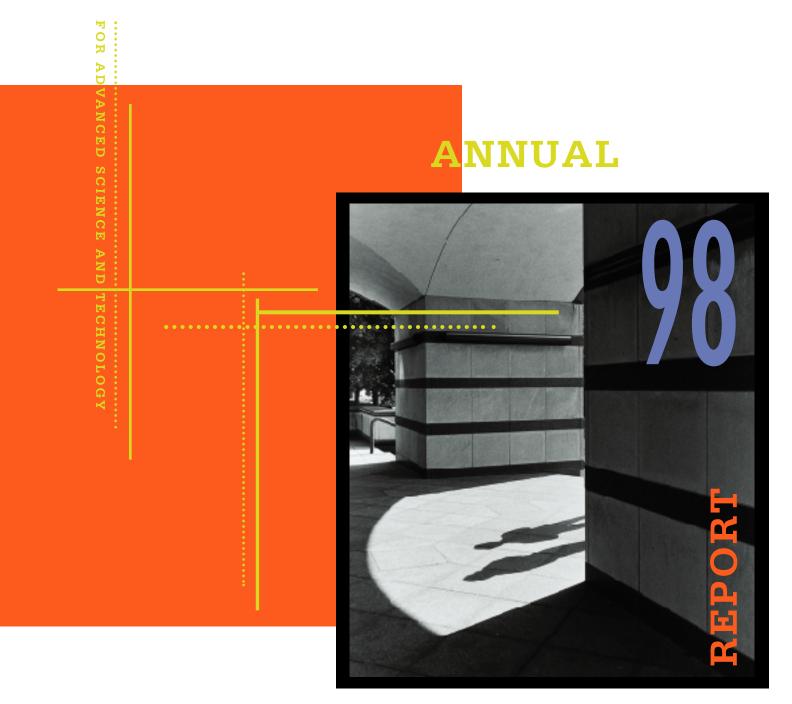
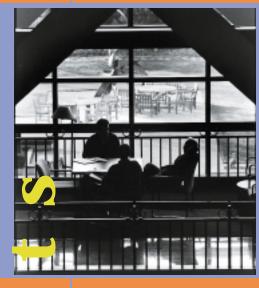
BECKMAN INSTITUTE



UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

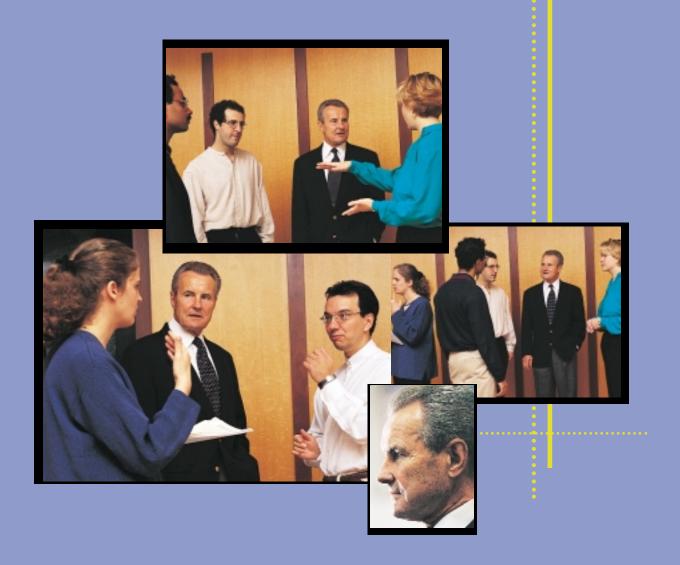
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The Beckman Institute's External Advisory Committee

the committee stated that:

visited us in May 1998 and reported their findings to the

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States and, perhaps, the world."

ciplinary research activities. In their report

Among our many activities and projects, I shall highlight only a few to illustrate how productive the past year was.

Thanks to the continuing support of the Arnold and Mabel Beckman Foundation, we welcomed two new Beckman Fellows, Michal Balberg and Gregory J. DiGirolamo. Dr. Balberg completed her Ph.D. degree at the Hebrew University of Jerusalem in June 1998. Her research interests center around nonlinear optics, artificial neural networks, and visual perception. As a Beckman Fellow, she is using the methodology of information theory to investigate the performance of the visual system and an "artificial" multi-spectral imaging system. She has started working with several groups at the Institute, including Photonic Systems, Image Formation and Processing, and Artificial Intelligence.

