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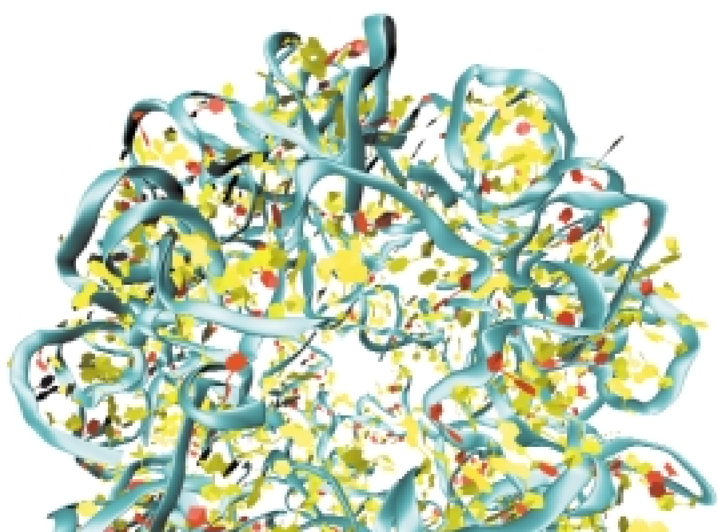

BECKMAN INSTITUTE

AT THE UNIVERSITY OF ILLINOIS

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

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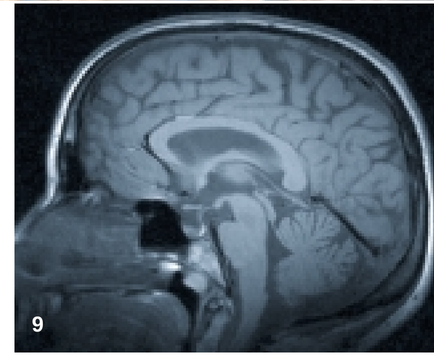
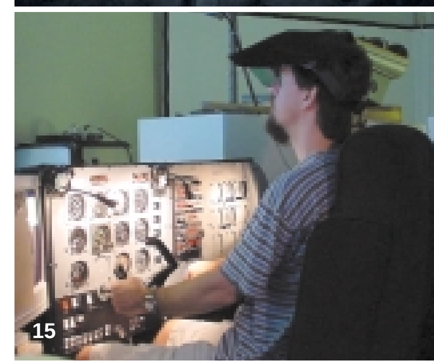




"Our three main research initiatives (Biological Intelligence, Human-Computer Intelligent Interaction, and Molecular and Electronic Nanostructures) are thriving. **I'm convinced their continued excellence would make the late Arnold O. Beckman proud as they uphold his vision of creating a world-class institute committed to interdisciplinary research."**

DIRECTOR'S MESSAGE

It is hard to believe that five years have passed since I first began as the Director of the Beckman Institute. It has been a wonderful journey and I have enjoyed tackling the challenges, sharing in the discoveries, and applauding the accomplishments of the talented and innovative researchers at the Beckman Institute and the University of Illinois.

On the campus level we are pleased to be a part of such a highly regarded research institution, and we have been an active participant in President Joseph White's strategic planning process. One of the main initiatives of the University of Illinois' strategic plan is to implement interdisciplinary approaches to emerging opportunities. The Beckman Institute has been held up as a model for this initiative and as the strategic plan continues to develop and unfold, it is critical that we dovetail our vision and planning into the campus-wide effort for complete synergy and a smooth transition to the future.

Our three main research initiatives (Biological Intelligence, Human-Computer Intelligent Interaction, and Molecular and Electronic Nanostructures) are thriving. I'm convinced their continued excellence would make the late Arnold O. Beckman proud as they uphold his vision of creating a world-class institute committed to interdisciplinary research.

This past year researchers at the Beckman Institute continued to push the envelope, and the current relevance and future possibilities of their work is vigorously supported by the National Institutes of Health (NIH), the National Science Foundation (NSF), and numerous other public and private funding agencies. Our faculty members are extremely active in seeking and securing grants to support their work.

Beckman Institute researchers Eric Jakobsson and Umberto Ravaioli recently secured a $6.2 million grant from the NIH's new Pathways to Discovery program to fund one of four national nanomedicine centers. Named the National Center for Design of Biomimetic Nanoconductors, their mission is to develop nanoscale devices that function like biological systems. Additionally, Klaus Schulten and his group have been awarded just over $2 million by the NIH's National Human Genome Research Institute. The grant will be used in the daunting challenge to bring the cost of reliably sequencing DNA to $1,000 — it currently costs about $10 million to sequence human DNA. Scott White, Nancy Sottos, and Jeff Moore were awarded a $5 million grant from the Air Force for their work on microvascular autonomic composites. In Biological Intelligence, Neal Cohen and Kathryn Bock were awarded just over $2 million from the NIH for a study on the hippocampal system and relational memory processes. This study examines communication in amnesic patients and provides insight into language production and acquisition. These are only a select few of the grants received by Beckman researchers, but, I hope they illustrate the level of support our researchers are earning.

We are also grateful to the Arnold and Mabel Beckman Foundation, which continues to fund the Beckman Fellows program as well as the Arnold O. Beckman Lecture in Research & Innovation. With the Foundation's help we are able to provide a stimulating interdisciplinary environment for young investigators as they initiate their post-doctoral research careers. I am also especially pleased to have been recently appointed as the Chairman of the Grants Advisory Council for the Arnold and Mabel Beckman Foundation.

Last year Beckman researchers made numerous breakthroughs which garnered national attention. John Rogers was spotlighted in numerous publications including being named to the *Scientific American* Top 50 list for his advances in stretchable silicon. Issues relating to aging were also a hot topic and Beckman researchers and Center for Healthy Minds co-directors Art Kramer and Denise Park were featured in national publications including the *Wall Street Journal*, the *New York Times*, and the *Washington Post* just to name a few. Their work explores brain physiology and cognition, with a special focus on aging. Beckman researcher Al Feng — and a small Chinese frog — also gained national attention when Feng's groundbreaking discovery of ultrasonic hearing in the species was published in *Nature*. In computational sciences, Klaus Schulten's group was able to simulate — for the first time ever — a complete atomic scale computer simulation of a life form, the satellite tobacco mosaic virus. The breadth and depth of these discoveries and the exposure that Beckman researchers earn is incredibly rewarding for them, the Institute, and the University of Illinois.

Many Beckman researchers were also in the spotlight for receiving awards in their fields of study. Noteworthy accomplishments include Bill Greenough being named Fellow to the National Academy of Arts and Sciences, and Karl Hess being nominated to the National Science Board. Congratulations to Bill, Karl and the rest of the Beckman researchers who received awards last year.

Last Fall we held an open competition for seed proposals which yielded 11 new research awards. Many new ideas were brought to the table and the new proposals will continue the process of renewal and reinvention that is critical to maintaining the vitality of the Beckman Institute. Ultimately we hope these proposals will eventually lead to externally funded programs and will form the building blocks of a new research initiative.

I hope you enjoy perusing our annual report and learning more about our facility, our research initiatives, and the diverse group of people that makes the Beckman Institute a global leader in interdisciplinary research.

Pierre Wiltzius

Pierre Wiltzius, Director

The Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign is an interdisciplinary research center devoted to leading edge research in the physical sciences, computation, engineering, biology, behavior, cognition, and neuroscience.

Host to more than 600 researchers from more than 30 different departments, the Beckman Institute provides an environment that fosters interdisciplinary work of the highest quality, transcending many of the limitations inherent to traditional settings. The freedom to collaborate across disciplines allows researchers to imagine possibilities without boundaries, yielding novel research advances of global proportions.

Researchers at the Beckman Institute are broadly categorized into three research initiatives: Biological Intelligence (BI), Human-Computer Intelligent Interaction (HCII), and Molecular and Electronic Nanostructures (M&ENS). The mission of the BI initiative is to understand brain function and its role in behavior. HCII research spans a wide range of fields, but the overriding goal is to examine the complex relationships between humans and machines. The general goal of the M&ENS research initiative is to develop a fundamental understanding of chemical and physical processes involving structures on the nanometer scale. Each research initiative is constantly growing and evolving to lead the way in scientific discovery and advancement.

To assist research efforts, the Beckman Institute provides state-of-the-art resources, including the Biomedical Imaging Center (BIC), the Imaging Technology Group (ITG), and the Integrated Systems Laboratory (ISL). BIC offers a trio of powerful magnets that are a key resource for investigators using MRI and fMRI technology. ITG helps researchers bring their work to life with advanced imaging tools in the Visualization, Media, and Imaging Laboratory. ITG also hosts the Microscopy Suite, which provides a wide range of imaging modalities and equipment for the preparation, imaging, and analysis of microscopic specimens. ISL provides researchers with a place to conduct experiments in human multimodal perception and cognition, and connects art and technology in innovative ways.

The construction of the six-story, 313,000-square-foot Beckman Institute building was made possible by a generous gift from Arnold O. Beckman and his wife Mabel M. Beckman, with a supplement from the state of Illinois. Arnold Beckman was a University of Illinois alumnus and founder of Beckman Instruments, Inc. His gift of $40 million was the largest one-time donation ever to a public university and it turned the dream of a world-class interdisciplinary research institute on the UIUC campus into a reality. The Beckman Institute was dedicated in 1989. The Beckman Foundation continues to provide ongoing financial assistance for various Institute programs, including the Beckman Fellows program.

Just five years after the Beckman Institute for Advanced Science and Technology opened, the increasingly diverse branches of investigation taking place in it were exciting Beckman researchers, but also signaling a need to channel the output of the Institute. In 1994, the Beckman Institute was organized broadly around what were then called three main research themes: Biological Intelligence (BI), Human-Computer Intelligent Interaction (HCII), and Molecular and Electronic Nanostructures (M&ENS).

Today they are known as the Beckman Institute research initiatives and serve as home to lines of investigation that are as vibrant and open to new conclusions and possibilities as when the research first coalesced around the areas of human-machine interaction, biological intelligence, and nanoscale research and development. The evolving nature and continuing vitality of the projects and programs within these initiatives was demonstrated this past year when several new groups were formed, and by the tremendous response to a call for proposals to seed a possible fourth initiative.

MOLECULAR & ELECTRONIC NANOSTRUCTURES

When it was formed, **Molecular & Electronic Nanostructures** was given the mission of advancing understanding of physical and chemical processes and structures at the nanometer scale. Many goals have been realized in the past 12 years, and new projects have emerged involving areas such as nanomedicine, electronics, and sensors. Accompanying these projects are unparalleled research tools developed at Beckman like large-scale molecular dynamics simulation applications and proven self-assembly techniques, as well as advanced microscopy equipment.

HUMAN-COMPUTER INTELLIGENT INTERACTION

Technology development is also a cornerstone of the **Human-Computer Intelligent Interaction** research initiative's goal of enhancing our relationships with machines. Research aimed at realizing the potential of computers through improved interfaces with humans is aided by software developments for superior computer vision and emotion- and face-recognition applications, as well as advanced laboratory technologies like state-of-the-art driving and flight simulators.

BIOLOGICAL INTELLIGENCE

The **Biological Intelligence** research initiative studies neural networks and cognition from their molecular beginnings, through the neural pathways that guide behavior, to the expressions of intelligence we recognize and use every day in the forms of speech, learning, memory, and perception. Researchers within BI may investigate anything from neural cellular development to areas of cognition such as the aging mind or how we accomplish tasks. They use a variety of advanced technologies, including specialized imaging techniques for viewing the brain, and unique experimental settings such as virtual reality environments for understanding memory, perception, and attention.

Fact:
Six Beckman faculty members have joined Presidents, Nobel laureates, and artists in being named Fellows at the American Academy of Arts and Sciences, including William Greenough in 2006.

SEED PROPOSALS

The call for seed proposals yielded a number of intriguing ideas. Those ideas were narrowed to 11 proposals that will receive funding support in hopes of building a fourth research initiative.

The Beckman Institute was founded on the principle of reducing boundaries between academic disciplines, and the research initiatives are organized with that ideal in mind. They were formed as guideposts so that research won't be constricted but enhanced through deliberate, imaginative collaborations that lead scientists down new paths of discovery.

Tom Huang (foreground), co-chair of the HCII research initiative, and Bill Greenough, co-chair of the BI research initiative, review information during a meeting at the Beckman Institute.

Ben Grosser, Director of the Imaging Technology Group, describes the mandible reconstruction project. The project's aim is to develop a new approach to the surgical treatment for bone loss from disease or trauma. Instead of extracting donor bone from the patient's own hip, surgeons will be able to automatically design and fabricate custom-fitting "artificial" bone implants — saving money, pain, and recovery time. This project is a multidisciplinary effort involving the departments of mechanical engineering, bioengineering, computer science, the Beckman Institute, and Carle Foundation Hospital.

As more research endeavors aspire to an interdisciplinary approach and terms such as nanotechnology increasingly enter the popular imagination, the Beckman Institute for Advanced Science and Technology continues to expand the realm of scientific possibilities like no place else on Earth.

The relevance of the widely varying Institute projects is demonstrated by the faith of the National Institutes of Health (NIH), the National Science Foundation (NSF), and other governmental and private agencies that continue to fund the truly diverse and innovative research taking place at Beckman.

Large nanotechnology grants approved this past year will help ensure Beckman's decade-long leadership role in this rapidly evolving area of research. The NIH's New Pathways to Discovery program awarded a $6.2 million grant to establish a national nanomedicine center to be located at the Institute. The Center, one of four in the nation, is part of the NIH Roadmap for Medical Research initiative. The goal of the National Center for Design of Biomimetic Nanoconductors is to develop nanoscale devices that function like biological systems for the treatment and diagnosis of diseases. Another big grant from the NIH's National Human Genome Research Institute (NHGRI) thrusts Beckman into a competitive challenge to sequence DNA in an inexpensive and reliable way for use in biomedical research and health care.

Both of these projects are taking place within the Institute's Molecular and Electronic Nanostructures (M&ENS) research initiative, a group that continues to receive national attention for its breakthroughs in nanoscale research. John Rogers' investigations into using low-tech materials for high-tech applications earned him recognition on both the Scientific American 50 and Technology Review's list of top 10 emerging technologies this past year for his group's discoveries involving silicon. Another well-known and continuing area of investigation within M&ENS, self-healing materials, got a boost with a $5 million grant from the Air Force Office of Scientific Research for work on microvascular autonomic composites for self-repair of aircraft, among many other applications.

A national spotlight was also focused this past year on Beckman's researchers in the areas of brain physiology and cognition, especially those with a focus on issues related to aging. Denise Park, co-director of the Center for Healthy Minds at Beckman, testified before Congress on why older adults are susceptible to scams, while Co-Director Art Kramer garnered attention from the *New York Times* to *USA Today* for his discoveries regarding the cognitive benefits of fitness for older adults.

Kramer and several colleagues in the Human-Computer Intelligent Interaction research initiative also investigate the current topic of driver distraction using the Beckman Institute driving simulator. Studies have focused on the effects of speech comprehension and production during cell phone usage, how people perceive the space around their vehicle, and how a desktop trainer might aid older drivers.

Art Kramer, co-chair for the HCII research initiative, has recently made headlines for his discoveries on the cognitive benefits of exercise for older adults.

Daniel Weber, Manager of the Visualization, Media, and Imaging Lab at the Beckman Institute, works on extracting a 3-D printed model of an artificial bone scaffold.

The innovative ways in which Beckman researchers tackle issues was demonstrated by Albert Feng of the Biological Intelligence research initiative with his groundbreaking finding of ultrasonic communication in an amphibian. Feng's multi-year pilgrimages to a remote part of China resulted in the discovery of a species of frog that uses ultrasound, marking the first time a non-mammalian creature was found to communicate ultrasonically.

Current software developments at Beckman give our researchers and their collaborators ever-more-powerful tools for investigating the world around us.

The Theoretical and Computational Biophysics group (TCB) led an effort that completed the first-ever atomic scale computer simulation of an entire life form. Using software developed by TCB, Klaus Schulten's group performed a simulation of the satellite tobacco mosaic virus featuring more than a million atoms in a dynamic, high-resolution recreation of this organism.

Researchers in the Biological Intelligence research initiative also fashion their own tools for studying brain function and cognition. Kara Federmeier has created an electrophysiological cap that records event-related brain signals for her research into memory and language production. Stephen Boppart developed an optical coherence tomography (OCT) system with non-invasive or minimally invasive techniques that uses light for optical imaging of tissue at very high resolution. Boppart and his collaborators have now demonstrated functional OCT (fOCT) for detecting neural activity in nerve fibers and individual neurons. A newly formed group within BI is centered around the growing field of biomedical imaging, both in traditional magnetic resonance imaging, and in developing new imaging techniques.

In addition, the equipment, technology, and people of Beckman's centralized facilities — the Imaging Technology Group, the Biomedical Imaging Center, and the Integrated Systems Laboratory — provide scientists the means to investigate a dizzying array of subjects, from the workings of the human brain to particles one million times smaller than a human hair.

These research projects demonstrate the diverse, creative, and important contributions the Beckman Institute for Advanced Science and Technology continues to make to science, industry, medicine, and thus, to us all.

