based Grubbs' catalyst, which was expensive and therefore impractical for widespread applications. This past year Sottos, White and Moore, along with graduate students **Mary Caruso** and **Benjamin Blaiszik,** reported on the development of a new catalyst-free, less-expensive self-healing system that uses environmentally friendly solvents as healing agents. The catalyst-free system demonstrated high healing efficiencies of 82 percent for a polymer containing solvent microcapsules. Later, an improved solvent-based self-healing system was studied and showed 100 percent healing efficiencies and recovery of fracture toughness. This system incorporates microcapsules containing epoxy monomers and solvent into epoxy resin matrices that rupture upon crack damage, sealing the crack face closed.



This image is a 3-D representation of a polymeric microcapsule rupturing to release the healing agent. The liquid is comprised of an epoxy monomer, EPON 828, whose chemical structure is shown in the inset and solvent (depicted as the purple liquid) into a damaged fracture plane.

Aleksei Aksimentiev of the Theoretical and Computational Biophysics group and Greg Timp of the Nanoelectronics group are working to create a synthetic nanopore for sequencing DNA.

Braun's Group Develops Technique for Guiding Light around a Bend

Paul Braun of the 3-D Micro- and Nanosystems group used optical features embedded in self-assembled three-dimensional photonic crystals to achieve a first: guiding near-infrared light along a complex pattern, including around a bend. In their cover article for *Nature Photonics*, Braun and his collaborators described their innovative method: starting with a self-assembled, photonic band gap colloidal crystal, they then use a photoactive monomer, laser light, silicon filler, and an etching process to fabricate a new material exhibiting photonic activity. The 3-D optical waveguide embedded in the crystal can guide light around micron-sized bends and the band gap created is the same wavelength as that used by industry for fiber-optic cable, two intriguing characteristics toward future applications in the telecommunications industry such as fiber optics, or for creating high-speed chip circuits. Braun said the fabrication technique is simpler and less expensive than conventional fabrication methods, especially for large-area photonic crystals.

Site-specific Control of Distances between Gold Nanoparticles

Yi Lu's research involving nanoscale biology has led to advancements in areas such as biosensor technology and to applications like an easy-to-use dipstick test for drugs like cocaine that was based on gold nanoparticle technology. Lu, a member of Beckman's 3-D Micro- and Nanosystems group, has now reported on a method for precise control of both the position of nanomaterials and the distances between them. DNA-based nanostructures have great potential for a number of applications but current methods are impractical for making them functional with nanomaterials. Lu and his group developed a simple method for precisely controlling the assembly of gold nanoparticles on DNA by using phosphorothioate modification on DNA as an anchor and a bi-functional linker that can connect a gold nanoparticle to DNA as a fastener. Lu wrote that the distance between gold nanoparticles assembled on DNA "could be controlled by simply changing the position of the modification on DNA with identical sequences and it could be observed on the surface by Scanning Electron Microscopy (SEM) images and statistical analyses. The methodology demonstrated can be applied to using DNA for precise distance and topological control of nanomaterials in one, two, and three dimensions."

Advancements in Synthetic Nanopore for Sequencing DNA Project

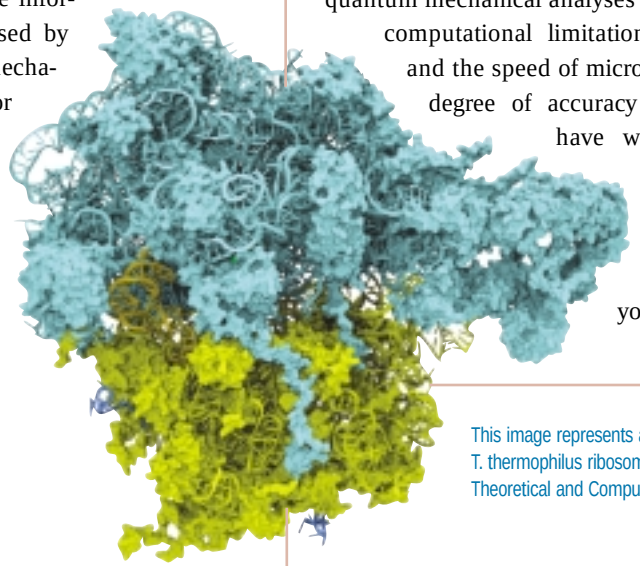
Continuing work in their mission to create a synthetic nanopore for sequencing DNA, **Alek Aksimentiev** of the Theoretical and Computational Biophysics group and **Greg Timp** of the Nanoelectronics group reported on two important advancements this past year. Using an electric field to force single hairpin molecules to translocate through a synthetic pore in a silicon nitride membrane, the researchers found that by stretching and unzipping nucleic acid hairpin molecules they were able to gather data about the electromechanical properties of DNA. Reporting their results in *Nucleic Acids Research*, Timp and Aksimentiev write that their data indicates that it may be possible to use a synthetic nanopore like a molecular gate in order to discriminate between secondary structures in DNA. The researchers also reported in *Nanoletters* on the discovery of a voltage threshold measure in a synthetic nanopore that could make it possible to discriminate between two variants of the same gene (alleles) that differ in one base.

Beckman Researchers Key Players in MEMS/NEMS Center

Faculty members from the Computational Multiscale Nanosystems (CMN) group continued to advance research at the multi-university IMPACT Center for Advancement of MEMS/NEMS VLSI. The Center's goal is to advance the development of microelectromechanical systems (MEMS) and nanoelectromechanical systems (NEMS) for integration with very large systems. Headquartered at the Beckman Institute, the Center is headed by Beckman researcher **Andreas Cangellaris** and includes Institute colleagues **Narayana Aluru, Philippe Geubelle, Ioannis Chasiotis,** and **Umberto Ravaioli,** as well as researchers from three other top universities. Cangellaris and Aluru look at what is called uncertainty quantification in MEMS and how uncertainties in, for example, the geometries of tiny structures, can affect the performance of devices like radio frequency (RF) switches. This past year they developed a new computational tool for dealing with uncertainties in their goal of making MEMS devices, which may run millions and millions of cycles, more reliable. Each Beckman researcher at the IMPACT Center has a goal of improving NEMS/MEMS reliability, with Cangellaris and Aluru currently looking at dielectric charging in RF MEMS switches. Problems involving mechanical properties such as stress-strain behavior are analyzed by Chasiotis (on the experimental side) and Geubelle (on the computational side), while Ravaioli investigates how heat issues affect the reliability of MEMS devices. The ultimate goal, the researchers write, is to "develop the physics-based knowledge needed to enhance the lifetime performance and functionality of highly integrated MEMS/NEMS-based micro- and nanosystems, and proliferate their insertion in military and commercial applications."

Simulations Provide New Information on Ribosome

Researchers in the Theoretical and Computational Biophysics (TCB) group developed a method called molecular dynamics flexible fitting (MDFF) for performing what is called flexible fitting of X-ray crystallography structures into cryo-electron microscopy maps (cryo-EM) using their NAMD molecular dynamics simulations software. The method was applied to the ribosome, the molecular site of protein synthesis and where the translation of genetic information into protein sequences required for life takes place. The technique complements crystallography and cryo-EM by providing both functional data and atomic-scale resolution of the ribosome. Using the MFDD method, the group obtained data on 12 ribosome structures at different stages of translation, revealing atomic-resolution interactions between the ribosome and its factors in detail not seen before. The information gathered could be used by researchers looking at the mechanisms of translation and for researchers who are designing experiments or creating new antibiotics.



This image represents an all-atom model of the T. thermophilus ribosome. Image courtesy the Theoretical and Computational Biophysics Group.

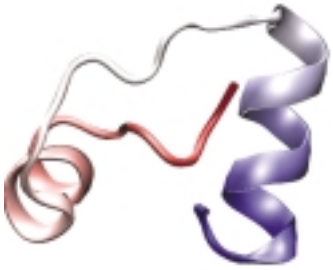
Breakthrough Computational Models for Nanofluidics, NEMS

Molecular and Electronic Nanostructures Co-chair **Narayana Aluru** produced two breakthroughs in his work developing innovative computational methods for analysis and design in the areas of microelectromechanical systems (MEMS), nanoelectromechanical systems (NEMS), and micro- and nanofluidics. In a finding important for nanofluidics, Aluru and his collaborators made the counter-intuitive discovery that on a graphite surface for low surface coverage, longer molecules diffuse faster compared to shorter molecules, giving scientists and others working in areas such as nanomanufacturing new insight into how molecules behave on very small surfaces. Aluru also reported on the development of new multiscale algorithms that seamlessly combine heterogeneous quantum-mechanical models with semi-classical and classical models for electrostatic and mechanical analysis of NEMS. Aluru said these new computational tools provide the accuracy capabilities of quantum mechanical analyses (without that method's computational limitation to small structures) and the speed of microscopic theories (with a degree of accuracy that method doesn't have when applied to large structures). "We have developed this theory where you can mix these length scales and you will get the accuracy

and the speed," Aluru said. "This multiscale method is the first one developed for NEMS. What this means is now that we have these tools we should be able to understand the physics of NEMS devices in detail that we haven't been able to before."

Klaus Schulten's Theoretical and Computational Biophysics group is home to the NIH Resource for Macromolecular Modeling and Bioinformatics.

The molten globule shown below forms during the 10 ms protein folding simulation by the Theoretical and Computational Biophysics group.



Simulation of Protein Folding in 10 Microseconds

The Theoretical and Computational Biophysics (TCB) group under Director **Klaus Schulten** took on one of the most important problems in structural biology when it adapted its computer simulation software for observation of the folding mechanism and folded structure of a protein. Nanoscale Molecular Dynamics (NAMD), a parallel code developed by TCB for high-performance simulations of large-scale biomolecular systems, was used in the effort but improved through various techniques for the challenging problem of simulating smaller molecules for longer times. The improved NAMD, used to simulate protein folding, achieved timescales up to 10 microseconds, or a millionth of a second, which are necessary to observe protein-folding events. The achievement was a promising first step in providing a better framework for describing the protein-folding process. Creating a new tool for describing this process will aid researchers trying to understand diseases caused by point mutations in proteins and allow for the design of protein variants with novel functions.

Simulations Reveal for First Time Binding of Molecule to Carrier Protein

Emad Tajkhorshid of the Theoretical and Computational Biophysics (TCB) group used molecular dynamics simulations to reveal, for the first time ever, binding of molecules to a carrier protein when he simulated a delicate cycle that powers the cellular processes required for many aspects of life. Extensive molecular dynamics simulations performed on a membrane protein named ADP/ATP carrier revealed the recycling of adenosine triphosphate (ATP), the main energy source of most cellular functions, and adenosine diphosphate (ADP) from which ATP is synthesized during a process that powers many chemical reactions in cells. The simulations also revealed ADP binding sites on the ADP/ATP carrier protein on the inner membrane of the mitochondrion. Tajkhorshid said that these unbiased simulations described in full atomic detail the first example of a complete ligand binding event, illuminating key structural elements of the carrier involved in the nucleotide transportation cycle.

Gating of a Mechanosensitive Channel

The Theoretical and Computational Biophysics (TCB) group is applying its NAMD molecular dynamics simulations software to simulate the workings of mechanosensitive (MS) ion channels, providing new insights into the workings of these channels that play important mediation roles in biological processes. A TCB effort with researchers at the University of Chicago aimed at increasing understanding of the gating mechanism and mechanotransduction in the mechanosensitive channel of small conductance (MscS) provided a thorough characterization of the MscS channel. Combined with electrophysiological measurements at Chicago, the researchers were able to conclude that the MscS crystal structure represents an intermediate state between open and closed conformations and the computational data suggested a gating mechanism that agreed with recent experimental results. The results could be used to guide the design of future simulations and experiments testing the function of MscS and other mechanosensitive channels at the experimental level.

