2001

Annual Report

Beckman Institute
for Advanced Science
And Technology

University of Illinois at Urbana-Champaign

Contents

This year was marked by changes and transitions for the Beckman
retired in August. I would like to take the opportunity to reflect
during his tenure at the helm of the Institute. It was under his
were put in place. As you will read in the following pages, all
Human Computer Intelligent Interaction (HCII), and Molecular

Institute. Dr. Jiri Jonas, who had been the Director since 1993,

on the outstanding accomplishments that Dr. Jonas achieved

leadership that the current programmatic research themes

three Main Research Themes—Biological Intelligence (BI),

and Electronic Nanostructures (M&ENS)—are thriving.

INTRODUCTION

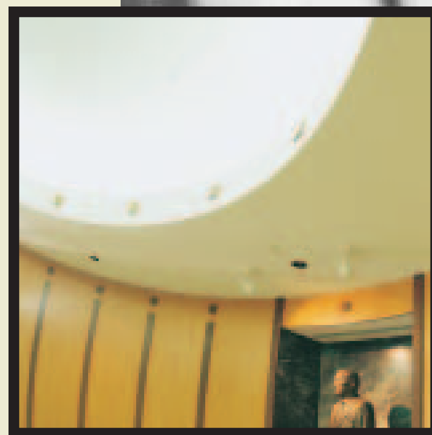
Message From the Director

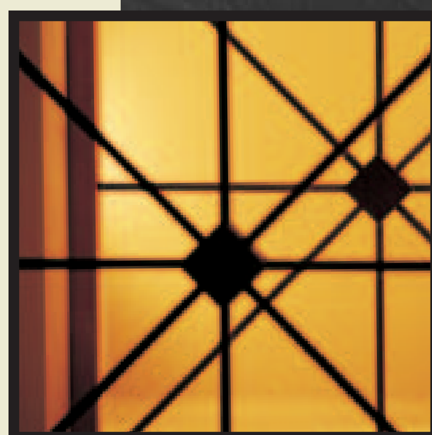
As a testimony to Dr. Jonas' vision, the themes are still remarkably well-suited to attract researchers across many academic disciplines to engage in multidisciplinary research on important questions that are too complex to be solved by a single-discipline approach.

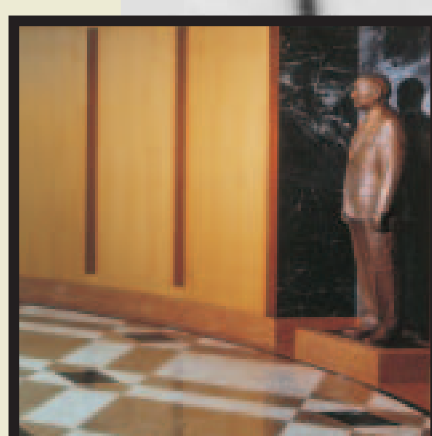
The research groups of the Beckman Institute have been able to expand the level of activities and their funding substantially over the past few years. In the BI Main Research Theme, (MRT) this includes two ongoing programs on learning and memory funded by the National Science Foundation. In addition, the functional brain-imaging project, after significant investment from the Beckman Institute and the campus, has received several new grants in 2001 from the National Institutes of Health, the Institute for the Study on Aging, and the National Science Foundation. Researchers in the HCII Main Research Theme recently received significant funding from the General Motors Corporation to carry out research in the area of driver performance and safety. There are also two large, ongoing multidisciplinary grants in the HCII MRT funded by the National Science Foundation's Information Technology (ITR) program. In the M&ENS Main Research Theme, researchers have been awarded a Nanoscale Interdisciplinary Research Teams (NIRT) grant from the National Science Foundation.

Since assuming my new position on September 21, 2001, I have been immersing myself in my new responsibilities. Above all is our vision to strengthen the Institute's status as a world-class, leading edge, interdisciplinary research organization. In its relatively short life, it has reached a unique and ambitious position, and it is my goal to lead it to yet greater heights.

During the past several months I have spent a substantial amount of time getting to know in detail the various research programs. Both the breadth and the depth of these activities continuously impress me. As part of the periodic evaluation process, the HCII program was reviewed in October with the help of a Program Review Committee composed of outside experts. In particular, HCII received very high marks for its activities, placing it at the forefront of its field. Some recommendations by the Review Committee for additional research directions, which we







will address, include haptics ("touch and feel"), computer vision and psychophysics, and graphics expertise in artificial intelligence.

One aspect of the Beckman Institute's activities is the protection and capitalization of valuable intellectual property. I am looking forward to increased interactions with the new Campus Office of Technology Management. A recent example is the licensing of patents on the intelligent hearing aid, which was developed by BI researchers, to the Swiss company Phonak. Phonak has also established a presence in the University's South Research Park, with the goal of incorporating the Beckman technologies into their existing line of hearing aids.

Needless to say, in these times of success for the Beckman Institute, we have to also look for new opportunities and areas of growth. We would like to increase the biological side of M&ENS

and in particular the development of new tools and techniques useful for BI and HCII. In the following pages you will find examples in that direction: optical coherence tomography; biological membranes as miniaturized sensors, devices, and systems; and self-generating and self-healing materials. We also look forward to the creation of a Department of Bioengineering on campus, which should provide further stimuli, and the enhancement of the magnetic resonance imaging (MRI) capabilities with a new 3T full-head machine and a micro-MRI, which can be used to study biological tissue with micron resolution.

In March, I had the opportunity to visit with Dr. Beckman. Needless to say, he is a tremendous inspiration for all of us, and we have greatly benefited from his vision.

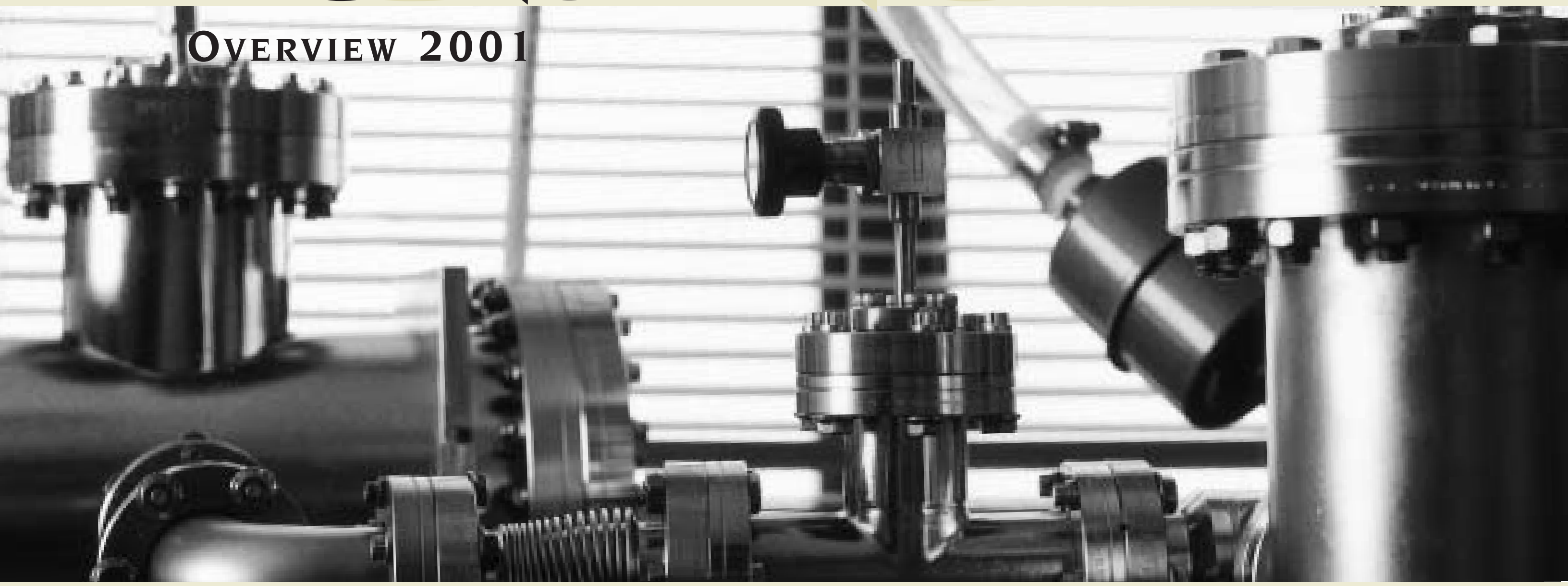
—Pierre Wiltzius, Director

M&ENS

Molecular and Electronic Nanostructures

Research in the area of Molecular and Electronic Nanostructures has seen some major qualitative shifts in the past year, which can be seen as a consequence and fruition of the interdisciplinary mission of the Beckman Institute and its orientation toward

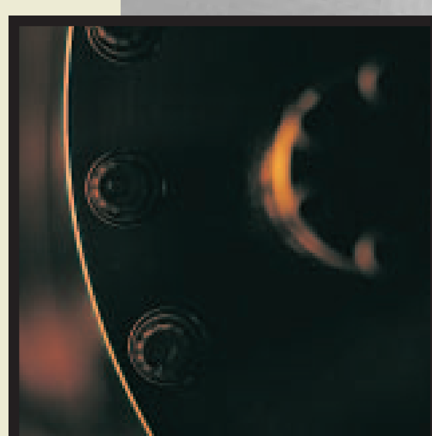
APPLICATIONS. THIS IS PARTICULARLY SO IN AREAS THAT COMBINE BIOLOGY, AND THE PHYSICAL AND CHEMICAL SCIENCES. THESE EFFORTS ARE DIRECTED ALONG BOTH FUNDAMENTAL AND TECHNOLOGICAL FRONTS WITH THE AIM OF UNDERSTANDING AND MIMICKING BIOLOGICAL PROCESSES.



The Photonics Group has taken a major turn toward medical applications under the leadership of Professor Stephen Boppart. His research centers on the early detection of cells or bio-molecules that are precursors to cancer. Professor Boppart's research group has constructed an optical coherence tomography system that is capable of resolution on the micrometer scale and thus provides opportunities for a variety of medical and biological applications.

Groups emphasizing computation and simulation have made major steps toward the simulation of biological ion-channels. Professors Narayana Aluru, Umberto Ravaioli, and Karl Hess have demonstrated the use of software that was developed in the computational electronics area for the simulation of these channels. They have also received funding from the Defense Advanced Research Projects Agency to investigate ionic channels in biological membranes used as miniaturized sensors, devices, and systems. This work is performed in collaboration with the Rush Medical Center, Chicago (Richard Eisenberg) and with the groups of professors Klaus Schulten and Erik Jakobsson. Professor Schulten's group has achieved significant progress in the area of biological channels. Highlights of their 2001 research include the study of aquaporins, which are channel proteins abundantly present in all life forms. The simulations revealed in unprecedented detail how cells conduct water and glycerol.

Quantum computation emerges as a major area of collaboration. The work over the past years on quantum wells, wires, and dots has developed to include the area of spintronics. This, in turn, has stimulated investigations related to quantum computing. Professor Jean-Pierre Leburton is collaborating with an international team on designing elements suitable for use in a future quantum computer. Professors Hess and Walter Philipp have devoted considerable efforts to the theoretical foundations of quantum computing, particularly to Bell's Theorem. They have shown that Bell's Theorem does



M&ENS

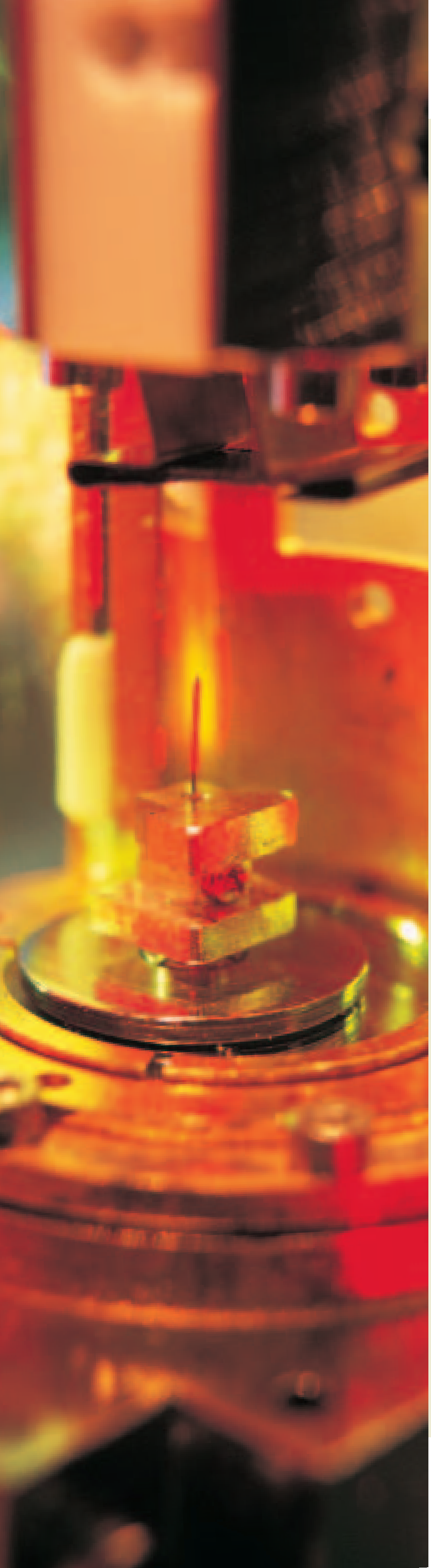
not include time-related parameters and therefore lacks the generality that is usually ascribed to it. The consequences for the assessment of quantum information complexity are currently being investigated.

Scanning tunneling microscopy and lithography continues to be central to a number of research collaborations. Professor Joseph Lyding continues collaborations related to functional group chemistry on silicon surfaces passivated by hydrogen (with Professor Jeffrey Moore) and has also established a new research program related to carbon nanotubes in collaboration with two Beckman Fellows (Slava Rotkin and Lolita Rotkina). This work has a strong emphasis on nano-electromechanical systems (NEMS) and explores, in collaboration with Professor Aluru, applications in the area of sensing and the development of integrated NEMS systems. A new National Science Foundation grant, titled "Protein Logic," combines the efforts of eight Beckman investigators from five

departments toward the goal of fabricating cellular neural network architectures that merge molecular nano-biotechnology with silicon integrated circuit technology.

New faculty additions to the Molecular and Electronic Nanostructures MRT have opened areas in materials synthesis and engineering. The biologically inspired concept of self-healing is an effort being undertaken by professors Scott White, Nancy Sottos, Jeffrey Moore, and Paul Braun. The past year saw major progress on this project, which aims to achieve automatic repair in structural materials. New developments in other materials areas include the fabrication of nanoscale and microscale structures for chemical and biological sensors (professors Paul Bohn, Mark Shannon, and Jonathan Sweedler) and the creation and study of new hyperbranched polymers (Professor Moore).

Karl Hess and Jeffrey S. Moore, Co-chairs



M&ENS

HIGHLIGHTS 2001

- Professor **Stephen Boppart's** Biophotonics Imaging Laboratory is continuing to develop novel optical techniques for biomedical imaging and diagnostics at the cellular level. A major research focus is the early detection of cells or biomolecules that are precursors to cancer. Professor Boppart's research group has constructed an optical coherence tomography (OCT) system for micron-scale resolution imaging in highly scattering tissues. This OCT system has diverse medical and biological applications. Professor Boppart is also teaming up with professors Lutgarde Raskin (Civil and Environmental Engineering), David Brady (Duke University), and former Beckman Institute Fellow Michal Balberg to investigate how OCT and multi-photon microscopy can be used to assess and refine design parameters in microfluidic mixing and bioMEM (micro electromechanical) systems. Three-dimensional structural and functional imaging will be performed as molecular beacons flow through microfluidic systems and serve as optical markers for identifying bacteria in environmental and biological fluids. A project recently funded jointly by the National Aeronautics and Space Administration and the National Institute of Health's National Cancer Institute involves an interdisciplinary collaboration between Professor Boppart, professors **Martin Gruebele** and Dana Dlott (Chemistry), and Professor Barbara Kitchell (Veterinary Medicine). This project's goal is to develop non-linear optical techniques for OCT to identify the 3D spatial distribution of specific biomolecular precursors to cancer in living tissue.

- As part of grant funded by the Defense Advanced Research Projects Agency, professors **Narayana Aluru**, **Karl Hess**, **Umberto**

Ravaioli, and **Eric Jakobsson**, in collaboration with researchers at the Rush Medical Center, Chicago, are investigating ionic channels in biological membranes as miniaturized sensors, devices, and systems. The research team is developing continuum, molecular, and multiscale computational design tools to investigate the conduction, selectivity, and sensitivity properties of ion channels. An important aspect of the research is to understand the gating mechanisms exhibited by channels and to engineer the concepts to develop nanoscale sensors and devices. Using the continuum theory-based computational design tools, the team was able to predict experimental data for two well-known ion channels—gramicidin and porin. The researchers are currently investigating the gating mechanisms of these two channels.

□ A major breakthrough in new materials was achieved this year with the development of autonomic healing polymers and composites. These self-healing materials have the ability to automatically repair internal damage whenever and wherever it occurs, prolonging the life of polymers in everything from microelectronics to airplanes. This self-healing action is achieved by the incorporation of a microencapsulated healing agent and an embedded catalyst within a polymer matrix. Professor **Scott White** leads a team of researchers, including professors **Jeffrey Moore**, **Nancy Sottos**, and Philippe Geubelle (Aeronautical and Astronautical Engineering), on this Air Force Office of Scientific Research-sponsored project. Carefully controlled fracture toughness testing has revealed that an epoxy system utilizing a dicyclopentadiene healing agent and Grubbs' catalyst will recover 90% of the virgin mechanical toughness after healing. Current research is focused on optimizing the materials system and assessing the healing efficiency under a variety of external conditions. This work is part of a broader-based effort in autonomic materials systems, encompassing both self-generation and self-regulation functions in one integrated materials system.

□ A new National Science Foundation Nanoscale Interdisciplinary Research Teams grant, titled



"Protein Logic," combines the efforts of eight Beckman investigators from five departments toward the goal of fabricating cellular neural network architectures that merge molecular nanobiotechnology with silicon IC technology. In this program, genetically engineered proteins (Professor **Stephen Sligar**) will be attached to atomically precise molecular templates. Professors **Jeffrey Moore** and **Joseph Lyding** are the principal investigators. The protein array will be embedded in a silicon CMOS transistor matrix (Professor **Gregory Timp**), in which the transistors serve as two-way transducers of chemical information into and out of the protein array. Optical characterization of array activity (professors **Stephen Boppart** and **Martin Gruebele**), and the design and characterization of its associated microfluidic and diffusion aspects (professors **Narayana Aluru** and **Paul Braun**) will be integral parts of the program. Also participating in this program is Professor Leon Chua at the University of California at Berkeley, a world-renowned expert in cellular neural network functionality. Silicon IC wafers for the program are being provided by Lucent Technologies, Inc.