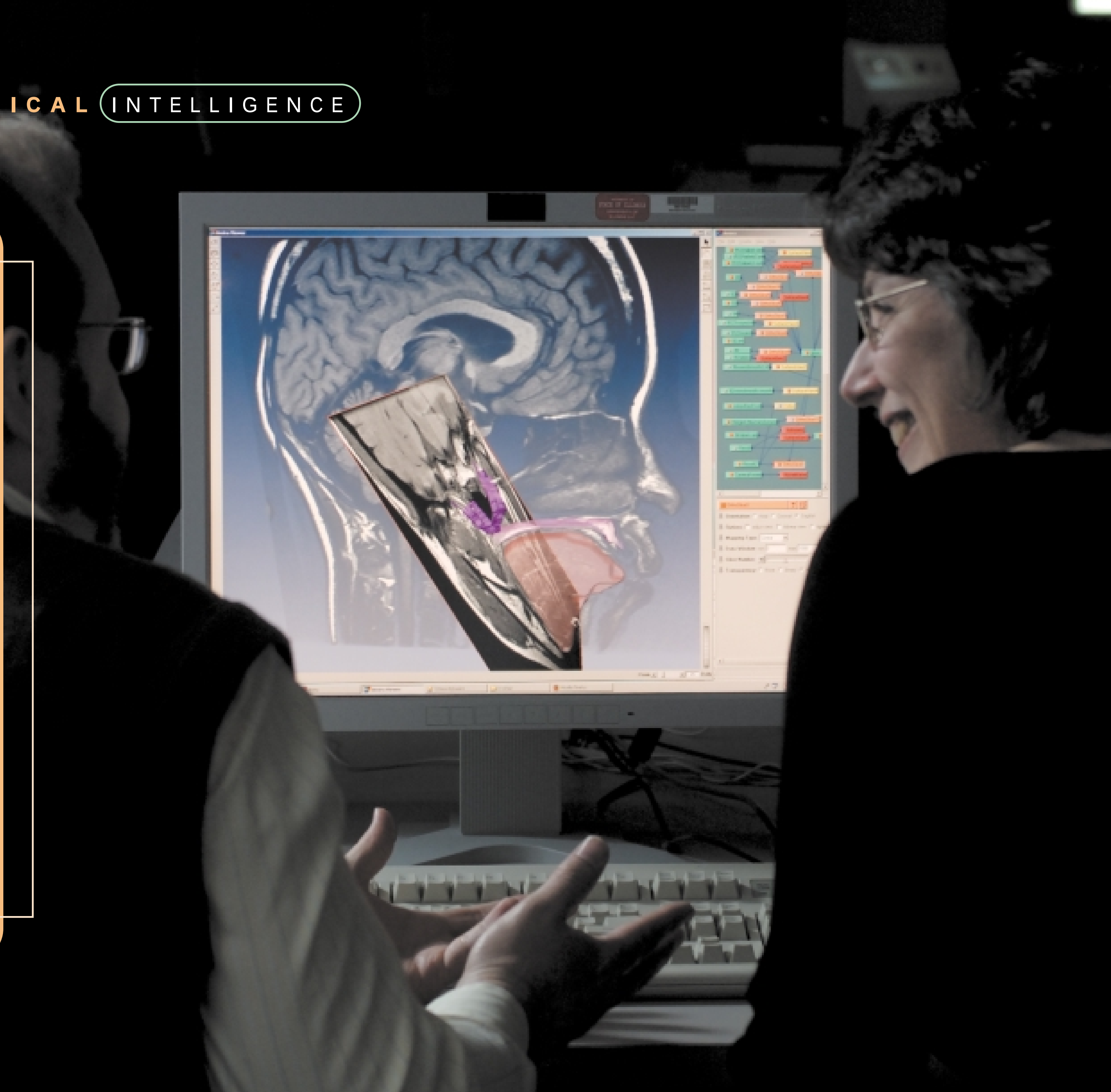
Fact:

The Beckman Institute for Advanced Science and Technology boasts more than 150 faculty members engaged in research, aided by 14 post-doctoral fellows, six graduate fellows, several hundred students, and numerous laboratory and facility staff members.

Emad Tajkhorshid of the Theoretical and Computational Biophysics group investigates permeation, selectivity, and gating of aquaporins.

BIOLOGICAL INTELLIGENCE

The mission of the **Biological Intelligence** research initiative is to understand the links between the brain, cognition, and behavior. The diversity of perspectives within BI offers a comprehensive approach to that mission as research topics range from understanding nervous system development to observing human behavior using highly advanced technology.



Beckman Institute researcher Albert Feng discovered a frog species that communicates ultrasonically. This groundbreaking discovery debuted in the March 16, 2006 issue of *Nature* and has received worldwide recognition.

Biological Intelligence researchers explore the links between the biology of the brain and the manifestations of intelligence using multiple technologies, including functional magnetic resonance imaging (fMRI), electrophysiology, optical imaging, and spectroscopy, to understand the chemistry, molecular function, and behavioral expressions of mental processes.

This ability to look at all of the manifestations of intelligence from their physical origins in the workings of neurons and synapses, to observable responses such as speech patterns or blood flow in the brain, gives researchers within BI a fuller understanding of brain development, function, and expressions of intelligence like speech and memory.

By combining laboratory work and technological developments such as innovative imaging systems, BI researchers in 2005 profiled brain cells (**J. Sweedler**), viewed neuronal activity in the brain during task performance (**M. Fabiani, G. Gratton, K. Federmeier, A. Kramer,** others), and added to our knowledge of brain disorders (**N. Cohen and K. Bock, G. Dell**). These are just a few of the areas representing the wide scope of research taking place in the Biological Intelligence research initiative.

Beckman researchers recently identified novel brain messengers called neuropeptides and showed, using a novel mass spectrometric method, where such neuroactive compounds were located in the individual neurons that make up the wiring diagram of the brain. In an exciting marriage of biology and cognition, Beckman scientists studied the ability of synapses, the tiny connections through which neurons communicate, to make new proteins involved in memory **(J. Sweedler, W. Greenough)**.

A large segment of research within Biological Intelligence involves behavior. Ongoing studies on the impact of exercise on brain function and cognitive health (**A. Kramer**) offer timely information for people in their everyday lives. Another extensive area of investigation centers on aging, both to understand this process and present findings of beneficial interventions derived from the research (**M. Fabiani, D. Park, K. Federmeier**). Linguists and psychologists from several different areas add to the Biological Intelligence body of work with research into how humans learn, produce speech, remember, and navigate their worlds (**M. Nelson, B. Ross, E. Stine-Morrow, J. Cole,** others).

Topics in BI aren't limited to issues involving the human brain, cognition, and behavior. Researchers investigate other biological systems for insight into the workings of neural networks and biological processes, and for future technology development, such as in the design of biologically inspired devices like sensing systems for robots (**M. Nelson, C. Liu**).

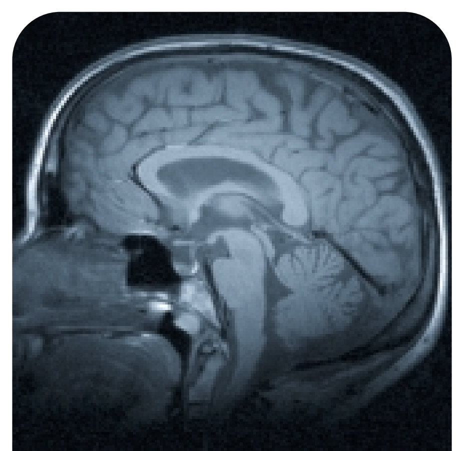
Nearly all of the projects within Biological Intelligence take advantage of advanced technology by using Beckman's own imaging and visualization facilities, specialized imaging techniques, and a myriad of software applications and computer analysis methods. Magnetic resonance imaging continues to be a tremendous tool for BI researchers, even while they are complementing MRI with their own novel imaging techniques.

The topics within Biological Intelligence are as varied as its researchers' imaginations, but the overall defining goal of this research initiative is clear: to enhance our understanding of biological intelligence for the benefit of science and mankind.

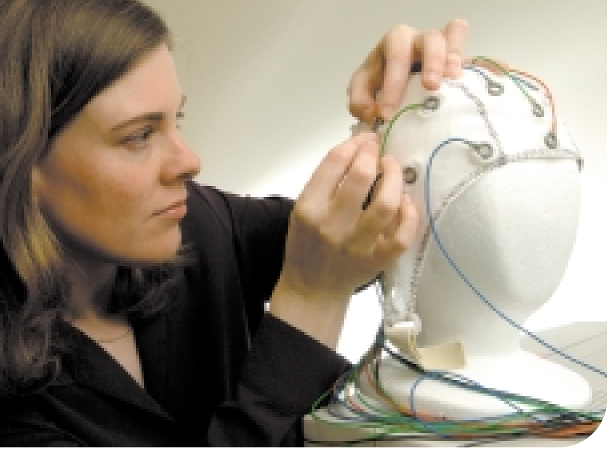
Fact:
Research at the Beckman Institute reaches across the globe, with studies investigating the impact of culture on cognition.

Neal Cohen, Kathryn Bock, and their collaborators are exploring communication in amnesic patients and have gained valuable insights into language production and changes.

IMAGE COURTESY BIOMEDICAL IMAGING CENTER



Magnetic resonance imaging is used extensively by BI researchers. MRI is also combined with their own novel imaging techniques to explore cognitive function.



Kara Federmeier attaches electrodes to an electrophysiological cap which measures event-related brain potentials (ERPs).

COMMUNICATION IN AMNESIC PATIENTS GIVES INSIGHT INTO LANGUAGE LEARNING AND CHANGE

Cognitive Neuroscience group member Neal Cohen and Cognitive Science group members Kathryn Bock, Gary Dell, and their collaborators have integrated language production and acquisition into a new theory of implicit learning that has implications for understanding how language is learned and how it changes over time. The theory says that structural persistence, a speech pattern in which speakers reuse previously produced sentence structures with different words, is a product of fairly primitive implicit learning mechanisms. The theory's predictions find support in evidence that structural persistence occurs even in patients with severe memory deficiencies who cannot remember their previous utterances. The findings imply that structural persistence, first reported by Bock in 1986, may play an important role in shaping basic language patterns over time. It also further expands the domain of preserved learning abilities in amnesia, which has been the focus of work by Cohen's group.

ELECTROPHYSIOLOGICAL STUDIES OF MEMORY AND LANGUAGE CHALLENGE THEORY

As part of her research into how we comprehend language, Kara Federmeier of the Cognitive Neuroscience group has studied acronyms in order to gain a more complete picture of how all words are processed — an important area of study in a world that increasingly uses terms like DVD to communicate meaning. Her research, conducted with graduate student Sarah Laszlo, challenges the "dual-process model" about how we understand words while reading. The dual-process model suggests that some words with regular spellings, such as "sigma," are internally "sounded out" before a person looks for meaning, while others with irregular spellings, for example "yacht," are mentally looked up, without using sound as part of the comprehension process. Federmeier's research uses an electrophysiological cap to measure event-related brain potentials (ERPs) that can gauge how the brain activates semantic information, such as during the comprehension of acronyms. Laszlo and Federmeier compared the processing of familiar yet irregularly spelled acronyms like DVD to unfamiliar but regular "pseudowords" such as DAWK. Their research found the same brain response to these two extreme kinds of stimuli, which argues against the idea that there are two processes involved in reading. Federmeier said the research results extend to normal words and suggests a critical role for familiarity in the reading process.

COMPREHENSIVE RESEARCH INTO THE AGING MIND

Research into the effects of aging on the brain and cognition, and how these effects are mediated by physical fitness and other factors is an area that cuts across several groups and projects within Biological Intelligence. BI Co-chair William Greenough and his collaborators have demonstrated that exercise in animals leads to improved cognitive function, as well as physical benefits such as the development of blood vessels and a small amount of neuronal cell generation in the motor cortex. Monica Fabiani and Gabriele Gratton use optical imaging methods to investigate the physiological workings of the brain, focusing on the relationship between brain cell signals and blood flow to the brain in older adults. These techniques provide a dynamic view of the brain as it relates to the effects of cardiovascular fitness on cognition in older adults. Two projects from Art Kramer's varied research interests have demonstrated the effects that tasks can have on neural activity. Kramer and his collaborators have recently found that cognitive training, and, more specifically, training for multi-tasking, can lead to the development of efficient prefrontal neural circuits in young and older adults. Recent research has also revealed that high levels of expertise can offset age-related decrements in basic perceptual and cognitive abilities. Denise Park, co-director with Kramer of the Center for Healthy Minds at Beckman, has focused on understanding why older adults use more frontal cortex than young adults do to perform cognitive tasks. Park and her collaborators have found that the representation of objects and scenes in the ventral visual cortex is less precise in older adults, and that when learning new material, older adults show decreased engagement of the hippocampus. The research showed that older adults compensate for this by engaging more frontal cortex than young people.

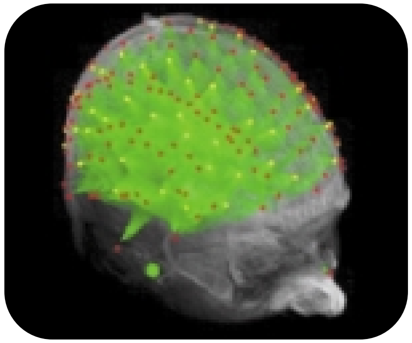
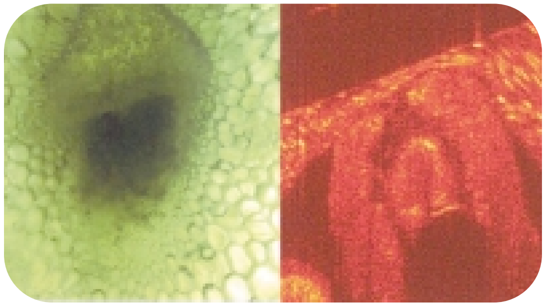


IMAGE COURTESY COGNITIVE NEUROIMAGING LAB.

Optical imaging techniques are being used by Monica Fabiani and Gabriele Gratton to investigate the physiological workings of the brain.

IMAGES COURTESY STEPHEN BOPPART.



Stephen Boppart and his collaborators are pioneering methods for non-invasive "optical biopsies"

FUNCTIONAL OCT APPLIED TO NEUROSCIENCE

Stephen Boppart has been a pioneer in using optical coherence tomography (OCT) methods as a way to do non-invasive or minimally invasive "optical biopsies" of tissues, focusing on such potential clinical applications as a diagnostic tool for detection of breast cancer. Now, as a member of the new Bioimaging Technologies group, Boppart is applying functional OCT to neuroscience. FOCT detects reflections of near-infrared light and images at resolutions that approximate microscopic imaging of cell tissues. Using fOCT, researchers can study neural activity in nerve fibers and brain cells by mapping the optical scattering changes in electrically active cells without chemicals or added dyes. In a clinical setting, this could be useful for identifying neuron communication circuits in the brain, or for non-invasively mapping the functional activity of the neural retina.

RESEARCHERS DEVELOPING HIGH-RESOLUTION COCHLEAR IMPLANT

Cochlear implants, tiny electronic devices surgically inserted underneath the skin behind the ear, help give an auditory experience to the deaf or those with severe hearing loss by picking up useful sounds, turning them into electrical impulses, and sending those impulses to the brain. Currently, cochlear implants are not able to provide a normal hearing experience, but Neurotech group researchers Al Feng, Bruce Wheeler, and Richard Kollmar are working toward development of a high-resolution biomolecular cochlear implant that would greatly enhance the hearing experience for those who wear them. The group is advancing the capabilities of implants by improving the interface between the electrodes that collect the impulses and the neurons that transmit them in the brain. They are using targeted drug delivery at the molecular level to promote neurite growth, a first step in enhancing the neural-electronic connection crucial to cochlear implant effectiveness. Laboratory work has already led to the screening of molecules involved in regulating and guiding neurite outgrowth, a system for assessing the efficacy of signaling molecules for promoting neurite outgrowth, and the testing of novel drug-delivery techniques to guide neurite outgrowth.

NEW BIOLOGICAL INTELLIGENCE GROUP FORMED

The creation of a new group, Bioimaging Science and Technology, within the Biological Intelligence research initiative reflects the growing capabilities of imaging methods and their increasing importance to medical and scientific research. A new group headed by Michael Insana is focused on the development of bioimedical technologies. Insana's lab uses ultrasound to study the biology of breast cancer and vascular disease. Ultrasound imaging is now able to image elastic properties of tumors that can help physicians determine whether a tumor will respond to radiation and chemotherapy. Using ultrasound to image the elastic properties of tumors and developing diagnostic methods that combine knowledge of polymer mechanics with novel instrumentation and signal processing will add greatly to our knowledge about the molecular biology of diseases. Ultrasound is also commonly used to image vascular blood flow, but current methods make it difficult to estimate the shear forces at the vessel wall surface that help protect arteries from forming plaques. The Insana Lab is developing techniques for measuring wall shear stress to provide physicians with the ability to probe vessels most likely to develop atherosclerotic disease. The Bioimaging Science and Technology group includes researchers who are expanding the potential of imaging methods, such as Stephen Boppart (optical coherence tomography for non-invasive or minimally invasive diagnostic procedures), Brad Sutton (magnetic resonance imaging acquisition, reconstruction, and functional MRI methods for reduction of magnetic susceptibility effects and faster imaging), Rohit Bhargava (novel vibrational spectroscopic instrumentation, materials and numerical methods for examining molecular events in the pathogenesis of human cancers), Peter Wang (genetically-encoded fluorescence biosensors for visualizing biochemical signals in live cells with high temporal and spatial resolution), and Michelle Wang (structural and functional neuroimage analysis and measurement, and statistical inference for biomedical imaging and computation).

RESEARCH PROFILE

"I think I've always been interested in memory and I've always been interested in aging. I started looking at what was known about the aging memory about 25 years ago and almost nothing was known. When I got my Ph.D. it seemed like virgin territory. **Even back then I realized our population was going to age and these were going to be important questions**. It's something that has fascinated me my whole life."