Teaching + Research Equals Successful Science

In a little less than a decade spent as a full-time researcher, Paul Braun has already seen his work highlighted in international publications like *Nature* and *Science* and had numerous papers published in peer-reviewed journals. As a faculty member at the University of Illinois he earned a coveted University Scholar appointment in 2006 and in 2007 led a successful multi-department funding effort that will make the Beckman Institute and Illinois home to the only campus-based nano-computed tomography microscope in the country.

When pressed to name his greatest achievements, however, Braun is quick to put his work with students at the top of the list.

"The papers are great and we know we want to push them forward but the other thing that I do appreciate is that I've received several excellence awards for advising," said Braun, who has twice won the Accenture Engineering Council Award for Excellence in Advising. He has also been named several times to the list of teachers rated as excellent by their students. "It means something that the undergrads, who are the ones who pick those, appreciate your efforts too. We can all disappear in our work and pretend that we're not really here to teach but that really is our primary job."

Braun's "secondary job" as a researcher has worked out quite well too. He is an Associate Professor of Materials Science and Engineering with a large research group that garners national attention for its breakthrough work, especially in the area of photonics. Even with all his research success, however, Braun still focuses on teaching. His approach is one that allows his students to succeed — and sometimes fail — as they learn how to do scientific research.

"With graduate students I sometimes let them learn the hard way," Braun said. "You can give a student a project and give them every step to do but they're not going to learn that much. I try my best to give my students the opportunity to push the boundaries and push themselves to the edge of their comfort zone. If that means they spend a few weeks going down a blind alley, then that's fine; they'll learn from it."

A native of southern New Jersey, Braun earned an undergraduate degree from Cornell before settling on the University of Illinois and the field of materials science for his post-graduate work. The Beckman Institute, where Braun is a member of the 3-D Micro- and Nanosystems group, played a key role in both his school and career decisions.

"Beckman was one of the main reasons why I came here as a faculty member and in no small part why I came here as a graduate student," Braun said. "Even as an undergraduate I worked at the boundaries of areas, between materials science and chemistry for example. Beckman is a place that encourages and fosters that. It's a special place; there are very few places at other universities that have real, vibrant interdisciplinary research centers."

Braun made an impact early in his research career with a focus on studying and creating, through self and directed assembly, nanostructures and microstructures that have properties that are both interesting scientifically and useful for optical, electrical, and even biological applications. After coming to Illinois and the Beckman Institute in 1999, Braun concentrated his efforts in the area of photonic bandgap structures, a potentially important concept for high-speed optical communications.

In 2002 Braun's group was the first to demonstrate embedding of a three-dimensional optical waveguide in self-assembled, three-dimensional photonic crystals. In a 2008 paper Braun and his research group achieved optical waveguiding of near-infrared light with their method, producing a new photonic material with a bandgap at the same wavelength as that used by the telecommunications industry in its fiber optic cables.

Their innovative work showed that it was possible, using this material, to bend light in an arbitrary three-dimensional pattern, thereby achieving a goal that had been much sought after in the field but stymied due to fabrication and design issues.

"You can bend a fiber optic cable but if you bend it really sharply all the light leaks out," Braun said. "What we can do here is to bend the light around corners that are only hundreds of nanometers in bend radii. That's something you just can't do using conventional fiber optic technology. So it allows you to integrate light into much smaller packages. If you think about bringing information on and off of a computer chip, this would really enable a new way to use light to do this at very high speeds."

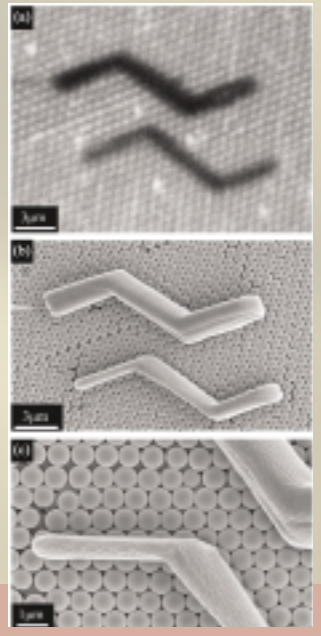
Braun has also seen success in other areas of his research. His work on self-healing materials with members of the Autonomous Materials Systems group has now grown into a start-up company. Braun said he sometimes uses current news stories in his classes to make the science more relevant to his students, so this foray into the commercial world should provide him with a very hands-on teaching opportunity.

"Sometimes it doesn't matter if you have the world's best product if you can't sell it," Braun said. "We're not here to teach them business, but they do need to learn that besides just coming up with the material they really have to think of the big picture, the product, or device; there has to be an application and there has to be a market."

Paul Braun

"I try my best to give my students the opportunity to **push the boundaries and push themselves to the edge of their comfort zone.** If that means they spend a few weeks going down a blind alley, then that's fine; they'll learn from it."

– Paul Braun



Biomedical Imaging Center: Migrating North and Acquiring a New Magnet

This past year the Biomedical Imaging Center (BIC) began the arduous task of moving their magnets, equipment, and staff from its own standalone building on the south side of the University of Illinois campus to the 313,000 square foot Beckman Institute on the north side of the campus. This move, which swaps the BIC space with the Integrated Systems Laboratory space, is a massive undertaking that will take over a year to fully complete. When finished, the new BIC space will house a new cutting-edge three Tesla (3T) whole-body MRI system. This new 3T whole body MRI system will accommodate the next generation of multimodal imaging including expansion into areas such as cardiac imaging, animal imaging, and neural activity.

BIC Associate Director Tracey Wszalek has been instrumental in the planning and implementation of the move and the acquisition of the new 3T whole-body MRI system.

"We are incredibly excited to be aquiring the new 3T whole body magnet, "Wszalek said. "To see everything coming together to best serve our users is very rewarding."

About the Biomedical Imaging Center

BIC provides invaluable resources for those conducting research and developing MRI and fMRI technologies. BIC is committed to developing novel, leading-edge techniques that combine magnetic resonance imaging with other imaging techniques such as optical imaging, eye-tracking, EEG, and transcranial magnetic stimulation.

The wide array of projects being conducted using BIC include researchers from more than 20 different departments, including psychology, electrical and computing engineering, kinesiology and community health, mechanical science and engineering, speech and hearing science, chemistry, veterinary clinical medicine, and pathology. A snapshot of the work they are conducting at BIC includes cognitive studies on the effects of aging and exercise, cortical plasticity and adult development, emotional and cognitive processing, multimodal imaging of cognition, and cancer imaging and treatment models.

The SISCO magnet being removed from the south campus BIC location.

Biomedical Imaging Center Equipment and Facilities

- 3T Siemens Whole-body MRI system (not yet operational; to be installed Spring 2009)
- 3T Siemens Magnetom Allegra MR Headscanner
- Varian/Spectroscopy Imaging Systems Corporation (SISCO) Imaging Spectrometer
- 600 MHz Varian MR System
- 512 Channel Bi-Wavelength Near-Infrared Imager
- 3T Allegra Mock Magnet
- Advanced AC magnetic field applicator for small animal hyperthermia treatment
- Low-magnetic field (5 ÷ 50 G) polarizer for gas and liquid DNP-enhanced MRI
- Reference library
- Computer laboratory
- Electronic shop
- Mechanical shop
- Wet lab
- Human subject preparation area

Hardware and software development is also an integral part of the work at BIC. Projects that are under way include RF coils development, creating

custom-built MRI accessories, pulse programming, developing k-t Spatiotemporal MRI, measuring flow velocities in micro-flowcells using the Diffusion Enhancement of Signal and Resolution (DESIRE) effect, using multiple micro-coil probes to reduce data acquisition time in multi-dimensional NMR spectroscopy, and using parallel imaging for NMR microscopy at 14.1T.

MRI and fMRI are being combined in innovative ways at the Beckman Institute. Image by Wolfgang Stollenwerk.

(Below) The SISCO magnet was recently quenched as part of BIC's move north to the Beckman Institute.

A Year of Growth for the Imaging Technology Group

The Imaging Technology Group (ITG) provides state-of-the-art resources via the Microscopy Suite and the Visualization, Media, and Imaging Lab. Through these two interrelated facilities, researchers from all disciplines are given the tools and help they need to document, enhance and showcase their work. The facilities are open to the entire Illinois campus, as well as workers from government, other universities, and industry.

In the past year the ITG has undergone major renovations which also include impressive equipment acquisitions that keep the group on the leading edge of research.

Microscopy Suite

New developments in the Microscopy Suite include a cutting-edge, ultra-high-resolution nanotomography (nano-CT) system that provides unparalleled, three-dimensional images of structures at the nanoscale. The Xradia nano-CT complements the Xradia micro-CT and the skyscam micro-CT that has been in operation more than three years. The nano-CT provides researchers with the ability to perform nondestructive, internal imaging of materials at sub-cellular scales. The nearly $2M grant for acquiring the Xradia nano-CT was provided by a National Science Foundation Major Research Instrumentation grant that is the largest grant of its kind ever awarded to the University of Illinois.

ITG microscopist Leilei Yin, who is in charge of both the micro-CT and nano-CT machines, said what they are providing is quite unique and that the nano-CT system, which will soon have a second independent component, is the first of its kind that may be operated without a synchrotron X-ray source.

Scott Robinson, the director of the Microscopy Suite, said their new equipment acquisitions open a new world of imaging possibilities for researchers that are not currently available.

"Faculty support for the micro-/nano-CT proposal was overwhelming," Robinson said. "Forty-seven University of Illinois faculty members from a variety of disciplines — biological, materials, and biomaterials — wrote enthusiastically in support of acquiring the equipment."

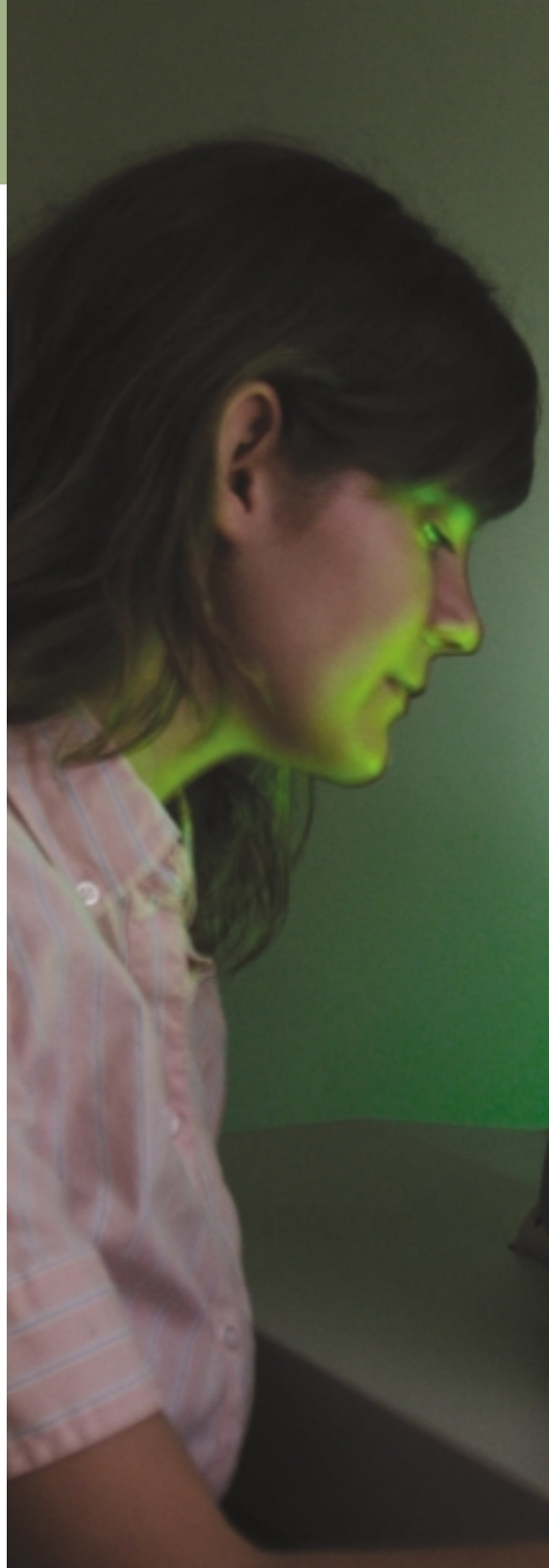
The high-resolution X-ray tomography capabilities of the new nano-CT instrument can provide imaging of samples as thick as 20 micrometers while resolving features as small as 50 nanometers in width.