Gregory DiGirolamo completed his Ph.D. degree at the University of Oregon in June 1998. His research interests focus on the cognitive neuroscience of attention and memory. As a Beckman Fellow, he is using fMRI, ERP, and eye tracking to help elucidate the cognitive and neural mechanisms of the interaction between attention and memory. He works closely with members of the Cognitive Science, Cognitive Neuroscience, and Human Perception and Performance groups.

The yearly competition for research assistantships is another important activity supported by the Beckman Foundation. The projects for 1998 were the following:

—"Electrode Modification for Improved Cell-Electrode Coupling," which is being pursued by John Chang working with the Neuronal Pattern Analysis, Biological Sensors, and Advanced Chemical Systems groups.

—"Physical and Electrical Properties of Hot Carrier Degradation of Si MOS Transistors Processed in Deuterium and Hydrogen," proposed by Zhi Chen, who is working with the Scanning Tunneling Microscopy and Computational Electronics groups.

—"Electronic Properties and Spin Effects in Artificial Molecules," by Satyadev Nagaraja in collaboration with the Computational Electronics and Photonic Systems groups.

—"Numerical Simulation of Biomolecular Diffusion," by Gang Zou, working with the Theoretical Biophysics and Molecular Biophysics groups.

These titles illustrate the multidisciplinary scope of projects that graduate students are working on in the Institute.

This past year, we purchased the environmental scanning electron microscope located in the Microscopy Suite of the Imaging Technology Group, and equipment for the Integration Support Laboratory. These two major acquisitions, discussed elsewhere in this report, were made possible by fund matching from the Beckman Foundation.

Among the new research projects, several deserve special mention. As part of the National Science Foundation's Knowledge and Distributed Intelligence program, two grants were awarded to multidisciplinary research teams led by professors Gary Dell and Eric Jakobsson. Even though the Beckman Institute has only recently begun microelectromechanical systems (MEMS) research, it is gratifying to note that a group led by Professor David Beebe already received a large multidisciplinary grant from DARPA. In addition, Professor David Brady received a large multidisciplinary grant from DARPA in the area of interferometric digital imaging.

The Computational Electronics Group

received a center award from the NSF for a Distributed Center for Advanced Electronics Simulations (DesCArtES), which is shared with research groups from Arizona State, Purdue, and Stanford universities and is co-directed by professors Karl Hess and Robert Dutton (Stanford). And, in April 1998, a new Multidisciplinary University Research Initiative (MURI) grant, entitled "Nanoelectronics: Low Power, High Performance Components, and Circuits," was awarded by the Office of Naval Research to Beckman researchers and their collaborators.

A critical issue now being addressed is related to the dynamic nature of the multidisciplinary research center. In order to take advantage of new research opportunities, the Beckman Institute must have the space and resources for new faculty members. Consequently, faculty appointments in the Institute should not be indefinite. Rather, a flow in and out of



faculty should be regulated by a rigorous review of all research activities. The main criterion for evaluating a project or program will always be its excellence. In view of our multidisciplinary mission, however, the Institute must insist that the work of individual faculty members or disciplinary groups must also meet the multidisciplinary criterion. By using an external review team of experts, we get an objective view of the quality of the multidisciplinary projects. In 1998, we finished the first three-year review cycle by reviewing the Biological Intelligence Main Research Theme.

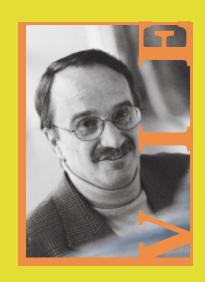
For a large multidisciplinary institute, benchmarking, critiques, and advice are even more important than for individual research projects. The Beckman Institute's External Advisory Committee serves this need. The committee is composed of distinguished scientists and engineers who are experts in multidisciplinary research activities. This advisory committee visited us in May 1998 and reported their findings to the University's higher administration and to the faculty of the Institute. In their report, the committee stated that: "The progress and the focus of the Institute make the Beckman Institute the most outstanding multidisciplinary research organization in the United States and, perhaps, the world."

On behalf of the Beckman Institute, I would like to thank the faculty, students, and staff for their dedicated and highly successful work in 1998.

—Jiri Jonas, Director



MOLECULAR & ELECTRONIC NANOSTRUCTURES















The Molecular and Electronic Nanostructures

(M&ENS) Main Research Theme (MRT) is focused on the development of materials and methods to understand and control **structure** and **function** at the nanometer **scale** and **beyond**.