Denise Park
Beckman Institute Faculty Member
in Biological Intelligence
Professor of Psychology
Co-director of the Center for Healthy Minds
Director of the Productive Aging Lab

Denise Park wanted to go where few researchers had gone before, so her career in psychology began with a focus on cognition and aging. The choice showed foresight. With the baby boomer population now reaching retirement age, Park's research is well funded, renowned among her peers, and receiving a tremendous amount of national attention.

Park has testified before the United States Congress, been called upon for expert analysis by media ranging from the *Washington Post* to *USA Today*, and has answered online questions from a national audience. As the population ages, Park's work has a growing relevance as she explores new research lines involving cognition and aging.

"I think I've always been interested in memory and I've always been interested in aging," Park said. "I always stayed focused on cognition. I started looking at what was known about the aging memory about 25 years ago and almost nothing was known. When I got my Ph.D. it seemed like virgin territory. Even back then I realized our population was going to age and these were going to be important questions. It's something that has fascinated me my whole life."

While her focus has remained constant, Park's research has expanded to incorporate new technology and take on new challenges. As a member of the Cognitive Neuroscience group, Director of the Productive Aging Laboratory, and co-director of the Center for Healthy Minds at Beckman, Park's research plate is full.

Park has been collaborating with neurologist Michael Chee of Singapore Hospital and others on original research into how older adults in East Asia and the West process information differently. Through the use of functional magnetic resonance imaging, Park said, "we actually can see that East Asians and Westerners engage their brains differently when they're looking at a complex scene."

These results tie in with other work showing how cognition can affect brain physiology. Park said this project, at least in its early stages, is showing that the more group-oriented East Asian culture and the more individualistic Western culture lead to differences in brain function between those cultures. This has implications for understanding neural function, as well as for understanding cultural differences and perceptions.

"The focus of our Asian work so far has been to see if we can show differential patterns of neural activation as a function of age and culture between the two sites," Park said. "We think that culture literally sculpts neural function in certain ways."

Park is beginning a large and novel study, thanks to a $5 million MERIT award by the National Institute on Aging, of cognitive and neural function across a lifespan. The study will look at people between the ages of 20 and 90, with a focus on how neural signatures change across the lifespan, with a particular interest in middle age. Park said it is typical for young brains to show a focal, unilateral activation, whereas brains of adults over 60 show activations on both sides (bilaterality).

"Almost no one has studied middle-aged adults, some of whom have a neural signature that looks more like an older person and some of whom have a signature that looks more like a young person," Park said. "We want to take those neural functions and see how they relate to their cognitive behavior."

Park also explores the efficacy of interventions that could improve our cognitive health as we age. She said the fact that people are starting to enjoy better physical health in older adulthood raises cognitive issues.

"Our bodies are starting to outlive our minds, so we need to play catch-up," Park said.

Park's research is playing a role in closing that gap.

"Now that we have these imaging tools, we are acquiring knowledge so rapidly it's mind-boggling," she said. "Even eight years ago, nobody was imaging the brain in older adults. All of this stuff is going to come together, the behavior, genetics, and neural function. I think we'll figure out how to let the mind keep pace with the body."

CHARLES VOTAW PHOTOGRAPHY

Denise Park was invited to Capitol Hill to deliver her testimony to the Senate Special Committee on Aging on July 27, 2005. She spoke about how changes in cognitive function due to age may leave older adults more susceptible to consumer fraud.

Projects within **Human-Computer Intelligent Interaction** may vary widely, but this research initiative still has the overall mission of understanding how people learn about and perceive the world around them, how the interplay between human cognition and machines works, and how such knowledge can be used to develop novel multimodal human-computer interfaces.

HUMAN-COMPUTER INTELLIGENT INTERACTION

Think of the myriad of ways in which we use computer technology — airline pilots relying on flight data, drivers getting warnings from their automobile, moviemakers creating special effects — and it becomes easier to understand the kinds of explorations taking place within the Human-Computer Intelligent Interaction (HCII) research initiative. Going beyond the human-machine interface, topics such as how the brain acquires complex knowledge **(J. Mestre)**, or how on-the-job expertise might affect our cognitive abilities as we age **(D. Morrow, A. Kramer)** show the true breadth of HCII research.

Collaborations within the Human-Computer Intelligent Interaction research initiative include computer scientists working with psychologists, engineers partnering with linguists, and kinesiologists teaming up with computer programmers. The goals of these collaborations may vary, but the over-arching mission of the HCII research initiative is to enhance the relationships between man and machine, particularly the human-computer interface.

The spectrum of human-computer interaction studies runs from improving the images displayed on a personal computer **(N. Ahuja)**, to gaining a better understanding of brain structure in older adults **(A. Kramer, E. McAuley)**, to the effects of cell phone usage on family life **(T. Kubose)**. As HCII researchers explore human-machine relationships, they are doing basic scientific research, adding to our knowledge in a variety of cognitive and computer related areas, and developing software and other tools aimed at advancing the human-computer interface.

The development of new technology and the use of sophisticated technologies as central research tools underpin the work that goes on inside the Human-Computer Intelligent Interaction research initiative.

Technology development in HCII has led to software that improves the quality of our interaction with the computer, such as greatly enhanced digital images **(N. Ahuja, J. Ponce)**, and applications that empower computers in newfound ways, like recognizing the emotions found in a facial expression **(T. Huang, J. Spencer-Smith)**. Basic scientific research in HCII has led to numerous technology advances. For example, one HCII collaboration studied how we communicate meaningful messages and then extract salient messages from speech. The results of this work have led to advances in voice-recognition software **(M. Hasegawa-Johnson)**.

IMAGE COURTESY DAN MORROW

This subject is taking part in a study that is explores pilot expertise and age-related decline. Dan Morrow is the principal investigator on the project.

HCII research also focuses on technologies like cell phones and other electronic devices that have become so much a part of our lives. Researchers look at both how their use affects our lives, and how we can improve device performance and the interface experience for people.

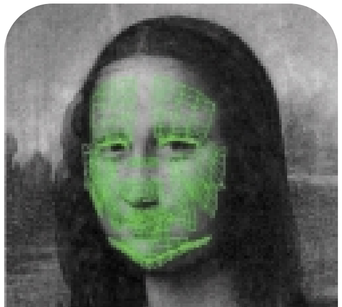
Neuroscience studies in HCII rely on the latest equipment and applications to reveal physiological information about the brain that complements theoretical research. Facilities like a state-of-the-art MRI center, driving and flight simulators, and virtual reality environments give researchers a detailed knowledge of topics like a driver's judgments prior to a collision **(D. Simons, A. Lleras)**, or how human memory works **(R. Wang, D. Simons)**.

New technologies and useful information go hand-in-hand with the Human-Computer Intelligent Interaction mission, as the work within this research initiative has an impact on humans in very real ways.

RESEARCH ON DRIVING PERFORMANCE, CELL PHONES

The study of real-world activities like using a cell phone while driving is a continuing and important part of research within Human-Computer Intelligent Interaction. HCII co-chair Art Kramer and Beckman faculty members Susan Garnsey, Kathryn Bock, and Gary Dell are expanding their research which has shown that in comprehending and producing speech, as is the case while using a cell phone, driving performance suffers. Ongoing studies are now examining how speech/driving interactions may change with novice and older adult drivers, and whether interactions differ between talking to a passenger or someone on a cell phone. A new project involving cell phones is concerned with the growing role these devices play in social interactions. HCII faculty members Charissa Lansing, Jason McCarley, Mark Hasegawa-Johnson, Jont Allen, and Kramer have begun a series of studies supported by Qualcom to examine the reasons why cell phones annoy bystanders, and to study the psychophysics of their use.

The role human perception plays in people's interactions with machines is a key focus for HCII researchers. Psychology professors Dan Simons and Alejandro Lleras are using the Beckman Institute's driving simulator to examine how perception affects drivers' abilities to avoid collisions. The researchers found that drivers at slow speeds overestimated the time they needed to avoid collisions, while drivers at high speeds underestimated the time required to avoid a collision. In another project involving cognition and driving, Kramer and graduate student Nick Cassavaugh have developed a desktop driving trainer to enhance the ability of older adults to drive safely in high pressure driving situations. This desktop trainer is based on previous theoretical and applied research conducted by Kramer and colleagues on age-related changes in multi-tasking from both a cognitive and neuroscience perspective. Research into driving and conversation by Mark Hasegawa-Johnson and HCII co-chair Tom Huang is geared toward developing of a corpus of speech in an automobile that can be used to test the efficacy of voice-recognition systems.



Using emotion recognition software developed by HCII Co-chair Tom Huang and his group, the emotions of DaVinci's Mona Lisa were decoded. The subject was found to be 83% happy.

TASK EXPERTISE AND COGNITIVE DECLINE

As part of studies into development and maintenance of cognition and brain function across a lifespan, the results of several research lines have added to our knowledge about task expertise and basic cognitive abilities. Dan Morrow investigates pilot expertise and age-related cognitive decline, with a current focus on external communication aids like notepads used by pilots for writing down air traffic control instructions. Morrow's research has shown that older pilots who use domain-relevant environmental support aids in a familiar communication task, don't show the same age-related cognitive decline found when pilots who do not use these aids or as those from a non-pilot control group. Morrow is currently testing an e-pad that may support communication as well as replace the kneepad many general aviation pilots now use to take notes. This could eliminate the heads-down time that may disrupt other flying tasks. In another project involving aviation and expertise, researchers Ashley Nunes and Art Kramer looked at whether many years of experience could reduce or eliminate age-related decline in complex skills like those possessed by air traffic controllers. They tested younger and older controllers to see if experience in air traffic control could actually reduce age-related decline on a number of standard neurological and neuropsychological tests. The researchers found that in tasks related to their domain of expertise, older air traffic controllers showed no signs of cognitive decline, while older adults from the control group did. "We found there was no age-related effect," Kramer said. "In fact, in a number of cases, the older controllers performed better than the younger controllers." Kramer said the results suggest that years of experience can moderate age-related decline for complex skill performance.

Researchers Denise Park and Elizabeth Stine-Morrow have focused on the effects learning new skills might have on age-related cognitive decline. Park is in the early stages of a project called Viva that teaches new skills such as digital photography to older adults to test the thesis that skill acquisition improves cognitive function. Stine-Morrow investigates the same topic with her Senior Odyssey of the Mind project in which older adults learn team problem-solving as a possible pathway to improved cognitive health.

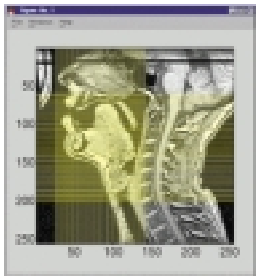
Depth-sensing images from the Table Top Depth 3-D Camera from Narendra Ahuja's Vision and Robotics Laboratory. From left to right: input image, depth map, and the corresponding new 3-D view.

ACQUISITION OF KNOWLEDGE OF PHYSICS

Jose Mestre came to the University of Illinois at Urbana-Champaign in 2005 in order to refine his research into how physics knowledge is transferred and acquired. Through collaborations with Beckman Institute researchers, Mestre is expanding upon his previous work by incorporating advanced technologies from Beckman in his research experiments. Mestre's current project uses eye-tracking equipment in Art Kramer's laboratory to determine where honors engineering students and non-engineering students are looking during an experiment that tests the role physics knowledge plays in making accurate observations of physical situations. The exercise has the students follow five different animations of steel balls going down and then up a v-shaped ramp and then report which of the animations they believe is closest to a real-world action. The purpose of the exercise is to find out how physics learned in the classroom might affect their perception of the observable motion of the balls. Research has shown that nearly two-thirds of the engineering students applied physics knowledge learned in the classroom and surprisingly incorrectly picked what actually happens — a much greater percentage than the non-engineering students. Previously, Mestre relied on standard techniques such as problem-solving tests for his research. By using technology such as eye-tracking and in the future functional MRI, Mestre is gaining new insight into how complex knowledge such as physics is learned.

HYBRID SPEECH RECOGNITION ALGORITHM FOR INCLUSION IN STANDARD SYSTEMS

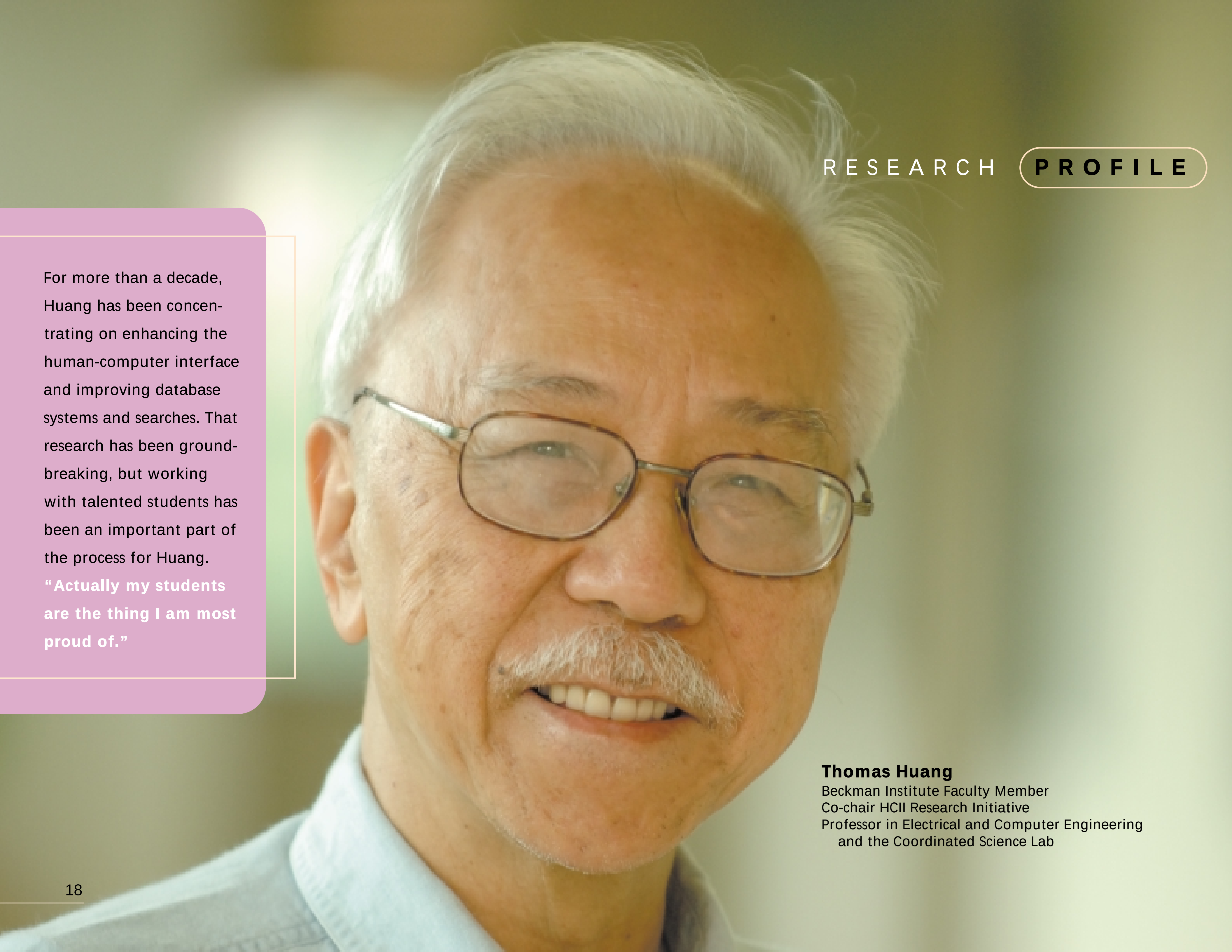
Full-time HCII faculty member Mark Hasegawa-Johnson has combined two speech recognition methodologies to create a unique, efficient hybrid approach that is being used at universities and tested in industry for future inclusion in standard speech-recognition systems. By combining the Hidden Markov Model (HMM), a statistical model good for characterizing large speech databases, and the support vector machine (SVM), useful for generalizing to new speakers from a small database of speakers, Hasegawa-Johnson has fashioned a system that utilizes the strengths of both models. The hybrid takes a 10-millisecond frame from an incoming acoustic signal and uses the SVM algorithms to produce a sequence of phonologically distinctive feature estimates for each frame. Normally, the Hidden Markov Model analyzes the signal waveform, but in the hybrid the HMM is used to characterize the output of the SVM. The result is a speech recognition method that is more accurate with less of what is called intertalker variability. The goal is to include the hybrid in future speech-recognition applications. Hasegawa-Johnson has also, along with HCII Co-chair Tom Huang, created and distributed a multi-camera, multimicrophone database of speech in an automobile that is being used by 15 institutions around the world to test new algorithms for audio-visual speech recognition. He has used speech recognition to study the linguistics of speech pathologies. In one current project in this area, Hasegawa-Johnson looked at three Cerebral Palsy subjects suffering from spastic dysarthria, a speech disorder characterized by articulation problems. Hasegawa-Johnson developed HMM-based and SVM-based algorithms in which one or other of the two models were successful in building speech-recognition systems for the subjects.



HCII faculty member Mark Hasegawa-Johnson's image illustrates a hybrid speech recognition algorithm applied to MRI slices.