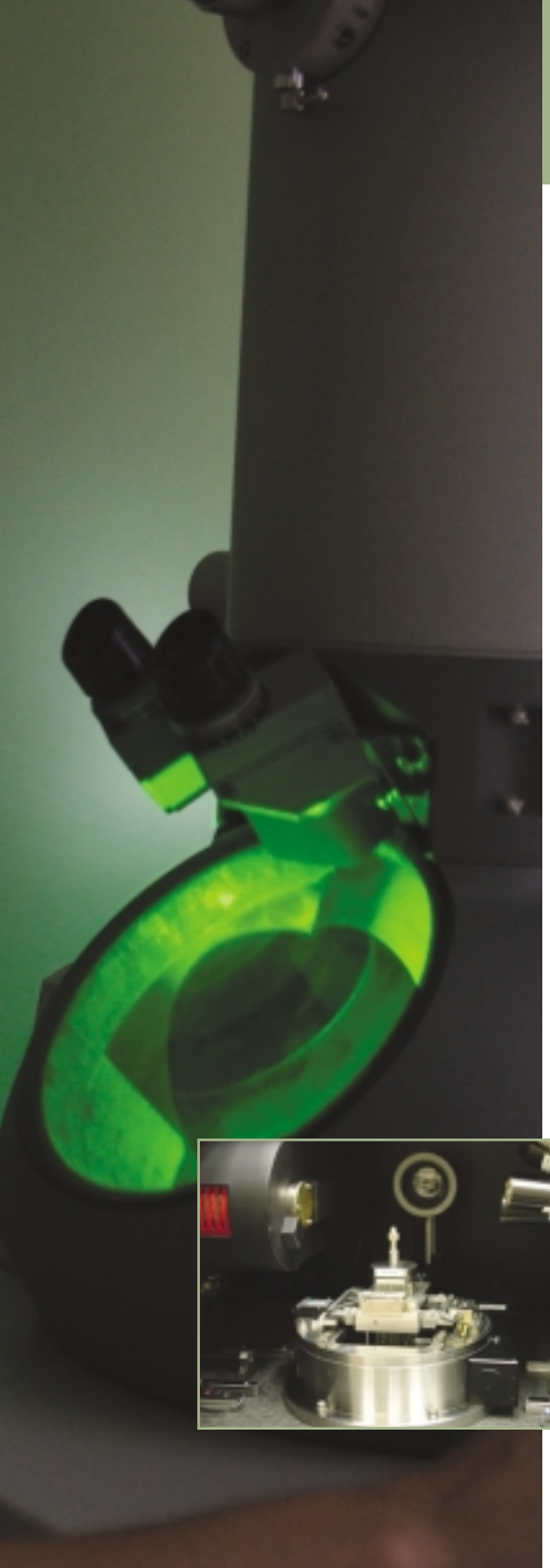
The micro- and nano-CT instruments add a new mode to the wide variety of instrumentation already supported by the Microscopy Suite:

Light Microscopy — including multiphoton confocal, with two-photon capability and a range of wavelengths from UV to IR; fluorescence, with structured illumination and excellent 2- and 3-D tiling capabilities, reflected light, with laser tweezers, UV and visible light spectrometers, and a high-sensitivity IR camera; stereozoom dissecting for low magnification imaging; and stereology/nerve tracing, primarily for neuroscience work;

Electron microscopy — including a 200-kV transmission electron microscope (TEM) with standard and custom-built holders, and a field-emission environmental scanning electron microscope (ESEM) with every useful option as well as excellent hi-vacuum (normal SEM) imaging capability;

Scanned Probe Microscopy — including a multimode atomic force microscope (AFM) and versatile nearfield scanning optical microscopes (NSOM). Along with the necessary preparation equipment, such as the ultramicrotome and critical point dryer, the suite maintains and supports light-scattering particle size analyzers as well as a range of sputtering, resistive evaporative, and plasma coating equipment.





Cate Wallace operates the Transmission Electron Microscope (TEM) in the Microscopy Suite.

(Inset) An inside look at the newly acquired Nano-CT.

Visualization, Media, and Imaging Lab

The Visualization, Media, and Imaging Laboratory (VMIL) has undergone a major transformation this year by nearly doubling its space and giving the VMIL staff the opportunity to better serve their users.

The VMIL, which is known for helping researchers visualize their work in innovative ways, is now even more conducive to creativity and problem-solving.

Darren Stevenson, the director of the VMIL, said the new facilities have improved the lab's operation by adding features like a meeting area, a dedicated 3-D printing environment, a much-improved photography setup area, and a ceiling-mounted projector.

"We will have a much less crowded space," Stevenson said. "To stay at the forefront of technology we've been continually adding new equipment. We not only needed more space for that, we also needed to add space for collaboration; a space where people can work on projects and solve problems."

Beckman student Robert Barry prepares a sample in the Microscopy Suite.

The VMIL provides resources, equipment, and services for:

- Image analysis
- Scientific visualization
- Animation and high-definition video production
- Color 3-D printing
- X-ray micro-CT scanning
- High-resolution macro photography
- 3-D object scanning
- Research presentation

Technology Development

ITG's secondary mission is to develop advanced imaging technologies, with an emphasis on remote and virtual instrumentation. These projects allow ITG to provide new methodologies for imaging and data viewing, while also enabling novel and substantive educational outreach opportunities for Beckman faculty. The Bugscope project, currently going strong in its 10th year of existence, allows children worldwide to remotely control ITG's high-resolution scanning electron microscope (ESEM). The students may collect insect specimens from their own backyard, mail them to ITG, and then log in from their classroom to operate the ESEM using a Web browser. They can then collect high-magnification images of the bugs while they "chat" with Beckman's "bugteam" during their session.

The Virtual Microscope project provides software to explore pre-captured high-resolution, multi-dimensional image data sets from light, electron, and scanning probe microscopes. Supporting features such as focus, excitation wavelength, and x-ray spectroscopy allow both students and researchers to use the Virtual Microscope just as they would the real instruments.

Both projects have been very successful. Bugscope has provided hundreds of sessions throughout the United States for K-12 teachers and students, while the Virtual Microscope enjoys thousands of downloads each month.

Changes Under way for the **Integrated Systems Laboratory**

ISL provides researchers with an advanced visualization environment — both immersive and ultra-high resolution — that is ideal for studies in human multimodal perception and cognition. Key components of ISL include the Beckman Driving Simulator, the Cube, the CAVE and CANVAS.

In the past year the Integrated Systems Laboratory has begun a massive undertaking — moving its operation across campus, essentially swapping spaces with the Biomedical Imaging Center. The move began in the Spring of 2008 and will continue into 2009. Guided by ISL Director Hank Kaczmarski, the group is making every effort to ensure that the least amount of interruption is being made to research projects being conducted using ISL technology and systems.

Key Components of the Integrated Systems Lab

The Driving Simulator

The Beckman Institute Driving Simulator is an integral part of the ISL and it is used extensively by perceptual psychologists who are examining the way drivers interact with both their environment and the increasingly complex nature of their automobiles. Using a General Motors Saturn automobile, the driving simulator surrounds the "driver" 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.

The CAVE™

The CAVE is a four-sided immersive reality environment operated by ISL. First constructed in 1995, it recently moved to a newly renovated space adjacent to the Cube that includes a new control and machine room. Several Immersadesks are in the same environment, connected to Onyx supercomputers and PC clusters, enabling users to quickly develop, test and remotely demonstrate new applications.

3-D models on display at the Dennos Museum in Grand Rapids, Michigan.

The Cube

The Cube is a world-renowned, six-sided virtual reality chamber that provides a completely immersive environment. Used extensively by researchers in psychology, the Cube is driven by a cluster of personal computers using an ISL-developed application called Syzygy. Current research projects in the Cube include human spatial navigation, object memory, visualization of urban planning data, virtual painting, and motion capture in virtual environments, just to name a few.

The Cube is also involved in several outreach projects using the latest addition to Syzygy, Myriad, a collaborative infrastructure that allows researchers anywhere with a network connection to interact with the images seen by researchers inside the Cube.

ISL Director Hank Kaczmarski at opening night for the Traveling Canvas exhibit at the Dennos Museum of Northwestern Michigan College. The kiosk allowed users to easily interact with the visual art.

CANVAS

(Collaborative Advanced Navigation Virtual Art Studio)

A CANVAS is a room-sized immersive 3-D environment with origins in CAVE™ technology. It is scalable, reconfigurable display technology that facilitates the creation and display of immersive art works. It is collaborative because it can be connected to an array of geographically dispersed immersive virtual spaces, has advanced navigation to allow viewers in different locations to interact with virtual art, and allows for the creation and presentation of virtual art that exists not in two or three-dimensional space like a painting or sculpture but in the multi-dimensional world of virtual images. In January the Traveling CANVAS debuted at the Dennos Museum Center at Northwestern Michigan College.

Users experience the virtual art in a multi-dimensional world.

New faculty

The Beckman Institute's commitment to keeping its research relevant and on the front lines of scientific exploration is embodied by the 11 new faculty members who joined our efforts this past year. The addition of new faculty members from areas as diverse as computational biology, phonetics, electronics, and thermal mechanics will help ensure that original, innovative research lines will continue to be generated at the Beckman Institute.

FULL-TIME FACULTY

Biological Intelligence

Gabriel Popescu is a new member of the Bioimaging Science and Technology group and an Assistant Professor in the Department of Electrical and Computer Engineering at the University of Illinois. Popescu is director of the Quantitative Light Imaging Laboratory, which focuses on developing novel optical methods based on light scattering, interferometry, and microscopy to quantify structure and dynamics of cells and tissues. His research focus is on quantitative phase imaging and dynamic light scattering and microrheology.

Molecular and Electronic Nanostructures

Emad Tajkhorshid served for many years as assistant director of the Theoretical and Computational Biophysics (TCB) group at Beckman, but now as a professor at Illinois has become a full-time faculty member in the TCB group. Tajkhorshid's research focus is in the area of computational biology, where his group is doing research into the biophysics of cellular membranes. Tajkhorshid is an Assistant Professor of Biochemistry, Pharmacology, and Biophysics in the Department of Biochemistry and at the College of Medicine at Illinois.

PART-TIME FACULTY

Biological Intelligence

Martin Ostoja-Starzewski has joined the Bioimaging Science and Technology group. Ostoja-Starzewski is a Professor of Mechanical Engineering at the University of Illinois. Ostoja-Starzewski's research areas are in stochastic mechanics, mechanics and transport in random media, computational mechanics, thermomechanics, waves, and helices. His research focuses on the intersection of mechanics, thermodynamics, materials science and applied/stochastic mathematics.

Human-Computer Intelligent Interaction

Ryan Shosted is a new faculty member in the Artificial Intelligence group. Shosted is an Assistant Professor in the Department of Linguistics and an experimental phonologist. His research focus is on the ways that phonetic principles shape phonological, typological, and diachronic outcomes in language. His specialty is in the aerodynamics of speech, which studies the properties of air as it passes through the vocal tract. He has interests in a variety of languages, including Portuguese, Tigrinya, Q'anjob'al, and Georgian.

Fatima Husain is a new faculty member in the Human Perception and Performance group and an Assistant Professor in the Department of Speech and Hearing Science at the University of Illinois. Husain's research focuses on auditory, speech, and language processing in the brain using fMRI neuroimaging and computational modeling techniques. Her research was recently expanded to include the study of disorders such as tinnitus (ringing in the ear) that is typically associated with hearing loss.