The members of the Theoretical Biophysics Group (professors **Klaus Schulten**, **Laxmikant Kale**, **Todd Martínez**, and **Robert Skeel**) and the National Institutes of Health's Resource for Macromolecular Modeling and Bioinformatics (RMMB) (www.ks.uiuc.edu/), have continued their diverse efforts at the forefront of research and technology development. Members have made significant contributions to the areas of interactive modeling, structure prediction of biomolecular assemblies, and molecular recognition and assembly. Recent highlights in 2001 include the study of a ubiquitous membrane channel, aquaporin. Aquaporins are channel proteins abundantly present in all life forms, for example in bacteria and plants, as well as in kidneys, eyes, and brains of humans. These proteins conduct water and small molecules, but no ions, across the cell walls. Their defective forms are known to cause diseases, e.g., diabetes insipidus and cataracts. In one of the largest molecular dynamics simulations ever (over 100,000 atoms), the Theoretical Biophysics Group modeled aquaporins in their natural environment of membrane and water. The simulations revealed in unprecedented detail how cells conduct water and glycerol. The simulations provided a movie of the entire conduction process, and identified the conduction pathway and the mechanism of the channel selectivity and efficiency. The research has become possible through an interdisciplinary approach that involved the development of a powerful modeling program, NAMD (www.ks.uiuc.edu/Research/namd), by a team of computer scientists, physicists, and biologists, all members of the Theoretical Biophysics Group.

- Professors **Narayana Aluru**, **Joseph Lyding**, **Jean-Pierre Leburton**, and Alexey Bezryadin (Physics), along with Beckman Institute Fellows Slava Rotkin and Lolita Rotkina, were recently awarded a Critical Research Initiative grant from the campus to investigate carbon nanotubes for design and development of integrated nanoelectromechanical systems. The computational aspect of the research deals with development of fundamental physical theories for modeling and simulation of carbon nanotube-based nanoelectromechanical systems. Using sophisticated experimental approaches, the team is fabricating carbon nanotube-based nanoelectromechanical switches. The eventual goal of the project is to create computational design tools to enable rapid computational prototyping of mixed-technology nanoelectromechanical systems based on carbon nanotubes.

- The group of Professor **Karl Hess** has been working with Professor **Joseph Lyding's** group on a very basic idea: how does the smallness of modern semiconductor devices influence chip reliability. This idea grew out of the deuterium processing work of the past years and is based on the following. As devices get smaller, the number N of defects that disturb a device significantly becomes small. N is in the low double digits. For the next genera-

tion of chips, it is known from probability theory that under very general conditions, the probability P to find a particular transistor with N defects or to generate N defects on a transistor through the stress of normal operation is proportional to 1/N! (! stands for factorial). The number of devices on a chip is rising exponentially and approaches several tens of millions. If N =11, then N! equals about 40 million. Since this is smaller than the number of devices on future chips, it becomes virtually certain that a chip will contain fully damaged transistors, i.e., "lemons" or latent failures. The groups of professors Hess and Lyding have developed experimental and simulation methods that permit the prediction of the number of latent failures on a chip and have designed strategies to avoid them.

□ Over the past several years, studies as part of an Army Research Office-sponsored Multi-university Research Initiative involving professors **Jeffrey Moore**, Tony McHugh (Chemical Engineering), and others have led to a new general understanding that will enhance performance and facilitate processing of polymeric materials. The studies involve a combination of synthetic polymer chemistry, physical characterization, materials processing, and computer simulation. The new polymeric materials are known as polyether-imides, whose molecular architectures are continuously and systematically varied to cover a broad spectrum of branching from completely hyper-branched to linear. Through a combination of rheological and laser light scattering optical experiments, researchers have found a critical change in the molecular dimensions and associated flow properties for materials with fractions of linear-forming units of 0.8 or greater. Brownian dynamics mole cular simulations of dilute polymer solutions have provided fundamental insights to understand this important observation. The transition from a more or less globular hyper-branched structure

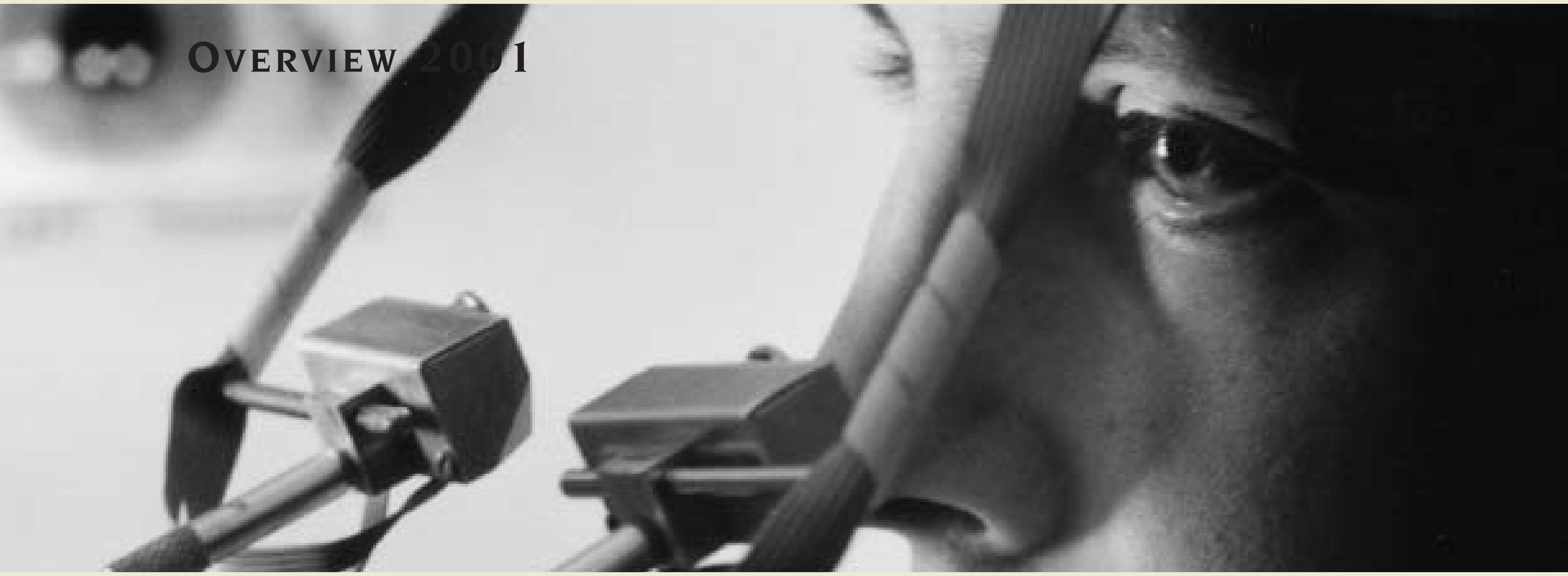
to a more linear and open structure can be predicted from first principles. For melts and concentrated polymer solutions, the molecular simulations have also been able to capture the evolution of strong viscoelastic effects associated with chain entanglements. This appears to be the first such complete experimental and theoretical characterization of the interaction of chain architecture and properties to be reported in the literature. A major outcome of this work is that there is now a rational scheme for using process characterizations and molecular simulations as feedback tools for optimizing the development of polymerization schemes to produce materials with desirable processing and end-use properties. Current studies focus on the combined effects of chain architecture and end-group functionality on the blending behavior of these new materials with more traditional homopolymers, such as polyethylene, polypropylene, and polystyrene. Characterization of the mechanical, optical, surface, and other properties of extruded films will be used as benchmarks for the types of property improvements that can be achieved with this new class of materials. Preliminary work with blends shows that branching and end-group functionality have significant effects on processing characteristics and surface properties. Characterization and further understanding of the role of these molecular variables will allow us to improve the processability and tune the surface properties of inexpensive traditional linear polymers. As an example, work is underway to design a hyper-branched polymer with fluorocarbon end-groups that will tune the surface properties of polyolefins to Teflon-like, at a fraction of the cost of Teflon.

HCII

Human-Computer Intelligent Interaction

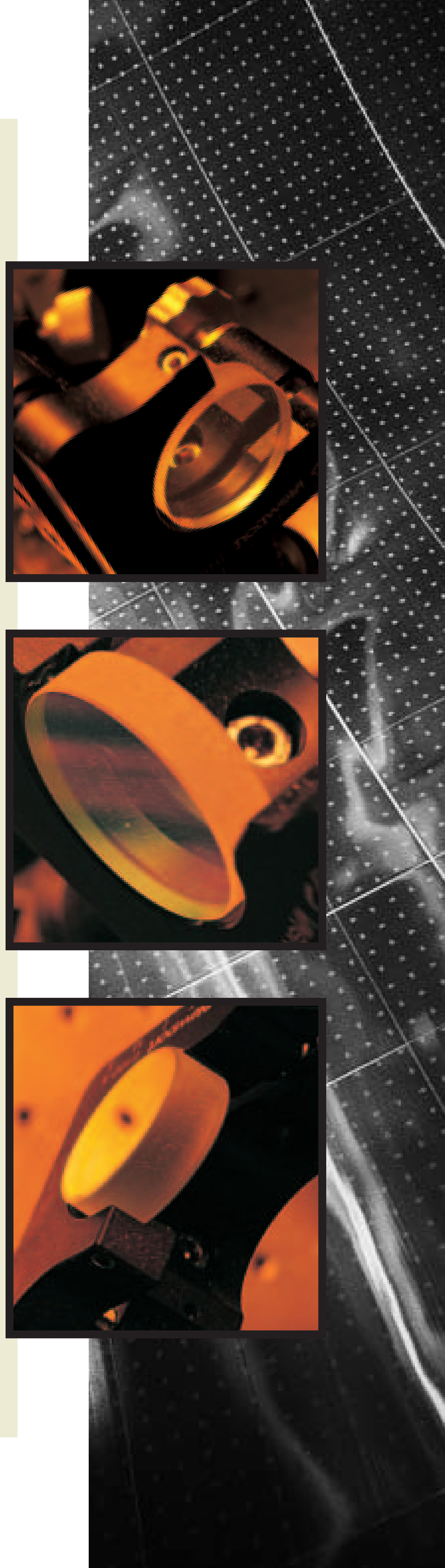
The Human Computer Intelligent Interaction (HCII) main research theme (MRT) seeks to enhance human-machine interface design through the optimization of state-of-the-art technology development and engineering of multimodal interface design concepts, along with an explication of mechanisms of human perception, cognition, and action of relevance to

complex systems. To this end, projects in the HCII MRT often involve the close collaboration of cognitive scientists, computer scientists, electrical engineers, human factors researchers, educational psychologists, kinesiologists, and linguists in pursuit of knowledge relevant to the design of interfaces for complex systems



A major goal of the MRT is the integration of the engineering and computer science expertise of the HCII faculty, graduate students, and post-doctoral students in the design and construction of hardware and software interfaces with the development of formal models of human perception, cognition, and action. The new Integrated Systems Laboratory, under the direction of Henry Kaczmarski, figures prominently in this endeavor.

During the past year, a number of new projects have begun, and other projects have continued to produce important new knowledge and products. For example, the General Motors Corporation has funded, through a series of grants and gifts, a new center for the study of driver safety and performance that has enabled a number of Beckman researchers to "scale-up" their interests in areas such as scene perception, multimodal attention, computational modeling of human performance, and adaptive human-machine interfaces to examine these issues in simulated high-fidelity environments such as driving. As part of this effort, the Beckman Institute has established a driving simulation facility that will be interfaced with other such facilities at universities and industry. The computer companion project, which is sponsored by the Yamaha Motor Corporation and involves a number of HCII faculty members and students, has made considerable progress in many areas, including image databases, graphical user interfaces for Web search, and intelligent agents. Researchers at the Beckman Institute have also recently been awarded a five-year, $3 million grant by the National Science Foundation's Information Technology Research Program. The main theme of this project is to make



HCII

computers and, more generally, information systems, more proactive in their interaction with the users. The test-bed of basic research results will be an educational task—helping middle-grade students to learn science and engineering concepts using Lego/ Mindstorms construction and robotics materials.

When the HCII MRT was first established in 1994, it was comprised of a diverse group of scientists and engineers who shared a common vision of integrated research teams pursuing basic and applied issues relevant to the design of better interfaces for human users of recreational, educational, industrial, and military systems. In the short time the theme has been in existence, HCII researchers have been able to turn their dream into a reality, as evidenced by their success in obtaining funding for a variety of

both large and small research and engineering projects whose goal has been to develop better human-computer interfaces. We fully expect the next decade will see continued development of a truly multidisciplinary approach to the study and design of intelligent human computer interfaces at the Beckman Institute.

Thomas Huang and Arthur F. Kramer, Co-chairs

HCII

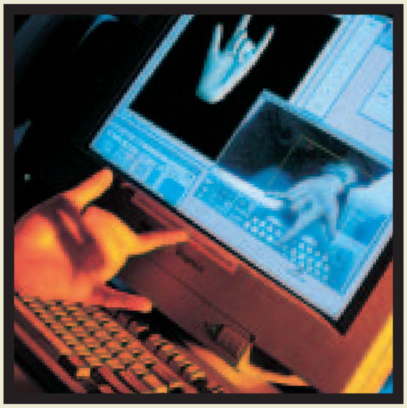
HIGHLIGHTS 2001

- In 2001, Beckman Institute researchers completed the fifth and final year of the Army Research Laboratory Project on Advanced Displays. During the past five years, researchers at the Beckman Institute, led by professors **Thomas Huang**, **Arthur Kramer**, and **George McConkie**, as well as collaborators at Rockwell Corporation, Sytronics Corporation, North Carolina Agricultural and Technical College, and the Army, have conducted basic and applied research on issues of relevance to the development of next-generation multimodal displays and intelligent decision aiding systems. For example, professors Huang and Kramer and their graduate students have developed and validated AVATARs (i.e., talking heads) as a means to enhance the comprehension of speech in noisy environments. Professors **Christopher Wickens**, Polly Baker, and Larry Shattuck (West Point Military Academy) have investigated the utility of two- and three-dimensional display concepts for the presentation of tactical information in cluttered environments. Professors Patricia Jones (currently at NASA Ames) and Caroline Hayes (currently at the University of Minnesota) have developed and validated a number of decision-aiding tools for strategic and tactical planning. Much of the research and engineering conducted by the Beckman Institute researchers, in collaboration with their government and industry partners, has made the transition to government facilities. Other research has led to the development of handbooks and research compendiums, which provide theoretically based, empirically verified guidelines for the design and implementation of interactive multimodal displays and systems.

- Automobiles have changed dramatically over the past decade with the addition of features and systems to enhance driver

performance and safety, as well as to enable drivers to stay in contact with their families and places of business. Such changes have included anti-lock brakes, air bags, GPS navigational systems, cellular phones, and vision enhancement systems for nighttime driving. Although each system, in and of itself, serves specific functions, an increasing concern is the manner in which such systems interact to impact driver safety and performance under varied driving conditions with drivers of different abilities and experience. General Motors Corporation; Beckman Institute scientists and engineers (professors **Arthur Kramer**, **Christopher Wickens**, and **George McConkie**; Beckman Fellow Jason McCarley; and Henry Kaczmarski) have teamed up to address these questions by conducting both basic research on human perception, cognition, and action, as well as more applied research on driver distraction, training, and individual differences. The project will utilize the resources of the Beckman Institute's Integrated Systems Laboratory (ISL), including the CUBE™ and the new driving simulator facility, as well as research facilities at the General Motors technical center in Detroit.

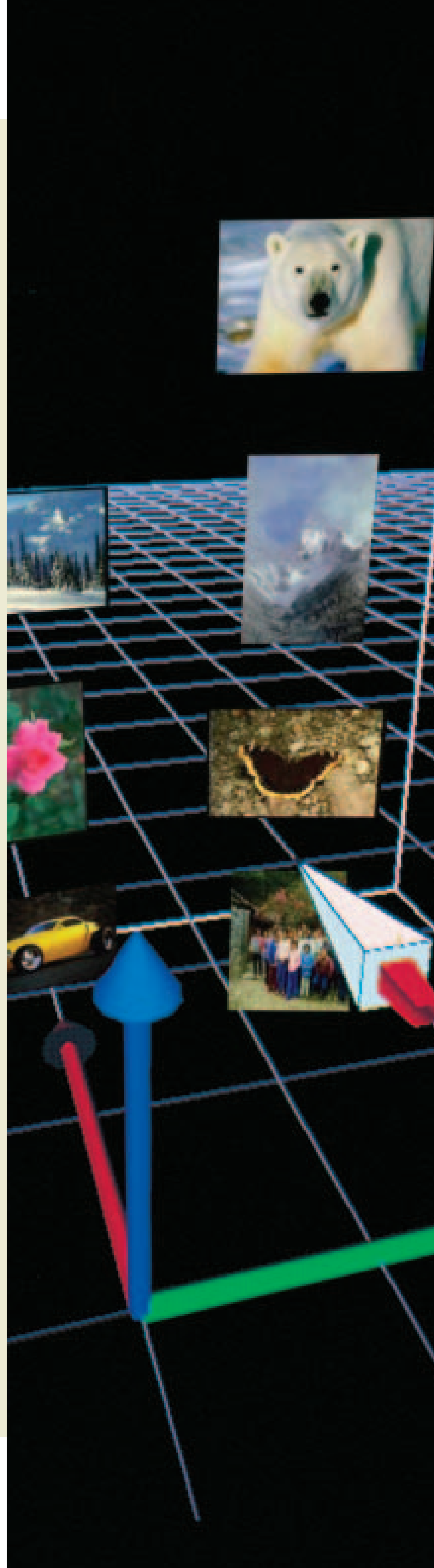
□ The Beckman Institute's collaboration with the Yamaha Motor Corporation is entering its fifth year. During 2001, the emphasis of the research has centered on image indexing and retrieval (Professor **Thomas Huang**) and graphical user interface design for web searching (Professor **James Levin**). In image/video data and metadata preparation, algorithms have been developed for feature extraction in the compressed domain (especially JPEG2000), and performance evaluations have been carried out on the novel multiplicative image watermarking method, which was recently developed. In user interface for image retrieval, research has focused on combining keywords and low-level features (color, texture, and structure) in relevance feedback; searching images by navigating through image space in 2D and 3D; and linking a dialog system to image retrieval system. Progress has been made in the visualization and sonification of Internet-based information. Substantial improvements have been made in the performance and utility of the VisIT™ software. This software now has sonification capabilities that will be further explored to examine

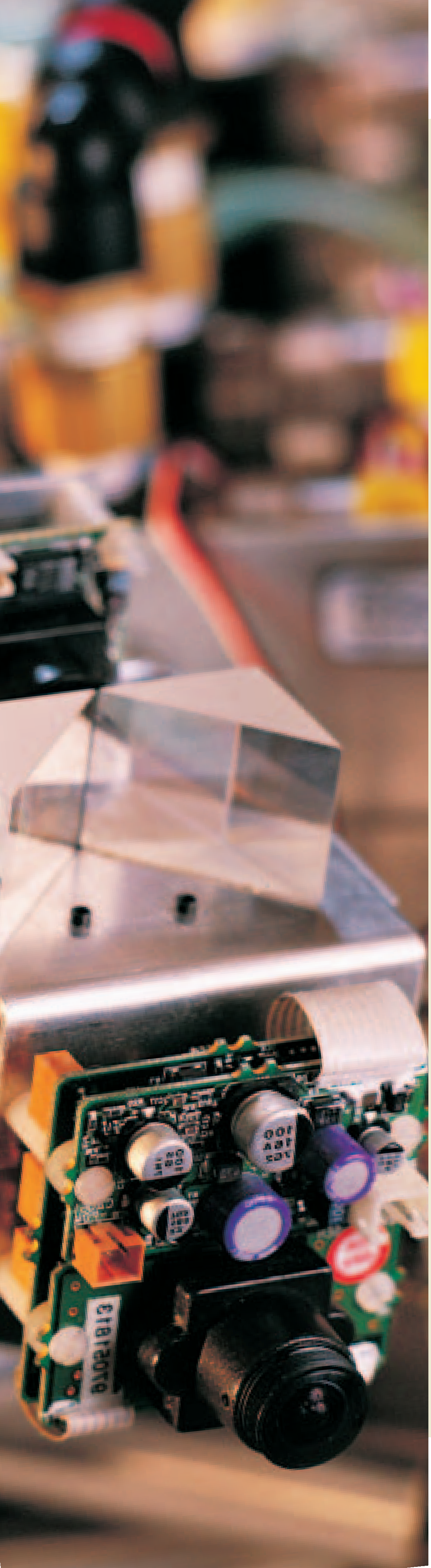
  

ways that this capability can improve the interface to rich Internet information. Progress has also been made with integrating advanced clustering algorithms, so that information can be presented to users in ways that substantially improve their comprehension and use of Internet-based information.