TABLE TOP DEPTH 3-D CAMERA

Narendra Ahuja's Computer Vision and Robotics Laboratory is a leader in developing technologies for the next generation of cameras. Ahuja and postdoctoral researcher Chunyu Gao have now developed a single camera that outperforms conventional multi-camera systems in producing striking 3-D super-resolved images. They have fashioned a refractive camera that acquires a large number of the equivalent of stereo images and then generates super-resolved 3-D images with an accuracy that is superior to those produced by normal multi-camera systems. The table top camera relies on a novel depth-sensing system composed of a transparent plate rotating around the optical axis of a single camera. As the plate rotates, the camera captures a sequence of images for creating a depth map of the object(s) being captured. The large number of input images yields better depth accuracy for creating a 3-D view of the object(s) and helps reduce matching ambiguities, even for objects with low texture. The results provide a texture and depth for outstanding three-dimensional images.



For more than a decade, Huang has been concentrating on enhancing the human-computer interface and improving database systems and searches. That research has been groundbreaking, but working with talented students has been an important part of the process for Huang. **"Actually my students are the thing I am most proud of."**

Thomas Huang
Beckman Institute Faculty Member
Co-chair HCII Research Initiative
Professor in Electrical and Computer Engineering and the Coordinated Science Lab

Tom Huang's group is developing a real-time shrug detector as another method of using computer vision to analyze the emotion of a subject. This work is motivated by potential applications in video surveillance, computer animation, human-machine interfaces, and augmented reality and emotion recognition.

Tom Huang's office at the Beckman Institute is filled almost to capacity with scholarly papers, journals, and books, many of which he has written or contributed to as an internationally recognized pioneer in computer science research.

Two of his most cherished books, however, don't have Professor Huang's name on the spine cover. One is co-authored by his son Greg and the other is a compilation of research papers edited by three of his former students and done as a tribute to him.

"I've written and edited many books but two books I'm most proud of are these two," Huang said.

Half of the research papers in the compilation — titled *Advances in Image Processing and Understanding* — bear Huang's name as a co-author, but it's the book's subtitle that reveals his true attachment to it. His ex-students subtitled the book *"A Festschrift for Thomas S. Huang."*

The Festschrift, or celebration publication, demonstrate both Huang's seminal contributions to the field of image processing, and the importance of his relationships to his students.

Huang began his research career focusing on technologies like digital filters for image analysis, compression, and enhancement, and 3-D motion estimation from 2-D video. These were areas in which he was doing groundbreaking work, but often as a lone researcher. For more than a decade now, Huang has been concentrating on enhancing the human-computer interface and improving database systems and searches. That research has also been groundbreaking, but working with talented students has been an important part of the process for Huang.

"Actually my students are the thing I am most proud of," he said. "You do research but who knows what will happen. It's very concrete, your achievements in your students."

Huang's research shift to a focus on human-computer interactions and database systems had a purpose.

"When a person is young, they tend to be idealistic," he said. "You do things because you're interested in them. But when you grow older you tend to think more about the impact on society. These two things I've been working on the past 10 to 15 years, have a great impact on society."

Using applications like emotion and voice recognition software he and his group developed, Huang is trying to improve the quality and depth of users' interactions with their computers. Potential future applications include computers that sense a user's emotions or public displays in businesses that "read" customers' faces and display information catered to that customer.

Huang's emotion recognition software garnered worldwide attention in December of 2005 when a researcher who had studied with him applied the technology to an image of the Mona Lisa in what was described as a fun science project. A few months later, Huang and his students applied gender recognition software they developed to the famous painting to try and answer the age-old question of whether the subject was male or female. The conclusion that the Mona Lisa was most likely female was also widely covered in the press.

Among his peers, Huang is best known for original contributions such as combining audio and visual information through face, emotion and voice recognition software, developing relevant feedback for database searches, and writing fundamental algorithms for multi-dimensional digital filters.

Huang's body of work has earned him some of the top honors in computer science and engineering in recent years. He was awarded the Jack S. Kilby Medal in 2000 and the King-Sun Fu Prize in 2002, the top awards, respectively, in the fields of signal processing and pattern recognition. In 2005 he joined an exclusive group of scientists from outside of Japan who have been honored with the Okawa Prize. The awards aren't that important to Huang, however.

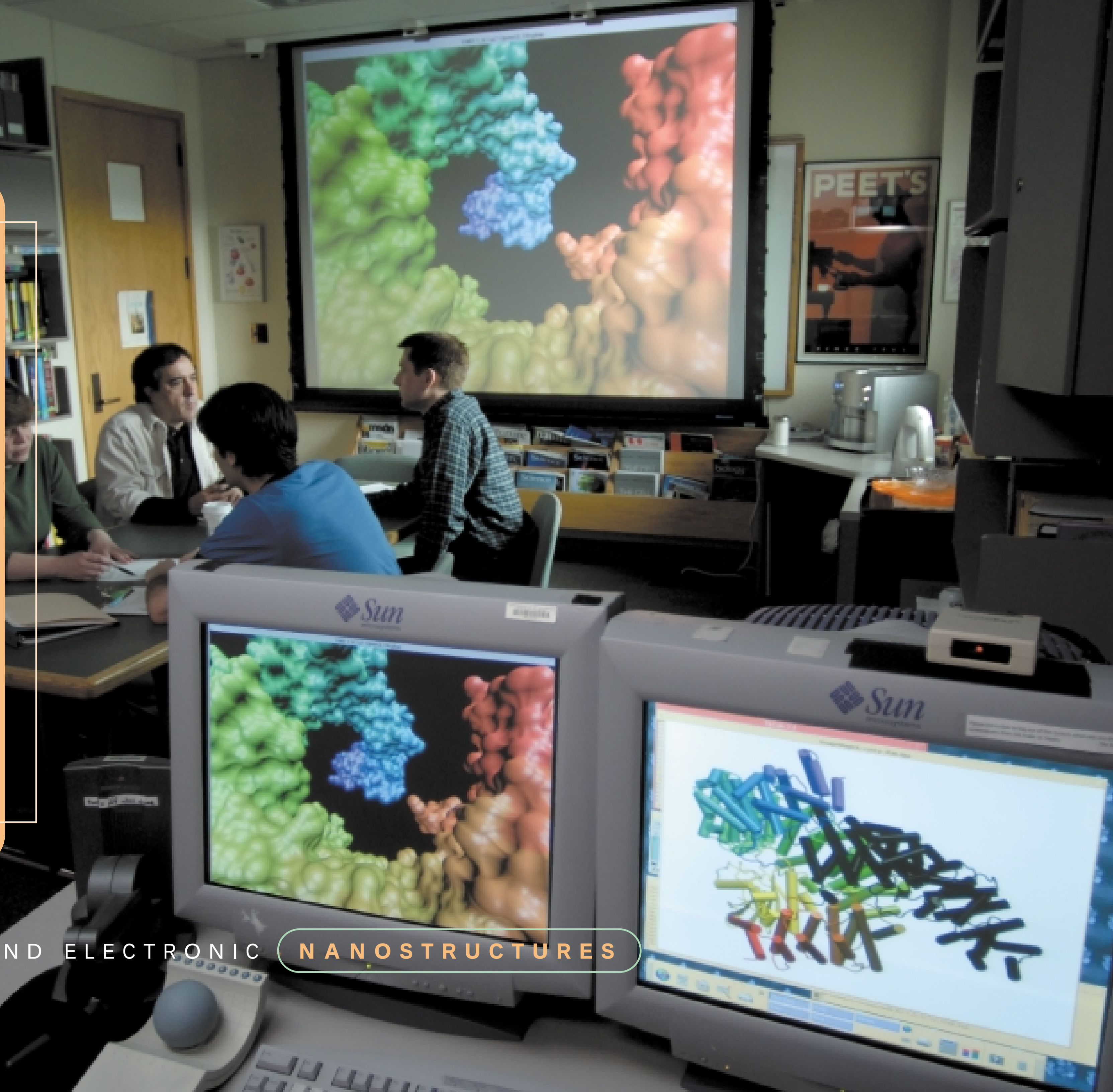
"I don't really put that much weight on these awards and honors," he said. "They somewhat depend on circumstances and luck and politics. They can easily go to some other person. I'm more concerned with the research and my students."

That's why he appreciates the book by his former students.

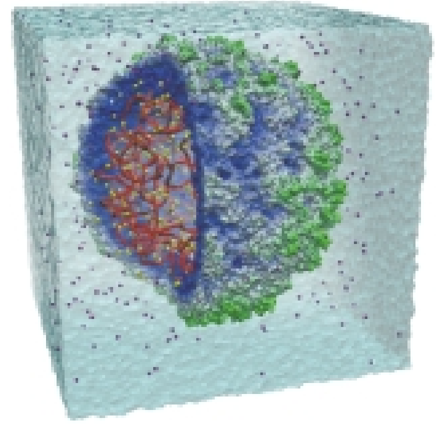
"It means my students appreciate me," Huang said. "I really am proud of my students."

And he is proud of his son Greg, a science writer, whose book about Microsoft's plans in China was published in 2006. The book's title is *Guanxi*, Chinese for the art of relationships. It is an art that Tom Huang has obviously mastered. The book's dedication says "to Thomas and Margaret Huang, parents who opened doors to a strange new land, with love."

Working along the scale of a billionth of a meter, researchers within the **Molecular and Electronic Nanostructures (M&ENS) research initiative** seek to understand the processes and properties of structures at the nanoscale level. M&ENS researchers analyze biological processes, develop novel semiconductor-based systems, and explore the characteristics of nanostructures toward a myriad of future applications.



THEORETICAL AND COMPUTATIONAL BIOPHYSICS GROUP



The first-ever computer simulation of an entire life form was performed this past year by a research team led by TCB Director Klaus Schulten. The group simulated the satellite tobacco mosaic virus in a simulated system that also included water and ions with a total of more than one million atoms.

When the Molecular and Electronic Nanostructures (M&ENS) research initiative was formed more than a decade ago, it began exploring the world of nanometer-scale chemical processes and physical structures in ways no research facility had attempted in the past. Grant awards, national honors, and research results from this past year show that M&ENS is still leading the way in nanoscale discoveries.

Two large-scale, highly focused funding initiatives by the National Institutes of Health made two M&ENS research groups integral parts of new nanoscale medical efforts. One initiative, charged with developing four national nanomedicine centers, funded the National Center for Design of Biomimetic Nanoconductors (**E. Jakobsson, N. Aluru,** others) at Beckman. The first project will be to develop an implantable, nanoscale battery for powering an artificial retina. The other grant is part of a “Revolutionary Genome Sequencing Technologies” initiative aimed at advancing the development of innovative technologies intended to reduce the cost of DNA sequencing and expand the use of genomics in biomedical research and health care (**G. Timp, J-P. Leburton, K. Schulten, S. Sligar, A. Aksimentiev**).

Grants from funding agencies are but one way to assess the impact of research within M&ENS. Recognition from leading scientific publications and foundations also demonstrate the guiding role that M&ENS plays in advancing nanoscale research. MIT’s *Technology Review* and *Scientific American* recognized developments by the Rogers Research group (**J. Rogers**), including development of a stretchable form of silicon, as top emerging technologies this past year. Another prestigious honor went to M&ENS faculty member **Todd Martínez**, who was named a 2005 MacArthur Fellow for his research into how atoms move in space and how their energy changes over time.

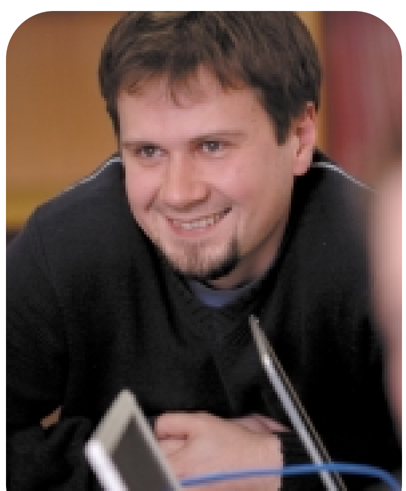
Of course, the honors and grant awards follow the research, and work within M&ENS continues to break new ground. This past year, the Theoretical and Computational Biophysics (TCB) group were the first researchers ever to perform an atomic-scale computer simulation of an entire life form. In what is considered a huge step forward in “biological reverse engineering,” researchers were able to perform a computer simulation of the satellite tobacco mosaic virus, the first time a complete organism, rather than a piece of a living cell, had been recreated “in silicon.”

Continuing research in M&ENS includes projects such as self-healing materials and autonomic materials systems (**S. White, N. Sottos, J. Moore,** others), nanotubes (**J-P. Leburton, J. Lyding, M. Strano**), and physical theories and computational design tools for the modeling of nanoscale structures and systems (**N. Aluru, TCB,** others), as well as self- and directed-assembly of structures for use in multifunctional materials (**P. Braun, Y. Lu, P. Wiltzius**).

The vitality of M&ENS was demonstrated this year by a reorganization in which several new groups were formed to better reflect the changing interests of this research initiative. The Autonomic Materials Systems, Computational Multiscale Nanosystems, and 3-D Micro- and Nanosystems groups were created, while several faculty members joined the Theoretical and Computational Biophysics group.

With interests as diverse as optoelectronics, microfluidics, transistors, and the workings of living cells, research within M&ENS continues to explore the nanoscale world in truly unique ways, providing results that are important in everything from physics to medicine to consumer electronics.

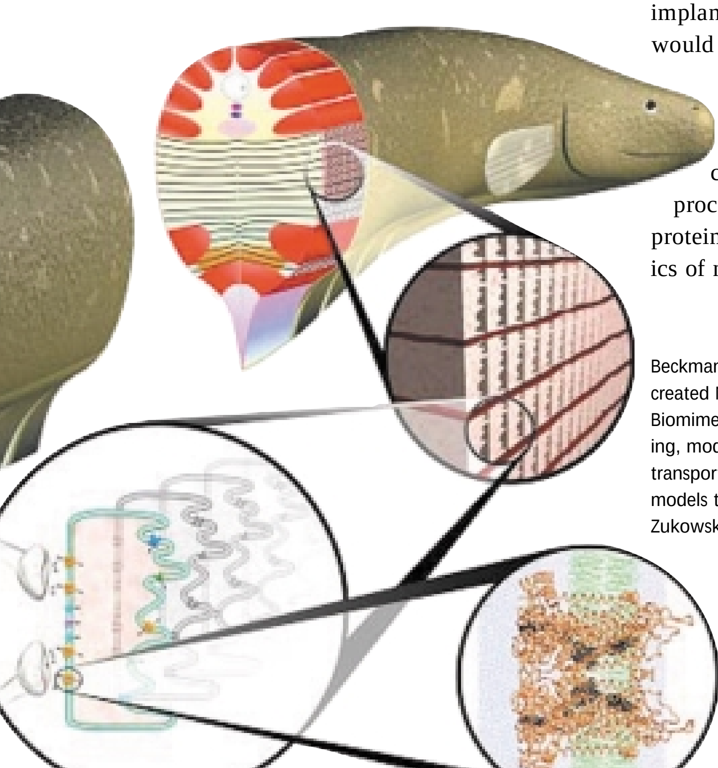
Fact:
Numerous governmental agencies, foundations, and corporations continue to view the Beckman Institute and its researchers as valuable partners.



Beckman Institute researcher Aleksei Aksimentiev is taking part in a National Institutes of Health challenge to create gene-sequencing technologies for less than $1,000. The team is striving to develop a synthetic nanopore-capacitor for reading the electrical signals of single-strand DNA as it is forced through the nanopore.

NEW NIH NANOMEDICINE CENTER FORMED

A unique, multi-institutional approach to developing nanoscale medical technologies has been headquartered at the Beckman Institute as part of a key initiative by the National Institutes of Health. The National Center for the Design of Biomimetic Nanoconductors is one of four advanced national centers funded by the NIH for developing new medical technologies and methods at the nanoscale. Center Director Eric Jakobsson, M&ENS Co-chair Narayana Aluru, and their lead team from the Beckman Institute collaborate with researchers representing a dozen universities and laboratories from across the United States and England. Using biomimetics (the study and use of nature as a blueprint for creating artificial devices), the Center's broad mission is to develop self-assembled, biologically functional transport molecules and membranes supported on silicon scaffolds as foundations for future devices. The team has used the "natural battery" of the electric eel as a model for its first goal of creating an implantable, nanoscale battery that would power an artificial retina. Early results have been promising in developing functional membranes and in developing computational simulations of processes such as ion flux through protein channels and the hydrodynamics of nanoscale pores.



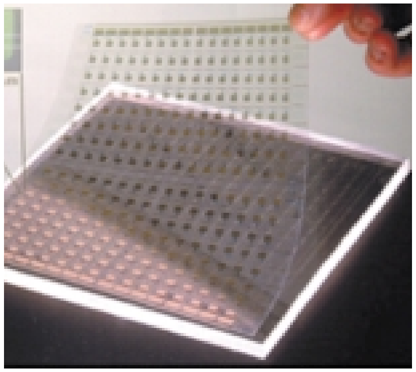
Beckman researchers are a part of a newly created National Center for the Design of Biomimetic Nanoconductors. They are designing, modeling, and creating new types of ion transport devices. The electric eel is one of the models they are using. Image by Daniel Zukowski.

NEW MURI GRANT AWARDED FOR DEVELOPMENT OF MICROVASCULAR AUTONOMIC COMPOSITES

A multi-university effort involving the University of Illinois, Duke, and UCLA to develop microvascular autonomic composites was launched in 2005 with a $5 million grant from the Air Force Office of Scientific Research. Building upon previous research into self-healing, or autonomic, materials that self-repair cracks and other failures, this new grant will empower further research into microvascular autonomic composites. Previous research demonstrated that a microencapsulated self-healing system with a catalytic chemical trigger could respond to cracks and fissures by releasing a healing agent when ruptured and bond the crack face closed. This new research line looks at putting an autonomic circulatory system featuring a series of branched networks into a material. Led by principal investigator Scott White and collaborators Nancy Sottos, Jeffrey Moore, Philippe Geubelle and Jonathan Freund from the newly formed Autonomous Materials System group, this project has the potential to reduce maintenance and replacement costs for airplanes, or any manufactured item that could benefit from an autonomic healing system.