Molecular and Electronic Nanostructures

William P. King, an Associate Professor in the Department of Mechanical Science and Engineering, joined the 3-D Micro- and Nanosystems group at Beckman. King is Director of the Nanoscale Thermal Processing Laboratory at Illinois, which designs, fabricates, and uses tools for thermal and thermo-mechanical processing at the micro- and nanometer scales. His research group focuses on thermal engineering of microscale and nanoscale mechanical devices (such as micro-electromechanical systems or MEMS) and topics, including thermo-mechanical data storage and nanoscale thermal processing.

Harley Johnson has joined the Beckman Institute as a member of the Computational Multiscale Nanosystems group. Johnson is a faculty member in the University of Illinois Department of Mechanical Science and Engineering. Johnson's research interests involve the mechanics and physics of nanoscale materials. Johnson's Nano-Electro-Opto-Mechanics research group studies the mechanics of electronic and optical materials at the micro- and nanoscale using atomistic and continuum modeling methods toward understanding phenomena and toward simulating real systems for experimental design.

AFFILIATE FACULTY

Biological Intelligence

Torrey Loucks, an Assistant Professor in the Department of Speech and Hearing Science, is a new member of the Cognitive Neuroscience group. Loucks' research explores neural control of speech and voice production and neurological voice disorders in normal and stuttering individuals. His areas of professional interest include neural control of speech and voice production in the normally developing system, sensorimotor integration for speech production in children and adults, and speech motor learning in normally fluent individuals and persons who stutter, as well as those with neurological voice disorders.

Ling Meng has joined the Bioimaging Science and Technology (BST) group. Meng is an Assistant Professor in the Department of Nuclear, Plasma and Radiological Engineering at the University of Illinois. Meng's research interests focus on ultra-high resolution imaging systems for biomedical/molecular imaging applications and on a novel imaging sensor based on room temperature semiconductor detectors.

Feniosky Peña-Mora from the Department of Civil and Environmental Engineering is a new faculty member in the Artificial Intelligence group. Peña-Mora's research interests include information technology support for collaboration in preparedness, response, and recovery during disasters involving critical physical infrastructures. He has published works in peer-reviewed journals, book chapters, and textbooks on topics such as computer-supported design, and project control and management of large-scale engineering systems.

Molecular and Electronic Nanostructures

Eric Pop has joined the Beckman Institute as a member of the Computational Electronics group. Pop is a faculty member in the Illinois Department of Electrical and Computer Engineering. Pop's research is in the area of solid-state electronics, with a focus on power and thermal issues in nanoscale integrated circuits, carbon nanotubes, and graphene for electronic and thermal applications, and alternative solid-state memory devices.

Beckman Institute **Fellows Program**

The Beckman Institute Fellows program provides an excellent opportunity for young scholars to initiate a post-Ph.D. career of independent research in a stimulating and supportive interdisciplinary environment.

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

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 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

Jacob Eisenstein, 2008 Fellow

Jacob is currently a post-doctoral student at the Massachusetts Institute of Technology where he is expected to earn his Ph.D. in Computer Science in June of 2008. His research focuses on non-verbal modalities, such as gestures, that supplement speech. At the Beckman Institute he plans to build computational statistical models of the relationship between gesture, speech, and discourse with the goal of improving natural language understanding.

Agustín Mihi, 2008 Fellow

Agustín will join the Beckman Institute from the Spanish National Research Council where in July of 2008 he completed his Ph.D. work at its Institute of Materials Science of Seville. His research explores new optical architectures to enhance light harvesting efficiency in solar cells. At the Beckman Institute, Agustín will work toward his goal of developing next generation solar cells that are more efficient, less expensive, and easier to implement than current options.

Amy Shih, 2008 Fellow

This spring Amy will complete her Ph.D. in Biophysics and Computational Biology at the University of Illinois at Urbana-Champaign. Her research interests are focused on biophysical characterizations of the structure and function of health-relevant biomolecules. During her time as a Beckman Institute Fellow she plans to use advanced computational modeling to study proteins of biomedical and pharmaceutical interest.

Joel Voss, 2008 Fellow

Joel received his Ph.D. in Neuroscience from Northwestern University in June of 2007. He will join the Beckman Institute after spending the past year as a post-doctoral researcher at Northwestern University. His research examines the operation of explicit and implicit expressions of memory. At the Beckman Institute he plans to use resources including the Biomedical Imaging Center to tackle key theoretical controversies in the cognitive neuroscience of human memory.

Jongseung Yoon, 2007 Fellow

Jongseung was a Postdoctoral Fellow at the Massachusetts Institute for Technology, where he received his Ph.D. in Materials Science and Engineering. His research seeks to understand the physical properties and microstructure of soft and hybrid materials such as polymer/inorganic composites, and to control their structure and patterning for applications in advanced photonic, phononic, and electronic technologies. Jongseung's research at Beckman will focus on novel approaches to materials and processing methods toward development of high performance photovoltaic devices for solar energy cells.

Séverine Lepage, 2007 Fellow

Séverine completed her Ph.D. in Aerospace and Mechanical Engineering at the University of Liège, Belgium. Her research in the areas of structural dynamics and computational engineering is concerned with the development of efficient computational methods for the analysis and design of micro-electromechanical systems (MEMS). At Beckman, she is using the stochastic finite element method to advance MEMS development by improving design and reliability through the elaboration of a probabilistic CAD tool.

Zhi Jiang, 2007 Fellow

Zhi earned a Ph.D. in Electrical and Computer Engineering from Purdue University, where he worked as a post-doctoral research associate in the area of spectral pulse shaping of ultrafast optical pulses. While at Purdue Zhi built the first grating-based spectral line-by-line pulse shaper. At Beckman he is applying optical pulse shaping techniques and coherent control to improve biomedical imaging applications such as optical coherence tomography (OCT).

Derek Hoiem, 2007 Fellow

Derek received his Ph.D. in Robotics at Carnegie Mellon University in Pittsburgh, Pennsylvania. His research focuses on computer vision with an emphasis on learning appearance models and image-based scene understanding. As a Fellow at the Beckman Institute, he is working on developing computer vision algorithms that allow computers to truly understand the scene before them. His plan is to formulate the vision problem in terms of the underlying 3-D scene and apply real-world knowledge to gain a spatial understanding of the scene layout and its contents. He is investigating the extent, source, and use of spatial understanding in humans while developing computer algorithms to replicate these abilities.

Joe Geddes, 2006 Fellow
Joe joins Beckman from Penn State where he earned his doctorate in Engineering Science. His thesis work focused on the time-domain optical response of inhomogenous, anisotropic, and nonlinear materials like chiral sculptured thin films to excitation by ultrashort optical pulses. At Beckman he is extending that work into new areas, particularly the design of novel photonic materials.

Yael Gertner, 2006 Fellow
Yael was a Postdoc Fellow in the Department of Psychology at the University of Illinois. Her research interests deal with how children acquire words and rules of their native languages and how these processes can be modeled using computational tools. Gertner is pursuing further research in this area using experimental psycholinguistics and techniques from computational learning theory. She is using the knowledge derived from the experiments to design better learning algorithms.

Ming Hsu, 2006 Fellow
Ming Ming came to the Beckman Institute from the California Institute of Technology where he received his Ph.D. in Social Sciences. His thesis work focused on decision theory, microeconomic theory, behavioral economics, and neuroeconomics. At the Beckman Institute Ming is continuing his work in neuroeconomics. His research uses brain imaging to examine which brain processes are engaged in the Ellsberg Paradox and the role of home bias phenomenon in investment decisions.

Mark Neider, 2006 Fellow
Mark came to Beckman from the SUNY Stony Brook Department of Psychology. His thesis work examined the effects of target-background similarity on visual search. Neider's research goals are to reconcile the basic search literature with behavior observed under life-like conditions, while concurrently providing environmentally valid data from which to inform current models of visual attention and visual search.

Stephanie Rinne, 2006 Fellow
Stephanie received her Ph.D. in Materials Science and Engineering at the University of Illinois. Her research interests include optical coherence tomography (OCT), which affords cellular resolution and *in vivo* imaging capability. Stephanie is exploring contrast in this imaging modality and hopes to ultimately improve the current contrast mechanisms to help provide earlier diagnosis techniques for cancer.

Dirk Bernhardt-Walther, 2006 Fellow
Dirk earned his Ph.D. in Computational and Neural Systems at the California Institute of Technology in Pasadena, California. His research topic was "Modeling interactions of visual attention and object recognition in human and machine vision." As a Beckman Fellow, he is investigating the effects of task on human visual processing and their applications.

Sarah Brown-Schmidt, 2006 Fellow
Sarah earned her Ph.D. from the University of Rochester in Brain and Cognitive Sciences. Her research focuses on the mechanisms by which people produce and understand utterances during the most basic form of language use: interactive conversation. She also has strong interests in language production, in particular how messages are planned during conversation.

Chandramallika Basak, 2005 Fellow
Chandramallika earned a Ph.D. in Experimental Psychology at Syracuse University. Her dissertation research was "Capacity limits of focus of attention and dynamics of focus switching in the N-Count task of working memory." Her research included work on the perception of accelerated motion, age deficits in counting, and time-series modeling on continuous recognition memory. At the Beckman Institute her research is concentrated on two aspects of cognition: focus-switching and using cognitive training to lessen the effects of aging.

Silvio Savarese, 2005 Fellow
Silvio earned his Ph.D. in Electrical Engineering at the California Institute of Technology, completing his dissertation on "Perception and 3-D reconstruction of specular surfaces." His research interests include: computer vision; shape representation, modeling and estimation; image-based modeling and rendering; three-dimensional scene modeling; human-machine interfaces; image processing, early vision processes; machine learning; human visual perception; and visual psychophysics.

Zhihong Zeng, 2005 Fellow
Zhihong earned his Ph.D. from the Institute of Automation, Chinese Academy of Sciences, with his dissertation "Real-time shape tracking under various circumstances." He has been working with the Image Formation and Processing group at the Beckman Institute since 2002. Zhihong's research interests in multimodal emotion assessment for human-computer interaction includes the psychological analysis of human emotion perception, computer vision, speech processing, and machine learning. Zhihong does research in the HCII research initiative, focusing on multimodal emotional state assessment for human-computer interactions in naturally occurring settings.

Beckman Institute **Graduate Fellows Program**

The Beckman Graduate Fellows Program, supported by funding from the Arnold and Mabel Beckman Foundation, offers University of Illinois graduate students at the M.A., M.S., or Ph.D. level the opportunity to pursue interdisciplinary research at the Institute.

Research projects must involve at least one Beckman faculty member in addition to a second U of I faculty member, and preference is given to those proposals that are interdisciplinary and involve the active participation of two Beckman faculty members from two different groups.

The 2007-2008 Beckman Institute Graduate Fellows are:

Peter Freddolino
Peter is pursuing his Ph.D. in Biophysics and Computational Biology from the School of Life Sciences. As a Beckman Graduate Fellow he plans to focus his research on creating a better theoretical framework to describe the protein folding process. Peter hopes this research path will both aid in the understanding of diseases caused by point mutations in proteins, and will also allow the design of protein variants with novel function.

Justin Haldar
Justin is pursuing his Ph.D. in Electrical Engineering. His research is developing a novel multi-modal approach to magnetic resonance neuroimaging which allows brain physiology to be characterized from structural, biochemical, and functional perspectives. Current limitations for multi-modal studies include long acquisition times and low signal-to-noise ratios. Justin's work will fuse information from multiple modalities to permit high-quality image reconstructions from significantly shorter experiments.

Agatha Luszpak
Agatha is part of the Medical Scholars Program (M.D./Ph.D. Program) where she is working on her M.D. from the College of Medicine and Ph.D. in Neuroscience. Her work is exploring the causes of Fragile X syndrome, a genetic disorder that includes mental retardation, attention deficit, hyperactivity, and behaviors characteristic of autism. Luszpak's research will look at deficits in neuropeptide release as a possible cause of some neurobehavioral abnormalities of Fragile X syndrome. Her goal is to discover therapeutics that could alleviate neuropeptide release and provide a possible therapy for Fragile X syndrome.