□ Funded by a five-year, $3 million Information Technology Research grant from the National Science Foundation, a group of Beckman Institute researchers (professors **Thomas Huang**, **David Kriegman**, **Stephen Levinson**, **George McConkie**, **Daniel Roth**; and David Brown, from Curriculum and Instruction), are working toward making computers more proactive. They are focusing on two primary issues: first, how to give computers more information about their users, including cognitive state, affective state, motivational state, and task state information; and second, how to use this information as a basis for computer-initiated interaction with users. The proactive computing methods are being developed within the context of science education. Children from the Don Moyers Boys and Girls Club in Champaign, Illinois, come to the Beckman Institute to learn basic science principles using Lego/Mindstorms materials. Currently, they are learning properties of gears, including gear ratios and mechanical advantage (how to gain speed versus power). During these sessions the tutor, the child, the child's hands, and Lego materials are all videotaped. These videotapes are being extensively analyzed not only for what the student and tutor say and the actions the student carries out with the Legos, but also for facial expressions, postural changes, voice signal characteristics, and other indicators of emotional, motivational, and cognitive state. Eye movement analysis is currently being added, giving a real-time indication of where the child is attending and what types of mental activities he or she might be performing. These annotated videotapes are being used both to develop real-time, automated state detectors (for example, detecting delight, discouragement, boredom, attentiveness to the task, confusion, distraction, exploration activities, etc.), and to identify the conditions under which the tutor tends to initiate different types of interactions with the child (for example, giving general encouragement, giving specific suggestions, asking a question to call attention to something that has been overlooked, trying to re-engage the child in the task, etc.). As this interdisciplinary project proceeds, the participating researchers are developing the tools that will allow the computer to have the type of information that a human assistant might have. They are also exploring the ways in which that information can be used to allow the computer to become an active participant in its interaction with the human, rather than a silent partner. These methods may enable the development of a friendly human-computer interface of the future. The project also serves as an example of the type of interdisciplinary integration, with psychologists and educators working with computer scientists and engineers, which is facilitated and fostered at the Beckman Institute.

New technologies based on magnetic resonance imaging (MRI) and speech recognition are being focused on the diagnosis and treatment of certain speech pathologies. Professors **Mark Hasegawa-Johnson**, David Kuehn (Speech and Hearing Science), **Zhi-Pei Liang**, and **Andrew Webb** are collaborating to capture speech anatomy and speech kinematics using MRI, anatomical imaging using microscopic and diffusion tensor MRI, and dynamic imaging using Professor Liang's high-speed constrained reconstruction algorithm. Meanwhile, Professor Hasegawa-Johnson's group has developed a landmark-based speech recognizer that models consonant releases and closures more carefully than most recognizers, thus improving the recognition of explosive speech sounds like "p," "t," and "k." The landmark-based recognizer is finding potential applications in the automatic recognition of stress and rhythm (collaborative work with Professor **Jennifer Cole**), in the recognition of speech in complex acoustic environments, such as movie soundtracks (collaborative work with Professor **Thomas Huang**), and of course in the analysis and diagnosis of speech pathology. A collaborator at Children's Hospital in St. Louis is collecting acoustic and video recordings of the speech of children with macroglossia (enlarged tongue),





HCII

including both children with and without any perceptible speech pathology. By training the landmark-based speech recognizer to match expert ratings of speech pathology, professors Hasegawa-Johnson and Kuehn intend to develop an automatic "second opinion" tool that will help professional speech pathologists judge the nature and severity of a perceived disorder.

- The National Science Foundation-funded Information Technology Research project, "Development of Head-mounted Projective Displays for Distance Collaborative Environments," is being carried out jointly between the Beckman Institute and the University of Central Florida (UCF). The objectives of the project are: to develop a novel visualization device, called head-mounted projective display (HMPD), that allows real-time superposition of a direct image of the scene with a stored virtual view; to build a multi-user interactive workbench by integrating the developed HMPD with a high-performance, real-time image acquisition system; and to evaluate the performance of the resulting system as a tool for remote collaboration. In collaboration with Professor Jannick P. Rolland at the UCF, a lightweight and compact HMPD prototype has been designed and implemented. The prototype provides the capability of optical see-through of the real world, augmentation of real scene with virtual objects, and natural occlusion of virtual objects by their real counterparts. Experiments have been designed to quantify the characteristics of the design components and investigate their effects on resulting imaging quality. Applications have been developed that exploit and demonstrate the capabilities of the HMPD technology in collaborative augmented environments. The imaging system consists of a high-resolution panoramic camera under development. The camera is capable of capturing a 360-degree panoramic view at high resolution and video rate from a single viewpoint. This camera will serve as the source of high-fidelity visual information for remote collaborative work, facilitating tele-presence at remote sites. Finally, an

interactive workbench for multi-user collaborative work is being developed using the HMPD technology and the panoramic image acquisition system. The workbench will be equipped with several HMPD's and other subsystems for object tracking and other interactions. The HMPD can be used for a wide range of collaborative environments and visualization tasks that involve tele-presence and tele-manipulation.

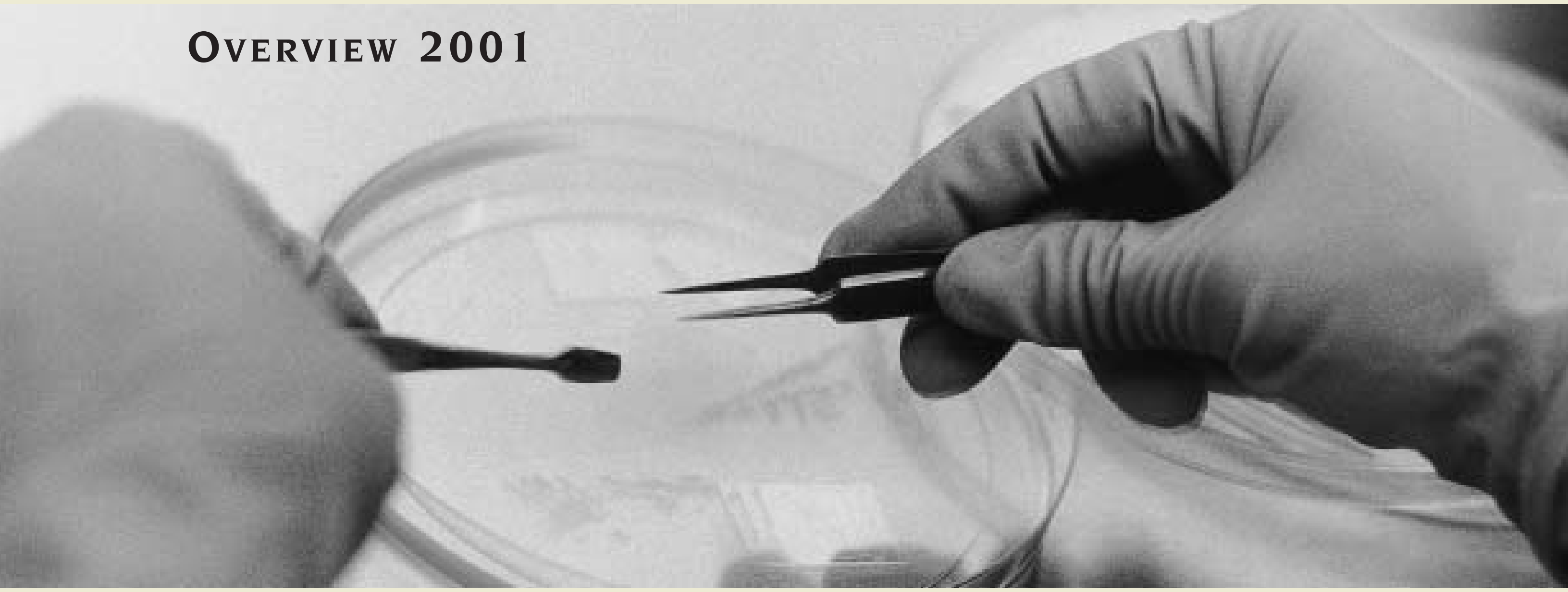
□ Professor **Seth Hutchinson** and colleagues at the Beckman Institute and elsewhere are concerned with problems that confront robots operating in dynamic or uncertain environments. One thrust of their work is vision-based control of robot manipulators. With Peter Corke (of the Criticality Safety Information Resource Center in Australia) and his graduate students, Professor Hutchinson has investigated performance measures and hybrid control architectures for visual servo systems. This work also benefits from collaboration with Professor **Jean Ponce**, an expert on the geometry of multiview computer vision. This research has led to new control algorithms for, and new understanding of, fundamental issues concerning the relationship between vision and control. A second aspect involves sensor-based planning and control for mobile robots. This work is part of a collaboration between professors Hutchinson and Ponce, and French researchers at the Laboratoire d'Analyse et d'Architecture des Systemes (LAAS) in Toulouse, France. This work was initiated under a collaboration between the University of Illinois and the Centre Nationale de la Recherche Scientifique (CNRS), a national French research organization. Algorithms developed at the Beckman Institute have been implemented in the robotics laboratories of the Beckman Institute and LAAS, producing robot systems that use computer vision, laser range scanners, and sonar sensing to construct maps and then use these maps for navigation tasks.

□ A group of Beckman researchers, including professors **Arthur Kramer** and **Christopher Wickens** and Beckman Fellow Jason McCarley, have recently begun a program of research concerned with understanding the visual search and identification processes involved in search through complex cluttered displays. This research, funded by the Federal Aviation Administration's security division, entails characterizing search strategies that lead to accurate detection of weapons in X-ray imagery of airport baggage. The research is also focused on the development of training strategies and human-computer interfaces to enhance the detection process.

Biological Intelligence

The Biological Intelligence main research theme (MRT) seeks to understand the links between the brain and intelligent behavior. Research in biological intelligence starts with the study of the individual molecules that comprise the cells of the brain, and builds toward an

UNDERSTANDING OF THE ANATOMY AND PHYSIOLOGY OF BRAIN REGIONS AND SENSE ORGANS. FROM THERE, RESEARCHERS CONSIDER THE FUNCTIONING OF THE BRAIN AND HOW ITS PARTS WORK TOGETHER TO ACHIEVE BASIC ABILITIES, SUCH AS PERCEPTION, ATTENTION, LEARNING, AND MEMORY.



Ultimately, the Biological Intelligence MRT considers how adapted forms of these abilities can lead to the highest manifestations of intelligence, such as when a child acquires the ability to speak and understand language or learns mathematics in school.

As the second decade of the Beckman Institute takes root, the Biological Intelligence MRT is poised to take advantage of the explosion in new knowledge and scientific tools that have come from breakthroughs in neuroscience, molecular biology, the physical sciences, and computation. For example, the ability to create micro-electromechanical systems, which are capable of studying the smallest compartments of nerve cells, reflects dramatic advances in the field called nanotechnology.

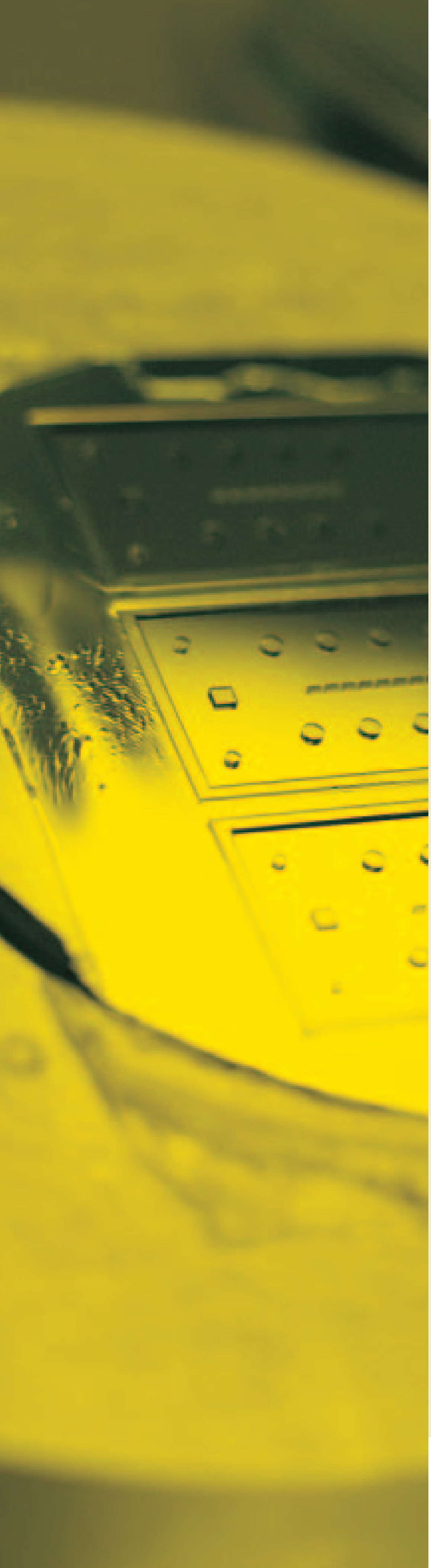
Similarly, at a larger scale, but often using very similar chemical and physical principles, the creation of new brain imaging techniques, such as functional magnetic resonance imaging (fMRI), has revolutionized our ability to relate the activity of the brain to behavior and learning. By using fMRI in combination with related technologies, such as electroencephalograms, eye-movement monitoring, and near-infrared optical imaging of the brain, Beckman researchers are able to tell not only where something is happening in the brain, but also how many different parts of the brain are involved and what sequence of brain events underlies a seemingly smoothly executed intelligent behavior. Altogether, these techniques have extraordinary potential for revealing the nature of

the computations that underlie intelligent behavior.

At the same time, interdisciplinary research in Biological Intelligence is leading to important applications in a variety of domains. For example, the intelligent hearing aid project brings together researchers from the neurosciences, signal processing, and the speech and hearing sciences. The real-time system that has been developed has great promise for hearing enhancement technology. Similarly, researchers interested in learning and education are making use of video technology to improve the teaching of mathematics and reading. In addition, research important to lifestyle choices is emphasizing the importance of physical exercise to brain function and cognition.

As the research highlights below illustrate, the efforts in Biological Intelligence are as diverse as intelligent behavior itself. If there is an underlying theme, it is that progress to date and progress in the future have depended and will depend on combinations of technologies and disciplines. The Beckman Institute provides a near-ideal environment for scientists with vastly different backgrounds to come together to pursue mutually important and interesting goals.

William T. Greenough and Gary S. Dell, Co-chairs



BI

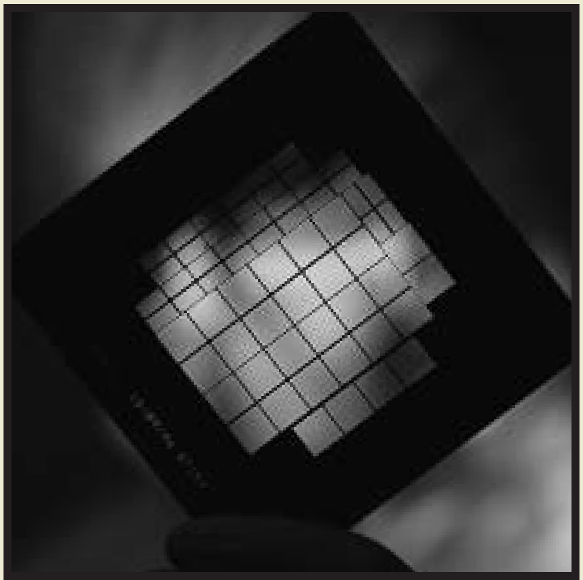
HIGHLIGHTS 2001

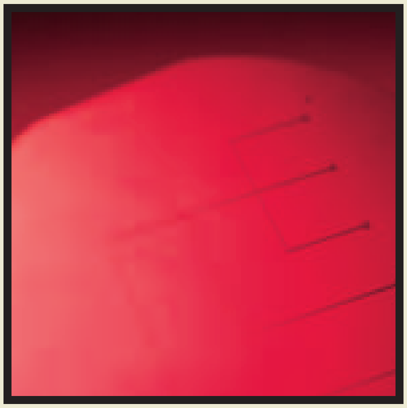
- The intelligent hearing aid project is aimed toward developing efficient signal processing systems that can extract a desired speech signal with high fidelity in the presence of multiple interfering sounds. In 2001, the first patent (U.S. 6,222,927) covering this technology, was issued on April 24, 2001; several additional applications are pending. The intelligent hearing aid team (professors Robert Bilger, **Albert Feng**, Douglas Jones, **Charissa Lansing**, **William O'Brien Jr.**, and **Bruce Wheeler**) has also received funding this year from several external sources to support different aspects of the overall program. The goal of the National Institutes of Health-funded project is validation of the concept of using binaural hearing aids to assist hearing-impaired listeners to extract speech amidst noisy backgrounds. The Defense Advanced Research Projects Agency-funded project is aimed toward applying their signal processing schemes to build devices that may be used in battlefield applications. Finally, the Beckman Institute signed a licensing and sponsored research agreement this year with Phonak AG, a major Swiss hearing aid manufacturer with a manufacturing plant in Warrenville, Illinois. The overall goal of this agreement is to incorporate the Beckman technologies into Phonak's existing lines of hearing aids to advance their performance.