NEW APPROACHES FOR FABRICATING CARBON NANOTUBES

Exploiting the tremendous potential of single-walled carbon nanotubes (SWCNT) has been a goal ever since these versatile but unruly materials were discovered 15 years ago. This past year, M&ENS researchers John Rogers, Joseph Lyding, Moonsub Shim, Michael Strano, and Karl Hess made an important breakthrough as they reported the first guided growth of carbon nanotubes into straight, dense, well-aligned arrays useful for thin film type electronic systems. Rogers, the principal investigator for the effort, said that building a systematic way to integrate SWCNTs into devices and circuits is probably the biggest challenge currently facing researchers in the field. "I think this is one of the Holy Grails in carbon nanotube science and technology, to try and grow aligned arrays," Rogers said. "I think we've made an enormous step in that direction. We haven't solved all the problems, but I believe this is a very robust, reliable way to generate exactly the kinds of arrangements of tubes that you ultimately need for electronics." The next step for the group is to report on device applications for the approach.



JOHN ROGERS RESEARCH GROUP

The field of large area, flexible electronics has the potential to enable useful devices — flexible paperlike displays, woven electrotextiles, low-cost identification tags, etc. — that might be difficult to achieve with established silicon technologies.

DEVELOPMENT OF STRETCHABLE SILICON

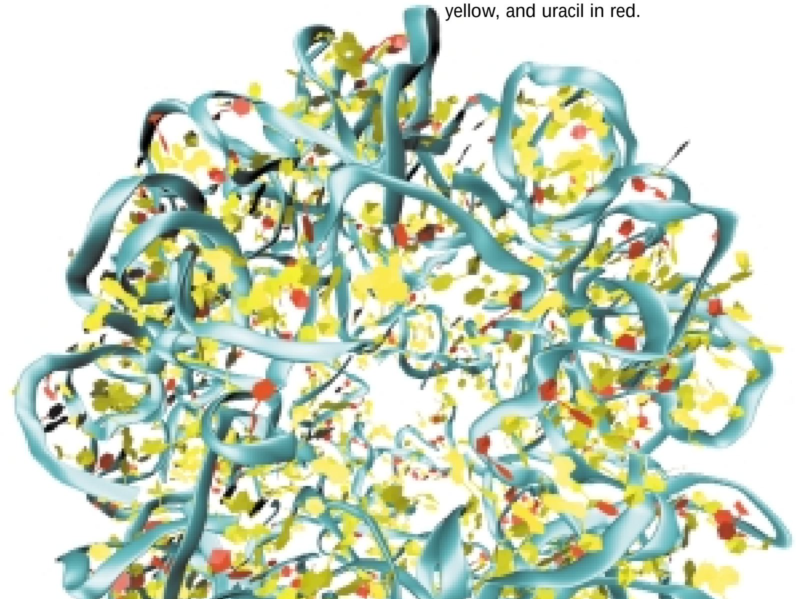
The Rogers Research group, known for its innovative work in electronics, made a discovery in 2005 that could change the nature of electronic devices. Led by John Rogers, the group developed a stretchable form of single crystal silicon on substrates that could be used in high-performance electronics. The researchers formed thin strips of silicon into wavy geometrical patterns that are mechanically stretchable and attached them to a rubber-like polymer substrate, This discovery, which was recognized as one of the top 10 new technologies for 2005 in MIT's *Technology Review*, could lead to stretchable electronic devices, or electronics that are integrated into stretchable materials. The potential applications of stretchable silicon could include their use in sensors, or new lines of consumer devices.

SIMULATION OF MECHANOSENSITIVE CHANNELS

M&ENS researchers Umberto Ravaioli and Klaus Schulten completed a successful computer simulation of transport through a mechanosensitive channel of small conductance (MscS), one of the largest such particle simulations ever attempted for a channel of this size. Ion channels are proteins that form pores on cell membranes and channels that are mechanosensitive respond to mechanical stress, exhibiting changes in their electrical behavior. MscS is a large channel found in *Escherichia coli* bacteria that acts like a safety valve in response to an imbalance in the cell's ion concentrations. When ions and pure water are concentrated inside the cell but there are no ions outside it, the cell increases in size like a balloon. MscS protects the cell from bursting by serving as a release valve for solutes, thus recovering the cell's balance. Using the biological Monte Carlo simulation program (BioMOCA) developed by Ravaioli's group, researchers were able to do simulations of MscS that serve as an engineering tool and as a supplement to molecular dynamics simulations. The simulations, successfully adapted from a methodology previously used in semiconductor device simulations, were able to provide 3-D maps on voltage and ion distribution in the channels, which indicated a strong separation of ions with opposite charges.

TCB RESEARCHERS PERFORM FIRST-EVER ATOMIC-LEVEL COMPUTER SIMULATIONS OF AN ENTIRE LIFE FORM

The Theoretical and Computational Biophysics group continued its breakthrough work in large-scale computer simulations of atomic-scale processes and systems by completing the first-ever computer simulation of an entire life form, the satellite tobacco mosaic virus. In a form of reverse engineering, TCB Director Klaus Schulten and his collaborators used VMD, a molecular visualization program developed by his group, to visualize the dynamics of more than one million atoms that made up the virus and a small drop of salt water surrounding it. Computer simulations had been previously performed on parts of living cells, but this was the first time anyone had performed a dynamic simulation of an entire organism. This unprecedented view into the dynamics of the virus provided information on the key physical properties of the viral particle as well as data about its assembly. The ability of TCB researchers to view biological processes and systems dynamically and at an atomistic level of resolution is an important tool in adding to our knowledge of viruses, diseases, and other medical issues.



Crystal structure of the RNA from the satellite tobacco mosaic virus, with an artificial nucleic acid sequence. Adenine residues are shown in yellow, and uracil in red.

THEORETICAL AND COMPUTATIONAL BIOPHYSICS GROUP

RESEARCH PROFILE

"It's a good space to be in right now because in terms of high-performance materials and this kind of approach, we're alone. **But the real excitement is the sense we have that there's a whole world of applications out there that are just waiting for this kind of technology,** so many that we can't even anticipate a fraction of them."

John Rogers
Beckman Institute Faculty Member in M&ENS
Professor of Materials Science and Engineering
Founder Professor of Engineering
Professor of Chemistry


IMAGING TECHNOLOGY GROUP

Stamp-printable micro/nanostructures from the Rogers Research Group were featured in the January 2006 issue of *Nature Materials.*

John Rogers has gained national attention by using unconventional materials for applications in electronic structures and devices. So it came as no surprise that when an opportunity arose to use silicon, the most common material currently powering modern electronics, in a completely new way, Rogers took advantage.

A fortuitous handling mistake by a postdoctoral researcher in the Rogers Research Group led to the realization that thin strips of silicon can form wavy geometries that buckle but don't break when stretched. They later built upon this discovery by attaching the wavy silicon strips to a rubber-like polymer substrate. A little over a year after that lab processing slip-up, the Rogers Research Group introduced stretchable silicon to the world. The potential importance of this discovery can make the imagination run wild: stretchable silicon-based transistors could be used for a myriad of high-performance electronics, or for sensors placed along a hospital wall or into an artificial limb.

In other words, stretchable silicon-based electronic devices could expand and contract, or the electronics could be manufactured into a material that stretches to fit an airplane wing, for example, or a human hand. Freeing electronics from the rigidity now associated with items like digital music players or a medical monitor opens so many possibilities, Rogers prefers to leave those ideas to others. But one potential use intrigues him.

"We're interested in this concept of smart surgical gloves, a rubber glove that's similar to the type of latex glove that surgeons currently use while they are performing operations," Rogers said. "What if you could integrate waveguides and micro-fluidic channels, sensor electronics, readout systems, wireless communications capabilities, into the rubber glove? There you would need all those components to be stretchable because they need to fit and conform to the surgeon's hands. If you could do that then maybe you could enhance the ability of the surgeon to understand what's going on locally in the patient as he's doing the surgery."

Rogers has a history of making creative, groundbreaking discoveries in the areas of new materials and devices for electronics. In just the past two years, his work has been recognized as a top emerging technology, twice by MIT's *Technology Review* and in 2005 by *Scientific American*.

With degrees in chemistry and physics, a Ph.D. from MIT in physical chemistry, and a career as a researcher at Bell Laboratories, Rogers positioned himself well for his current research themes. He has explored the use of unconventional, "soft" materials like biological tissue and liquid crystals for their electronic and photonic responses.

Rogers' work with organic semiconductors has led to the development of flexible, paper-like displays for electronics, such as roll-up screens that fit inside a pen-like tube. Begun during his time at Bell Labs, this research could soon be seen in the form of "electronic newspapers" made from thin strips of plastic that display the news through a wireless Internet link. Rogers said his work with flexible displays has led naturally to stretchable silicon.

"For the flexible displays, we are looking at printing techniques and flexible materials you can use to build circuits," Rogers said. "So a display consists of a circuit component as well as an optical component that allows you to view the information. We've always been focused on the circuit component of the flexible displays, so stretchable is the next frontier."

Rogers sees a research line going from rigid silicon wafers to flexible organic displays, to bendable circuits, to inorganic, stretchable silicon. While some of the unconventional materials Rogers works with inspire the imagination, they do not have the high-speed processing power needed for most of today's electronics. Stretchable silicon can provide that power and offer many of the same flexibility factors.

"With stretchable silicon you would have all the essential mechanical characteristics that you would ever probably want," Rogers said. "A lot of the work on flexible electronics happened here through an interdisciplinary group at Beckman and the silicon approach is conceptually related to that work as well."

While his work with "soft" materials has been fruitful, the new research line into stretchable silicon has obvious benefits in that silicon is widely used in applications and large amounts of funding are available for exploring its potential. And when it comes to stretchable silicon, the Rogers group is exploring new territory.

"It's a good space to be in right now because in terms of high-performance materials and this kind of approach, we're alone," Rogers said.

"But the real excitement is the sense we have that there's a whole world of applications out there that are just waiting for this kind of technology, so many that we can't even anticipate a fraction of them."

BIOMEDICAL IMAGING CENTER (BIC)

Tracey Wszalek, associate director for BIC, helps a subject become comfortable in the 3T Allegra mock magnet.

The Biomedical Imaging Center (BIC) traces its heritage to the Biomedical Magnetic Resonance Laboratory founded at UIUC by Professor Paul Lauterbur, 2003 winner of the Nobel Prize in medicine. BIC is home to a wide variety of research programs and provides facilities, equipment, and training for research on nuclear magnetic resonance imaging and spectroscopy.

Art Kramer, director of BIC and co-chair of the Human-Computer Intelligent Interaction research initiative at the Beckman Institute, says BIC's goal is to conduct research and develop MRI technology that addresses questions ranging from the single cell to the complex inter-dependent systems underlying cognitive function. BIC is committed to the development of cutting-edge techniques which integrate magnetic resonance methods with other imaging techniques, including optical imaging, eye-tracking, EEG and transcranial magnetic stimulation.

"Researchers are using BIC resources on an increasingly wide array of projects," says Kramer. "A snapshot of the work that is going on 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."

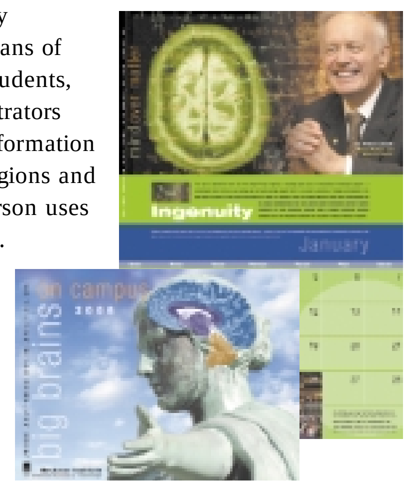
BIOMEDICAL IMAGING CENTER EQUIPMENT AND FACILITIES

- 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 work at BIC. Projects that are under way include RF coils development, creating custom-built MRI accessories, pulse programming, developing k-t Spatio-temporal MRI, measuring flow velocities in micro-flowcells using the Diffision 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.

MAKING A SPLASH WITH THE "BIG BRAINS ON CAMPUS" CALENDAR

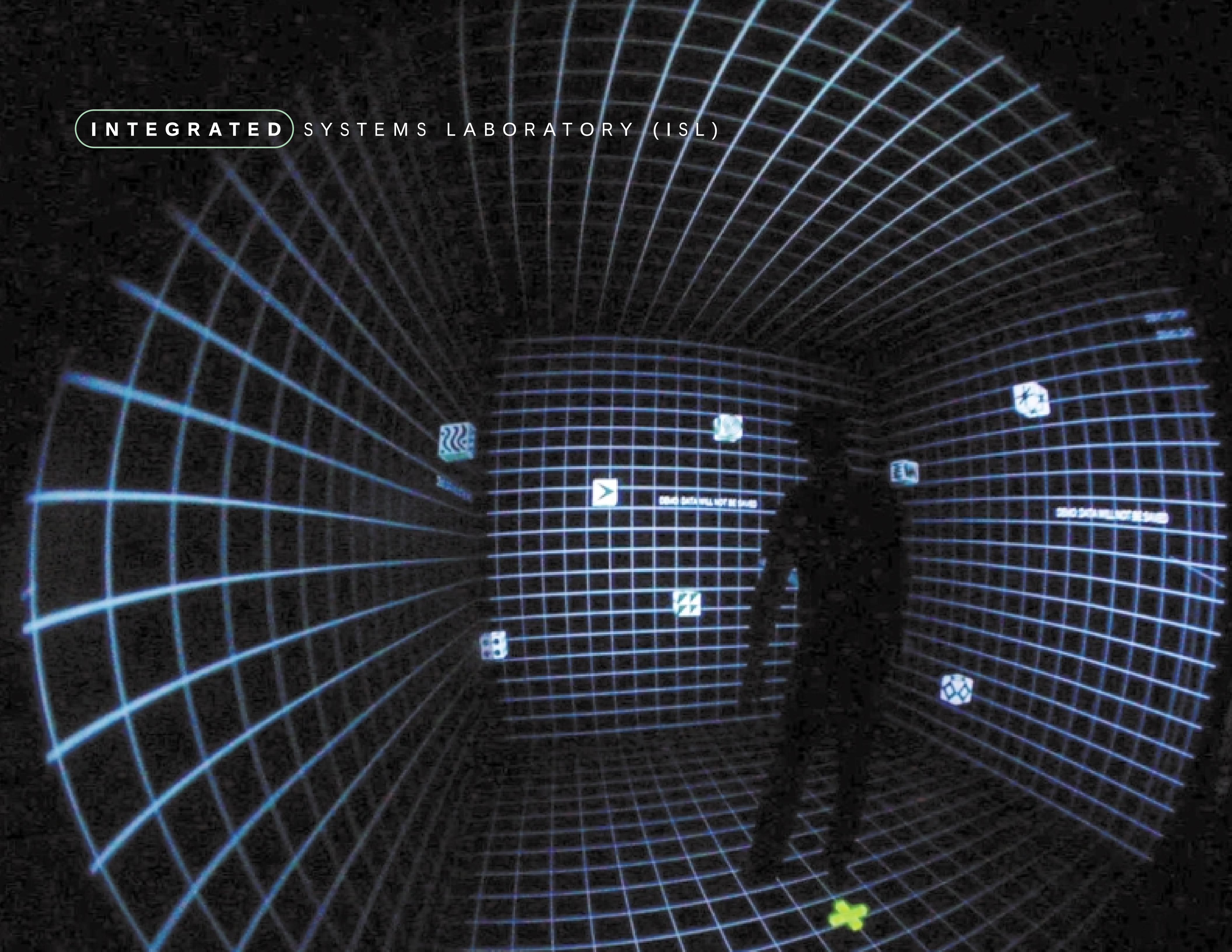
Last year BIC was in the media spotlight around the world for its incredibly popular "Big Brains on Campus" calendar. The calendar featured artistically enhanced brain scans of campus faculty, students, staff, and administrators and it provided information about the brain regions and functions each person uses in his or her work. Highlighted individuals included 2003 Nobel Prize winner and UI physics professor Anthony Leggett, whose brain scan focused on the regions of the brain that contribute to ingenuity, as well as Illinois women's basketball coach Theresa Grentz, whose passion for the game was shown via a scan of the brain's limbic system, and Chancellor Richard Herman, whose brain scan focused on the blood vessels to demonstrate his connection to all parts of the campus.



Tracey Wszalek, associate director for BIC, was instrumental in getting the Big Brains on Campus calendar produced. "This project allowed us to bring together our technology and our people to underscore the incredible brain power we have on this campus, and the cutting-edge resources we have at Beckman," said Wszalek. "It was a great opportunity to showcase magnetic resonance imaging research by personalizing the science."

The Big Brains on Campus calendar was featured on *CBS News*, *Good Morning America*, the *Chicago Tribune*, the *Washington Post*, the *Boston Globe*, and numerous other newspapers, magazines, radio programs, and television broadcasts.

INTEGRATED SYSTEMS LABORATORY (ISL)



A visitor explores the Calcul*rt installation at the Krannert Art museum.

The Integrated Systems Laboratory (ISL) provides research opportunities that stretch the limits of imagination in a diverse range of fields. From psychology to urban planning and earthquake visualization to art and technology, the tools found in ISL advance the understanding of human-computer interactions. 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.