Mahdi Rastad
Mahdi is working toward a Ph.D. in Economics. His research is probing the effects of emotions on economic behavior, specifically on fostering or reducing trust and cooperation. In his experiments participants are given the opportunity to send signals about their emotions by way of dynamic facial expressions thorough a 3-D animation software (Poser). Coupling this novel methodology with a special statistical technique, Functional Data Analysis, provides Mahdi with way to effectively measure and quantify emotions as they relate to trust and cooperation.

BIOLOGICAL INTELLIGENCE RESEARCH INITIATIVE FACULTY

(name followed by home department)

Bioacoustics Research Laboratory
William D O'Brien, *Electrical and Computer Engineering*
Michael L Oelze, *Bioengineering*

Bioimaging Science and Technology
Rohit Bhargava, *Bioengineering*
Marni D Boppart, *Kinesiology and Community Health*
Stephen Allen Boppart, *Electrical and Computer Engineering*
Paul Scott Carney, *Electrical and Computer Engineering*
Michael Insana, *Bioengineering*
Jianming Jin, *Electrical and Computer Engineering*
John A Katzenellenbogen, *Chemistry*
Zhi-Pei Liang, *Electrical and Computer Engineering*
Ling Jian Meng, *Nuclear, Plasma and Radiological Engineering*
William C Olivero, *Surgery*
Gabriel Popescu, *Electrical and Computer Engineering*
Martin Starzewski, *Mechanical Science and Engineering*
Kenneth S Suslick, *Chemistry*
Bradley P Sutton, *Bioengineering*
Ning Wang, *Mechanical Science and Engineering*
Yingxiao Wang, *Bioengineering*
Yongmei Michelle Wang, *Statistics*
Kenneth L Watkin, *Speech and Hearing Science*

Cognitive Neuroscience
Diane M Beck, *Psychology*
Neal J Cohen, *Psychology*
Monica Fabiani, *Psychology*
Kara Federmeier, *Psychology*
Susan M Garnsey, *Psychology*
Brian D Gonsalves, *Psychology*
Gabriele Gratton, *Psychology*
Christopher M Grindrod, *Speech and Hearing Science*
Wendy Heller, *Psychology*
Torrey Loucks, *Speech and Hearing Science*
Gregory A Miller, *Psychology*
Hernando C Ombao, *Statistics*
Denise Park, *Psychology*
Richard S Powers, *English*

Cognitive Science
Aaron Benjamin, *Psychology*
J Kathryn Bock, *Psychology*
William F Brewer, *Psychology*
Kiel Christianson, *Educational Psychology*
Jennifer S Cole, *Linguistics*
Gary S Dell, *Psychology*
Cynthia L Fisher, *Psychology*
Jose Mestre, Educational *Psychology*
Michelle Perry, Educational *Psychology*
Brian H Ross, *Psychology*
Chilin Shih, *East Asian Languages and Cultures*
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*
Charles (Lee) Cox, *Molecular and Integrative Physiology*
Albert S Feng, *Molecular and Integrative Physiology*
Martha U Gillette, *Cell and Developmental Biology*
William T Greenough, *Psychology*
Douglas L Jones, *Electrical and Computer Engineering*
Janice M Juraska, *Psychology*
Richard J Kollmar, *Molecular and Integrative Physiology*
Joseph G Malpeli, *Psychology*
Mark E Nelson, *Molecular and Integrative Physiology*
Justin S Rhodes, *Psychology*
Gene E Robinson, *Entomology*
Edward J Roy, *Psychology*
Jonathan V Sweedler, *Chemistry*
Bruce C Wheeler, *Electrical and Computer Engineering*

SELECTED HONORS AND AWARDS

Rohit Bhargava
Incomplete List of Teachers Ranked Excellent by their Students, 2007

Marni D Boppart
National Institutes for Aging (NIA) Summer Research Fellow, 2007

Stephen Allen Boppart
Visiting Professorship, Raine Medical Research Foundation, 2007-2008
Engineering Council Award for Excellence in Advising, 2007

Paul Scott Carney
Outstanding Advisor Award, College of Engineering, 2007-2008
Incomplete List of Teachers Ranked Excellent by their Students, 2007
Fulbright Scholar, 2008-09 (Netherlands)

Kiel Christianson
Review panel member for Interagency Language Roundtable and Center for the Advanced Study of Language; ad-hoc reviewer for National Science Foundation, 2008

Albert S Feng
Chancellor's Award Lecture in Neuroscience, 2007
Keynote Lecture, Neuweiler Symposium at Ludwig Maximillian Univ. of Munich, 2008
Huber Lecture, International Society for Neuroethology, 2007

Zhi-Pei Liang
Engineering Council Award for Excellence in Advising, 2007
List of Teachers Ranked as Excellent by their Students, 2007

Jose Mestre
National Academies Education Mentor in the Life Sciences, National Academies/National Research Council

Justin S Rhodes
Young Scientist Award, International Behavioural and Neural Genetics Society, 2008

Chilin Shih
2007-2008 Helen Corely Petit Scholar, The College of Liberal Arts and Sciences, University of Illinois at Urbana-Champaign

Martin Ostoja-Starzewski
Fellow, American Academy of Mechanics
Presentation, *10th Pan American Congress of Applied Mechanics*, selected among the best papers and invited to a special issue of *Journal of Mechanics of Materials and Structures*, January 2008

Kenneth S Suslick
Sir George Stokes Medal, Royal Society of Chemistry, 2007
Editorial Board, *Journal of American Chemical Society*, 2006-09
Editorial Board, *Accounts of Chemical Research*, American Chemical Society, 2005-08

Jonathan V Sweedler
James R. Eiszner Family Professor of Chemistry, 2008
Award for Outstanding Team Effort, Engineering Research and Development Center, Army Core of Engineeers, 2007
Theophilus Redwood Lecturer, Analytical Division, Royal Society of Chemistry, 2007
Pittsburgh Analytical Chemistry Award, Society of Analytical Chemists of Pittsburgh, 2007

Yingxiao Wang
Phase II Translational Biomedical Research Early Career Award; Wallace H. Coulter Foundation, 2008
Poster Award by Neuroscience Program (adviser to graduate student Jihye Seong), 2007

Yongmei Michelle Wang
Advisory Board, The Encyclopedia of Measurement and Statistics, Sage Publications
Journal Reviewer, IEEE Trans. on Medical Imaging (TMI); NeuroImage; IEEE Trans. on Pattern Analysis and Machine Intelligence (PAMI); Computer Vision and Image Understanding (CVIU); Physical Review Letters; Medical Image Analysis (MedIA); Int. Journal of Image and Graphics (IJIG); Journal of Electronic Imaging (JEI); International Journal of Computer Vision (IJCV); IEEE Signal Processing Letters; Pattern Recognition Letters; Statistica Sinica; Annals of Biomedical Engineering; IEEE Journal of Selected Topics in Signal Processing
Program Committee, International Conf. on Computer Vision Theory and Applications, 2006-2009
Review Committee, Int. Conf. on Medical Image Computing Computer Assisted Intervention (MICCAI), 2003-2008
Membership, IEEE Engineering in Medicine and Biology Society (EMBS); Organization of Human Brain Mapping

Bruce C Wheeler
IEEE Fellow, 2008
Editor in Chief IEEE Transactions on Biomedical Engineering, 2007, 2008

SELECTED PATENTS AND PATENT APPLICATIONS

(Beckman faculty members in **bold**)

Faculty members from Biological Intelligence were responsible for 18 patent applications during fiscal year 2008 (FY2008). This represents 9.8% of the 138 patent applications filed by the campus. The following four patents (7.9% of the 38 patents issued to campus) were issued to Beckman faculty members during FY2008 (Beckman Institute faculty members are listed in bold):

Albert S. Feng, Chen Liu, Robert C. Bilger, **Douglas L. Jones**, **Charissa R. Lansing**, **William D. O'Brien**, and **Bruce C. Wheeler**: "Binaural Signal Processing Techniques," Patent Issued September 25, 2007, Patent Number 2,348,894.

Kenneth S. Suslick, Neal A. Rakow, Avijit Sen, William B.McNamara, and Margaret E. Kosal: "Colorimetric Artificial Nose Having an Array of Dyes and Method for Artificial Olfaction," Patent Issued August 23, 2007, Patent Number 209296; and Patent Issued August 28, 2007, Patent Number 07,261,857.

Christopher D. Schmitz, Crista Malick, **Douglas L. Jones**, François Callias, Jeffery B. Larsen, Mitesh Parikh, Qi Xie, and Steven J. Franke: "Systems, Devices, and Methods of Wireless Intrabody Communication," Patent Issued January 24, 2008, Patent Number 200420543.

SELECTED GRANTS AWARDED

Brian Ross and **Jose Mestre**, Institute of Education Sciences "Conceptual Analysis and Student Learning in Physics," 7/1/07 – 6/30/10.

Yanyan Wang, NIH, (University of Alabama Birmingham), "Pathophysiology of DYT1 Dystonia: Targeted Mouse Models," 7/15/07 – 3/31/10.

Stephen Boppart, Martin Gruebele, and Daniel Marks, NIH, "Nonlinear Interferomatic Vibrational Imaging of Cancer," 8/22/07 – 7/31/09.

Ivan Jeanne Weiler and **William Greenough**, Early Detect, "New Diagnostic for Evaluating Fragile X Syndrome," 1/1/08 – 12/31/09.

Richard Kollmar, **Albert Feng**, and **Bruce Wheeler**, National Organization for Hearing Research, "Interaction of Wnt-frizzled- and BDNF-Signaling During Neurite

Regeneration from Adult Spiral Ganglion Neurons," 1/16/08 – 1/15/09.

Rohit Bhargava and **William King**, Anasys Instruments, "Cantilever Probe Technology and Spectroscopy for Nanoscale IR Imaging," 1/16/08 – 12/31/09.

Gary Dell, **Cynthia Fisher**, and **Jennifer Cole**, NIH, "Production and Perception of Phonological Sequences," 4/1/08 – 3/31/11.

Freddy Nguyen and **Stephen Boppart**, US Army Medical Research & Material Command, "Development of Optical Coherence Tomography (OCT) Targeted Contrast Agents for Breast Cancer," 5/16/08 – 6/15/11.

Zhi-Pei Liang and **Van Anderson**, NSF, "A Special Symposium on Magnetic Resonance Imaging," 6/1/08 – 5/31/09.

SELECTED PUBLICATIONS

(Beckman faculty members in **bold**)

Amaya, K. R.; Monroe, E. B.; **Sweedler, J. V.**; **Clayton, D. F.**, Lipid imaging in the zebra finch brain with secondary ion mass spectrometry. *International Journal of Mass Spectrometry* **2007**, 260, (2-3), 121-127.

Astolfi, L.; Fallani, F. D.; Cincotti, F.; Mattia, D.; Marciani, M. G.; Bufalari, S.; Salinari, S.; Colosimo, A.; Ding, L.; Edgar, J. C.; **Heller, W.**; **Miller, G. A.**; He, B.; Babiloni, F., Imaging functional brain connectivity patterns from high-resolution EEG and fMRI via graph theory. *Psychophysiology* **2007**, 44, (6), 880-893.

Dalavoy, T. S.; Wernette, D. P.; Gong, M. J.; **Sweedler, J. V.**; **Lu, Y.**; Flachsbart, B. R.; **Shannon, M. A.**; Bohn, P. W.; Cropek, D. M., Immobilization of DNAzyme catalytic beacons on PMMA for Pb2 + detection. *Lab on a Chip* **2008**, 8, (5), 786-793.

Davis, B. J.; Ralston, T. S.; Marks, D. L.; **Boppart, S. A.**; **Carney, P. S.**, Autocorrelation artifacts in optical coherence tomography and interferometric synthetic aperture microscopy. *Optics Letters* **2007**, 32, (11), 1441-1443.

Federmeier, K. D.; Laszlo, S., Deriving meaning from ERPS ... and other acronyms. *Psychophysiology* **2007**, 44, S6-S6.