M&ENS



A major objective is to provide the underlying science and technology that will support the development of nanoscale integrated circuits (NICs). Several multidisciplinary research programs are underway and made important progress in 1998, while new ones in computational electronics and nanoelectronics were initiated. These externally funded programs support efforts among the Advanced Chemical Systems, Scanning Tunneling Microscopy, and Computational Electronics groups at the Beckman Institute.

Research continues in an attempt to merge molecular components with electronically relevant surfaces. The atomic precision of function group chemistry is ideally matched to the exquisite control of STM nanolithography, thereby yielding the highest resolution possible. We are convinced that this powerful combination will enable site-specific placement of single molecules, opening the way to new molecular-based phenomena for NIC design.

An emerging mission is the development of microelectromechanical systems (MEMS)—an effort that involves close ties to the Biological Intelligence Main Research Theme. Improvements in device fabrication and design are being made through advances in new materials and simulation methods.

The M&ENS laboratories have maintained their lead in the development of advanced characterization methods. Coupled with sophisticated computational approaches, a wide scope of questions has been probed, ranging from self-assembling systems to atomistic dynamics on silicon surfaces. As was recently demonstrated by the discovery of deuterium incorporation for improving chip lifetime, the insight gained from the research performed here at the Beckman Institute will lead the way to new technology with a significant future impact.

Highlights

received a center award from the National Science Foundation. This Distributed Center for Advanced Electronics Simulations (DesCArtES) is shared with research groups from Arizona State, Purdue, and Stanford universities and is co-directed by professors Karl Hess and Robert Dutton (Stanford). **Professors Thomas Kerkhoven, Jean-Pierre** Leburton, and Umberto Ravaioli are the other Beckman faculty members participating in this effort. The project's purpose is to foster research and education in various areas of computational electronics, encompassing simulations on the atomistic and nanostructure level and also including optoelectronics (e.g., simulations of quantum well laser diodes). Some of the software developed will be made available and usable on the internet by the group at Purdue. Ten university faculty will interact with a number of industrial groups (Lucent, Intel, and others), groups at NASA, the Jet Propulsion Laboratory, and with each other to attack a wide range of problems posed by these different

• The Computational Electronics Group

• A new Multidisciplinary University Research Initiative (MURI) grant, entitled "Nanoelectronics: Low Power, High Performance Components and Circuits," was awarded by the Office of Naval Research

groups. The simulations include electronic material

properties and surface and interface physics and chemistry (using density functional theory), as well

as simulations of electronic transport (quantum and

semi-classical) in nanoscale structures and ultra-

small semiconductor devices.

to Beckman researchers and their collaborators in April 1998. Professors Karl Hess, Joseph Lyding, Richard Martin, and Jeffrey Moore, along with Dr. Hyungsoo Choi, are combining STM nanofabrication with atomistic simulations to develop novel nanoelectronic device structures on the atomic and molecular size scale. This program uses the unique capabilities developed at the Beckman Institute during a previous URI grant on "STM-based Nanolithography." The Beckman team is collaborating with researchers at Arizona State University, Notre Dame, and Berkeley to merge nanoelectronic devices with more conventional technologies and to explore interconnect schemes based on cellular neural networks.

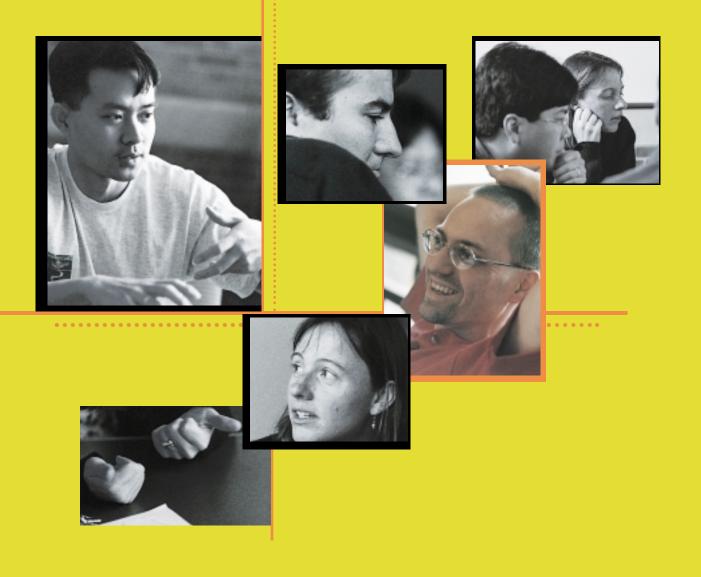
• 1998 has seen the general acceptance by major chip manufacturers that deuterium dramatically improves chip lifetimes by reducing hot electron effects. This effect was originally discovered by professors Joseph Lyding and Karl Hess in 1995. Several companies are now testing deuterium on their commercial production lines. Paralleling this is a comprehensive experimental/theoretical deuterium research program at the Beckman Institute under the direction of Lyding and Hess. Low temperature STM desorption and chip reliablity experiments have been conducted and are being correlated with atomistic simulations to elucidate the detailed desorption pathways for hydrogen and deuterium. A new high pressure deuterium furnace has also been constructed further to explore the limits of deuterium incorporation. This program involves active collaboration with about ten companies.