DRIVING SIMULATOR

During the past year, Art Kramer's (HCII Co-Chair) research on cell phones and driving distraction was featured in newspapers, magazines, and television and radio stations throughout the world. His research relied on one of the cornerstones of ISL: the driving simulator. 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.

Hank Kaczmarski, director of ISL, says tools such as the driving simulator are increasingly important as researchers try to improve the way people interact with their environment.

"The Beckman Driving Simulator provides perceptual psychologists with a highly developed tool to conduct research concerning driver interaction with increasingly complex automobiles," Kaczmarski said. "It enables the testing of very young and very senior individuals in repeatable scenarios not possible in real road situations."

THE BECKMAN 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.

Kaczmarski said the continuing development of multi-dimensional data visualization applications is allowing researchers with mathematically and computationally complex challenges the opportunity to examine their data in the Cube.

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.

A user interacts with the Beckman Institute Cube and takes advantage of the six-sided perspective.

CANVAS (COLLABORATIVE ADVANCED NAVIGATION VIRTUAL ART STUDIO)

ISL also continues to push the envelope in art and technology via CANVAS, a collaborative project bringing CAVE technology to the Krannert Art Museum. CANVAS allows artists to have access to immersive graphics displays, with an initial installation called CALCUL*RT. The exhibit opened in March of 2006 and featured an array of media exploring the boundaries between mathematics and art, including the 3-D wonders of the CANVAS; Internet-driven art pieces developed by collaborations between Mathematics, Art and Design, and English departments; art works featuring holographic images by Ellen Sandor, a pioneer in the use of digital media, and Donna Cox of the NCSA; and a variety of sculptures, created using everything from mathematics to computer-generated 3-D imaging to old-fashioned wood. Kaczmarski was co-curator of CALCUL*RT. Fellow curators were George Francis and Rose Marshack.

Kaczmarski said the type of art/science interface provided by CANVAS is unique to the University of Illinois and is a joint effort between the Beckman Institute, Mathematics, the School of Art and Design, and the Krannert Art Museum

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 ernvironment, connected to Onyx supercomputers and PC clusters, enabling users to quickly develop, test and remotely demonstrate new applications.

IMAGING TECHNOLOGY GROUP (ITG)

VMIL user and UI researcher Jodi Blumenfeld has recently used the ITG ShapeCam while touring some of Europe's premier museums and scientific institutions. She is collecting 3-D surface data for her research on fossil hominin browridge morphology.

The cover of the January 2006 issue of *Nature Materials* featured stamp-printable micro/nanostructures from the John Rogers Research Group. Chas Conway (pictured) and Ben Grosser, ITG director, helped lead author Matt Meitl create the cover.

If a picture says a thousand words the Imaging Technology Group (ITG) would be speaking volumes. The primary mission of the ITG is to provide state-of-the-art imaging facilities for researchers at the Beckman Institute and the University of Illinois. This service mission is accomplished through two facilities: the Microscopy Suite and the Visualization, Media, and Imaging Laboratory (VMIL). These facilities are open to the entire UIUC campus as well as their campus and industrial collaborators.

MICROSCOPY SUITE

The Microscopy Suite provides a wide range of imaging modalities and supporting equipment for the preparation, imaging, and analysis of microscopic specimens. The Microscopy Suite features the following:

Light Microscopy:

- multi-photon confocal
- fluorescence with structured illumination
- reflected
- dissecting
- stereology

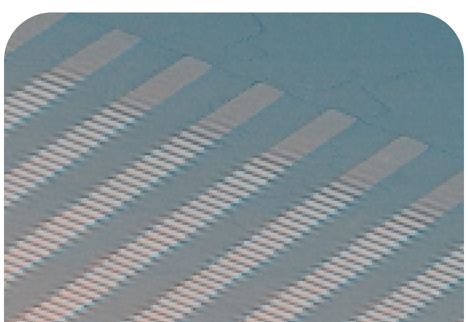
Electron Microscopy:

- transmission electron (TEM)
- environmental scanning electron (ESEM)

Scanning Probe Microscopy:

- atomic force (AFM)
- near-field scanning optical (NSOM)

The Microscopy Suite staff has more than over 40 years of combined experience in the field of microscope imaging. This allows them to provide specialized training for individual needs, as well as to design custom imaging solutions that enable new research.



This image of stretchable silicon from John Rogers' group was captured using the Microscopy Suite's Environmental Scanning Electron Microscope. The pseudo-coloring was by Chas Conway, and the data is by Matt Meitl, Won Mook Choi, Dahl-Young Khang, and John Rogers.

VISUALIZATION, MEDIA, AND IMAGING LABORATORY

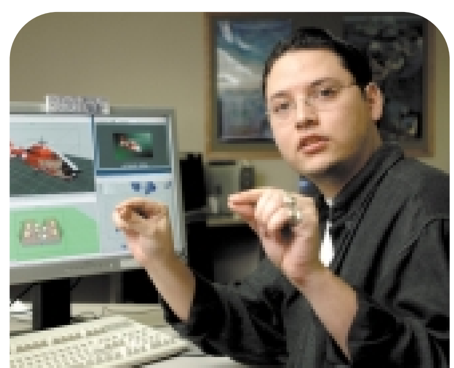
The Visualization, Media, and Imaging Laboratory (VMIL) at the Beckman Institute provides researchers with an incredible state-of-the-art facility that supports a wide range of projects. From providing computer animations that illustrate scientific concepts to helping with volumetric data analysis, the VMIL enables its users to stay on the leading edge of research.

The VMIL provides resources, equipment, and services to support:

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

What sets the VMIL apart from its peers is its dedication to providing an expert and diverse staff that intimately understand the software and hardware resources of the facility. VMIL staff members use this knowledge to provide custom training to Beckman researchers that helps them not only meet the goals of their projects, but exceed them.

Alex Jerez from VMIL illustrates a point about a self-healing materials animation he created for Scott White, a researcher in the M&ENS research initiative at Beckman.



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 allows children worldwide to remotely control ITG's ESEM. These students collect an insect specimen from their own backyard, mail that specimen to ITG, and then log in from their classroom to operate the ESEM using a Web browser. The students 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, allows 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.

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 research interests that correspond to one or more of the Beckman Institute's research initiatives.

Pierre Wiltzius, director of the Beckman Institute, says the Fellows program is invaluable. "The Fellows program brings talented, young scholars from around the world to the Beckman Institute. Their varied backgrounds and leading-edge research topics complement the global work that is being done at Beckman," says Wiltzius.

CURRENT BECKMAN INSTITUTE FELLOWS

Chandramallika Basak, *2005 Fellow*
Chandramallika Basak earned a Ph.D. in experimental psychology at Syracuse University. Her current research interests include aging and the effect of video-game training on brain and cognition; and individual differences in working memory span and retrieval dynamics of items in working memory — both from behavioral and biological perspectives. Chandramallika collaborates with faculty in the Cognitive Neuroscience and Human Perception and Performance research groups.

Emma Falck, *2005 Fellow*
Emma Falck joined the Beckman Fellows program after completing a Ph.D. in physics at the Helsinki University of Technology. Her current research interests are focused on the computational modeling of biological matter, specifically the bacteria ribosome, and the computational study of lipid membranes. Emma collaborates with members of the Theoretical and Computational Biophysics research group as well as faculty from the Howard Hughes Medical Institute, Tampere University of Technology, the University of Western Ontario, and the Helsinki University of Technology.

Silvio Savarese, *2005 Fellow*
Silvio Savarese 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 current research in computer vision is focused on the recognition of scene and object categories and the perception and recognition of reflective surfaces. Silvio is pursuing those interests as a member of the Human-Computer Intelligent Interaction (HCII) research initiative.

Zhihong Zeng, *2005 Fellow*
Zhihong Zeng earned his Ph.D. from the Institute of Automation, Chinese Academy of Sciences, with his dissertation research on "Real-time Shape Tracking Under Various Circumstances." Zhihong's research explores multimodal emotion recognition with the long-term goal of making machines that can interpret the human's affective states automatically in much the same way people do. Zhihong collaborates with the HCII research initiative.

Ryan Kershner, *2004 Fellow*
Ryan J. Kershner received his Ph.D. in Materials Engineering from the Massachusetts Institute of Technology in February 2004. His research interests focus on surface forces during the assembly of materials on the micro- and nanoscale. Ryan's recent efforts have been directed toward the templated epitaxial growth of submicron silica colloidal crystals for photonic band gap applications. As a Beckman Fellow, Kerschner collaborates with members of the M&ENS research initiative.

Byron McCaughey, *2004 Fellow*
Byron McCaughey completed his Ph.D. at Tulane University in the summer of 2004. His research interests include conjugated polymer nanocomposites and self-assembly of advanced materials. As a Beckman Fellow, he works on self-healing and self-sensing polymer composites. Byron works closely with faculty members in the M&ENS research initiative.

Michelle Meade, ***2004 Fellow***
Michelle Meade completed her Ph.D. in May, 2003, from Washington University in St. Louis. Her research interests involve the intersection of cognitive and social processes as they relate to the aging mind and brain. As a Beckman Fellow, she works to determine the role of social interaction in mediating cognitive decline in older adults, and to determine the neurological correlates underlying changes in memory in collaborative contexts. She works with members of the Cognitive Neuroscience, Human Perception and Performance, and Image Formation and Processing research groups.

Timothy Nokes, ***2004 Fellow***
Timothy Nokes earned his Ph.D. at the University of Illinois at Chicago in 2004. His research interests focus on knowledge acquisition and understanding the mechanisms of cognitive change. As a Beckman Fellow, he investigates the mechanisms of cognitive change, specifically focusing on issues of learning and knowledge transfer. He works with the Cognitive Science and Artificial Intelligence research groups.

Maxim Raginsky, ***2004 Fellow***
Maxim Raginsky completed his Ph.D. from Northwestern University in June 2002. His research interests are in the area of statistical physics, information theory, probability theory, and discrete mathematics. As a Beckman Fellow, Maxim applies the paradigm of collective phenomena in complex multi-component systems to the following two problems: (1) development of unified information–theoretical methods for statistical learning and (2) mathematical modeling of information storage in the brain. Maxim works with the Image Formation and Processing, NeuroTech, and Artificial Intelligence research groups.

Joshua Ballard, ***2003 Fellow***
Joshua Ballard received his Ph.D. in physical chemistry from the University of Colorado in 2003. His primary research aims to develop new tools for coherently manipulating single molecules on a surface through the coupling of a Scanning Tunneling Microscope with laser excitation. He is collaborating with faculty in the Nanoelectronics and Biophotonics research group.

Richard Godijn, ***2003 Fellow***
Richard Godijn received his Ph.D. in cognitive psychology from Vrije Universiteit in Amsterdam in 2003. His research interests include the areas of visual selection and the brain mechanisms related to visual attention and eye movements. As a Beckman Fellow, he is working with members of the Cognitive Neuroscience and Human Perception and Performance research groups.

Mathews Jacob, ***2003 Fellow***
Mathews Jacob received his Ph.D. from the Swiss Federal Institute of Technology (EPFL). His research interests center mainly in the area of biomedical image processing, as it deals with various problems related to the acquisition, reconstruction, and analysis of biomedical images. As a Beckman Fellow, he works with members of the Image Formation and Processing and Cognitive Neuroscience research groups.

BECKMAN INSTITUTE GRADUATE FELLOWS PROGRAM

40°06'55.39"N 88°13'32.57"W is the longitude/latitude of the Beckman Institute at the University of Illinois. The campus straddles the border between the twin cities of Champaign and Urbana and is about 140 miles south of Chicago, 125 miles west of Indianapolis, and 180 miles northeast of St. Louis. With a combined population of 105,000, Champaign-Urbana is large enough to support cultural and entertainment opportunities usually associated with major metropolitan areas, yet small enough to maintain its identity as a friendly, Midwestern community.

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 2005-2006 BECKMAN INSTITUTE GRADUATE FELLOWS AND THEIR AREAS OF RESEARCH ARE AS FOLLOWS:

Aveek Chatterjee
"Embedding Multiscale Methods for Electrolyte and Macromolecule Transport Through Nanopores"

Ph.D. Candidate in Mechanical Engineering

Molecular and Electronic Nanostructures/Computational Electronics group

Heidi Lorimor
"Conjunction and Grammatical Agreement: When Wholes Differ from the Sums of their Parts"

Ph.D. Candidate in Linguistics

Human-Computer Intelligent Interaction/Artificial Intelligence group

Elena Rykhlevskaia
"Anatomically Informed Models of Functional Connectivity in the Brain: A Quantitative Approach to Combining Modalities in Neuroimaging"

Ph.D. Candidate in Quantitative Psychology

Biological Intelligence/Cognitive Neuroscience group

Noureddine Tayebi
"Four-Terminal Scanning Tunneling Microscopy and Spectroscopy of Carbon Nanotube Field-Effect Transistors: Theory and Experiments"

Ph.D. Candidate in Electrical and Computer Engineering

Molecular and Electronic Nanostructures/Nanoelectronics and Biophotonics group

Kathleen Toohey
"Continuous Self-Healing Polymer Composites"

Ph.D. Candidate in Theoretical and Applied Mechanics

Molecular and Electronic Nanostructures/Autonomous Materials Systems group

FACULTY AWARDS, PATENTS, GRANTS AND SELECT PUBLICATIONS

For a complete list visit www.beckman.uiuc.edu.

BIOLOGICAL INTELLIGENCE RESEARCH INITIATIVE FACULTY

(name followed by home department)

Bioacoustics Research Laboratory
Leon A. Frizzell, *Electrical and Computer Engineering*
William D. O'Brien, *Electrical and Computer Engineering*
Michael L. Oelze, *Electrical and Computer Engineering*

Bioimaging Science and Technology
Rohit Bhargava, *Bioengineering*
Stephen A. Boppart, *Electrical and Computer Engineering*
Paul Scott Carney, *Electrical and Computer Engineering*
Michael Insana, *Bioengineering*
Zhi-Pei Liang, *Electrical and Computer Engineering*
Kenneth S. Suslick, *Chemistry*
Bradley Sutton, Bioengineering
Yingxiao Wang, *Bioengineering*
Kenneth Watkin, *Speech and Hearing Science*

Cognitive Neuroscience Group
Diane Beck, *Psychology*
Neal J. Cohen, *Psychology*
Monica Fabiani, *Psychology*
Kara Federmeier, Psychology
Susan M. Garnsey, *Psychology*
Brian Gonsalvas, *Psychology*
Gabriele Gratton, *Psychology*
Wendy Heller, *Psychology*
Gregory A. Miller, *Psychology*
Denise Park, *Psychology*
Richard Powers, *English*

Cognitive Science
Aaron Benjamin, *Psychology*
J. K. Bock, *Psychology*
William F. Brewer, *Psychology*
Kiel Christianson, *Educational Psychology*
Jennifer S. Cole, *Linguistics*
Gary S. Dell, *Psychology*
Cynthia L. Fisher, *Psychology*
Jose Mestre, *Physics*
Brian H. Ross, *Psychology*
Chilin Shih, *East Asian Languages and Cultures*
Jonathan A. Waskan, *Philosophy*
Duane Watson, *Psychology*

NeuroTech
Thomas J. Anastasio, *Molecular and Integrative Physiology*
David F. Clayton, *Cell and Structural Biology*
Charles (Lee) Cox, *Molecular and Integrative Physiology*
Albert S. Feng, *Molecular and Integrative Physiology*
William T. Greenough, *Psychology*
Douglas L. Jones, *Electrical & Computer Engineering*
Yuqing Li, *Molecular and Integrative Physiology*
Mark E. Nelson, *Molecular and Integrative Physiology*
Justin Rhodes, *Psychology*
Jonathan V. Sweedler, *Chemistry*

SELECTED HONORS AND AWARDS

Aaron Benjamin
Editorial Board Appointment, Memory & Cognition
Editorial Board Appointment, Psychonomic Bulletin & Review
Editorial Board Reappointment, Journal of Experimental Psychology: Learning, Memory, & Cognition
Elected Co-President, International Assoc. for Metacognition

J. Kathryn Bock
Chair of the Governing Board, Psychonomic Society
Editor-in-Chief, Journal of Memory and Language

Stephen A. Boppart
Senior Member, IEEE
Outstanding Alumni Award, Alpha Chapter Tau Beta Pi
Early Career Achievement Award, IEEE

David F. Clayton
Fellow, American Association for the Advancement of Science

Jennifer S. Cole
Associate Editor, Language

Gary S. Dell
Fellow, Cognitive Science Society, 2005
Fellow, American Psychological Society, 2005

Monica Fabiani
Foundations of Augmented Cognition Award, DARPA

Kara Federmeier
Early Career Awards, Society for Psychophysiological Research

Gabriele Gratton
Foundations of Augmented Cognition Award, DARPA

William T. Greenough
Fellow, American Academy of Arts and Sciences
Matthew J. Wayner-NNOXe Pharmaceuticals Award in Behavioral Systems Neuroscience

Michael Insana
Senior Member, IEEE

Zhi-Pei Liang
Fellow, IEEE
Vice-President Elect (Conferences), IEEE-EMBS

Gregory A. Miller
Fellow, Association for Psychological Science (APS)

William D. O'Brien
National Institutes of Health MERIT Award
American Institute of Ultrasound in Medicine's William J. Fry Lecture Award

Denise Park
Chair, The Beirat (oversight committee), Max Planck Institute, Berlin, 2005-2008
Chair, NIH Cognition and Perception Study Section
Science Editor, American Psychologist
Fellow, American Association for the Advancement of Science

Brian H. Ross
Editor, Memory & Cognition

Kenneth S. Suslick
Fellow, American Association for the Advancement of Science
Fellow, Acoustical Society of America

Jonathan V. Sweedler
Theophilus Redwood Lecturer, Analytical Division, Royal Society of Chemistry, 2007
Pittsburgh Analytical Chemistry Award, SACP, 2007
Fellow, Royal Society of Chemistry (UK)

Yingxiao Wang
Research Recognition Award, American Physiological Society and International Union of Physiological Sciences

SELECTED PATENTS AND PATENT APPLICATIONS

(Beckman Faculty members in bold.)