Hernando, D.; Haldar, J. P.; **Sutton, B. P.**; Ma, J.; Kellman, P.; **Liang, Z. P.**, Joint estimation of water/fat images and field inhomogeneity map. *Magnetic Resonance in Medicine* **2008**, 59, (3), 571-580.

Kim, B. Y.; Swearingen, C. B.; Ho, J. A. A.; Romanova, E. V.; Bohn, P. W.; **Sweedler, J. V.**, Direct immobilization of Fab ' in nanocapillaries for manipulating mass-limited samples. *Journal of the American Chemical Society* **2007**, 129, (24), 7620-7626.

Kim, S. H.; Markham, J. A.; Weiler, I. J.; **Greenough, W. T.**, Aberrant early-phase ERK inactivation impedes neuronal function in F ragile X syndrome. *Proceedings of the National Academy of Sciences of the United States of America* **2008**, 105, (11), 4429-4434.

London, S. E.; **Clayton, D. F.**, Functional identification of sensory mechanisms required for developmental song learning. *Nature Neuroscience* **2008**, 11, (5), 579-586.

Polk, T. A.; Park, J.; Smith, M. R.; **Park, D. C.**, Nature versus nurture in ventral visual cortex: A functional magnetic resonance imaging study of twins. *Journal of Neuroscience* **2007**, 27, (51), 13921-13925.

Rykhlevskaia, E.; **Gratton, G.**; **Fabiani, M.**, Combining structural and functional neuroimaging data for studying brain connectivity: A review. *Psychophysiology* **2008**, 45, (2), 173-187.

Sass, S. M.; **Heller, W.**; Stewart, J. L.; Levin, R. L.; Edgar, C. J.; **Fisher, J. E.**; **Miller, G. A.**, Time course of attentional bias in anxiety. *Psychophysiology* **2007**, 44, S51-S51.

Shen, J.-X.; **Feng, A. S.**; Xu, Z. M.; Yu, Z. L.; Arch, V. S.; Yu, X. J.; Narins, P. M., Ultrasonic frogs show hyperacute phonotaxis to the female's courtship calls. *Nature* **2008**, 453, 914-917.

Tse, C. Y.; Lee, C. L.; Sullivan, J.; **Garnsey, S. M.**; **Dell, G. S.**; **Fabiani, M.**; **Gratton, G.**, Imaging cortical dynamics of language processing with the event-related optical signal. *Proceedings of the National Academy of Sciences of the United States of America* **2007**, 104, (43), 17157-17162.

Vieira, M.; Christensen, B. L.; **Wheeler, B. C.**; **Feng, A. S.**; **Kollmar, R.**, Survival and stimulation of neurite outgrowth in a serum-free culture of spiral ganglion neurons from adult mice. *Hearing Research* **2007**, 230, (1-2), 17-23.

Yang, S. G.; **Cox, C. L.**, Excitatory and anti-oscillatory actions of nitric oxide in thalamus. *Journal of Physiology* **2008**.

HUMAN-COMPUTER INTELLIGENT INTERACTION RESEARCH INITIATIVE FACULTY

(name followed by home department)

Artificial Intelligence

Narendra Ahuja, *Electrical and Computer Engineering*
Jont B Allen, *Electrical and Computer Engineering*
Eyal Amir, *Computer Science*
Timothy W Bretl, *Aerospace Engineering*
Todd P Coleman, *Electrical and Computer Engineering*
Gerald F DeJong, *Computer Science*
Roxana Girju, *Linguistics*
Mark A Hasegawa-Johnson, *Electrical and Computer Engineering*
Seth Hutchinson, *Electrical and Computer Engineering*
Steven M LaValle, *Computer Science*
Stephen E Levinson, *Electrical and Computer Engineering*
Silvina A Montrul, *Spanish, Italian, and Portuguese*
Feniosky Pena-Mora, Civil and Environmental Engineering
Dan Roth, *Computer Science*
Ryan K Shosted, *Linguistics*
Richard W Sproat, *Linguistics*

Human Perception and Performance

Wai-Tat Fu, *Human Factors Division*
Charles Hillman, *Kinesiology and Community Health*
Fatima T Husain, *Speech and Hearing Science*
David E Irwin, *Psychology*
Alex Charles Kirlik, *Human Factors Division*
Arthur F Kramer, *Psychology*
Charissa Lansing, *Speech and Hearing Science*
Yi-Ching Lee, *Human Factors Division*
Alejandro Lleras, *Psychology*
Edward McAuley, *Kinesiology and Community Health*
Jason S McCarley, *Human Factors Division*
Deana C McDonagh, *Art and Design, School of*
Dan G Morrow, *Human Factors Division*
Karl S Rosengren, *Kinesiology and Community Health*
Daniel J Simons, *Psychology*
Jacob J Sosnoff, *Kinesiology and Community Health*
Jesse Benjamin Spencer-Smith, *Psychology*
Elizabeth Al Stine-Morrow, *Educational Psychology*
Sharon Tettegah, *Curriculum and Instruction*
Ranxiao Wang, *Psychology*

Image Formation Processing

Brian P Bailey, *Computer Science*
Yoram Brelser, *Electrical and Computer Engineering*
Minh N Do, *Electrical and Computer Engineering*
Robert M Fossum, *Mathematics*
George K Francis, *Mathematics*
Jiawei Han, *Computer Science*
Thomas S Huang, *Electrical and Computer Engineering*
Yi Ma, *Electrical and Computer Engineering*
Pierre Moulin, *Electrical and Computer Engineering*
Klara Nahrstedt, *Computer Science*

SELECTED HONORS AND AWARDS

Narendra Ahuja

Distinguished Alumnus Award, University of Maryland, April 2008

Minh N Do

IBM Student Paper Award (co-author), IEEE International Conference on Image Processing, 2007

Roxana Girju

LAS Alumni Discretionary Award, UIUC, 2007

Thomas S Huang

DoCoMo Innovation Paper Award (co-author), IEEE International Conference on Image Processing, September 16-19, 2007
Honorary Chair, IEEE Conference on Computer Vision and Pattern Recognition, June 24-27, 2008

Arthur F Kramer

Swanlund Chair, Zukunftskolleg award, Germany

Stephen E Levinson

Honorary Faculty Member, Eta Kappa Nu, April 2008

Alejandro Lleras

Early Career Award, National Science Foundation, 2008

Edward McAuley

1st Shahid and Ann Carlston Khan Professor in Applied Health Sciences, October, 2007

Deana C McDonagh

Arnold O. Beckman Research Award

Dan G Morrow

Editorial Board, Journal of Experimental Psychology: Applied, 2007
Member, US Pharmacopeia Health Literacy and Prescription Container Labeling Ad hoc Advisory Panel, 2008

Elizabeth A Stine-Morrow

Associate Editor, *Memory and Cognition*, Psychonomic Society, 2007-2009; Associate Editor, *Journal of Gerontology: Psychological Sciences*, Gerontological Society of America, 2008-2010; Associate, Center for Advanced Study, University of Illinois, 2008-2009

Richard W Sproat

Center for Advanced Studies Associate, UIUC, Fall 2007
University Scholar, UIUC, 2007

SELECTED PATENTS AND PATENT APPLICATIONS

(Beckman faculty members in **bold**)

Faculty members from HCII were responsible for 2 patent applications during fiscal year 2008 (FY2008). This represents 1.1% of the 138 patent applications filed by the campus. The following patent (2.6% of the 38 patents issued to campus) was issued during FY2008 (Beckman Institute faculty members are listed in bold):

Samit Basu and **Yoram Bresler**: "Fast Hierarchical Backprojection Method for Imaging," Patent Issued December 12, 2007, Patent Number in process.

SELECTED GRANTS AWARDED

(Beckman faculty members in **bold**)

Arthur Kramer, Monica Fabiani, Gabriele Gratton, Wai-Tat Fu, Bradley Sutton, Dmitri Williams, and **Daniel Simons**, ONR, "Capitalizing of Research on Animal & Human Brain Plasticity to Enhance Warfighter Training and Performance," 9/1/07 – 8/31/10.

Elizabeth Stine-Morrow, Daniel Morrow, Denise Park, and **Arthur Kramer**, NIH, "The Senior Odyssey: A Test of the Engagement Hypothesis of Cognitive Aging," 9/15/07 – 8/31/12.

Daniel Morrow and **Elizabeth Stine-Morrow**, NIH, Health Literacy and Aging: A Process-Knowledge Approach," 3/1/08 – 2/28/13.

Elizabeth Stine-Morrow and **Susan Garnsey**, Sandia National Labs, "Domain-Knowledge Effects on Reading Time Allocation," 3/3/08 – 6/21/08.

Arthur Kramer, **Edward McAuley**, and **Neal Cohen**, NIH, "Influence of Fitness on Brain and Cognition," 4/15/08 – 6/30/08.

SELECTED PUBLICATIONS

(Beckman faculty members in bold)

DiGirolamo, G. J.; **McCarley, J. S.**; **Kramer, A. F.**; Griffin, H. J., Voluntary and reflexive eye movements to illusory lengths. *Visual Cognition* **2008**, 16, (1), 68-89.

Fu, Y.; Li, Z.; **Huang, T. S.**; Katsaggelos, A. K., Locally adaptive subspace and similarity metric learning for visual data clustering and retrieval. *Computer Vision and Image Understanding* **2008**, 110, (3), 390-402.

Gordon, B. A.; Rykhlevskaia, E. I.; Brumback, C. R.; **McAuley, E.**; **Kramer, A. F.**; Colcombe, S.; **Gratton, G.**; **Fabiani, M.**, The effects of education and physical fitness on brain anatomy. *Psychophysiology* **2007**, 44, S54-S55.

Hillman, C. H.; Erickson, K. I.; **Kramer, A. F.**, Be smart, exercise your heart: exercise effects on brain and cognition. *Nature Reviews Neuroscience* **2008**, 9, (1), 58-65.

McClain, M.; **Levinson, S.**, Semantic based learning of syntax in an autonomous robot. *International Journal of Humanoid Robotics* **2007**, 4, (2), 321-346.

Park, D. C.; Gutchess, A. H.; Meade, M. L.; **Stine-Morrow, E. A. L.**, Improving cognitive function in older adults: Nontraditional approaches. *Journals of Gerontology Series a-Biological Sciences and Medical Sciences* **2007**, 62, 45-52.

Ross, B. H.; **Wang, R. F.**; **Kramer, A. F.**; **Simons, D. J.**; Crowell, J. A., Action information from classification learning. *Psychonomic Bulletin & Review* **2007**, 14, (3), 500-504.

Zeng, Z. H.; Tu, J. L.; Liu, M.; **Huang, T. S.**; Pianfetti, B.; **Roth, D.**; **Levinson, S.**, Audio-visual affect recognition. *IEEE Transactions on Multimedia* **2007**, 9, (2), 424-428.