- The Beckman Institute/Carle Clinic Association functional brain mapping project experienced great expansion this year. Two new faculty, **Monica Fabiani** and **Gabriele Gratton**, moved to the campus and joined the project. Professors Fabiani and Gratton add to the group's efforts to combine the techniques of optical imaging, electrophysiological imaging, and functional magnetic

resonance imaging. Another combined technology, the simultaneous collection of brain activity and eye movement data, was initiated when the group installed an eye tracker in the magnet suite at Carle Clinic in Urbana. Combining technologies in these ways allows investigators to validate and complement the data derived from one type of technique with another. Under the direction of professors **Gregory Miller** and **Andrew Webb**, and with the support of a number of departments on campus, including the Beckman Institute, the group significantly expanded their imaging enterprise in another way. The group purchased a new high-field magnetic resonance imager. The new 3-tesla machine will have 24-hour access and will allow investigators to develop and test new imaging protocols. Finally, each of the project's associated faculty received external funding this year. Professor **Neal Cohen**, in collaboration with Professor Andrew Webb and post-doctoral participant Tracey Wszalek, received funding from the National Science Foundation. These studies combine behavioral, eye movement, and functional neuroimaging studies of normal subjects and amnesiac patients in order to explore the nature of relational (declarative) memory and its dependence on the hippocampal system. The Institute for the Study of Aging awarded Professor **Arthur Kramer** and his colleagues, professors Neal Cohen, Andrew Webb, and **Edward McAuley**, funding to allow them to examine changes in cognition and functional brain activity in response to improvements in the aerobic fitness of healthy but sedentary older adults. Professor **Gregory Miller**, in collaboration with Professors **Wendy Heller**, Marie Banich (University of Colorado), and Andrew Webb, will use their new grant from the National Institute of Drug Abuse to investigate individual differences in a brain attentional/emotional network, emphasizing the development of methods for classifying subjects and for measuring activity in the orbital frontal cortex via functional magnetic resonance imaging scan parameter development.

□ What happens in the brain when new memories form? How are specific perceptions represented in the synaptic interactions of neuronal subsets in the brain? These questions are addressed in a research project funded by the National Institutes




of Health involving Beckman Institute faculty members **David Clayton** and **Bruce Wheeler**. Their work uses a songbird (the zebra finch) as a model, as these animals use song to identify and discriminate among individuals in their colony. Past work showed that the first exposure to a novel song induces a wave of gene expression in auditory centers in the zebra finch brain. As the song becomes familiar, this genomic activity ceases. Yet another novel song will induce the same genomic response all over again. How does the brain differentiate between novel and familiar songs, and why do only novel songs activate new gene expression? In the past year, the research group developed and applied methods of recording electrical signals from multiple sites in the brain simultaneously to probe the biological architecture of song representations in the brain. The group also developed new statistical analyses of the birds' behavioral responses to song, as captured on videotape. Their work suggests that both novel and familiar songs activate similar patterns of electrical activity, but additional "neuromodulatory" signals may be associated with the experience of novelty, the induction of gene expression, and the formation of new memories. These results may lead the way to further study of the mechanisms that account for the selectivity of memory formation.

□ Having a portable sensor to detect toxins and other biological agents has certainly been thrust into the limelight during 2001. Beckman Institute faculty members **Paul Bohn**, **Mark Shannon**, and **Jonathan Sweedler** and their research teams made significant progress on a collaborative project funded through the Defense Advanced Research Projects Agency to design a new category of measurement device, the Biofluidic Intelligent Processor, to measure botulism toxins using a field portable sensor. This device allows the active manipulation, detection, and characterization of biological fluids with volumes more than a million times smaller than a single drop of blood. At the heart of the Biofluidic Intelligent Processor are molecular gates with active areas not much larger than transistors in microprocessors. The molecular gates can intelligently separate specific components, passing the rest, concentrating them in attoliter volumes, then digitally tagging them for detection. As digitizing electronics has permitted complex operations to be processed, digitizing molecular fluid flow can potentially solve the daunting challenges posed by trace levels of extraordinarily lethal toxins. The active component, the molecular gate, is analogous to transistors in that switching, gain, and digital manipulation of specific molecules, such as proteins, are now possible. In addition to the creation of new sensors, a number of interesting fundamental studies are under way. Because the flow occurs in a completely new size regime (10 –100 nm), control of fluid transport accomplishes digital transfer of fluids, and the Achilles' heel of prior microfluidics devices, the device interconnects, are integral to the intelligent movement of biomolecules. This work builds upon the foundations from both the Biological Intelligence and the Molecular and Electronic Nanostructures main research themes.

- Video cameras installed in public places allow security personnel to monitor several locations simultaneously. Most remote surveillance cameras, however, are fixed and limited to one view of the surroundings. Ideally, a surveillance camera should be moveable and should direct its lens at the source of sensory cues that might indicate where something is happening, just as a human security guard monitors an area. An interdisciplinary team at the Beckman Institute (professors **Thomas Anastasio**, **Sylvian Ray**, and **Pierre Moulin**), funded by the Office of Naval Research, is developing a video camera that aims itself in a brain-like way. The design of the self-aiming camera is based on a model of a part of the brain known as the superior colliculus, which integrates information from multiple sensory systems and initiates orienting responses toward the source of the sensory cues. The model was originally proposed to account for the multisensory response properties of individual neurons in the superior colliculus, and it suggests that collicular neurons use sensory input to compute the probability that something worth looking at has appeared in the

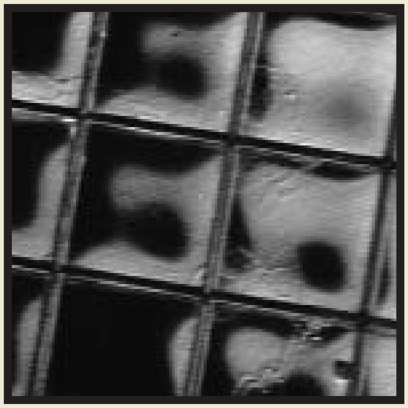
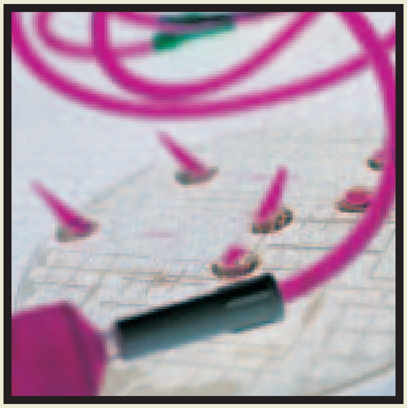
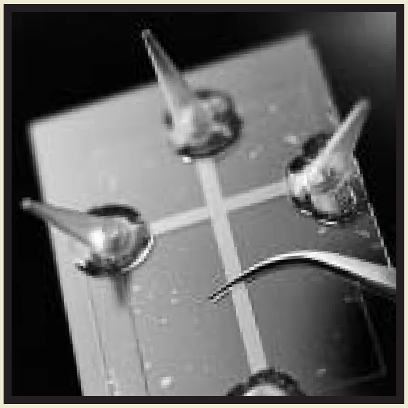
surroundings. This model lends itself readily to practical application. A working prototype of the self-aiming camera which implements the superior colliculus model on a computer has been developed. The prototype fuses audio and video input and "looks around" in much the same way that a person would. Because it combines the audio with the video, the camera is more likely to aim at a speaking person than at a shadow cast against the wall.

□ Language researchers at the Beckman Institute from the Cognitive Science, Artificial Intelligence, and Image Formation and Processing groups continue to work on their three-year project from the Knowledge and Distributed Intelligence Program of the National Science Foundation. The project, titled "The Role of Experience in Language Processing," brings together psychologists, linguists, and computer scientists with the goal of studying how people produce and understand language, and how this knowledge can be used to develop language technology. The group studies how people's speaking and comprehension skills change with experience by using a number of methods, including assessments of eye movements, electrical brain potentials, and functional magnetic resonance imaging. At the same time, the group is developing computational models of the language processing system, models that learn from experience and adapt to their current circumstances through these learning mechanisms. One important aspect of this year's work concerns the development of "unobtrusive measures" of language processing, techniques that can assess the mental and neural activities involved in speaking and comprehending without interrupting those activities. For example, Professor **J. Kathryn Bock** and colleagues monitor the eye movements of people as they describe a scene. The relations between eye fixations and the ongoing speech provide useful cues about the process of speaking. The investigators

are professors **Gary Dell** (principal investigator), J. Kathryn Bock, **Jennifer Cole**, **Cynthia Fisher**, **Susan Garnsey**, **Adele Goldberg**, **Stephen Levinson**, and **Daniel Roth**.

◻ We all know that exercise is good for us, that is, that exercise improves health by enhancing cardiorespiratory function, limiting weight gain, and improving balance, flexibility, and strength. But does exercise improve mental function as well? A group of researchers at the Beckman Institute, in collaboration with colleagues at the Carle Clinic Association in Urbana, Washington University in Saint Louis, and Wayne State University in Detroit, have been investigating this question with the assistance of older adult participants from the local community. Professors **Arthur Kramer**, **Edward McAuley**, **Neal Cohen**, and **Andrew Webb**, along with post-doctoral researcher Stanley Colcombe, have discovered that improvements in aerobic fitness, engendered by six months of aerobic fitness training, can lead to robust enhancements in selective aspects of cognition, including working memory, task coordination, ability to selectively focus attention, and control of action. In on-going research funded by the National Institute on Aging, the Institute for the Study of Aging, and the University of Illinois' Critical Research Initiative program, the team of Beckman researchers is examining changes in brain function via functional magnetic resonance imaging. These changes underlie the performance changes that they have previously observed in response to improved fitness among healthy but sedentary older adults. The goal of the project is to understand the nature of brain and cognitive plasticity during aging.

◻ In related work, professors **Erik Wiener**, **William Greenough**, and **Paul Lauterbur**, and their colleagues have found that both resting blood flow and blood flow changes in response to diminished availability of oxygen are enhanced in rats following a period of voluntary exercise. Rats allowed to run freely in an activity wheel attached to their cages were compared with rats that did not have a wheel available. Resting blood flow was greater in the motor cortex of

the exercised animals. Moreover, when excess carbon dioxide replaced some of the oxygen in the air supply of these animals, the exercised animals showed a greater compensatory response in motor cortex blood flow. Changes of this sort may well contribute towards the cognitive effects of aging described above.

◻ Research is also continuing on a National Science Foundation-funded, cross-disciplinary initiative on Learning and Intelligent Systems. The goal of this project is to construct an integrated theory of concept learning in humans and machines. The theory will be integrated in that it will investigate and account for a wide variety of concept learning results that are often studied separately, and it will pool the research strengths of psychology, artificial intelligence, and computational learning theory. These goals will lead toward a comprehensive theory that is psychologically and computationally plausible, while at the same time sufficiently rigorous to be analyzed with the mathematical tools of computational learning theory. The interdisciplinary focus in 2001 has led professors **Jerry DeJong**, **Gregory Murphy**, Leonard Pitt, **Karl Rosengren**, and **Brian Ross** to address two issues with computational and experimental techniques. First, a major goal has been the understanding of how prior knowledge interacts with learning from experience. There are models of learning the statistical regularities of concepts and theories of how knowledge may influence concept judgments. However, there is no model that integrates the statistical regularities and knowledge during learning, which is necessary for intelligent functioning (and which people do easily). In previous years, the researchers completed a large number of empirical studies of this interaction. In 2001, they developed a psychologically plausible connectionist model that provides an account of many of the learning-knowledge interactions. Second, the researchers have concentrated on how explanations can be used to help people and machines to more efficiently and usefully learn concepts in complex learning situations. In the last year, they have continued a number of empirical studies of how people use the coherence of concepts and explanations to help learn new concepts and make inferences about concepts they have. In parallel, they have been developing a computational model that improves the learning of new concepts by using detailed explanations of earlier concepts to invent new features that help re-code and re-interpret the features of the new concept.

□ The National Science Foundation-supported neuronal pattern analysis project in neuroinformatics is continuing efforts to develop computational tools for neuroscience. This project brings state-of-the-art computing technology to bear on the problem of storing, retrieving, analyzing, visualizing, and modeling of time series neuronal data, particularly in relation to the very large data sets yielded by fast multichannel data-acquisition technologies. A collaboration between the laboratories of Professor **Michael Gabriel** (principle investigator) and Professor **Mark Nelson** has led to the development of a novel database table schema, which allows multiple laboratories to implement customized graphical user interfaces that work with a shared relational database system. This collaboration also brought to maturity the Time Series Data Protocol (TSDP). Touted in a recent N*ature* article, TSDP is a standard for representation, transfer, and analysis of time series data in a platform-independent manner; a suite of flexible/intuitive tools for data analysis and visualization; and a programming library for development of TSDP-compliant tools. Current work is being carried out collaboratively between members of Professor Gabriel's laboratory, Computer Science doctoral candidate Rongkai Zhou, and master's candidate Tao Tao to merge the database and analysis tools with digital brain atlases and associated interfaces. This merger will provide high-resolution neuroanatomical images for use in associating neuronal time series data with their brain sites of origin, with 3D objects such as nuclei and lesions, and for visualization of dynamic brain activations indicated by time series data in realistic neuroanatomical contexts. Ultimately, this project intends to develop a complete neuroscience workbench that will be interoperable within the research community and will serve as a means to facilitate collaboration and sharing of data.

ITG/ISL

ITG/ISL

Imaging Technology Group
Integrated Systems Laboratory

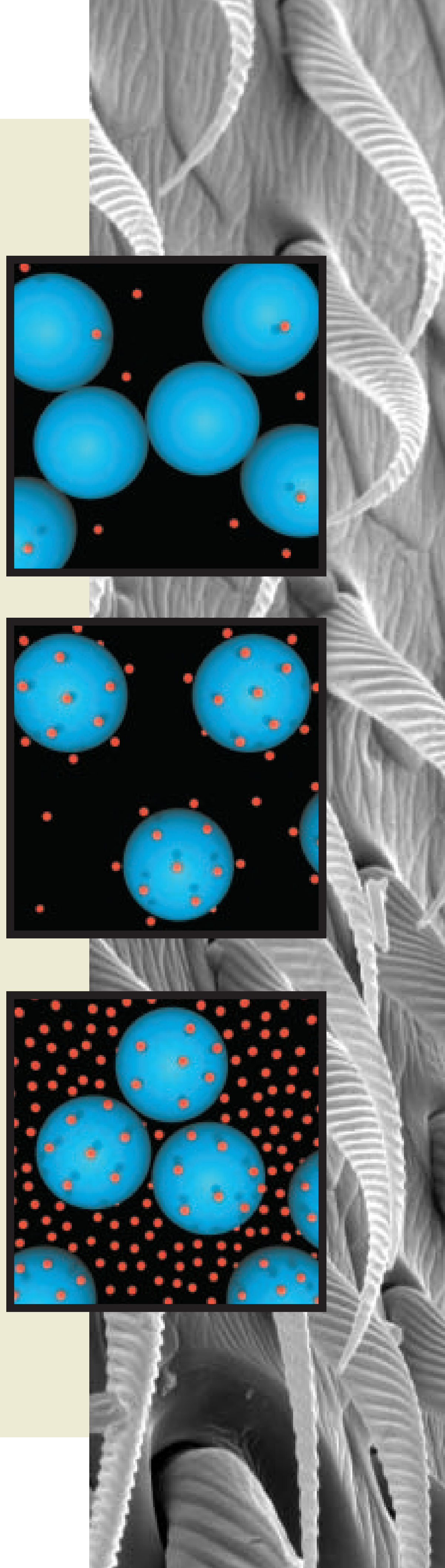
The Beckman Institute is committed to providing the most advanced facilities and resources for research programs centered in the building. These include a microscopy suite; a Visualization, Media, and Imaging Laboratory; and an Integrated Systems Laboratory. These various facilites are used by research groups to conduct experiments in

HUMAN MULTIMODAL PERCEPTION AND COGNITION, AND IN THE AUTOMATED AND INTELLIGENT AQUISITION OF IMAGES FROM A TRANSMISSION ELECTRON MICROSCOPE. OTHER PROJECTS FOCUS ON COMBINING NOVEL ENGINEERING RESEARCH WITH PSYCHOLOGICAL STUDIES TO DETERMINE THE EFFICACY OF THE ENGINEERED SOLUTIONS TO HUMAN-MACHINE COMMUNICATION.

ITG

The primary mission of the Imaging Technology Group (ITG) is to provide Beckman Institute researchers with state-of-the-art service facilities in the Microscopy Suite and the Visualization, Media, and Imaging Laboratory. There are currently over 300 users of these facilities drawn from almost every department on campus. The Suite houses a broad range of microscopes, including an Atomic Force Microscope, Transmission Electron Microscope, Near-field Scanning Optical Microscope, Leica SP2 Confocal Microscope, and an Environmental Scanning Electron Microscope. The microscopes are designed for both biological and materials research, and all are equipped with digital aquisition systems. A secondary focus of the group is to develop advanced imaging technologies, with an emphasis on projects in remote scientific instrumentation. Additional information on the group, its facilities, and its projects can be found at www.itg.uiuc.edu.