• Professor Jeffrey Moore and his group are investigating new types of dendritic polymers that have potential to enhance the performance and processibility of conventional polymeric materials. In conjunction with a team of investigators forming a MURI group, which was funded by the Army Research Office in 1997, the first examples of high-performance polyetherimide hyperbranched polymers have been prepared and are being studied. Although several varieties of dendritic structures have been reported over the past five years, two obstacles have prevented their use in bulk materials applications. Previous dendritic materials have proven difficult to produce in large quantity and few have been made with exceptional thermal,

oxidative, and hydrolytic stability. The new scale-up laboratory in the Beckman Institute is now making it possible to produce testable quantities of hyperbranched polymers. Polyetherimide hyperbranched materials under investigation exhibit exceptional stability (up to 500°C) and solubility. An efficient preparation of both the monomer and polymer has been developed and large quantities are being produced. One of the most exciting properties of these polymers is their water solubility that may enable the development of water-borne high temperature coatings.

• Professors Jeffrey Moore and David Beebe have worked to combine dentritic materials with microfabrication to address an important problem



The M&ENS laboratories have maintained their lead

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atomistic dynamics on silicon surfaces.

in microelectromechanical systems (MEMS). In MEMS, a common problem involves the use of sacrificial layers to realize suspended structures. Typically, a wet etchant is used to remove the thin sacrificial layer (1 vm). During the drying process, the phenomena known as stiction occur: Large capillary forces tend to pull the suspended structure into contact with and subsequent adhesion to the substrate. Stiction can render the devices useless. Beebe and Moore have demonstrated the use of hyperbranched polymers as a sacrificial layer. The advantage of these materials is that they decompose from the solid state directly to the vapor state upon heating. The lack of a liquid state completely eliminates the strong capillary forces that normally lead to stiction.

- A computational MEMS group led by Professor Narayana Aluru is involved in developing innovative numerical methods for analysis and simulation-based design of microelectromechanical systems. The group is currently involved in developing multiscale techniques for rapid and accurate simulation of MEMS. Of particular interest are approaches where continuum and atomic scale techniques are combined efficiently to model microscale sensors and actuators. The group has recently developed new meshless methods for continuum analysis and is applying it to analysis of MEMS, microfluidics, piezoelectric sensors and actuators, and optomechanical systems.
- The Ultrafast Surface Science Laboratory was established in 1996 with funding from the National Science Foundation to study light-matter interaction and ultrafast effects on surfaces at atomic resolution. This collaborative effort involves two Beckman Institute groups, **Photonic Systems** (Professors

David Brady, Martin Gruebele, and Nancy Makri) and Scanning Tunneling Microscopy (Professor Joseph Lyding). The lab is equipped with (a) a custom scanning tunneling microscope (STM) enclosed in an ultra high vacuum chamber with optical access ports, and (b) several laser light sources (argon ion continuous wave visible pump, titanium-sapphire continuous wave near infrared tunable, titanium-sapphire femtosecond near infrared tunable, and synchronously pumped optical parametric oscillator operating in the near-mid infrared). In 1998, the dynamics of the silicon-hydrogen bond were studied by pumping a hydrogen-passivated silicon surface with infrared light at the resonance wavelength of the bond. The excitation increases the desorption rate of the hydrogen by several orders of magnitude and is monitored by use of the STM probe. The understanding of silicon-hydrogen dynamics is important for the VLSI industry, where the highly reactive silicon surfaces of integrated circuits are routinely hydrogen passivated to prevent oxidation.