Albert Feng and **Douglas Jones**: "Binaural Signal Processing Techniques," Issue date: December 20, 2005, Patent No. 6,978,159.

Albert Feng and **Douglas Jones**: "Binaural Signal Processing Techniques," Issue date: January 17, 2006, Patent No. 6,987,856.

Albert Feng, **Douglas Jones,** and Erik Larsen: "Room Volume and Room Dimension Estimation," Publication date: October 26, 2005, Application No. 11/259,619.

Yuqing Li, Dang Mai, and Fumiaki Yokoi: "Methods and Compositions for the Treatment of Dystonia," Publication date: October 7, 2005, Application No. 60/724,925.

SELECTED GRANTS AWARDED

(Beckman Faculty members in bold.)

Thomas Anastasio and **Sylvian Ray**: TRECC, "Intelligent Multisensor Fusion," *3/1/05-2/28/06*.

Stephen Boppart and **Narayana Aluru**: NSF, "Optical Coherence Elastography and Biomechanical Modeling of Developing Tissues," *7/15/05-6/30/08*.

Neal Cohen and Stanley Colcombe: NIH, "The hippocampal system and relational (declarative) memory processes," *7/1/06-4/30/07*.

Gabriele Gratton and **Monica Fabiani**: Archinoetics, LLC, "Fast optical imaging as a tool for deriving cognitive gauges," *8/16/05-8/15/06*.

William Greenough: NIH, "Fragile X syndrome: Banbury conferences," *3/1/01-2/28/11*.

Yuqing Li and Jianyong Li: NIH, "Pathophysiology of Myoclonas Dystonia: Sgce Mutant Mice," *5/1/06-4/30/07*.

Yuqing Li and Jianyong Li: Bachmann-Strauss Dystonia & Parkinson Foundation Inc, "Dissecting the functional role torsinA in mid brain dopaminergic system" *1/1/06-12/31/06*.

Yuqing Li and Jianyong Li: Dystonia Medical Research Foundation, "siRNA intervention strategy for DYT1 dystonia," *9/1/06-8/31/08*.

Denise Park, **Bradley Sutton**, Angela Gutchess, and Ying-Yi Hong: NIH, "Cognitive neuroscience of aging, culture and cognition," *9/30/05-6/30/10*.

Chilin Shih and Gary Cziko: NSF, "Collaborative Research: Translating prosody in an English/Chinese language tutoring system," *2/15/06-1/31/07*.

SELECTED PUBLICATIONS

(Beckman Faculty members in bold.)

Abel, S.; Grande, M.; Huber, W.; Willmes, K.; **Dell, G. S.**, Using a connectionist model in aphasia therapy for naming disorders. *Brain and Language* **2005,** 95, (1), 102-104.

Beck, D. M.; Muggleton, N.; Walsh, V.; Lavie, N., Right parietal cortex plays a critical role in change blindness. *Cerebral Cortex* **2006,** 16, (5), 712-717.

Stephen Boppart, Adam Zysk, Steven Adie, Julian Armstrong, Matthew Leigh, and David Sampson: "Method and Apparatus for Measurement of Optical Properties in Tissue," Publication date: January 31, 2006, Application No. 60/764,178.

Stephen Boppart and Chenyang Xu: "Contrast Enhanced Spectroscopic Optical Coherence Tomography," Publication date: April 14, 2006, Application No. 11/405,005.

Stephen Boppart, **Kenneth Watkin**, **Kenneth Suslick**, and **Andrew Webb**: NIH, "Magnetomotive optical molecular imaging probes," *9/15/05-8/31/09*.

Paul Scott Carney and Daniel Marks: "Multiplex Near-Field Microscope with Diffractive Elements," Publication date: April 28, 2006, Application No. 11/413,633.

Chee M.W.; Goh J.O.; Venkatraman V.; Tan J.C.; Gutchess A.; **Sutton, B.**; Hebrank A.; Leshikar E.; **Park D.,** Age-related changes in object processing and contextual binding revealed using fMR adaptation. *Journal of Cognitive Neuroscience* **2006**, 18, (4), 495-507.

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Erickson, K. I.; Colcombe, S. J.; Raz, N.; Korol, D. L.; Scalf, P.; **Webb, A.; Cohen, N. J.; McAuley, E.; Kramer, A. F.,** Selective sparing of brain tissue in postmenopausal women receiving hormone replacement therapy. *Neurobiology of Aging* **2005,** 26, (8), 1205-1213.

Fabiani, M.; Low, K. A.; Wee, E.; Sable, J. J.; **Gratton, G.**, Reduced suppression or labile memory? Mechanisms of inefficient filtering of irrelevant information in older adults. *Journal of Cognitive Neuroscience* **2006**, 18, (4), 637-650.

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Herrington, J. D.; Mohanty, A.; Koven, N. S.; Fisher, J. E.; Stewart, J. L.; Banich, M. T.; **Webb, A. G.; Miller, G. A.; Heller, W.,** Emotion-modulated performance and activity in left dorsolateral prefrontal cortex. *Emotion* **2005,** 5, (2), 200-207.

Kim, S. H.; Dong, W. K.; Weiler, I. J.; **Greenough, W. T.,** Fragile X mental retardation protein shifts between polyribosomes and stress granules after neuronal injury by arsenite stress or in vivo hippocampal electrode insertion. *Journal of Neuroscience* **2006,** 26, (9), 2413-2418.

Kubose, T. T.; **Bock, K.; Dell, G. S.; Garnsey, S. M.; Kramer, A. F.;** Mayhugh, J., The effects of speech production and speech comprehension on simulated driving performance. *Applied Cognitive Psychology* **2006,** 20, (1), 43-63.

Ralston T.R.; Marks D.L.; **Carney P.S.; Boppart S.A.**, Inverse scattering for optical coherence tomography. *Journal of the Optical Science of America A* **2006**, 23, 1027-1037.

Romanova, E. V.; Oxley, S. P.; Rubakhin, S. S.; **Bohn, P. W**.; **Sweedler, J. V**., Self-assembled monolayers of alkanethiols on gold modulate electrophysiological parameters and cellular morphology of cultured neurons. *Biomaterials* **2006,** 27, (8), 1665-1669.

Rykhlevskaia, E.; **Fabiani, M.**; **Gratton, G.**, Lagged covariance structure models for studying functional connectivity in the brain. *NeuroImage* **2006**, 30, (4), 1203-1218.

Toublan, F. J. J.; **Boppart, S.; Suslick, K. S.,** Tumor targeting by surface-modified protein microspheres. *Journal of the American Chemical Society* **2006,** 128, (11), 3472-3473.

Xu, C. Y.; Vinegoni, C.; Ralston, T. S.; Luo, W.; Tan, W.; **Boppart, S. A.,** Spectroscopic spectral-domain optical coherence microscopy. *Optics Letters* **2006,** 31, (8), 1079-1081.

FACULTY AWARDS, PATENTS, GRANTS AND SELECT PUBLICATIONS

For a complete list visit www.beckman.uiuc.edu.

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*
Corina 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*
Fei Fei Li, *Electrical and Computer Engineering*
Jean A. Ponce, *Computer Science*
Dan Roth, *Computer Science*
Yoshihisa Shinagawa, *Electrical and Computer Engineering*
Richard W. Sproat, *Linguistics*

Human Perception and Performance

David E. Irwin, *Psychology*
Alex C. Kirlik, *Institute of Aviation*
Arthur F. Kramer, *Psychology*
Charissa Lansing, *Speech and Hearing Science*
Alejandro Lleras, *Psychology*
Edward McAuley, *Kinesiology*
Jason S. McCarley, *Institute of Aviation*
Deana McDonagh, *Art and Design*
Dan G. Morrow, *Institute of Aviation*
Karl S. Rosengren, *Kinesiology*
Daniel J. Simons, *Psychology*
Jesse B. Spencer-Smith, *Psychology*
Elizabeth A. Stine-Morrow, *Educational Psychology*
Ranxiao Wang, *Psychology*
Douglas A. Wiegmann, *Institute of Aviation*

Image Formation Processing

Minh N. Do, *Electrical and Computer Engineering*
Robert M. Fossum, *Mathematics*
George Francis, *Mathematics*
Thomas S. Huang, *Electrical and Computer Engineering*
Yi Ma, *Electrical and Computer Engineering*
Pierre Moulin, *Electrical and Computer Engineering*

SELECTED HONORS AND AWARDS

Narendra Ahuja
Associate in the Center for Advanced Study, UIUC, 2005-06

Roxana Girju
Center for Advanced Study Award (editorial position at Computational Linguistics Journal) UIUC, 2006

Thomas S. Huang
Okawa Prize for Information and Telecommunications Technology, Okawa Foundation, Japan, 2005
2006 Electronic Imaging Scientist of the Year Award from the Society for Imaging Science and Technology, and SPIE: The International Society for Optical Engineering
Pioneering Research in Picture Coding Award at the 25th International Picture Coding Symposium

David E. Irwin
Fellow, American Psychology Society

Fei-Fei Li
International Conference on Computer Vision (ICCV), Best Short Course Award, IEEE, 2005
Microsoft Research New Faculty Fellowship Award

Edward McAuley
Fellow, Gerontological Society of America, June, 2005
Fellow, Society of Behavioral Medicine, March, 2005

SELECTED GRANTS AWARDED

(Beckman Faculty members in bold.)

Narendra Ahuja and Charlotte Barkan: Transportation Research Board, "Machine vision for improved safety inspection of rail-cars," *9/13/05-9/12/06*.

Mark Hasegawa-Johnson, **Thomas Huang**, Jon Gunderson, and Adrienne Perlman: NSF, "Audio visual distinctive-feature-based recognition of dysarthic speech," *11/15/05-10/31/08*.

Mark Hasegawa-Johnson, Adrienne Perlman, **Thomas Huang**, Jon Gunderson, and **Kenneth Watkin**: NIH, "Description and recognition of audible and visible dysarthric phonology," *4/1/06-3/31/08*.

Mark Hasegawa-Johnson, **Chi-Lin Shih**, and **Jennifer Cole**: NSF, "Prosodic & voice quality correlates of disfluency," *5/16/06-7/31/07*.

Mark Hasegawa-Johnson, Adrienne Perlman, **Thomas Huang**, Jon Gunderson: NSF, "Audio visual distinctive-feature-based recognition of dysarthic speech," *5/1/06-10/31/06*.

Thomas Huang and **Jesse Spencer-Smith**: Yamaha Motor Corp Ltd, "Computer recognition of face, gender, and age group," *4/1/05-12/31/05*.

Thomas Huang: Microsoft, "Unrestricted contribution for conduct of research," *10/1/05-9/30/06*.

Arthur Kramer, **Edward McAuley**, and **Neal Cohen**: NIH, "Influence of Fitness on Brain and Cognition," *7/15/05-6/30/10*.

Arthur Kramer, **Daniel Simons**, **Gabriele Gratton**, and **Monica Fabiani**: ONR, "A cognitive neuroscience approach for enhancing warfighter training & performance," *9/15/05-6/14/06*.

Charissa Lansing, **Arthur Kramer**, **Jont Allen**, **Mark Hasegawa-Johnson**, and **Jason McCarley**: Qualcomm, "Annoying cell phone research evidence," *1/1/06-12/31/06*.

Silvio Savarese and **Fei Fei Li**: NSF-CA Inst of Technology, "3D perception of specular surfaces," *11/1/05-2/28/08*.

SELECTED PUBLICATIONS

(Beckman Faculty members in bold.)

Allen, J. B., Consonant recognition and the articulation index. *Journal of the Acoustical Society of America* **2005,** 117, (4), 2212-2223.

Choi, J. Y.; **Hasegawa-Johnson, M.; Cole, J.,** Finding intonational boundaries using acoustic cues related to the voice source. *Journal of the Acoustical Society of America* **2005,** 118, (4), 2579-2587.

Do, M. N.; Vetterli, M., The contourlet transform: An efficient directional multiresolution image representation. *IEEE Transactions on Image Processing* **2005,** 14, (12), 2091-2106.

Erickson, K. I.; Colcombe, S. J.; Raz, N.; Korol, D. L.; Scalf, P.; **Webb, A.; Cohen, N. J.; McAuley, E.; Kramer, A. F.,** Selective sparing of brain tissue in postmenopausal women receiving hormone replacement therapy. *Neurobiology of Aging* **2005,** 26, (8), 1205-1213.

Hannula, D. E.; **Simons, D. J.; Cohen, N. J.,** Opinion - Imaging implicit perception: promise and pitfalls. *Nature Reviews Neuroscience* **2005,** 6, (3), 247-255.

Lleras, A.; Rensink, R. A.; Enns, J. T., Rapid resumption of interrupted visual search. *Psychological Science* **2005,** 16, (9), 684-688.

Morrow, D. G.; Miller, L. M. S.; Ridolfo, H. E.; Menard, W.; **Stine-Morrow, E. A. L.;** Magnor, C., Environmental support for older and younger pilots' comprehension of air traffic control information. *Journals of Gerontology Series B-Psychological Sciences and Social Sciences* **2005,** 60, (1), P11-P18.

Motl, R. W.; **McAuley, E.;** Snook, E. M., Physical activity and multiple sclerosis: a meta-analysis. *Multiple Sclerosis* **2005,** 11, (4), 459-463.

Moulin, P.; Koetter, R., Data-hiding codes. *Proceedings of the IEEE* **2005,** 93, (12), 2083-2126.

Wu, Y.; Lin, J.; **Huang, T. S.,** Analyzing and capturing articulated hand motion in image sequences. *IEEE Transactions on Pattern Analysis and Machine Intelligence* **2005,** 27, (12), 1910-1922.

FACULTY AWARDS, PATENTS, GRANTS AND SELECT PUBLICATIONS

For a complete list visit www.beckman.uiuc.edu.

3-D Micro- and Nanosystems
Paul Bohn, *Chemistry*
Paul Braun, *Materials Science and Engineering*
Sahraoui Chaieb, *Mechanical and Industrial Engineering*
Nick Fang, *Mechanical and Industrial Engineering*
Paul J. Kenis, *Chemical and Biomolecular Engineering*
Deborah Leckband, *Chemical and Biomolecular Engineering*
Chang Liu, *Electrical and Computer Engineering*
Yi Lu, *Chemistry*
John A. Rogers, *Materials Science and Engineering*
Mark Shannon, *Mechanical and Industrial Engineering*
Stephen G. Sligar, *Biochemistry*
Pierre Wiltzius, *Physics*

Automomous Materials Systems
Ioannis Chasiotis, *Aerospace Engineering*
Jonathan Freund, *Theoretical and Applied Mechanics*
Philippe Geubelle, *Aerospace Engineering*
Jeffrey S. Moore, *Chemistry*
Nancy R. Sottos, *Theoretical and Applied Mechanics*
Scott R. White, *Aerospace Engineering*

Computational Multiscale Nanosystems
Narayana R. Aluru, *General Engineering*
Andreas Cangellaris, *Electrical and Computer Engineering*
John Georgiadis, *Mechanical and Industrial Engineering*
Eric Jakobsson, *Molecular and Integrative Physiology*
Umberto Ravaioli, *Electrical and Computer Engineering*

Computational Electronics
Karl Hess, *Electrical and Computer Engineering*
Jean-Pierre Leburton, *Electrical and Computer Engineering*
Richard M. Martin, *Physics*
Walter Philipp, *Statistics*

Nanoelectronics
Martin Gruebele, *Chemistry*
Joseph W. Lyding, *Electrical and Computer Engineering*
Gregory Timp, *Electrical and Computer Engineering*

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

SELECTED HONORS AND AWARDS

Paul W. Bohn
Clifford C. Hach Lecturer, Univ. of Wyoming, 2005
Bomem-Michelson Award, Coblentz Society, 2005

Sahraoui Chaieb
Fellow of the Center for Advanced Study, UIUC, 2005-2006

Ioannis Chasiotis
Best Research Paper Award, 6TH International Symposium on MEMS and Nanotechnology, Annual, Meeting of the Society for Experimental Mechanics, Portland, OR.

Nicholas X. Fang
One of 14 faculty participants in the U. S.-Japan Young Researcher Exchange Program for Nanotechnology and Nanomanufacturing, NSF, 2006
The work of optical superlens listed by Web of Science as fast breaking paper of physics, April 2006

Martin Gruebele
Friedrich Wilhelm Bessel Research Award of the von Humboldt Society (Germany), awarded for Sept. 2005 - August 2006

Karl Hess
Member of the National Science Board

Eric Jakobsson
Donald B. McMullen Memorial Lecture in Biology at Monmouth College

Paul J. Kenis
Career Award, NSF, 2005

Jean-Pierre Leburton
Fellow, Electro-chemical Society, (October 2005)

Deborah E. Leckband
Fellow, American Association for the Advancement of Science

Yi Lu
IUPAC Young Observer Fellowship Award, US National Committee for the International Union of Pure and Applied Chemistry, 2005

Todd J. Martinez
Fellow, John D. and Catherine T. MacArthur Foundation
Fellow, American Physical Society

John A. Rogers
Selected for one of the "Top 10 Emerging Technologies," MIT's Technology Review, for stretchable silicon, 2006
Innovation Discovery Award, Champaign County Economic Development Council and the Vice Chancellor for Research of the University of Illinois, 2005
Selected as one of Scientific American's 50 research leaders, Scientific American, 2005

Mark A. Shannon
James W. Bayne Professor of Mechanical Engineering, UIUC, 2006
BP Innovation Award in Undergraduate Education, BP Foundation, 2006

Stephen G. Sligar
The Human Frontier Science Program Award, 2005
IC Gunsalus Endowed Professorship Award, 2005

Nancy R. Sottos,
Donald Biggar Willett Professorship, UIUC, 2005

Scott R. White
Donald Biggar Willett Professorship, UIUC, 2005

SELECTED PATENTS AND PATENT APPLICATIONS

(Beckman Faculty members in bold.)