During the spring, a multi-photon confocal light microscope (Leica TCS MP two photon imaging system) was installed in the facility. The new instrument has shown itself to be an extremely popular instrument due to the combination of capabilities it provides. Its multi-photon imaging capabilities have been used to image biological samples as well as to photopolymerize polymer patterns with micron-scale futures in colloidal crystals. Its spectral imaging capabilities have been used to image fluorescence shifts in pH sensitive dyes with pH changes in micro channels. The Microscopy Suite also installed a new cooled color camera on our fluorescence microscope. The new camera will allow fluorescence images of multiple labels to be acquired simultaneously, as well as quadrupling the pixel density of transmitted light images.

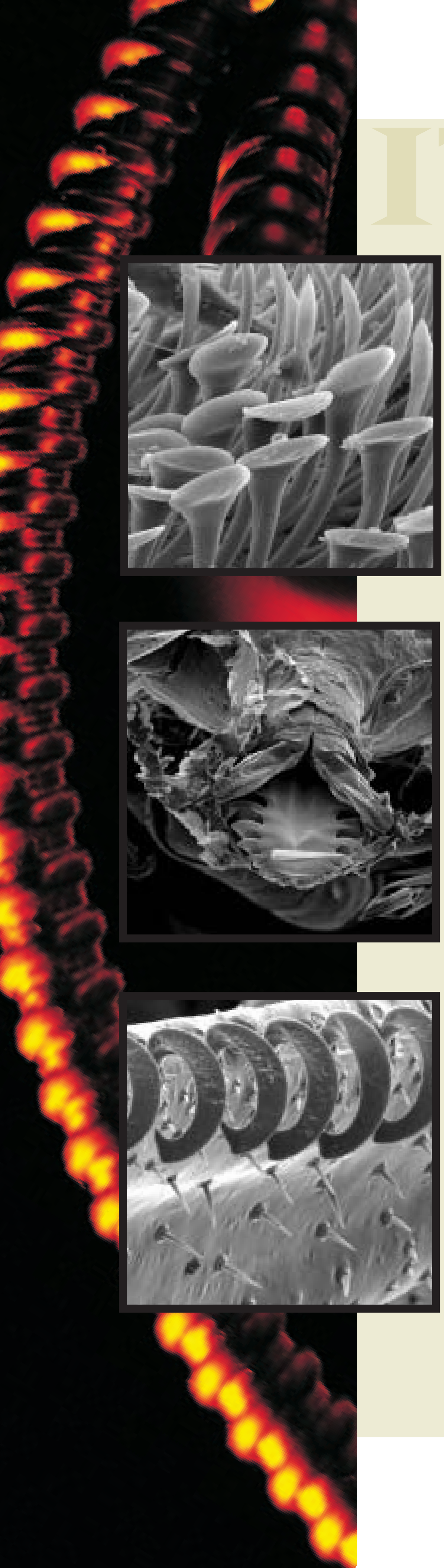


In addition to these instrument improvements, the Microscopy Suite hosted the Central States Microscopy and Microanalysis Society (CSMMS) Annual Meeting in May. Several ITG members gave presentations on ITG facilities and technology projects.

For additional information on the Microscopy Suite, please visit www.itg.uiuc.edu/ms/.

Visualization, Media, and Imaging Lab

This year, the Visualization, Media, and Imaging Laboratory (VMIL) concentrated its additions on digital imaging, infrastructure, and user services. In imaging, two new high-resolution digital cameras were added, facilitating a wide variety of image capture needs for biological intelligence researchers. Also, a new slide and negative scanner for scanning 35mm, medium format, and TEM film provides increased resolution and shadow detail over previous options. In infrastructure upgrades, many workstations were replaced with new high-end, dual-processor systems, and significant amounts of networked data storage were added to accommodate the increasing needs of our users. Our low-end video editing station was upgraded to provide real-time effects



and DVD authoring. In user services, we have made two changes. First, we have significantly revamped new user orientation. The introductory session now takes less time to complete (about 20 minutes) and gets new users up and running very quickly. As part of this orientation, new users schedule time with our consultants to get individual, one-on-one help with their primary project. Second, we have started a weekly 'training hour,' which provides a structured time slot during which users or potential users can come by and ask any questions they want on the topic of the hour.

Finally, we are pleased to announce that an image produced in the VMIL was featured on the cover of the July 31, 2001, issue of the *Proceedings of the National Academy of Science*. Biological Intelligence faculty members **Jennifer Lewis** and **Paul Braun** authored the paper, and graduate student Valeria Tohver created the cover image.

For information on the VMIL, *please visit www.itg.uiuc.edu/vmil/.*

Bugscope

Bugscope is an educational outreach program for K-12 classrooms. The program provides a resource to classrooms so that they can remotely operate an environmental scanning electron microscope (ESEM) to image arthropods at high magnification. The microscope is remotely controlled from a classroom computer in real-time over the Internet using a web browser. Bugscope provides a state-of-the-art microscope resource for teachers that can be readily integrated into classroom activities. The project continues to thrive and to date has provided ESEM access to over 70 classrooms around the nation. The project has been supported for several years by grants from the Illinois Consolidated Telephone Company.

For additional information, please visit www.bugscope.beckman.uiuc.edu/.

Technology Development

Technology development this year has focused on visualization technology. In the area of molecular visualization, we have written a suite of tools that enable high-quality rendering, animation, and visualization of molecule data. These tools include: *mol2mel*–software for automatic conversion of data from common molecular formats into 3D animation packages; *molSlicer*–software that enables boolean intersections on groups of objects, allowing users to interactively define areas of a complex molecule for segmentation; and *dot2mel*–a package that converts molecular point cloud data into a renderable 3D format. In the area of microscopy data visualization, we have developed a package called *top2maya*, which converts 2-dimensional data (i.e., topographical, intensity, magnetic, etc.) into a renderable 3D format, automatically animating the scene in the process. T*op2maya* also offers the option to render a stereographic sequence for viewing with our custom stereographic animation software.

For additional information, please visit www.itg.uiuc.edu/technology/.

Outreach

The ITG Forum series provides an opportunity to learn about the tools, techniques, and technologies available within the group. Thirty-nine forums were presented during 2001 and included presentations from members of the ITG, users of the ITG facilities, members of the Beckman Institute, the university campus, and local and national communities. Additionally, a total of 20 technical reports were published to document the techniques and applications developed within the Imaging Technology Group.

—Glenn Fried and Benjamin Grosser, Co-directors

ISL

The Integrated Systems Laboratory (ISL) is a Beckman Institute facility for advancing scientific understanding of human-computer interactions. The primary mission of the ISL is to support the integration of advanced visualization, sonification, and interface technologies so that Institute researchers can conduct experiments in human multimodal perception and cognition. To facilitate this mission, the ISL maintains discrete laboratories allowing the incorporation of individualized multimodal control and monitoring technologies into extant virtual-reality display environments. As a core facility of the Beckman Institute, the ISL provides fertile environments for interdisciplinary research across the three Main Research Themes. ISL staff collaborate with researchers in the Human-Computer Intelligent Interaction MRT at the Beckman Institute to prepare environments and to develop and assist in programming individual cognitive science experiments.

The Beckman CUBE™, a six-surface, three-meter virtual reality chamber, has been successfully constructed in the basement of the Beckman Institute building. A grant from the Major Research Instrumentation program in the Computer and Information Science and Engineering Directorate of the National Science Foundation, and major support from the Beckman Foundation, now make it possible for researchers to perform multimodal human perception experiments in a virtual environment unique in the world. The CUBE™ is a virtual laboratory providing untethered data acquisition from subjects through commercial wireless body tracking technologies, but most importantly by using eye tracking, gesture, and speech recognition technologies developed within the research groups of the Beckman Institute.

Reliance on expensive, easily outmoded visualization supercomputers is a thing of the past, thanks to ISL-developed cluster PC technology. Researchers using the Syzygy toolkit software, written by Benjamin Schaeffer, now have a standardized, portable API that greatly simplifies the task of programming media-rich applications. The Syzygy toolkit enables researchers to develop applications for cognitive science studies in the six-projector CUBE™ that can then seamlessly scale to a single projection surface and even to a desktop computer. Untethered multimodal human perception studies are now possible in the CUBE™, thanks to head-related, transfer-function spatialized sonification and 6DOF navigation tools developed by Camille Goudeseune.

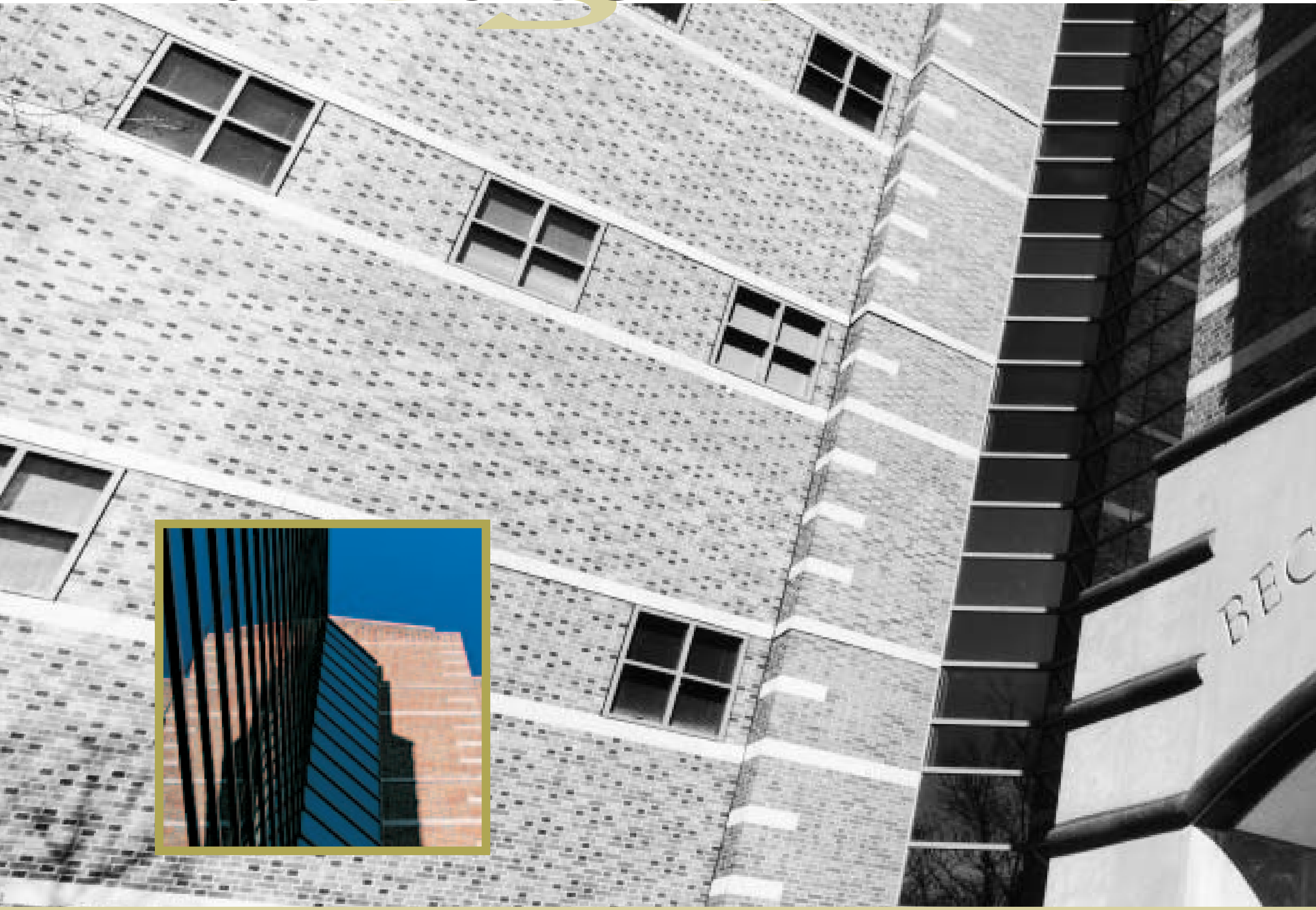
The addition of a 10-camera Motion Analysis motion capture system gives researchers in Kinesiology, and Electrical and Computer Engineering a human motion analysis tool unequaled at the University. The ability to capture and analyze human motion in real time, coupled with discrete kinesiologic and animation modeling software, allows research such as modern and anthropological gait comparisons to be performed concurrently with low-bandwidth-enhanced AVATAR creation.

Human factors research in driver safety and satisfaction has been greatly enhanced by the addition of the recently installed KQ Hyperion automotive driving simulator. Professors **Arthur Kramer**, **Christopher Wickens**, and **George McConkie** are the principal investigators on initial simulator studies designed to analyze training interventions to reduce driver distraction, monitor and predict driver workload, and develop a quantitative model of driver performance to predict driver responses to new technology interventions. Integration of this six-projected surface simulator with ISL-developed haptic, tracking, and sonification interfaces provides another unique research environment at the Beckman Institute.

—Henry J. Kazcmarski, Director

Programs

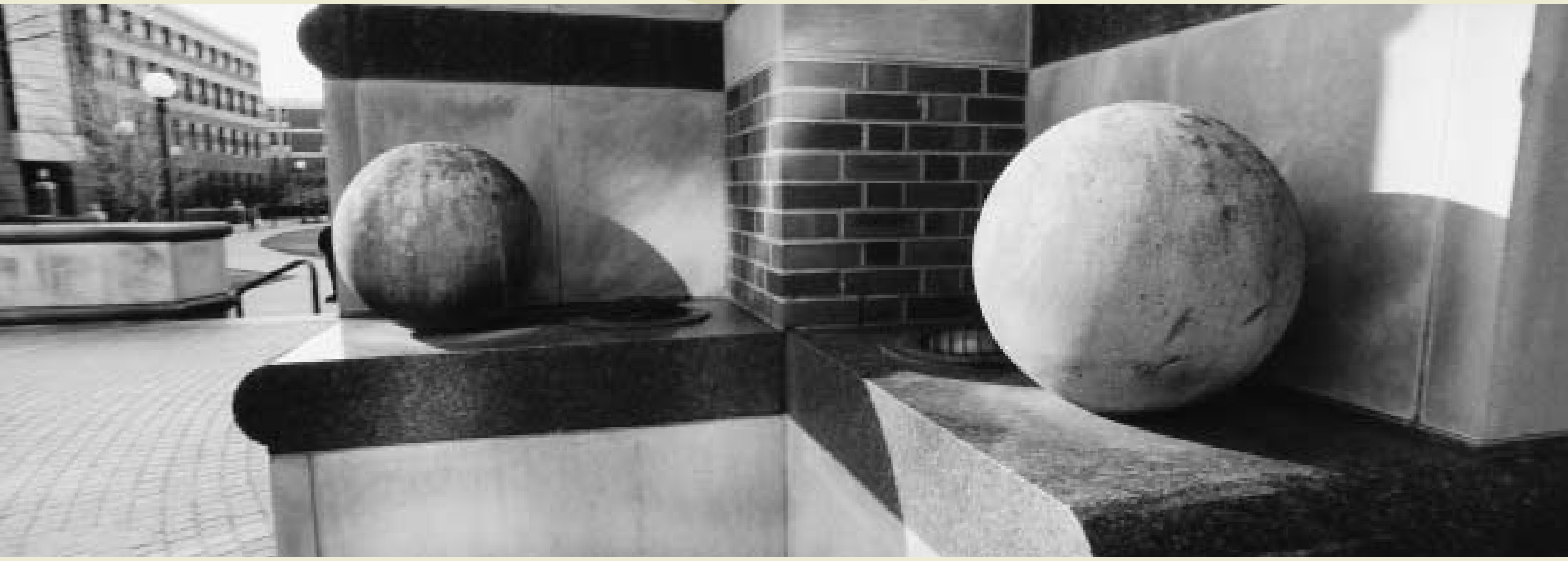
Facilities



The Beckman Institute welcomed several new faculty members in 2001. Some of these new additions were also new to the University of Illinois at Urbana-Champaign; others have been on the campus for some time, but have only recently become members of the Institute. A total

of 33 academic departments on the University campus now have faculty represented in the Beckman Institute. This large cross-section of disciplines, ranging from psychology and linguistics to engineering and computer science, is absolutely critical to the Institute's long-term success.

Facilities



In the Biological Intelligence Main Research Theme (MRT), professors Monica Fabiani and Gabriele Gratton have joined the Department of Psychology at the University of Illinois at Urbana-Champaign and the Cognitive Neuroscience Group at the Beckman Institute. They have become part of a growing community at the Beckman Institute that uses functional magnetic resonance imaging to study the human brain. Other new faculty members in the Biological Intelligence MRT include Professor Matthew Wheeler from the Department of Animal Sciences and Professor Aaron Benjamin from the Department of Psychology. Professor Wheeler has joined the Biological Sensors Group and is collaborating with several other members in the Institute in microelectromechanical systems (MEMS) research. Professor Benjamin is a member of the Cognitive Science Group and is collaborating with other researchers in this group to study learning and memory.

In the Human Computer Intelligent Interaction MRT there were also several new additions. These included Yoshihisa Shinagawa, who recently joined the Department of Electrical and Computer Engineering and is now a member of the Artificial Intelligence

Group at the Institute. Professor Shinagawa will work with this group in the areas of computer vision and computer graphics. In addition, Professor Steven LaValle, from the Department of Computer Science, joined the Artificial Intelligence Group. Professors Gordon Binsted, from the department of Kinesiology, and Esa Rantanen, from the Institute of Aviation, are new additions to the Human Perception and Performance Group.

Professors Scott White, from the Department of Aeronautical and Astronautical Engineering, and Nancy Sottos, from the Department of Theoretical and Applied Mechanics, have recently joined the Advanced Chemical Systems Group in the Molecular and Electronic Nanostructures MRT. They are heading a relatively new effort in the Institute in the area of self-healing materials. Professor Paul Kenis, a new member of the Department of Chemical Engineering, is also a new member in the Advanced Chemical Systems Group. He will be collaborating with other members of the Institute working in the area of MEMS research. Finally, Professor P. Scott Carney recent-

ly joined the University's Department of Electrical and Computer Engineering and the Nanoelectronics and Biophotonics Group at the Beckman Institute.

Many of these new faculty additions have required a substantial amount of programmatic remodeling in the Institute to meet their diverse research needs. Wet and dry laboratory renovations and office reconfigurations have been done to provide the functionality that each of these new members requires. This has included the addition of several new fume hoods, autoclaves, gas safety cabinets, and various pieces of support equipment for centralized warm and cold rooms.

Enhancements to common infrastructure resources have also been pursued in order to add new levels of functionality for Institute researchers. During the past year, the auditorium and conference room audio/visual systems have been upgraded and are now state-of-the-art. The Institute's building network upgrade was completed this year, and researchers have already started to take advantage of the newly added gigabit networking capabilities. In

addition, the machine shop as well as the craft and trade workshops have been outfitted with new tools and equipment in order to add some expanded capabilities.