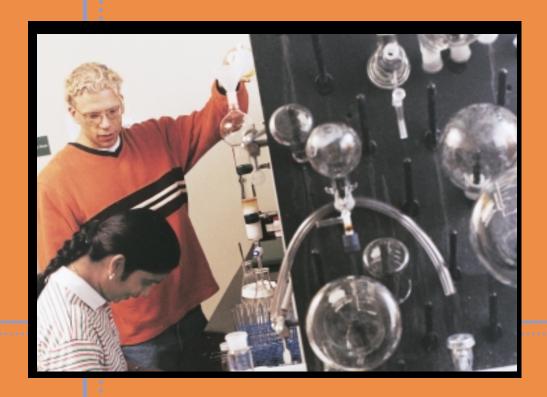
• The Illinois Interferometric Imaging Initiative (4Is) is a DARPA-funded program to explore multidimensional optical imaging which involves several Beckman faculty, including professors David Brady, David Munson, and Eric Michielssen. The goal of the project is to demonstrate that integrated cross-disciplinary design of physical optical components and image formation and processing algorithms substantially improves the information capacity and utility of optical imaging systems. In 1998, this program demonstrated several approaches to extended depth of field imaging. The most impressive demonstration involved the rotational shear interferometer (RSI), which measures coherence

functions of the field. The RSI forms multispectral images with essentially infinite depth of field without using a lens. Furthermore, it has been demonstrated that extended depth of field imaging systems, such as the RSI, can be combined with tomographic algorithms to produce high resolution 3D images of incoherent optical objects without active or structured lighting. These imaging systems hold great promise for 3D video, target recognition and tracking, microscopy, and object characterization.

- The near field scanning optical microscope (NSOM), which is part of the Imaging Technology Group's Microscopy Suite, is now in full operation and is being used on a daily basis. Professor Paul Bohn's laboratory has successfully used the instrument this year to study the properties of mesoscopic assemblies of electronic materials—specifically, the behavior of electrochemically oxidized gallium arsenide. Previous work in this area was based on far field luminescence and had attributed an observed large blue shifted emission to quantum confinement effects. The NSOM was used to show that the luminescence originated from As (III) oxide microcrystals and that intrinsic emission from these structures is a much more plausible explanation for the observed effects. The spatial mapping and spectroscopic capabilities of the NSOM were critical in these measurements, since the relationship between morphology and emission holds the key to understanding the behavior. Other current research projects for which the NSOM is providing critical data include the examination of surface plasmons and the study of Langmuir-Blodgett films.
- Professor Klaus Schulten, with members of the Theoretical Biophysics Group and the NIH Resource for Macromolecular Modeling and Bioin-

formatics (RMMB) at the Beckman Institute, has recently simulated unfolding of immunoglobulinlike (Ig) and fibronectin type III-like (Fn-III) domains to explain specific mechanical properties of these proteins. The architecture of Ig and Fn-III domains constitutes one of the most prevalent protein structural motifs. Proteins which contain the domains serve numerous roles in cell-cell signaling, cell-cell aggregation, and embryogenesis, as well as in mechanically coordinating and strengthening cells and tissues. These proteins are implicated in the etiology of many diseases ranging from heart insufficiency to cancer. The research employed a new simulation technology developed at RMMB, steered molecular dynamics, which permits researchers mechanically to manipulate models of proteins. The technology is based on RMMB software, combining the high-end graphics tool VMD with the simulation program for parallel computers NAMD. The simulations demonstrated how Ig and Fn-III domains can withstand a specific force applied to their termini, and then unfold completely when this force threshold is exceeded. The results also revealed a possible novel mechanism by which an arginine-glycine-aspartate sequence (the RGD motif) in a looped region of the Fn-III domain could act as a force-activated molecular switch. This work was performed in collaboration with Professor Viola Vogel's research group at the University of Washington.