Paul Bohn, **Jonathan Sweedler**, **Mark Shannon**, and Bruce Flachsbart: "Multilayer Microfluidic Nanofluidic Device," Publication date: March 14, 2006, Application No. 11/375,525.

Paul Braun, **Scott White** and Soo Hyoun Cho: "Self-Healing Coating System," Publication date: January 5, 2006, Application No. 60/756,841.

Chang Liu and Xuefeng Wang: "Multifunctional Probe Array System," Publication date: September 21, 2005, Application No. 60/719,158.

Chang Liu and Xuefeng Wang: "Multifunctional Probe Array System," Publication date: September 23, 2005, Application No. 11/234,401.

Chang Liu and David Bullen: "Electrostatic Nanolithography Probe Actuation Device and Method," Publication date: March 16, 2006, Application No. 11/377,629.

Chang Liu, Jack Chen, Jonathan Engel, and Nannan Chen: "Micromachined Artificial Haircells," Publication date: June 2, 2006, Application No. 60/810,800.

Yi Lu, Juewen Liu, and Debapriya Mazumdar: "Lateral Flow Devices," Publication date: March 16, 2006, Application No. 60/782,949.

Yi Lu, Juewen Liu, and Daryl Wernette: "Nanomaterial Error Correction," Publication date: June 9, 2006, Application No. 11/423,307.

Yi Lu and Juewen Liu: "Aptamer-Based Colorimetric Sensor," Publication date: August 10, 2005, Application No. 11/202,380.

Joseph Lyding and Scott Schmucker: "Nanometer-Scale Sharpening of Conductor Tips," Publication date: April 26, 2006, Application No. 60/794.924.

Joseph Lyding, **Jeffrey Moore**, and Larry Markoski: "Electrochemical Cells Comprising Laminar Flow Induced Dynamic Conducting Interfaces, Electronic Devices Comprising Such Cells, and Methods Employing Same," Publication date: July 29, 2005, Application No. 11/193,005.

Jeffery Moore, Haim Weissman, Hyeon Cho, and Kyle Plunkett: "Heterogeneous Alkyne Metathesis," Publication date: June 2, 2006, Application No. 11/422,004.

John Rogers, Coskun Kocabas, **Moonsub Shim**, Seong Kang: "Methods of Making Spatially Aligned Nanotubes and Nanotube Arrays," Publication date: March 3, 2006, Application No. 60/779,714.

John Rogers, Ralph Nuzzo, Menard Etienne, Dahl-Young Khang, Heung Cho Ko, Keon Jae Lee, Matthew Meitl, Yugang Sun, and Zhengtao Zhu: "Methods and Devices for Transfer and Assembly of Printable Semiconductor Devices," Publication date: April 7, 2006, Application No. 60/790,104.

John Rogers, Ralph Nuzzo, Menard Etienne, Dahl-Young Khang, Heung Cho Ko, Keon Jae Lee, Matthew Meitl, Yugang Sun, and Zhengtao Zhu: "Printable Semiconductor Structures and Related Methods of Making and Assembling," Publication date: June 1, 2006, Application No. 11/421,654.

John Rogers, Ralph Nuzzo, Menard Etienne, Dahl-Young Khang, Heung Cho Ko, Keon Jae Lee, Matthew Meitl, Yugang Sun, and Zhengtao Zhu: "Pattern Transfer Printing by Kinetic Control of Adhesion to an Elastomeric Stamp," Publication date: June 9, 2006, Application No. 11/423,192.

John Rogers, Ralph Nuzzo, Menard Etienne, Dahl-Young Khang, Heung Cho Ko, Keon Jae Lee, Matthew Meitl, Yugang Sun, and Zhengtao Zhu: "A Stretchable Form of Single Crystal Silicon for High Performance Electronics on Rubber Substrates," Publication date: June 9, 2006, Application No. 11/423,287.

Stephen Sligar and Timothy Bayburt: "Membrane Scaffold Proteins and Tethered Membrane Proteins," Publication date: May 23, 2006, Application No. 11/439,458.

Stephen Sligar and Timothy Bayburt: "Membrane Scaffold Proteins and Embedded Membrane Proteins," Publication date: May 23, 2006, Application No. 11/432,466.

Stephen Sligar: "Membrane Scaffold Proteins," Issue date: May 23, 2006, Patent No. 7/048,949.

Stephen Sligar, James Morrissey, and Vincent Pureza: "Tissue Factor Compositions and Methods," Publication date: October 27, 2005, Application No. 11/259,950.

Scott White, **Nancy Sottos**, and Michael Keller: "Self-Healing Elastomer System," Publication date: June 2, 2006, Application No. 11/421,993.

SELECTED GRANTS AWARDED

(Beckman Faculty members in bold.)

Paul Braun and **Scott White**: ONR-TRECC, "Self-Healing Anti-Corrosion Polymer Coatings," *3/1/06-2/28/07*.

Eric Jakobsson, **Narayana Aluru**, and **Umberto Ravaioli**: NIH, "National center for design of biomimetic nanoconductors," *9/30/05-9/9/10*.

Klaus Schulten: NREL, "Structural, Functional, and Integration Studies on Bio-inspired Catalysts for Development of Bio-hybrid H2-production Systems," *1/1/06-12/31/08*.

Klaus Schulten and **Emad Tajkhorshid**: NIH, "Molecular mechanisms of cellular mechanics," *5/1/06-4/30/10*.

Nancy Sottos, Scott White, and **Jeffrey Moore**: Bayer Material Science, "Preparation and evaluation of isocyanate-filled microcapsules," *8/16/05-8/15/06*.

Gregory Timp, **Stephen Sligar**, **Jean Pierre Leburton**, and **Klaus Schulten**: NIH, "Sequencing a DNA molecule using a synthetic nanopore," *8/1/05-5/31/08*.

Scott White: AFOSR, "The 4th airforce workshop on multifunctional materials & structures," *5/1/05-9/30/06*.

SELECTED PUBLICATIONS

(Beckman Faculty members in bold.)

Ahn, H.; Lee, K. J.; Shim, A.; **Rogers, J. A.**; Nuzzo, R. G., Additive soft-lithographic patterning of submicrometer- and nanometer-scale large-area resists on electronic materials. *Nano Letters* **2005,** 5, (12), 2533-2537.

Aksimentiev, A.; Heng, J. B.; Cruz-Chu, E. R.; **Timp, G.**; **Schulten, K.**, Microscopic kinetics of DNA translocation through synthetic nanopores. *Biophysical Journal* **2005,** 88, (1), 352A-352A.

Ballard, J. B.; Carmichael, E. S.; Shi, D. X.; **Lyding, J. W.**; **Gruebele, M.**, Laser absorption scanning tunneling microscopy of carbon nanotubes. *Nano Letters* **2006,** 6, (1), 45-49.

Chang, I. H.; Tulock, J. J.; Liu, J. W.; Kim, W. S.; Cannon, D. M.; **Lu, Y.; Bohn, P. W.**; **Sweedler, J. V.**; Cropek, D. M., Miniaturized lead sensor based on lead-specific DNAzyme in a manocapillary interconnected microfluidic device. *Environmental Science & Technology* **2005,** 39, (10), 3756-3761.

Cho, S.H.; Andersson, H.M.; **White, S.R.**; **Sottos, N.R.**; **Braun, P.**, Environmentally stable polydimethysiloxane-based self-healing of polymers, *Advanced Materials* 18 (8), 997-1000 (2006).

Freddolino, P. L.; Arkhipov, A. S.; Larson, S. B.; McPherson, A.; **Schulten, K.**, Molecular dynamics simulations of the complete satellite tobacco mosaic virus. *Structure* **2006,** 14, (3), 437-449.

Gratson, G. M.; Garcia-Santamaria, F.; Lousse, V.; Xu, M. J.; Fan, S. H.; Lewis, J. A.; **Braun, P. V.**, Direct-write assembly of three-dimensional photonic crystals: Conversion of polymer scaffolds to silicon hollow-woodpile structures. *Advanced Materials* **2006,** 18, (4), 461-465.

Heng, J. B.; **Aksimentiev, A.**; Dimitrov, V.; Grinkova, Y.; Ho, C.; Marks, P.; **Schulten, K**.; **Sligar, S.**; **Timp, G.**, Stretching DNA using an artificial nanopore. *Biophysical Journal* **2005,** 88, (1), 659A-659A.

Ho, C.; Qiao, R.; Heng, J. B.; Chatterjee, A.; Timp, R. J.; **Aluru, N. R.; Timp, G.,** Electrolytic transport through a synthetic nanometer-diameter pore. *Proceedings of the National Academy of Sciences of the United States of America* **2005**, 102, (30), 10445-10450.

Jakobsson, E.; Chiu, S. W.; Khelashvili, G. A.; Mashl, R. J.; Pandit, S.; Scott, H. L., Multiscale simulation and analysis of membranes. *Biophysical Journal* **2005,** 88, (1), 32A-33A.

Jones, A. S.; Rule, J. D.; **Moore, J. S.**; **White, S. R.**; **Sottos, N. R.**, Catalyst morphology and dissolution kinetics of self-healing polymers. *Chemistry of Materials* **2006,** 18, (5), 1312-1317.

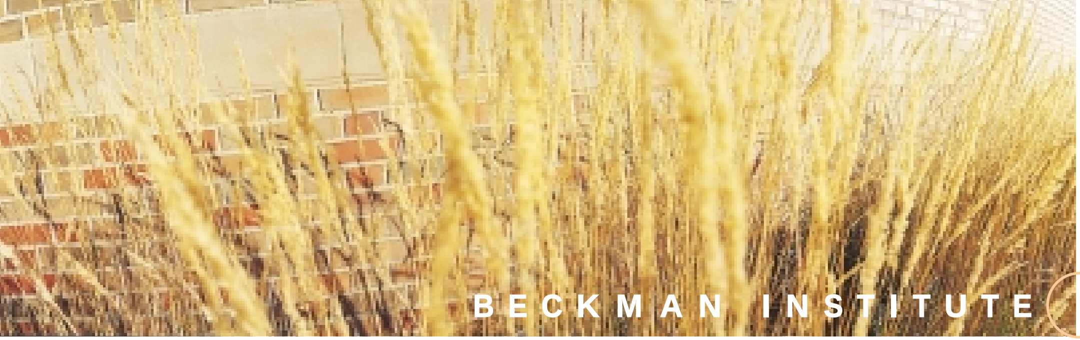
Khang, D. Y.; Jiang, H. Q.; Huang, Y.; **Rogers, J. A.**, A stretchable form of single-crystal silicon for high-performance electronics on rubber substrates. *Science* **2006,** 311, (5758), 208-212.

Kuroda, M. A.; **Cangellaris, A.**; **Leburton, J. P.**, Nonlinear transport and heat dissipation in metallic carbon nanotubes. *Physical Review Letters* **2005,** 95, (26).

Lu, D. Y.; Li, Y.; **Ravaioli, U.**; **Schulten, K.**, Ion-nanotube terahertz oscillator. *Physical Review Letters* **2005,** 95, (24).

Meitl, M. A.; Zhu, Z. T.; Kumar, V.; Lee, K. J.; Feng, X.; Huang, Y. Y.; Adesida, I.; Nuzzo, R. G.; **Rogers, J. A.**, Transfer printing by kinetic control of adhesion to an elastomeric stamp. *Nature Materials* **2006,** 5, (1), 33-38.

Rule, J. D.; Brown, E. N.; **Sottos, N. R.**; **White, S. R.**; **Moore, J. S.,** Wax-protected catalyst microspheres for efficient self-healing materials. *Advanced Materials* **2005,** 17, (2), 205-208.



BECKMAN INSTITUTE FUNDING 2005–2006[1]

Funding Awarded to Beckman Institute Faculty Administered by the Beckman Institute[2]

	FY02	FY03	FY04	FY05	FY06
Department of Defense	4,591,675	1,844,543	7,753,629	6,611,130	292,400
National Institutes of Health	3,250,386	7,116,945	5,787,586	3,702,180	19,934,911
National Science Foundation	4,446,613	3,720,355	1,049,941	4,151,987	1,588,341
Other	2,227,403	2,307,003	244,602	386,400	974,903
Total	**14,516,077**	**14,988,846**	**14,835,740**	**14,851,697**	**22,790,555**

Funding Awarded to Beckman Institute Faculty Administered by Other Departments[3]

	FY02	FY03	FY04	FY05	FY06
Department of Defense	3,604,747	3,995,832	*	*	*
National Institutes of Health	3,090,999	7,796,747	*	*	*
National Science Foundation	6,118,599	8,046,120	*	*	*
Other	2,953,591	1,709,599	*	*	*
Total	**15,767,936**	**21,248,298**	*	*	*

[1] In addition to the sources itemized in the chart, funding for the Beckman Institute is received from the following:

1. The state of Illinois to the University of Illinois and allocated through individual departments:
   - Faculty Salaries
2. The state of Illinois to the Beckman Institute:
   - Daily Operating Expenses
3. The Arnold and Mabel Beckman Foundation
   - Beckman Institute Fellows Program
   - Beckman Institute Graduate Fellows Program
   - Beckman Institute Equipment Competition

[2] All interdisciplinary grants with faculty investigators from multiple departments are administered by the Beckman Institute. Total funding for multi-year grants is reported in the fiscal year of the award.

[3] All single disciplinary grants, i.e., those with PIs and co-PIs from a single Department, are administered by the investigator's home department.

* Data for FY04, FY05, FY06 are not available at the time of printing due to the transition at UIUC to a new administrative system.

KARL HESS RETIRES

"Karl is an irreplaceable asset who helped shape the Beckman Institute as much as anyone in its history," Wiltzius said. "He has that rare combination of being a great man of science and a visionary. I greatly value his insights and advice. He also is one of the finest people you will ever meet, and he will be greatly missed at Beckman."

PHOTO BY STEVE MCGAUGHEY, BECKMAN INSTITUTE

Karl Hess, one of the guiding forces behind the creation of the Beckman Institute, retired in May after nearly three decades at the University of Illinois at Urbana-Champaign.

Hess' achievements have been historic enough to satisfy any scientist's lifetime goals. His work in electron transport was recognized worldwide as he forged a career that made important contributions to fields such as semiconductor physics and optoelectronics. He holds the rare distinction of selection as a Fellow to both the National Academy of Sciences and the National Academy of Engineering. Hess has been a valued teacher, mentor, and collaborator to hundreds of students, postdoctoral researchers, and colleagues.

At the Beckman Institute for Advanced Science and Technology, Hess is considered one of its founding fathers. He took part in early discussions about building an interdisciplinary research center on the U of I campus, and chaired one of two committees formed to foster proposals for such a facility. After the Beckman Institute opened in 1989, Hess served first as an associate director and later as co-chair of the Molecular and Electronic Nanostructures research initiative when it was formed in 1994.

Beckman Institute Director Pierre Wiltzius said that he has relied on Hess' counsel over the years.

"Karl is an irreplaceable asset who helped shape the Beckman Institute as much as anyone in its history," Wiltzius said. "He has that rare combination of being a great man of science and a visionary. I greatly value his insights and advice. He also is one of the finest people you will ever meet, and he will be greatly missed at Beckman."

Hess won't be retiring completely. He plans to continue his research efforts and will serve on the 24-member National Science Board, which sets policy for the National Science Foundation and advises the President and Congress on the nation's science priorities.

BECKMAN INSTITUTE CONTACT INFORMATION

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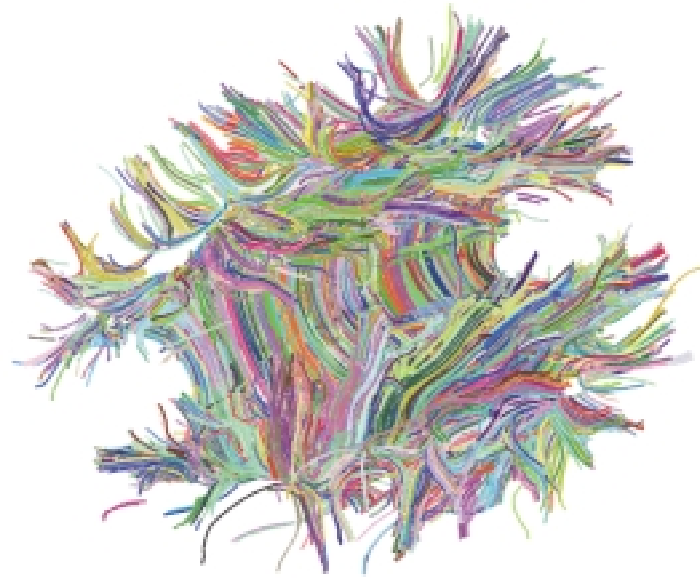

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