Lastly, the Institute has completed the restoration of many of its sculptures, paintings, and other fine artworks, restoring them to their original splendor. A great deal of time and attention is also being spent in maintaining the aesthetic presence of the Institute. Expendable items such as carpet and wall coverings are being replaced as deemed necessary, and replacement furnishings have been purchased. The never-ending goal is to maintain the Beckman Institute as Dr. Beckman envisioned, so that it will remain a leading, world-class, interdisciplinary research facility for many years to come.

Jennifer Quirk,

Associate Director for External Affairs and Research

Michael D. Smith,

Associate Director for Operations

Fellows 2001

The Beckman Institute Fellows Program was initiated in fall 1991, using funding provided by the Arnold and Mabel Beckman Foundation. It is intended for recent Ph.D.s or students in their final year of doctoral study in any of the research areas encompassed by the Institute. A competition for the fellowships is held once a year, with two or three Fellows being selected to spend a period of up to three years at the Beckman Institute.

Selection of Beckman Fellows is based upon evidence of professional promise, capacity for independent work, interdisciplinary interests, and outstanding achievement during their graduate careers. Because Fellows have no specific administrative or teaching responsibilities during their tenure, they are able to take maximum advantage of the opportunity to launch strong research careers. Past Fellows have competed effectively for research positions in major universities, and corporate and governmental laboratories throughout the nation such as Motorola, The State University of New York at Stonybrook and at Buffalo, Hughes Research Labs, Oxford University, and the University of North Carolina.

The Beckman Graduate Fellows Program, also supported by funding from the Arnold and Mabel Beckman Foundation, is intended for graduate students who are already working at the Beckman Institute. The purpose is to encourage interdisciplinary research at the graduate student level. Research projects must involve at least one Beckman faculty member in addition to a second faculty member, and preference is given to those proposals that involve the active participation of two faculty members from two different Beckman Institute groups.

2001 Fellows

Michael A. Bevan, 2001 Fellow

Ph.D. 1999, *Carnegie Mellon University*

Michael Bevan's research investigates methods to produce long-range nanostructured materials using colloidal and polymeric components. The goal of his work is to design and process materials on submicron-length scales where thermal motion and surface forces dominate particle interactions. Optimization of thermodynamic and kinetic factors that produce well-defined nanostructures is important for advanced material applications and understanding naturally occurring biological nanostructures. The general approach involves tuning interparticle forces to manipulate thermodynamic phase behavior, and using applied fields to control the kinetics of self-assembly. Templated interfaces are also being explored to heterogeneously nucleate local structure and to control its macroscopic orientation. Another goal of Bevan's work is to understand how stresses associated with drying affect structural relaxation and cracking in ordered materials initially created in solvent media. In addition to employing typical scattering methods, his experimental work has focused on adapting confocal microscopy to dynamically probe real space structure formation in mixed colloidal and polymeric systems.

Donald M. Cannon, Jr., 2001 Fellow

Ph.D. 2000, *The Pennsylvania State University*

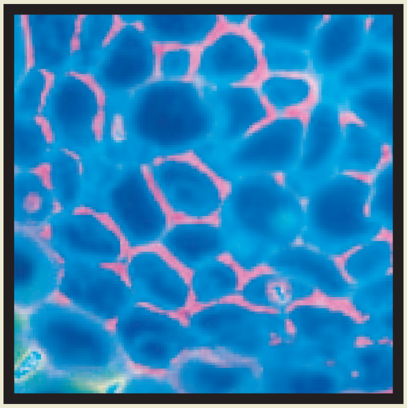
As a Beckman Fellow, Donald Cannon's research is aimed at the fundamental investigation of neuronal chemical dynamics through the application of a novel biofluidic intelligent processor (BIP), recently proposed by a team of researchers at the Beckman Institute. Professors **Paul Bohn**, **Mark Shannon**, and **Jonathan Sweedler** head the collaborative development of this analytical

device. These nanometer-scale fluidic processors are designed for the separation and concentration of multiple molecular species from extremely low (attoliter) volumes. The BIP technique, relying on nanometer dimensions, is a revolutionary step towards a yet unknown size regime (10-100 nm) for fluid control and molecular manipulation. Such devices will provide lower limits of detection than currently available, thereby opening new opportunities on single-cell and sub-cellular processes. Long-term research goals for Cannon include the further development of available bioanalytical techniques, as well as the implementation of novel strategies that are capable of elucidating neuronal function by interrogating the spatial and temporal chemical dynamics in and around single cells.

Jesse Spencer-Smith, 2001 Fellow

Ph.D. 2001, *Indiana University*

Jesse Spencer-Smith's research at the Beckman Institute focuses on how humans perceive emotional facial expressions. He has developed an interactive program for displaying facial expressions using a synthesized three-dimensional head, and is exploring the role dynamics play in understanding expressions. Results from previous work, in collaboration with James Townsend and Åse Innes-Ker at Indiana University, demonstrates that expressions that are imperceptible when presented in static images are readily identified when presented dynamically. Motion may also change the interpretation of an expression: an image that is labeled sad when displayed statically is labeled as happy when displayed dynamically. Spencer-Smith is working with Beckman Institute faculty in the Human-Computer Intelligent Interaction Main Research Theme to incorporate this work into a real-time system for human-computer interaction. He is also developing new mathematical modeling tools to investigate the psychological representations that underlie expression perception. In particular, he is developing new tests for curvature in psychological spaces using existing mathematical results for non-Euclidean geometries.

Christina Grozinger, 2001 Fellow

Ph.D. 2001, Harvard University

Christina Grozinger's research focuses on elucidating the molecular basis of social behavior and behavioral plasticity, using the honey bee as a model system. Bees display several distinct behaviors, which are modulated in response to the colony's requirements. As in many vertebrate and invertebrate species, these behavioral states are regulated by pheromones, some of which produce stable, extensive changes in behavior and physiology. These pheromones will be used to determine the gene expression changes underlying this regulation of behavior, using the bee brain microarrays developed in the laboratory of Professor Gene Robinson in the Department of Entomology. The transcriptional response of the brain to pheromones provides a novel link between the physiological state of the individual and the social state of the colony, which promises to shed light on the molecular basis of social behavior.

John Paul Minda, 2000 Fellow

Ph.D. 2000, University at Buffalo, State University of New York

Paul Minda's research deals with how people learn categories and how they use categorical information to make decisions. During his first year as a Beckman Fellow, Minda worked on several projects. One project expanded research that he started as a graduate student and looked at how people's knowledge for general aspects of a category and knowledge for specific category members decay over time. Another project, with Professor **Brian Ross**, investigated how people learn about categories of objects when no mention of category membership is given. Participants in these experiments learn to predict things about the objects, which may approximate how many real-world categories are learned. Minda has also worked on developing a new computational model of category learning. This model assumes that people learn general things about categories first, but also gradually build up knowledge about specific category members. This model can account for some data that many current models are unable to account for.

Minda plans to continue this research during his second year at the Beckman Institute.

Slava Rotkin, 2000 Fellow

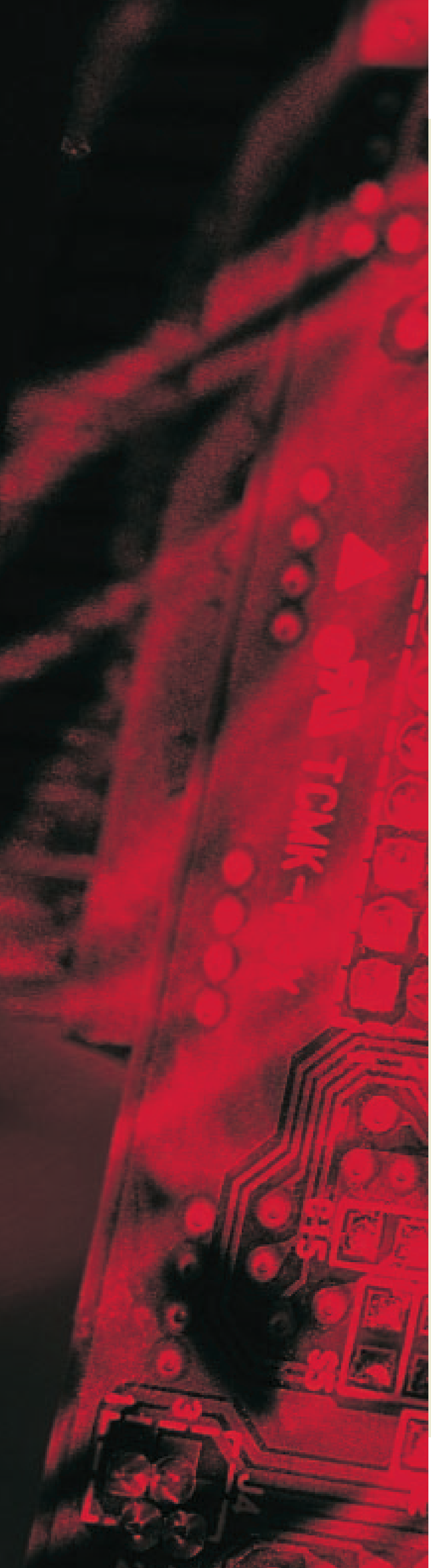
Ph.D. 1996, *Ioffe Physico-Technical Institute*, St. *Petersburg*

As a Beckman Fellow, Slava Rotkin's research has focused on developing a compact theory of carbon nanotube-based electromechanical systems. The semi-classical quantum mechanical approach, as well as the statistical approach, have been successfully used for the calculation of the atomistic capacitance of the single wall nanotube. New physical models have also been developed for van der Waals attraction in carbon shell structures. Finally, Rotkin has performed the quantum mechanical computation of the van der Waals energy in double wall nanotube systems, tube-tube systems, and tube-substrate systems for the first time.

Ilya Zharov, 2000 Fellow

Ph. D. 2000, U*niversity of Colorado*

The main focus of Zharov's doctoral work was on the preparation of R3M+ (M = Si, Ge, Sn, Pb) cations in non-polar media, on weakly nucleophilic carboranyl anions, on novel photoresist materials, and on lithium conducting polymers. As a Beckman Fellow, Zharov collaborates with the members of the Advanced Chemical Systems Group, and works on the use of dendrimers and hyperbranched polymers for molecular recognition. The general approach in this work is to covalently attach dendrons or hyperbranched polymeric chains carrying cross-linkable substituents to a template molecule. Cross-linking and removal of the template creates an imprint, which can be used for recognition or for catalysis. In addition to synthetic work, Zharov is using molecular mechanics, molecular dynamics, and quantum-chemical calculations to model dendrimers and carbon nanotubes.



Fellows

Dale Barr, 1999 Fellow

Ph.D. 1999, University of Chicago

Dale Barr's work investigates how people coordinate understanding in communication. Currently, his work employs eyetracking techniques to investigate the adaptability of the language processing system to experience. For example, in a project being conducted in collaboration with professors **Cynthia Fisher**, **Susan Garnsey**, and others, he is investigating how listeners adapt their interpretations of anaphoric cues, such as pronouns or phonological reduction, to the different "discourse styles" of individual speakers. In another set of studies, Barr is investigating how dyads establish and use lexical and syntactic conventions for referring to objects in visual scenes. Finally, he uses techniques of multi-agent computer simulation to illuminate how the individual adaptations that language users make in dyadic communication affect the conventional linguistic practices in the larger language community.

Hong Hua, 1999 Fellow

Ph.D. 1999, Beijing Institute of Technology

Hong Hua's research interests mainly focus on the development of the head-mounted projective display (HMPD) technology, a ubiquitous augmented environment, and the applications in collaborative augmented environments. She is also interested in panoramic vision techniques. Working with professors and students in the Artificial Intelligence group at the Beckman Institute, and with others, she led the development of a compact HMPD prototype and is exploring its applications in interactive augmented environments. She is also developing a ubiquitous augmented environment and an experimental framework to support remote collaboration in augmented environments. Her vision is to bring researchers at physically separated locations, together virtually to collaborate on a common project, or to hold a project meeting in a virtually

shared augmented space with intuitive interaction, through a high-speed Internet connection linking the collaborative laboratories. Collaborating with Professor **Narendra Ahuja** and students of the Artificial Intelligence group, she has also developed a prototype of a high-resolution panoramic camera that is capable of capturing high-resolution panoramic images from a single apparent viewpoint at video rate.

Jason McCarley, 1999 Fellow

Ph.D. 1997, *University of Louisville*

Jason McCarley earned his Ph.D. at the University of Louisville, studying experimental psychology with an emphasis on visual perception and cognition. He then spent a year as a postdoctoral associate in the Operations Research Department at the Naval Postgraduate School in Monterey, California, collaborating with psychologists, engineers, and physicists to explore human perception of electronically sensed images. At the Beckman Institute, McCarley now works with members of the Human Perception and Performance Group to study various basic and applied aspects of vision, attention, and eye movements. Current work employs behavioral techniques and eyetracking to explore topics that include the control of attention and awareness in dynamic naturalistic environments, and the nature of learning and object recognition in visual search of impoverished or degraded real-world displays.

Lolita Rotkina, 1999 Fellow

Ph.D. 1996, *Ioffe Physico-Technical Institute, St. Petersburg*

As a Beckman Fellow, Lolita Rotkina and other researchers at the Beckman Institute have developed a new concept for carbon nanotube growth, which includes a proposal to perform oriented growth of carbon nanotubes at silicide island edges. This would allow, for the first time, a means to integrate carbon nanotubes into an existing silicon technology, which is of enormous importance in nanotechnology. This group has recently received a two-year Critical Research Initiative (CRI) grant from the campus, titled "Manipulation of Carbon Nanotubes for Integrated Nanoelectromechanical Systems (NEMS)." They are currently building an experimental system (low-pressure chemical vapor deposition workstation) that will allow them to explore this concept of nanotube growth, and also to build a prototype of a nanotube-on-chip system for nanoelectromechanical applications.

Graduate Fellows

Franklin Chang:

"Examining Ways That Learning Influences Sentence Processing"

Chang's project will examine the ways that learning influences sentence processing by using both a computational model and human subjects. Advisors are professors **Gary Dell** (Psychology), Hiroko Yamashita-Butler (East Asian Languages and Cultures), and **J. Kathryn Bock** (Psychology).

Carla Heitzman:

"Self-assembled Pathways for Molecular Transport"

The goal of Heitzman's project is to develop a new method for the transport of specific molecules and ions through self-assembled pathways by designing and synthesizing molecules that will self-assemble into amorphous monolayers. Advisors are professors **Paul Braun** (Materials Science and Engineering), **Joseph Lyding** (Electrical and Computer Engineering), and **Jeffrey Moore** (Chemistry).

Michael Kessler:

"Autonomic Healing in Polymer Composites"

The goal of Kessler's proposed research is to develop and study a new class of polymer composite structural materials capable of self-healing based on the embedded microcapsule concept. Advisors are professors **Scott White** (Aeronautical and Astronautical Engineering), **Jeffrey Moore** (Chemistry), and **Nancy Sottos** (Theoretical and Applied Mechanics).

Elena Romanova:

"Determination of New Molecular Factors with Neurotropic Properties using MALDI-TOF *Mass Spectrometry and Bioassay"*

Romanova's project will apply a combination of separation methods with mass spectrometry to identify and characterize new endogenous molecular factors providing growth guidance cues for the neurites in the marine mollusk, Aplysia Californica. Advisors are professors **Jonathan Sweedler** (Chemistry) and **Paul Bohn** (Chemistry).

Shun-nan Yang:

"The Application of Gaze-contingent Display Changes and Event-related Optical Signals (EROS) *for Measuring Inhibitory Neural Signals Elicited by Reading Difficulties"*

Yang's project will use high-resolution eye tracking techniques to further develop a neurophysiologically based theory of eye movement control during reading. Advisors are **George McConkie** (Educational Psychology) and **Gabriele Gratton** (Psychology).

Facts & Figures 2001

97-01 Funding

Beckman Institute Funding[1]

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

	FY97	FY98	FY99	FY00	FY01
Department of Defense	3,018,926	4,244,105	8,596,145	3,567,490	7,220,570
National Institutes of Health	1,907,009	2,024,355	3,096,564	3,433,321	3,845,206
National Science Foundation	3,447,156	1,823,786	3,714,184	1,555,040	4,939,857
Other	1,645,026	817,864	1,161,601	890,974	1,882,971
Total	**$10,018,117**	**$ 8,910,110**	**$16,568,494**	**$9,446,825**	**$17,888,604**

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

	FY97	FY98	FY99	FY00	FY01
Department of Defense	4,524,577	6,475,573	7,480,679	8,736,643	4,300,552
National Institutes of Health	4,752,157	5,614,090	5,316,533	5,623,463	4,355,386
National Science Foundation	3,176,276	1,837,054	1,937,805	7,580,850	3,371,477
Other	2,218,587	2,452,133	632,688	2,737,686	2,681,499
Total	**$14,671,597**	**$16,378,850**	**$15,367,705**	**$24,678,642**	**$14,708,914**

[1]In addition to the sources itemized in the chart, funding for the 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.

[3]All single investigator grants are administered by the investigator's home department.