MOLECULAR AND ELECTRONIC NANOSTRUCTURES RESEARCH INITIATIVE FACULTY

(name followed by home department)

3D Micro- and Nanosystems
Paul Braun, *Materials Science and Engineering*
Sahraoui Chaieb, *Mechanical Science and Engineering*
Nicholas X Fang, *Mechanical Science and Engineering*
Robert B Gennis, *Biochemistry*
Steve Granick, *Materials Science and Engineering*
Iwona M Jasiuk, *Mechanical Science and Engineering*
Paul J A Kenis, *Chemical and Biomolecular Engineering*
William P King, *Mechanical Science and Engineering*
Deborah E Leckband, *Chemistry*
Yi Lu, *Chemistry*
John Ashley Rogers, *Materials Science and Engineering*
Mark A Shannon, *Mechanical Science and Engineering*
Stephen G Sligar, *Biochemistry*
Pierre Wiltzius, *Materials Science and Engineering*
Gerard Chee Lai Wong, *Materials Science and Engineering*
Steven C Zimmerman, *Chemistry*

Autonomous Materials Systems
Ioannis Chasiotis, *Aerospace Engineering*
Jonathan Freund, *Materials Science and Engineering*
Philippe Geubelle, *Aerospace Engineering*
Jennifer A Lewis, *Materials Science and Engineering*
Jeffrey S Moore, *Chemistry*
Nancy R Sottos, *Materials Science and Engineering*
Amy Jaye Wagoner Johnson, *Mechanical Science and Engineering*
Scott R White, *Aerospace Engineering*

Computational Electronics
Jean-Pierre Leburton, *Electrical and Computer Engineering*
Eric Pop, *Electrical and Computer Engineering*

Computational Multiscale Nanosystems
Narayana R Aluru, *Mechanical Science and Engineering*
Richard D Braatz, *Chemical and Biomolecular Engineering*
Andreas Cangellaris, *Electrical and Computer Engineering*
John G Georgiadis, *Mechanical Science and Engineering*
Eric Jakobsson, *Molecular and Integrative Physiology*
Harley Johnson, *Mechanical Science and Engineering*
Erik Luijten, *Materials Science and Engineering*
Christopher V Rao, *Chemical and Biomolecular Engineering*
Umberto Ravaioli, *Electrical and Computer Engineering*

Nanoelectronics
Ilesanmi Adesida, *Electrical and Computer Engineering*
Alexey Bezryadin, *Physics*
Martin Gruebele, *Chemistry*
Xiuling Li, *Electrical and Computer Engineering*
Joseph W Lyding, *Electrical and Computer Engineering*
Nancy Makri, *Chemistry*
Eric Michielssen, *Electrical and Computer Engineering*
Margery Osborne, *Curriculum and Instruction*
Moonsub Shim, *Materials Science and Engineering*
Gregory Timp, *Electrical and Computer Engineering*
Min-Feng Yu, *Mechanical Science and Engineering*

Theoretical and Computational Biophysics
Aleksei Aksimentiev, *Physics*
Laxmikant V Kale, *Computer Science*
Zaida (Zan) Luthey-Schulten, *Chemistry*
Todd J Martinez, *Chemistry*
Klaus Schulten, *Physics*
Emad Tajkhorshid, *Biochemistry*

SELECTED HONORS AND AWARDS

Aleksei Aksimentiev
IBM Faculty Award

Nicholas X Fang
MIT Technology Review Magazine's 35 Young Innovators Award, 2008
UIUC Engineering Council Award of Excellence in Advising, 2007

Philippe Geubelle
Best Paper of the Year Award, 2007, Materials Division, ASME for paper "Continuum- and molecular-level modeling of fatigue crack propagation in self-healing composite" co-authored by S. Maiti, C. Shankar, P. H. Geubelle and J. Kieffer (*J. Eng. Mater. Technology*, 128:4, 595-602, 2006)

Martin Gruebele
Elected member of the German National Academy of Sciences

Eric Jakobsson
IEEE Bioinformatics and Bioengineering Outstanding Achievement Award, awarded at IEEE BIBE October 2007

Outstanding Application Paper Award at IEEE BIBE 2007 for "MotifNetwork: A Grid-enabled Workflow for High-throughput Domain Analysis of Biological Sequences: Implications for annotation and study of phylogeny, protein interactions, and intraspecies variation" co-authored by Tilson, J.L; Rendon, G.; Ger, M.-F. Jakobsson, E

Jean-Pierre Leburton
Best paper finalists, IEEE-NANO 2007, Hong-Kong, SAR, China, Aug 2-5, 2007 (w/ M. Gracheva)

Jeffrey S Moore
Inducted into the American Academy of Arts & Sciences, 2008
AED Professor of the Year, 2008
Phi Kappa Psi Fraternity Outstanding Educator, 2007

John Ashley Rogers
Baekeland Award, American Chemical Society, 2007
Tau Beta Pi Daniel C. Drucker Eminent Faculty Award, UIUC, 2007
Fellow, Materials Research Society, 2008

Klaus Schulten
ISQBP Society, "Award in Computational Biology," 2008

Mark A Shannon
Engineering Council Award for Excellence in Advising, COE, 2008

Nancy R Sottos
Named to SciAm 50, Scientific American (2007)

Gregory Timp
Fellow, American Association for the Advancement of Science
Fellow, Institute of Electrical and Electronic Engineers

SELECTED PATENTS AND PATENT APPLICATIONS

(Beckman faculty members in **bold**)

Faculty members from M&ENS were responsible for fifty-five (55) patent applications during fiscal year 2008 (FY2008). This represents 30.1% of the 138 patent applications filed by the campus. The following 12 patents (31.6% of the 38 patents issued to campus) were issued during FY2008 (Beckman Institute faculty members are listed in bold):

Larry Markoski, **Paul Kenis**, and Eric Choban: "Fuel Cells Comprising Laminar Flow Induced Dynamic Conducting Interfaces, Electronic Devices Comprising Such Cells, and Methods Employing Same," Patent Issued August 7, 2007, Patent Number 7,252,898.

Chang Liu, Kashan Shaikh, Kee Ryu, Edgar Goluch, Zhifang Fan, and David Bullen: "Microfluidic Systems and Components," Patent Issued April 1, 2008, Patent Number 7,351,303.

Eric R. Choban, Piotr Waszczuk, **Paul J. A. Kenis**, Theodore Tzedakis, Seong Kee Yoon, and Cheikhou Kane: "Microfluid Device and Synthetic Methods," Patent Issued September 25, 2007, Patent Number 7,273,541.

Chang Liu, Jack Chen, and Jonathan Engel: "Sensor Chip and Apparatus for Tactile and/or Flow Sensing," Patent Issued April 15, 2008, Patent Number 7,357,035.

Chang Liu and Jonathan Engel: "Apparatus for Detecting Environmental Conditions for a Structure or Article," Patent Issued March 11, 2008, Patent Number 7,343,136.

Larry Markoski, **Joseph Lyding** and **Jeffrey Moore**: "Electrochemical Cells Comprising Laminar Flow Induced Dynamic Conducting Interfaces, Electronic Devices Comprising Such Cells, and Methods Employing Same," Patent Issued July 31, 2007, Patent Number 746,519.

Yi Lu and Juewen Liu: "Fluorescence Based Biosensor," Patent Issued February 19, 2008, Patent Number 7,332,283.

Ralph G. Nuzzo, **John Rogers**, Etienne Menard, Keon Jae Lee, Dahl-Young Khang: "Methods and Devices for Fabricating and Assembling Printable Semiconductor Elements," Patent Issued July 21, 2007, Patent Number I284423.

Xuefeng Wang and **Chang Liu**: "Multifunctional Probe Array System," Patent Issued October 16, 2007, Patent Number 7,281,419.

Chang Liu and David Andrew Bullen: "Electrostatic Nanolithography Probe Actuation Device and Method," Patent Issued July 24, 2007, Patent Number 7,247,895.

Matthew A. Meitl, Zheng-Tao Zhu, Vipan Kumar, Keon Jae Lee, Xue Feng, Yonggang Y. Huang, Ilesanmi Adesida, Ralph G. Nuzzo, and **John Rogers**: "Pattern Transfer Printing by Kinetic Control of Adhesion to an Elastomeric Stamp," Patent Issued January 21, 2008, Patent Number 10-0798431.

Amir Boag, **Yoram Bresler,** and Eric Michielssen: "A Multilevel Domain Decomposition Method for Fast Reprojection of Images," Patent Issued December 12, 2007, Patent Number in process.

SELECTED GRANTS AWARDED

(Beckman faculty members in **bold**)

Klaus Schulten, Laxmikant Kale, Zaida Luthey-Schulten, Emadeddin Tajkhorshid, and **Oleksii Aksimentiev**, NIH, "Resource for Macromolecular Modeling," 8/15/07 – 7/31/12.

Paul Braun, Walter Hurley, **Iwona Jasiuk, John Rogers,** and **Amy Wagoner-Johnson**, NSF, "MRI: Acquisition of Multi-Length Scale Ultra High-Resolution X-Ray Nanotomography Instrument," 8/15/07 – 7/31/08.

Narayana Aluru, Umberto Ravaioli, and **Eric Jakobsson**, Purdue University, "NSF: Network for Computational Nanotechnology," 9/1/07 – 8/31/08.

Scott White and **Nancy Sottos**, USAF AFRL, "Workshop on Autonomous Materials," 12/1/07 – 5/31/08.

Paul Braun, **Jeffrey Moore**, and **Nancy Sottos**, ARO, "Flouresecence Correlation Spectrometry System for Mechanophore Activation & Analysis," 6/1/08 – 5/31/09.

SELECTED PUBLICATIONS

(Beckman faculty members in **bold**)

Brzezinski, A.; Lee, J. T.; Slinker, J. D.; Malliaras, G. G.; **Braun, P. V.**; **Wiltzius, P. V.**, Enhanced emission from fcc fluorescent photonic crystals *Physical Review B* **2008**, 77, 233106 (1-4).

Carmichael, E. S.; Ballard, J. B.; **Lyding, J. W.**; **Gruebele, M.**, Frequency-modulated, single-molecule absorption detected by scanning tunneling microscopy. *Journal of Physical Chemistry C* **2007**, 111, (8), 3314-3321.

Caruso, M. M.; Blaiszik, B. J.; **White, S. R.**; **Sottos, N. R.**; **Moore, J. S.**, Full recovery of fracture toughness using a non-toxic solvent-based self-healing system *Advanced Functional Materials* **2008**, 18, (13), 1898-1904.

Chen, Y. C.; Geddes, J. B.; Lee, J. T.; **Braun, P. V.**; **Wiltzius, P.**, Holographically fabricated photonic crystals with large reflectance. *Applied Physics Letters* **2007**, 91, (24), 241103 (1-3).

Choi, H. K.; Park, J. U.; Park, O. O.; Ferreira, P. M.; **Georgiadis, J. G.**; **Rogers, J. A.**, Scaling laws for jet pulsations associated with high-resolution electrohydrodynamic printing. *Applied Physics Letters* **2008**, 92, (12).

Cruz, E.; **Aksimentiev, A.**; **Schulten, K.**, Computational studies of ionic conduction through silica nanopores. *Biophysical Journal* **2007**, 651A-651A.

Gracheva, M. E.; **Leburton, J. P.**, Simulation of Electrically tunable semiconductor nanopores for ion current/single bio-molecule manipulation. *Journal of Computational Electroncis* **2007**, 7, 6-9.

Kim, D. H.; Ahn, J. H.; Choi, W. M.; Kim, H. S.; Kim, T. H.; Song, J. Z.; Huang, Y. G. Y.; Liu, Z. J.; Lu, C.; **Rogers, J. A.**, Stretchable and foldable silicon integrated circuits. *Science* **2008**, 320, (5875), 507-511.

Mashl, R. J.; **Jakobsson, E.**, End-point targeted molecular dynamics: Large-scale conformational changes in potassium channels. *Biophysical Journal* **2008**, 94, (11), 4307-4319.

Moore, J. S.; Kraft, M. L., Chemistry - Synchronized self-assembly. *Science* **2008**, 320, (5876), 620-621.

Nelson, E. C.; **Braun, P. V.**, Enhancing colloids through the surface. *Science* **2007**, 318, (5852), 924-925.

Park, J. U.; Hardy, M.; Kang, S. J.; Barton, K.; Adair, K.; Mukhopadhyay, D. K.; Lee, C. Y.; **Strano, M. S.**; Alleyne, A. G.; **Georgiadis, J. G.**; Ferreira, P. M.; **Rogers, J. A.**, High-resolution electrohydrodynamic jet printing. *Nature Materials* **2007**, 6, (10), 782-789.

Park, K.; Lee, J.; **Bhargava, R.**; **King, W. P.**, Routine femtogram-level chemical analyses using vibrational spectroscopy and self-cleaning scanning probe microscopy tips. *Analytical Chemistry* **2008**, 80, (9), 3221-3228.

Potisek, S. L.; Davis, D. A.; **Sottos, N.**; **White, S. R.**; **Moore, J. S.**, Mechanophore-linked addition polymers. *Journal of the American Chemical Society* **2007**, 129, (45), 13808-13809.