• Atomic force microscopy is being utilized in Professor Stephen Sligar's laboratory to visualize and manipulate the supramolecular architectures in molecular medicine. Previously, his lab has reported the first direct observation of single nanometer scale high density lipoprotein particles which serve as the "good cholesterol" by transporting and clearing



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cholesterol esters from the peripheral vasculature. The protein component stabilizes discoidal structures on atomically flat surfaces that are 5.5 nm high with diameters of 10-20 nm depending on the stoichiometry of protein to lipid. In 1998, Sligar's lab succeeded in utilizing this natural lipid-protein complex as a nanostructured material to form supported phospholipid bilayers in which integral membrane proteins can be stabilized. These nanoparticles allow the direct visualization of single membrane protein structures, as well as direct measurement of physical properties on single molecules. The approach allows detailed structural information to be obtained for those systems that are normally recalcitrant to structure determination by NMR and X-ray crystallography. The ability to probe directly the function of single proteins incorporated into defined membrane structures could have enormous impact on the understanding and control of biological signaling and growth control processes and in the formation and operation of neuronal patterns.

• A team of geologists, microbiologists, and chemists at the Beckman Institute and the University of Illinois has joined together to investigate the origins of life on a microbial level. The team, which includes professors Bruce Fouke and Jonathan Sweedler from the Beckman Institute and Professor Abigail Salyers from the Department of Microbiology, is funded by a UIUC Critical Research Initiative grant. Complex multicellular organisms first appeared on earth as bacteria in extreme environments some 3.8 billion years ago. However, the process of microbial fossilization and therein the ability to identify these organisms in ancient rocks is poorly understood. Integrated sedimentological, crystallographic, and geochemical analyses of modern hot-spring deposits,



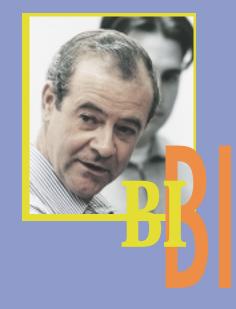
called travertines, will be studied to determine the process by which microbes are entombed in carbonate crystals. The hot spring waters and the actively precipitating travertines will be analyzed geochemically (to calculate what types of minerals the waters would precipitate and/or dissolve) and genetically (to determine what types of microbes are growing there). Results will be used to fine-tune strategies to search for fossilized microbial life forms on earth and other planets.

BIOLOGICAL INTELLIGENCE



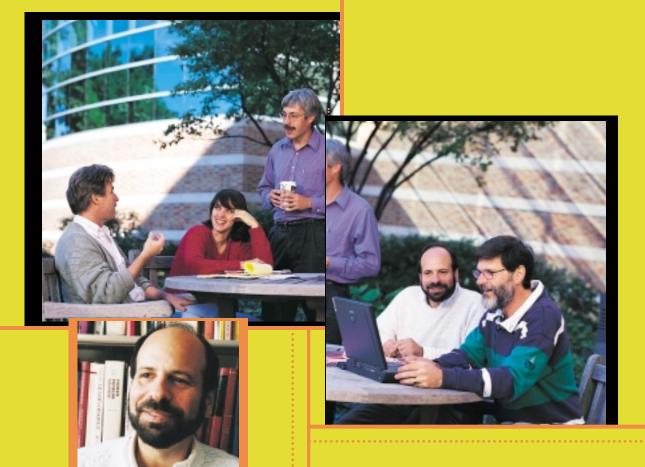












The goal of the Biological
Intelligence Main Research
Theme is to understand
intelligent behavior in
systems, whether they are
composed of neurons
or microchips.



The **Biological Intelligence** MRT is noted for its diversity of approaches—from examining how the structure of molecules and neurons changes with learning, to examining how language can be instantiated in computer systems.

One of the notable trends of 1998 was that Beckman Institute researchers were particularly successful at obtaining funding through new and highly competitive National Science Foundation initiatives that are geared explicitly toward multidisciplinary approaches to scientific inquiry. The success of Beckman researchers in obtaining such awards speaks to the truly multidisciplinary and integrative nature of the Institute. Another notable trend was the increasing involvement of Biological Intelligence researchers in using functional magnetic resonance imaging technology. Some of these efforts were directed toward refining the techniques themselves, so that they can be used with the low-level concentrations of molecules in biological systems, while others have been directed toward using these methods to uncover the neural systems that underlie a variety of mental functions, including attention, memory, and language.

Other trends involve increasing research in using biological systems to aid in the design of electronic devices, as in the case of the intelligent hearing aid, and in the fabrication of new devices whose adaptability is based on principles from biological systems. Finally, important strides have been made with regard to understanding the molecular bases of memory and learning.