M&ENS

Molecular and Electronic Nanostructures

Faculty by Beckman Institute Group

Advanced Chemical Systems Group ■ Paul W. Bohn: Chemistry ■ Paul V. Braun: Materials Science and Engineering ■ Paul J.A. Kenis: Chemical Engineering ■ Jeffrey S. Moore: Chemistry ■ Stephen G. Sligar: Biochemistry ■ Nancy R. Sottos: Theoretical and Applied Mechanics ■ Scott R. White: Aeronautical and Astronautical Engineering ■ **Computational Electronics** ■ Narayana R. Aluru: General Engineering ■ Karl Hess: Electrical and Computer Engineering ■ Jean-Pierre Leburton: Electrical and Computer Engineering ■ Richard M. Martin: Physics ■ Walter Philipp: Statistics and Mathematics ■ Umberto Ravaioli: Electrical and Computer Engineering ■ **Nanoelectronics and Biophotonics Group** ■ Ilesanmi Adesida: Electrical and Computer Engineering ■ Stephen A. Boppart: Electrical and Computer Engineering ■ P. Scott Carney: Electrical and Computer Engineering ■ Martin H.W. Gruebele: Chemistry ■ Joseph W. Lyding: Electrical and Computer Engineering ■ Gregory Timp: Electrical and Computer Engineering ■ Pierre Wiltzius: Materials Science and Engineering; Physics ■ **Theoretical Biophysics Group** ■ Laxmikant V. Kale: Computer Science ■ Todd J. Martínez: Chemistry ■ Klaus J. Schulten: Physics ■ Robert D. Skeel: Computer Science

Major Awards

Narayana R. Aluru
Distinguished Young Author Award, Computer Modeling in Engineering and Sciences

Stephen A. Boppart
Fellow, Whitaker Foundation
Resident Physician Research Award, College of Medicine, UIUC
Young Faculty Award, American Association of Anatomists

Paul V. Braun
Beckman Young Investigator Fellowship, Arnold and Mabel Beckman Foundation
3M Young Faculty Award, 3M

Karl Hess
Member, National Academy of Engineering
Heinrich Welker Memorial Medal for III-V Compound Research, Institute of Industrial Science at the University of Tokyo

Paul Kenis
3M Young Faculty Award, 3M

Paul C. Lauterbur
Chemistry in Service to Society, National Academy of Sciences

Jean-Pierre Leburton
Fellow, American Association for the Advancement of Science
Fellow, Optical Society of America

Jeffrey S. Moore:
Finalist, Credit Suisse First Boston Economic Development Award, The Tech Museum of Innovation Awards: Technology Benefiting Humanity

Stephen G. Sligar
Janet and William Lycan Professorship Medal, School of Chemical Sciences, UIUC

Nancy R. Sottos
Finalist, Credit Suisse First Boston Economic Development Award, The Tech Museum of Innovation Awards: Technology Benefiting Humanity

Todd J. Martínez
Excellence in Teaching Award, School of Chemical Sciences, UIUC

Scott White
Senior Xerox Research Award, College of Engineering, UIUC
Finalist, Credit Suisse First Boston Economic Development Award, The Tech Museum of Innovation Awards: Technology Benefiting Humanity

Pierre Wiltzius
R&D 100 Award, Lucent Technologies, E Ink Corporation

Patents and Patent Applications

(*Beckman Institute faculty in bold*)

David Beebe, **Jeffrey Moore**, and Jaisree Moorthy: "Method of Fabricating a Flow Constriction Within a Channel of a Microfluidic Device," File date (year only): 2001.

Paul Bohn, **Jonathan Sweedler**, and **Mark Shannon**: "Gateable Nanofluidic Interconnects for Three-dimensional Microfluidic Architectures," File date (year only): 2001.

Joseph Lyding, Jinju Lee, and **Karl Hess**: "Semi-conductor Devices, and Methods for Same," File date (year only): 2001.

Paul Bohn, **Jonathan Sweedler**, Xiuling Li, and **Ilesanmi Adesida**: "Metal Assisted Chemical Etch To Produce Porous Material Group III-V Materials," File date (year only): 2001.

Stephen Sligar and Timothy Bayburt: "Membrane Scaffold Proteins," File date (year only): 2001.

Jeffrey Moore, Scott D. Thompson and Larry Markowski: "Stable AmBn Etherimide Monomers (where m=1 and n>1), Am End-capping Agents (where m=1), Bn Cores (where n>1), and Their Resulting Polyethermide Polymers with Controllable Degrees of Branching (DB=0-1), Molecular Architectures, and End Group Compositions," Issue date: December 5, 2001, Patent No. 6,333,390.

Grants Awarded

(*Principal Investigator in bold*)

Ilesanmi Adesida: National Aeronautics and Space Administration, "Deep Etching of AIN Using Inductively-coupled Plasma Reactive Ion Etching Method," 01-May-01 to 31-Jul-01.

Ilesanmi Adesida: Office of Naval Research, "Ultra-high Frequency and Ultra-high Power AIGAN/GAN Power Transistors," 15-Aug-01 to 14-Aug-04.

Ilesanmi Adesida: Office of Naval Research, "Ultra-high Power AIGAN/GAN Transistors with Unity Current Gain Cut-off Frequency >200 GHZ," 15-Sep-01 to 30-Sep-02.

Ilesanmi Adesida: Office of Naval Research, "Low Power, High-speed Circuits Based on INAIAS/INGAAS/GAAS Metamorphic E/D HEMTS," 01-Oct-01 to 30-Sep-04.

Ilesanmi Adesida: National Science Foundation, "NIRT: Self-aligned and Self-limited Quantum Dot Nanoswitches," 01-Jul-01 to 30-Jun-02.

Ilesanmi Adesida: Kwanju Institute of Science, "Energy Band-bending and Fermi Level Shift at P-Type GAN/Metal Surfaces and Interfaces Due to Wet Chemical and Plasma Treatments," 01-Apr-01 to 31-Mar-02.

Narayana Aluru, Umberto Ravaioli, Karl Hess, and Eric Jakobsson**:** Air Force/Defense Advanced Research Projects Agency, "Computational, Experimental and Engineering Foundations of Ionic Channels as Miniaturize Sensors, Devices and Systems," 26-Apr-01 to 25-Feb-02.

Narayana Aluru: National Science Foundation, "A VLSI-like Design Methodology for Nanoelectromechanical Systems," 01-Feb-01 to 31-Jan-03.

Narayana Aluru, Chang Liu, Umberto Ravaioli, and Daneshmund Tafti: National Science Foundation, "ITR/SY: Computational Design of Mixed-technology Systems," 01-Oct-01 to 30-Sep-04.

Paul Bohn: National Institutes of Health, "Cell Migration Consortium: Subproject Dr. Bohn," 15-Sep-01 to 31-Jul-02.

Stephen Boppart and Kenneth Suslick: Whitaker Foundation, "Optical Contrast Agents for Optical Coherence Tomography," 01-Sep-01 to 31-Aug-04.

Paul Braun: Sandia Laboratories, "Microcontact Printing for Photonic Lithographic Applications," 21-Aug-01 to 30-Sep-01.

Paul Braun: Beckman Foundation, "Self-assembled Molecular Nanoconduits," 01-Jun-01 to 31-May-05.

Paul Braun: Foster-Miller Inc., "High Resolution Profiling of Membrane Materials Via Confocal Microscopy," 01-Aug-01 to 30-Nov-01.

Martin Gruebele: National Science Foundation, "Early Events of Protein Folding," 01-Apr-01 to 31-Mar-04.

Martin Gruebele: American Chemical Society, "American Chemical Society Journal of Physical Chemistry," 23-Jan-01 to 22-Jan-02.

Karl Hess: Office of Naval Research, "8th International Workshop on Computational Electronics," 01-Sep-01 to 31-Aug-02.

Karl Hess: Army, "Device Modeling from the Atomic Meso-scales Up," 01-Aug-01 to 15-Nov-01.

Laxmikant Kale, Sarita Adve, and Philippe Geubelle: National Science Foundation, "Performance Modeling and Programming Environments for Petaflop Computers and the Blue Gene Machine," 15-Sep-01 to 31-Aug-02.

Jean-Pierre Leburton: Army/Defense Advanced Research Projects Agency, "Scalable Spin-qubit Circuits with Quantum Dots," 01-Jun-01 to 28-Feb-02.

Joseph Lyding, Jeffrey Moore, Paul Braun, and Stephen Sligar: National Science Foundation, "Protein Logic," 01-Sep-01 to 31-31-Aug-05.

Richard Martin: Lawrence Livermore, "Subcontract to Lawrence Livermore Lab for R. Martin Sabbatical," 20-Jul-01 6o 31-Aug-02.

Jeffrey Moore: National Science Foundation, "Foldamers with Emergent Functionality," 01-Mar-01 to 28-Feb-03.

Jeffrey Moore: National Science Foundation, "Lipid-coated Microgels," 01-Jun-01 to 31-May-02.

Umberto Ravaioli: Army, "The Science and Technology of NanoMolecular Electronics: Theory, Simulation, and Experimental Characterization" 01-May-01 to 30-Nov-01

Stephen Sligar and Chang Liu: National Science Foundation, "Nanoscale Science and Engineering Center for Integrated Nanopatterning and Detection Techonologies," 01-Sep-01 to 31-Aug-02.

Stephen Sligar, Bridget Carragher, and Timothy Bayburt: National Institutes of Health, "Nanostructures for Solubilizing Serpentine Receptors," 01-Jul-01 to 30-Jun-03.

Stephen Sligar: National Institutes of Health, "Cell Migration Consortium," 15-Sep-01 to 31-Jul-02.

Scott White: National Science Foundation, "Magnetostrictive Composites for Sensors and Actuators," 01-Sep-01 to 31-Aug-02.

Selected Publications

(*Beckman Institute faculty in bold*)

- **Aluru, N.R.** and Li, G. (2001), "Finite Cloud Method: A True Meshless Technique Based on a Fixed Reproducing Kernel Approximation," *International Journal for Numerical Methods in Engineering*, **50/10**, pp. 2373-2410.

- Aktas, O., **Aluru, N.R.**, and **Ravaioli, U.** (2001), "Application of a Parallel DSMC Technique to Predict Flow Characteristics in Microfluidic Filters," *Journal of Microelectromechanical Systems*, **10/4**, pp. 538-549.

- Kruse, R.A., Li, X., **Bohn, P.W.**, and **Sweedler, J.V.** (2001), "Experimental Factors Determining the Efficiency of Analyte Ion Generation in Laser Desorption/Ionization Mass Spectrometry on Porous Silicon," *Analytical Chemistry*, **73**, pp.3639-3645.

- Kuo, T.-C., Sloan, L.A., **Sweedler, J.V.**, and **Bohn, P.W.** (2001), "Manipulating Molecular Transport Through Nanoporous Membranes by Control of Electrokinetic Flow: Effect of Surface Charge Density and Debye Length," *Langmuir*, **17**, pp. 6298-6303.

- **Boppart, S.A.**, Herrmann, J.M., Pitris C., Stamper D.L., Brezinski M.E., and Fujimoto, J.G. (2001), "Real-time Optical Coherence Tomography for Minimally Invasive Imaging of Prostate Ablation," *Computer Aided Surgery*, **6**, pp.94-103.

- **Boppart, S.A.**, Brezinski, M.E., and Fujimoto, J.G. (2001), "Surgical Guidance and Intervention," in B.E. Bouma and J.G. Tearney, eds., *The Optical Coherence Tomography Handbook*, (Marcel Dekker, Inc.).

- Tohver,V., Smay, J.E., Braem, A., **Braun, P.V.**, and Lewis, J.A. (2001), "Nanoparticle Halos: A New Colloid Stabilization Mechanism," *Proceedings of the National Academy of Science*, **98**, pp. 8950-8955.

- **Braun, P.V**., Zehner, R.W., White, C.A., Weldon, M.K., Patel, S.S., and **Wiltzius, P.** (2001), "Optical Spectroscopy of High Dielectric Contrast 3D Photonic Crystals," *Europhysics Letters*, **56**, pp. 207-213.

- **Carney, P.S.**, Markel, V., and Schotland, J.C. (2001), "Near-field Tomography Without Phase Retrieval," *Physical Review Letters*, **86**, pp. 5874-5877.

- **Carney, P.S.** and Wolf, E. (2001), "Power-excitation Diffraction Tomography with Partially Coherent Light," *Optics Letters*, **26/22**, pp. 1770-1772.

- **Gruebele, M.** (2001), "Fully Quantum Coherent Control," *Journal of Chemical Physics*, **267**, pp. 33-46.

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HCII

Human-Computer Intelligent Interaction

Faculty by Beckman Institute Group

Artificial Intelligence Group ■ Narendra Ahuja: Electrical and Computer Engineering ■ Nigel Boston: Mathematics ■ Gerald F. DeJong: Computer Science ■ Mark A. Hasegawa-Johnson: Electrical and Computer Engineering ■ Seth Hutchinson: Electrical and Computer Engineering ■ David J. Kriegman: Computer Science ■ Stephen E. Levinson: Electrical and Computer Engineering ■ Jean A. Ponce: Computer Science ■ Dan Roth: Computer Science ■ Michael J. Shaw: Business Administration ■ Yoshihisa Shinagawa: Electrical and Computer Engineering ■ David C. Wilkins: Institute of Aviation ■ **Human Perception and Performance Group** ■ David E. Irwin: Psychology ■ Arthur F. Kramer: Psychology ■ Charissa Lansing; Speech and Hearing Science ■ Edward McAuley: Kinesiology ■ George W. McConkie: Educational Psychology ■ Karl S. Rosengren: Psychology ■ Janet A. Sniezek: Psychology ■ Ranxiao (Frances) Wang: Psychology ■ Stanley Wasserman: Psychology ■ Christopher D. Wickens: Institute of Aviation ■ Douglas A. Wiegmann: Aviation Research Laboratory and Psychology ■ **Image Formation and Processing Group** ■ Weng C. Chew: Electrical and Computer Engineering ■ Thomas S. Huang: Electrical and Computer Engineering ■ Zhi-Pei Liang: Electrical and Computer Engineering ■ Pierre Moulin: Electrical and Computer Engineering ■ David C. Munson, Jr.: Electrical and Computer Engineering ■ Benjamin W. Wah: Electrical and Computer Engineering

MAJOR AWARDS

Weng Cho Chew
Schelkunoff Best Paper Award, IEEE *Transactions on Antennas and Propagation*
Campus-wide Excellence in Professional and Graduate Teaching Award, UIUC

Thomas S. Huang
IEEE Jack. S. Kilby Medal
Member, National Academy of Engineering
Foreign Member, Chinese Academy of Engineering

Arthur F. Kramer
Member, Scientific Advisory Board, Institute for the Study of Aging

Zhi-Pei Liang
University Scholar Award, UIUC

David C. Munson, Jr.
Robert C. MacClinchie Distinguished Professor of Electrical and Computer Engineering, UIUC

Dan Roth:
Xerox Award for Faculty Research, Xerox Foundation
Innovative Applications of AI Award, American Association of Artificial Intelligence

Janet A. Sniezek
Visiting Scholar, Stanford University,

Benjamin W. Wah
Best Paper Award, *Journal of Global Optimization*, "Efficient and Adaptive Lagrange Multiplier Methods for Nonlinear Continuous Global Optimization."

Christopher D. Wickens
Excellence in Research 2001 Award, Federal Aviation Administration

David C. Wilkins
Visiting Scholar, Stanford University

PATENTS AND PATENT APPLICATIONS

(*Beckman Institute faculty in bold*)

Narendra Ahuja and Hong Hua: "Method and Apparatus for a High-resolution and Real-time Panoramic Camera," File date (year only): 2001.

Albert Feng, Robert Bilger, Douglas Jones, **Charissa Lansing**, and Chen Liu: "Binaural Signal Processing Techniques," File date (year only): 2001.

Albert Feng, **Charissa Lansing**, Chen Liu, and **William O'Brien, Jr.**:"Binaural Signal Processing System and Method," Issue date: April 24, 2001, Patent No. 6,222,927.

GRANTS AWARDED

(*Principal Investigator in bold*)

Weng Chew, Jianming Jin, and Eric Michielssen: Air Force, "Fast Time Domain Integral Equation Solvers for Large-scale Electromagnetic Analysis," 01-Mar-01 to 28-Feb-02.

Weng Chew, Jianming Jin, and Eric Michielssen: Air Force, "Synthetic Electromagnetic Signature Prediction of Complex Objects," 20-Apr-01 to 20-Sep-02.

Weng Chew: Department of Energy, "Advanced Subsurface Imaging with Applications to Buried Structure Waste Pits, and Characterization of Vadose Zone," 01-Aug-01 to 31-Jul-04.

Gerald DeJong: Office of Naval Research, "Domain Knowledge, Explanation-based Control, and Reinforcement Learning," 01-Jan-01 to 31-Dec-03.

Thomas Huang and James Levin: Yamaha, "Research on Image/Video Databases and Graphical User Interfaces for Web Search," 01-Apr-01 to 20-May-02.

Seth Hutchinson: University of Connecticut, "Editorial Service for IEEE *Transactions on Robotics and Automation*," 01-Jan-01 to 31-Dec-01.

Arthur Kramer and Thomas Huang: Army (Rockwell), "Multimodal Display Augmentation," 05-Nov-01 to 04-Nov-02.

Arthur Kramer, Neal Cohen, William Greenough, and Edward McAuley: Institute for the Study of Aging, "Influence of Fitness on the Neurocognitive Function of Older Adults," 05-Jan-01 to 04-Jan-04.

Arthur Kramer and Henry Kaczmarski: General Motors, "Evaluation of the Efficacy of Proximity Warning Devices," 05-Sep-01 to 31-Dec-01.

David Munson: US Department of Transportation, "High-precision GPS for Continuous Monitoring of Rail," 27-Jun-01 to 26-Jun-02.

Benjamin Wah: National Aeronautics and Space Administration, "Stochastic Anytime Search Algorithms for Nonlinear Constrained Global Optimization," 01-Mar-01 to 30-Nov-01.

Christopher Wickens: National Aeronautics and Space Administration, "Computational Model of Pilot Situation Awareness Errors," 01-Feb-01 to 31-Oct-01.

Christopher Wickens: National Aeronautics and Space Administration, "Synthetic Vision System: Human Factors Analysis," 01-Dec-01 to 30-Nov-02.

Christopher Wickens: Army, "Human Machine Interface Analysis of Unmanned Vehicle Systems," 21-Jun-01 to 30-Sep-01.

Douglas Wiegmann and Esa Rantanen: National Aeronautics and Space Administration, "Defining the Relationship Between Human Error Classes and Technology Intervention Strategies," 01-Jan-01 to 31-Dec-01.

Douglas Wiemann: U.S. Department of Transportation, "Developing a Methodology for Assessing Organizational Factors Affecting Aviation Safety," 01-May-01 to 30-Apr-04.

Selected Publications

(*Beckman Institute faculty in bold*)

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- Aydiner, A.A., **Chew, W.C.**, Cui, T.J., Wright, D.L., Smith, D.V., and Abraham, J.D. (2001), "3D Imaging of Large Scale Buried Structure by 1D Inversion of Very Early Time Electromagnetic (VETEM) Data," IEEE *Transactions on Geoscience and Remote Sensing*, **39/6**, pp. 1307-1315.

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■ **Wiegmann, D.A.** and Shappell, S.A. (2001), "Human Error Analysis of Commercial Aviation Accidents: Application of the Human Factors Analysis and Classification System (HFACS)," *Aviation, Space, and Environmental Medicine*, **72**, pp.1006-1010.