Rinne, S. A.; Garcia-Santamaria, F.; **Braun, P. V.**, Embedded cavities and waveguides in three-dimensional silicon photonic crystals. *Nature Photonics* **2008**, 2, (1), 52-56.

Sener, M. K.; Olsen, J. D.; Hunter, C. N.; **Schulten, K.**, Atomic-level structural and functional model of a bacterial photosynthetic membrane vesicle. *Proceedings of the National Academy of Sciences of the United States of America* **2007**, 104, (40), 15723-15728.

Shih, A. Y.; **Sligar, S. G.**; **Schulten, K.**, Molecular models need to be tested: The case of a solar flares discoidal HDL model. *Biophysical Journal* **2008**, 94, (12), L87-L89.

Shyr, M.; Wernette, D.; **Wiltzius, P.**; **Lu, Y.**; **Braun, P. V.**, DNA and DNAzyme-mediated 2-D colloidal assembly. *Journal of the American Chemical Society* **2008**, 130, 8234-8240.

Sumant, P. S.; **Cangellaris, A. C.**; **Aluru, N. R.**, Modeling of dielectric charging in RF MEMS capacitive switches. *Microwave and Optical Technology Letters* **2007**, 49, (12), 3188-3192.

Toohey, K. S.; **Sottos, N. R.**; **Lewis, J. A.**; **Moore, J. S.**; **White, S. R.**, Self-healing materials with microvascular networks. *Nature Materials* **2007**, 6, (8), 581-585.

Yu, J.; **Ha, T.**; **Schulten, K.**, How directional translocation is regulated in a DNA helicase motor. *Biophysical Journal* **2007**, 93, (11), 3783-3797.

Beckman Institute **Outreach**

Outreach efforts are important at the Beckman Institute, both as part of educational programs aimed at students and for educating the general public about the work that goes on at one of the country's premier interdisciplinary research centers.

Efforts ranging from numerous educational outreach projects to collaborations with other institutions to our biennial Open House help bring the story of interdisciplinary research at the Beckman Institute to a wider audience.

This coming year will be an exciting one as the 20th anniversary of Beckman's founding is celebrated with seminars and other events. Spring of 2009 will also feature the Beckman Open House, where the general public is invited to tour the Institute, get a firsthand look—and sometimes hands-on experience—at current projects while learning about the research taking place at Beckman.

Educational outreach at the Beckman Institute takes many forms, from tours for students, to joint efforts with other institutions, to the ongoing Bugscope program.

The Institute's Imaging Technology Group has been a campus leader in educational outreach with its Bugscope program that has allowed thousands of students in grades K-12 to remotely control ITG's environmental scanning electron microscope. Students from all over the world have experienced the thrill of viewing samples they collected at high magnification levels on an instrument usually reserved for university researchers.

Locally, Hank Kaczmarski, Director of Beckman's Integrated Systems Laboratory, worked with the Orpheum Children's Science Museum in Champaign on a new exhibit that gives kids and other visitors a tugboat pilot's eye-view of Illinois waterways via a virtual, interactive tugboat that lets visitors take the captain's seat and sail a barge through a simulated, changing river scene.

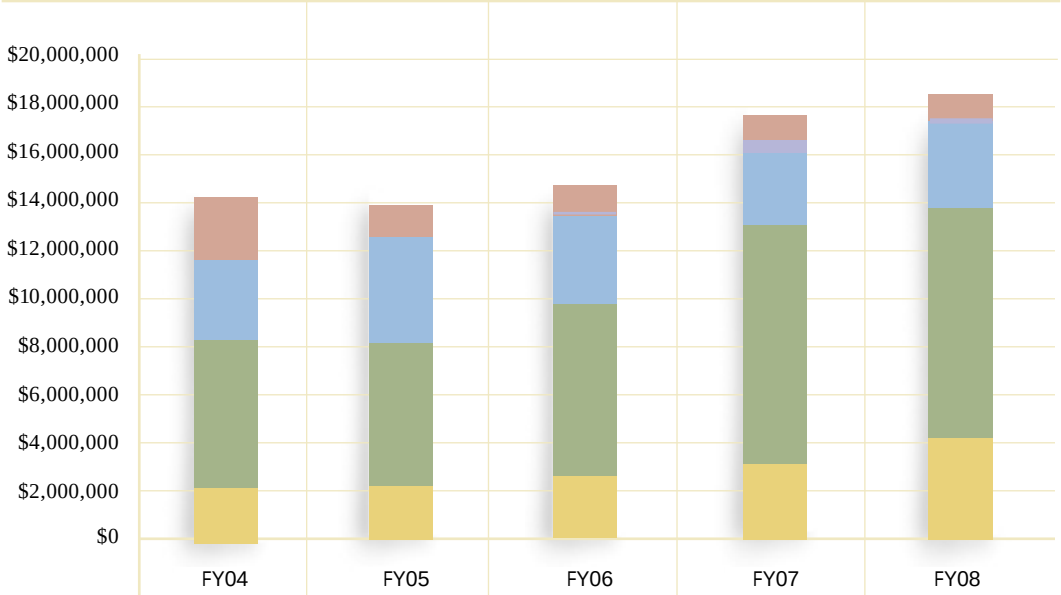
An ongoing exhibit on display this past year in the Beckman atrium highlights the work of faculty member John Rogers of the 3-D Micro and Nanosystems group and his students. Using wall-sized LED and PDLC display screens, the Rogers group demonstrated prototypes of visual display technology with its LED "smart wall" system that allows people to easily choose and change the color, images, or patterns for this "digital wallpaper" while the PDLC wall allows users to control each pixel independently.

Academic lectures and seminars on an amazing variety of topics are a regular feature of life at Beckman. The Robert and Robin Fossum Lecture, held annually at the Institute, this year featured a talk by Harvard University professor Arthur Jaffe, a world-renowned expert in mathematical physics.

All of these efforts help tell the ongoing story of Beckman research and fulfill part of the Institute's mission by giving back to the campus, community, and world at large.

Beckman Institute **Funding 2007-2008**

Beckman Institute Grant Expenditures by Funding Source[1]

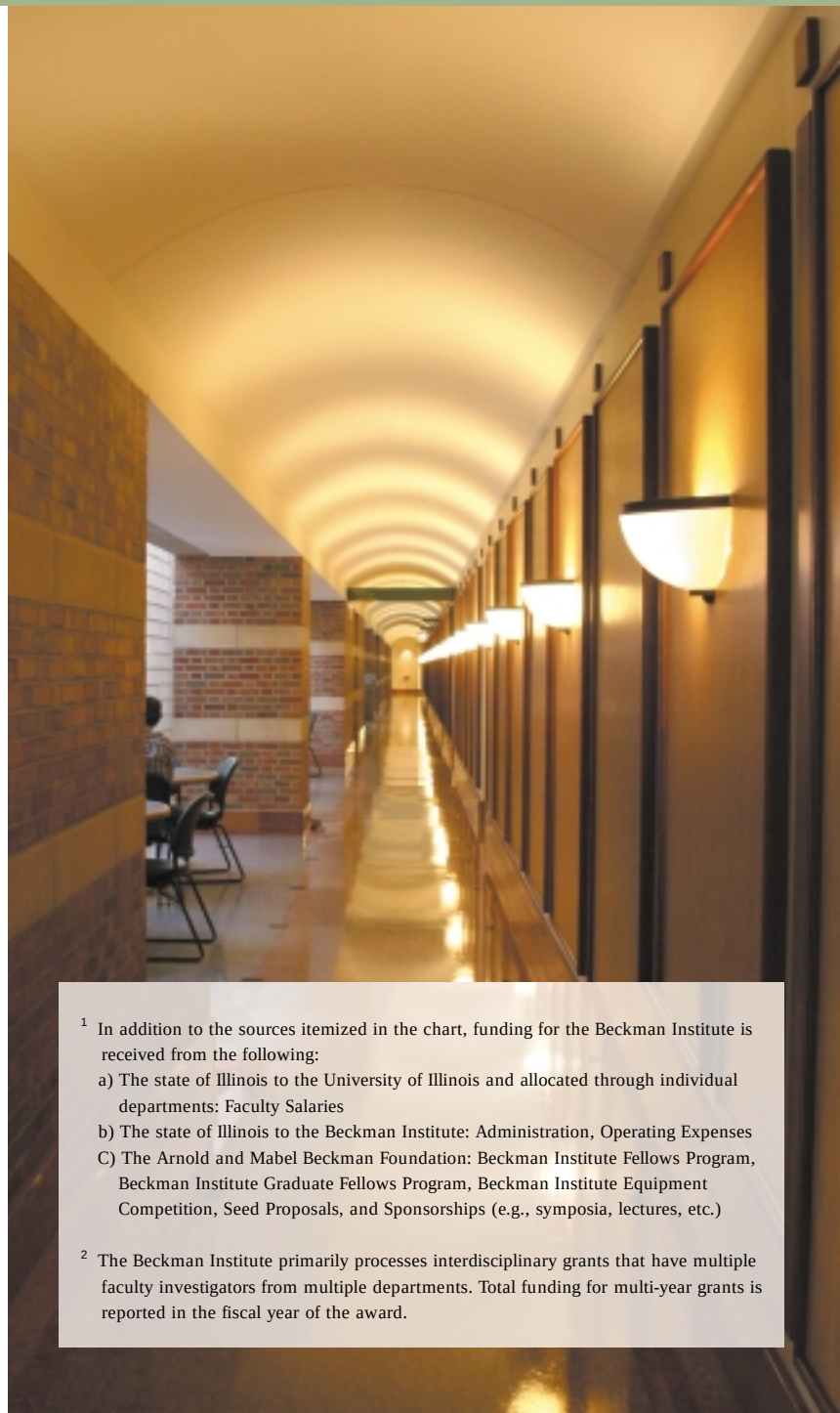


	FY04	FY05	FY06	FY07	FY08
DOD	$ 2,344,546	$ 2,322,793	$ 2,603,956	$ 3,172,803	$ 4,217,584
NIH	$ 6,153,758	$ 5,940,245	$ 7,144,039	$ 9,889,110	$ 9,444,099
NSF	$ 3,322,946	$ 4,412,354	$ 3,760,526	$ 3,004,266	$ 3,596,633
IBHE	$ -	$ 93	$ 156,333	$ 512,229	$ 223,626
Other	$ 2,559,179	$ 1,284,260	$ 1,087,590	$ 1,008,914	$ 1,151,309
Total	**$ 14,380,430**	**$ 13,959,746**	**$ 14,752,443**	**$ 17,587,322**	**$ 18,633,251**

Beckman Institute Awarded by Funding Source[2]

	FY04	FY05	FY06	FY07	FY08
DOD	$ 5,968,347	$ 6,379,539	$ 191,000	$ 11,012,039	$ 7,030,763
NIH	$ 5,418,065	$ 3,211,450	$ 20,527,604	$ 7,450,733	$ 15,036,128
NSF	$ 949,942	$ 2,757,986	$ 1,818,340	$ 2,349,181	$ 4,628,500
Other	$ 555,183	$ 709,338	$ 685,903	$ 5,262,943	$ 1,917,393
Total	**$ 12,891,537**	**$ 13,058,313**	**$ 23,222,847**	**$ 26,074,896**	**$ 28,612,784**

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



[1] In addition to the sources itemized in the chart, funding for the Beckman Institute is received from the following:
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] The Beckman Institute primarily processes interdisciplinary grants that have multiple faculty investigators from multiple departments. Total funding for multi-year grants is reported in the fiscal year of the award.

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We invite you to view the Beckman Institute Annual Report at our Web site. It includes a full listing of publications and links to specific research projects: www.beckman.uiuc.edu.

Coming soon...

Celebrating 20 Years of Imagining Possibilities without Boundaries

The Beckman Institute for Advanced Science and Technology 1989–2009

Planning is currently under way for a Beckman Institute 20th Anniversary Symposium. The Symposium will be held October 5-7, 2009, at the Beckman Institute. As details become available they will be posted to www.beckman.uiuc.edu.

Beckman Institute Annual Report Credits

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Beckman Institute

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