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BI

Biological Intelligence

Faculty by Beckman Institute Group

Bioacoustics Research Laboratory ■ Leon A. Frizzell: Electrical and Computer Engineering ■ William D. O'Brien, Jr.: Electrical and Computer Engineering ■ **Biological Sensors Group** ■ Ronald J. Adrian: Theoretical and Applied Mechanics ■ Sahraoui Chaieb: Theoretical and Applied Mechanics ■ Deborah E. Leckband: Chemical Engineering ■ Chang Liu: Electrical and Computer Engineering ■ Mark A. Shannon: Mechanical and Industrial Engineering ■ Andrew G. Webb: Electrical and Computer Engineering ■ **Cognitive Neuroscience Group** ■ Neal J. Cohen: Psychology ■ Monica Fabiani: Psychology ■ Susan M. Garnsey: Psychology ■ Gabriele Gratton: Psychology ■ Wendy Heller: Psychology ■ Gregory A. Miller: Psychology ■ **Cognitive Science Group** ■ Aaron Benjamin: Psychology ■ J. Kathryn Bock: Psychology ■ William F. Brewer: Psychology ■ Jennifer S. Cole: Linguistics ■ Gary S. Dell: Psychology ■ Cynthia L. Fisher: Psychology ■ Adele E. Goldberg: Linguistics ■ Georgia M. Green: Linguistics ■ Kevin Miller: Psychology ■ Brian H. Ross: Psychology ■ Edward J. Shoben: Psychology ■ Daniel D. Silverman: Linguistics ■ **Magnetic Resonance Imaging and Spectroscopy Group** ■ Paul C. Lauterbur: Medical Information Sciences ■ Erik Wiener: Nuclear Engineering ■ **Neuronal Pattern Analysis Group** ■ Thomas J. Anastasio: Molecular and Integrative Physiology ■ David F. Clayton: Cell and Structural Biology ■ Albert S. Feng: Molecular and Integrative Physiology ■ Michael Gabriel: Psychology ■ William T. Greenough: Psychology ■ Yuqing Li: Molecular and Integrative Physiology ■ Mark E. Nelson: Molecular and Integrative Physiology ■ Jonathan V. Sweedler: Chemistry ■ Bruce C. Wheeler: Electrical and Computer Engineering ■ **No Group** ■ Eric G. Jakobsson: Molecular and Integrative Physiology

MAJOR AWARDS

Ronald J. Adrian
Nusselt-Reynolds Prize, Assembly of World Conferences of Heat Transfer, Fluid Mechanics, and Thermodynamics
Fellow, American Academy of Mechanics

Adele Goldberg
Associate Editor, *Language*

Deborah Leckband
University Scholar, UIUC

Kevin Miller
Visiting Professor, Institute of Psychology, Chinese Academy of Sciences

Jonathan V. Sweedler
William H. and Janet G. Lycan Professor of Chemistry, UIUC
Associate, Center for Advanced Study, UIUC
Fellow, American Association for the Advancement of Science

Andrew G. Webb
Wolfgang Paul Prize, Alexander von Humboldt Foundation

PATENTS AND PATENT APPLICATIONS

(*Beckman Institute faculty in bold*)

Paul Bohn, **Jonathan Sweedler**, and **Mark Shannon**: "Gateable Nanofluidic Interconnects for Three-dimensional Microfluidic Architectures," File date (year only): 2001.

Paul Bohn, **Jonathan Sweedler**, Xiuling Li, and **Ilesanmi Adesida**: "Metal Assisted Chemical Etch To Produce Porous Material Group III-V Materials," File date (year only): 2001.

Richard Masel and **Mark Shannon**: "Microcombuster Having Submillimeter Critical Dimensions," Issue date: February 27, 2001, Patent No. 6,193,501.

Albert Feng, Robert Bilger, Douglas Jones, **Charissa Lansing**, and **Chen Liu**: "Binaural Signal Processing Techniques," File date (year only): 2001.

Albert Feng, **Charissa Lansing**, **Chen Liu**, and **William O'Brien, Jr.**: "Binaural Signal Processing System and Method," Issue date: April 24, 2001, Patent No. 6,222,927.

GRANTS AWARDED

(*Principal Investigator in bold*)

Neal Cohen and Andrew Webb: National Science Foundation, "Studies of Relational (Declarative) Memory Processing," 15-April-01 to 31-Mar-02.

Gary Dell and Scott Watter: National Institutes of Health, "Functional Mechanisms of Executive Control of Attention," 02-July-01 to 01-July-02.

Albert Feng: National Institutes of Health, "Oscillation in the Central Auditory System: Roles in Hearing," 10-Sep-01 to 31-Jul-06.

Albert Feng, Doug Jones, Bruce Wheeler, William O'Brien, and Charissa Lansing: Phonak, Inc., "Phonak Ag, Research and Development of Intelligent Hearing Aids," 01-Jan-01 to 31-Oct-03.

Gabriele Gratton and Monica Fabiani: Alcoholic Beverage Medical Research Foundation, "Cognitive Vulnerability to Alcohol Effects," 01-Jul-01 to 30-Jun-02.

William Greenough: National Institutes of Health, "Fragile X Syndrome: Banbury Conferences," 01-Mar-01 to 28-Feb-06.

William Greenough: FRAXA Research Foundation, "Fragile X Syndrome: Banbury Conferences," 01-Mar-01 to 28-Feb-06.

Eric Jakobsson and Richard Braatz: National Science Foundation, "GK-12: Edgrid Graduate Teaching Fellows Program," 01-Apr-01 to 31-Mar-02.

Eric Jakobsson: National Institutes of Health, "Simulations of Cholesterol and Ion Channels in Membranes," 01-Aug-01 to 31-May-04.

Deborah Leckband: National Institutes of Health, "Force Probe Investigation of NCAM Adhesion and Regulation by PSA," 01-Sep-01 to 31-Aug-05.

Chang Liu, Fred Delcomyn, and Douglas Jones: Air Force, "Development of Artificial Haircell Sensors," 01-Sep-01 to 28-Feb-02.

Gregory Miller, Marie Banich, Wendy Heller, and Andrew Webb: National Institutes of Health, "Neurocognitive Mechanisms: Appetitive and Aversive Emotion," 15-May-01 to 30-Apr-04.

Mark Nelson: National Institutes of Health, "Neural Control of Sensory Acquisition," 01-Dec-01 to 30-Nov-04.

William O'Brien, Jr.: Air Force, "Advanced Hearing Protection," 10-Nov-01 to 09-Oct-02.

Jonathan Sweedler, William Greenough, Stanislav Rubakhin, and Anna Klintsova: National Institutes of Health, "Neuropeptides in the CNS with Imaging Mass Spectometry," 30-Sep-01 to 31-Aug-03.

Andrew Webb: National Institutes of Health, "High Field Magnetic Resonance Research and Technology," 01-May-01 to 30-Apr-02.

Selected Publications

(*Beckman Institute faculty in bold*)

■ Olsen, M. and **Adrian, R.J.** (2001), "Measurement Volume Defined by Peak Finding Algorithms in Cross-correlation Particle Image Velocimetry," *Measurement Science and Technology*, **12**, pp. N14-N16.

■ Spengler, J.F, Jekel, M., Christensen, K.T., **Adrian, R.J.**, Hawkes, J.J., and Coakley, W.T. (2001), "Observation of Yeast Cell Movement and Aggregation in a Small Scale MHz-ultrasonic Standing Wave Field," *Bioseparation*, **9**, pp. 329-341.

■ **Anastasio, T.J.** (2001), "A Pattern-correlation Model of Vestibulo-ocular Reflex Habituation," *Neural Networks*, **14**, pp. 1-22.

■ **Anastasio, T.J.** (2001), "Input Minimization: A Model of Cerebellar Learning Without Climbing Fiber Error Signals," *NeuroReport*, **12**, pp. 3825-3831.

■ **Benjamin, A.S.** and Craik, F.I.M. (2001), " Parallel Effects of Aging and Time Pressure on Memory for Source: Evidence From the Spacing Effect," *Memory and Cognition*, **29**, pp. 691-697.

■ **Benjamin, A.S.** (2001), "On the Dual Effects of Repetition on False Recognition," *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **27**, pp. 941-947.

■ **Bock, J.K.**, Eberhard, K.M., Cutting, J.C., Meyer, A.S., and Schriefers, H. (2001), "Some Attractions of Verb Agreement," *Cognitive Psychology*, **43**, pp. 83-128.

■ **Chaieb, S.** (2001), "Singular Thin Viscous Sheet," *Physical Review E*, **64**.

■ Nayfe, M.H., Rao, S., Barry, N., Therrien, J., Belomoin, G., Smith, A., and **Chaieb, S.** (2001), "Observation of Laser Oscillations in Aggregates of Ultrasmall Silicon Nanoparticles," *Applied Physics Letters*, **80/1**, pp. 121-123.

■ Holloway, C.C. and **Clayton, D.F.** (2001), "Estrogen Synthesis in the Male Brain Triggers Development of the Zebra Finch Song Control Circuit In Vitro," *Nature Neuroscience*, **4**, pp. 170-175.

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- **Cole, J.** (2001) "Sindhi," J. McGarry ed., *Facts About the World's Languages: An Encyclopedia of the World's Major Languages, Past and Present*, (New York: H.W. Wilson).

- **Cole, J.** and K. Iskarous (2001), "Effects of Vowel Context on Consonant Place Identification: Implications for a Theory of Phonologization," in E. Hume and K. Johnson eds., *The Role of Speech Perception in Phonolog*,(New York: Academic Press), pp. 103-122.

- **Dell, G.S.**, Harris, H., and Guest, D.J. (2001), "Speech Errors, Phonotactic Constraints, and Recent Experience," *Psychologie Francaise*, **46**, pp. 55-64.

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- **Liu, C.**, **Wheeler, B.C.**, **O'Brien, W.D. Jr.**, Bilger, R.C., **Lansing, C.R.**, **Feng, A.S.** (2001), "Selective Extraction of a Desired Speech Sound in the Presence of Multiple Interferers," *Journal of the Acoustical Society of America*, **110/6**, pp. 3218-3231.

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■ **Goldberg, A.** (2001), "Patient Arguments of Causative Verbs Can Be Omitted: The Role of Information Structure in Argument Distribution," *Language Sciences*, **34/4-5**, pp. 503-524.

■ **Gratton, G.** and **Fabiani, M.** (2001), "Shedding Light on Brain Function: The Event-related Optical Signal," *Trends in Cognitive Sciences*, **5**, pp. 357-363.

■ **Gratton, G.**, Goodman-Wood, M.R., and **Fabiani, M.** (2001), "Comparison of Neuronal and Hemodynamic Measures of the Brain Response to Visual Stimulation: An Optical Imaging Study," *Human Brain Mapping*, **13**, pp. 13-25.

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■ Irwin, S.A., Patel, B., Idupulapati, M., Harris, J.B., Cristostomo, R., Larsen, B.P., Kooy, F., Willems, P.J., Cras, P., Kozlowski, P.B., Swain, R.A., Weiler, I.J., and **Greenough, W.T.** (2001), "Abnormal Dendritic Spine Characteristics in the Temporal and Visual Cortices of Patients with Fragile-X Syndrome: A Quantitative Examination," *American Journal of Medical Genetics*, **98**, pp. 161-167.

■ Mukherjee, D. and **Heller, W.** (2001), "Social and Institutional Factors in Adjustment to Traumatic Brain Injury," *Rehabilitation Psychology*, **46**, pp. 82-95.

■ Nitschke, J.B., **Heller, W.**, Imig, J., McDonald, R.P., and **Miller, G.A.** (2001), "Distinguishing Dimensions of Anxiety and Depression," *Cognitive Therapy and Research*, **25**, pp. 1-22.

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■ **Miller, G.A.** and Chapman, J.P. (2001), "Misunderstanding Analysis of Covariance," *Journal of Abnormal Psychology*, **110**, pp. 40-48.

■ Deldin, P.J., Keller, J., Gergen, J.A., and **Miller, G.A.** (2001), "Cognitive Bias and Emotion in Neuropsychological Models of Depression," *Cognition and Emotion*, **15**, pp. 787-802.

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■ Rehder, B. and **Ross, B.H.** (2001), "Abstract Coherent Categories," *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **27**, pp. 1261-1275.

■ **Ross, B.H.** (2001), "Concepts: Learning," in A. Kazdin, ed., *Encyclopedia of Psychology*, (NY: Oxford University Press).

■ Selby, J.C., **Shannon, M.A.**, Kun, K., and Economy, J. (2001), "Sub-micron Solid-state Adhesive Bonding with Aromatic Thermosetting Copolyesters for the Assembly of Polyimide Membranes in Silicon-based Devices," *Journal of Micromechanics and Microengineering*, **11/6**, pp. 672-685.

■ Hammonds, J.S., **Shannon, M.A.**, and Li, C. (2001), "Predicting the Spatial Output Field of a Laser Beam in a Thermally Self-induced Inhomogeneous Medium," *Optics Communications*, **194/1-3**, pp. 47-57.

■ Kautz, R.A., Lacey, M.E., Wolters, A.M., Foret, F., **Webb, A.G.**, Karger, B.L., **Sweedler J.V.** (2001), "Sample Concentration and Separation for Nanoliter-volume NMR Spectroscopy Using Capillary Isotachophoresis," *Journal of the American Chemical Society*, **123**, pp. 3159-60.

■ Li, L., Floyd, P.D., Rubakhin, S.S., Romanova, E.V., Jing, J., Alexeeva, V.Y., Dembrow, N.C., Weiss, K.R., Vilim, F.S., and **Sweedler, J.V.** (2001), "Cerebrin Prohormone Processing, Distribution, and Action in Aplysia Californica," *Journal of Neurochemistry*, **77**, pp. 156-180.

■ **Webb, A.G.** (2001), "Temperature Measurement Using Nuclear Magnetic Resonance," *Annual Reports NMR Spectroscopy*, **45**, pp.1-67.

■ Kautz, R.A, Lacey, M.E., Wolters, A.M., Foret, F., Webb, A.G., Kargar, B.L., and **Sweedler, J.V.** (2001), "Sample Concentration and Separation for Nanoliter-volume NMR Spectroscopy Using Capillary Isotachophoresis," *Journal of the American Chemical Society*, **123/13**, pp. 3159-3160.

■ Chang, J.C., Brewer, G.J., and **Wheeler, B.C.**, (2001), "Modulation of Neural Network Activity by Patterning," *Biotechnology and Bioengineering*, **16/7-8**, pp. 527-533.

■ Branch, D.W., **Wheeler, B.C.**, Brewer, G.J., and **Leckband, D.E.** (2001), "Long-term Stability of Microstamped Substrates of Polylysine and Grafted Polyethylene Glycol in Cell Culture Conditions," *Journal of Biomaterials*, **22**, pp.1035-1047.

■ Konda, S.D., Aref, M., Wang, S., Brechbiel, M., and **Wiener,E.C.** (2001), "Specific Targeting of Folate-dendrimer MRI Contrast Agents to the High Affinity Folate Receptor Expressed in Ovarian Tumor Xenografts," MAGMA, **12**, pp.104-113.

Fellows 2001

Beckman Institute Fellows in Residence

Dale J. Barr (1999)
Michael A. Bevan (2001)
Donald M. Cannon, Jr. (2001)
Christina Grozinger (2001)
Hong Hua (1999)
Jason S. McCarley (1999)
John Paul Minda (2000)
Slava Rotkin (2000)
Lolita G. Rotkina (1999)
Jesse Spencer-Smith (2001)
Ilya Zharov (2000)

Major Awards

John Paul Minda
Richard M. Griffith Award, Southern Society for Philosophy and Psychology

Patents and Patent Applications

(*Beckman Institute faculty in bold*)

Narendra Ahuja and Hong Hua: "Method and Apparatus for a High-resolution and Real-time Panoramic Camera," File date (year only): 2001.

Grants Awarded

(*Principal Investigator in bold*)

Jason McCarley, Arthur Kramer, and Christopher Wickens: Federal Aviation Agency, "Visual Search for Complex Shapes," 21-May-01 to 20-May-02.

Selected Publications

(*Beckman Institute fellows and faculty in bold*)

- **Barr, D.J.** (2001), "Trouble in Mind: Paralinguistic Indices of Effort and Uncertainty in Communication," in C. Cavé, I. Guaïtella, and S. Santi, eds. *Oralité et gestualité: Interactions et Comportements Multimodaux dans la Communication*, (Paris: L'Harmattan), pp. 597-600.

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- **Bevan, M.A.** and Priede, D.C. (2001), "Effect of Physisorbed Polymers on the Interaction of Latex Particles and Their Dispersion Stability," in V.A. Hackley, P. Somasundran, and J.A. Lewis, eds., *Polymers in Particulate Systems: Properties and Applications*, (New York: Marcel Dekker), **104**.

- **Cannon, D.M., Jr.**, Kuo, T.-C., Feng, W., Shannon, M.A., **Sweedler, J.V.**, and **Bohn, P.W.** (2001), "Characterization of Molecular Transport within Gateable Nanofluidic Interconnects for Three-dimensional Microfluidic Systems," in J.M. Ramsey and A. van den Berg, eds., *Micro Total Analysis Systems* 2001, (Kluwer Academic Publishers), pp. 199-200.

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Fellows

- **Hua, H.**, Gao, C., Biocca, F., and Rolland, J.P. (2001), "An Ultra-light and Compact Design and Implementation of Head-mounted Projective Displays," *Proceedings of the IEEE Virtual Reality Annual International Symposium 2001*, Pacifico Yokohama Conference Center, Yokohama, Japan, March, pp.175-182.

- **Hua, H.** and **Ahuja, N.**, (2001), "A High-resolution Panoramic Camera," *Proceedings of International Conference on Computer Vision and Pattern Recognition 2001*, Hawaii, December.

- Essock, E.A., **McCarley, J.S.**, Sinai, M.J., and DeFord, J.K. (2001), "Human Perception of Sensor-fused Imagery," in R.R. Hoffman and A.B. Markman, eds., *Interpreting Remote Sensing Imagery: Human Factors*, (Boca Raton, FL: CRC Press), pp.137-182.

- **McCarley, J.S.**, and He, Z.J. (2001), "Sequential Priming of 3D Perceptual Organization," *Perception and Psychophysics*, **63**, pp.195-208.

- **Minda, J.P.** and Smith, J.D. (2001), "Prototypes in Category Learning: The Effects of Category Size, Category Structure, and Stimulus Complexity," *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **27**, pp. 775–799.

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- **Spencer-Smith, J.**, Wild, H., Innes-Ker, Å., Townsend, J.T., Duffy, C., Edwards, C., Ervin, K., Paik, J.W., and Prause, N. (2001), " Making Faces: Creating 3-dimensional, Ecologically-motivated Poseable Expressions," *Behavior Research Methods, Instruments and Computers*, **33/2**, pp. 115-123.

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