-Marie Banich and William T. Greenough, Co-chairs

Highlights

 Language researchers at the Beckman Institute were awarded a three-year grant from the Knowledge and Distributed Intelligence program of the National Science Foundation. The investigators on this project are Gary Dell (PI), Kathryn Bock, Jennifer Cole, Cynthia Fisher, Susan Garnsey, Adele Goldberg, Stephen Levinson, and Dan Roth. Their project, titled "The Role of Experience in Language Processing," brings together psychologists, linguists, and computer scientists from the Cognitive Science, Cognitive Neuroscience, Artificial Intelligence, and Image Formation and Processing groups. The goal of the project is to study how people produce and understand language and how this knowledge can be used to develop language technology for computerized systems. As such, this project not only examines a basic scientific issue, but also attempts to apply that knowledge to technology transfer. Although we often think of people acquiring language relatively early in life, the central idea of the project is that a successful language processing system (whether in a person or a machine) is constantly changing. Language processing adapts quickly to recent experience, while continuing to reflect the accumulated experience of a lifetime of speaking, listening, reading, and writing.

The group is studying how people's speaking and comprehension skills change by exposing them to particular words and sentences, and is using a wide variety of measures to examine change as a function of this experience. Many of these measures are more sensitive in revealing change in language processing than traditional measures of performance, such as how quickly or accurately an individual can make decisions about sentences. For example, the group plans to use eye movement patterns and electrical brain potentials to obtain a better idea of how language processing is modified by experience. At the same time, the group is developing computational models of the language processing system, with the goal of creating models that learn from experience and adapt to their current circumstances.

 Professors Eric Jakobsson and Shankar Subramaniam also received a three-year grant from the NSF's Knowledge and Distributed Intelligence program to create methods that would make it possible to predict the detailed function of a protein from its structure and internal motion. Protein structure is, of course, fundamental to protein function, but equally important are the internal thermal motions that a protein continually undergoes. The basic problem is that protein structure is so complicated and proteins have so many potential ways to move that it is impossible to do a "brute force" simulation of all the possible protein motions and to catalog their effects. The solution that the Beckman Institute researchers are taking is to break the problem of describing protein motion into a hierarchy of problems and treat each level of the hierarchy separately, moving from the most detailed to more "coarse-grained" descriptions. In



Work at the Beckman Institute during 1998 led to excit-

The goal of this work is

ing breakthroughs in understanding the molecular bases

to find ways to bypass

of memory and learning. Researchers discovered that the

the absence of FMRP in

fragile X mental retardation protein (FMRP), the absence of

patients who exhibit this

which causes mental retardation, was synthesized at the

genetically inherited disease.

synapses that interconnect nerve cells in the brain.









each case, the numerical results from the most detailed calculation will be used as parameters for a more coarse-grained calculation.

In order to predict function from structure, three levels of description will be developed: quantum chemistry, classical molecular dynamics, and kinetic theory. The results from the kinetic theory will be compared directly with experimental results. To validate this approach, work will focus on ion channels, the membrane proteins that permit ions to cross biological membranes. All software developed in the course of the project will be embedded in the Biology Workbench (http://bioweb.ncsa.uiuc.edu). The Biology Workbench is a Web-based computing environment for molecular biology that assembles database and analysis programs from disparate sources

into a single package that any user can easily customize to suit specific needs.

• Last year, Beckman researchers Brian Rose, Gregory Murphy, Gorald DeJang, Karl Rosengren, and Leannard Pitt received a three-year grant from the National Science Foundation in a cross-disciplinary initiative on Learning and Intelligent Systems. The goal of this grant is to construct an integrated theory of concept learning that can account for the behavior of both humans and machines. The theory will be integrated in that (1) it will account for a wide variety of results in concept learning that are often studied in isolation (e.g., conceptual learning in children, conceptual learning by machines); and (2) it will pool the research strengths of cognitive science, artificial intelligence, and computational learning theory.

During 1998, the project moved forward on several fronts. First, the group has identified specific gaps in knowledge that exist in certain domains (e.g., artificial intelligence) that have been addressed in another domain (e.g., cognitive science) with an eye towards being able to use knowledge in one domain to understand similar problems in the other domain. Second, a variety of psychological experiments have been initiated to study category use, the development of concepts, the role of explanations in conceptual knowledge, and the influence of prior knowledge on learning concepts. Third, efforts have begun to take knowledge gained from psychological experiments on how concepts are formed to build a computational model that accounts for the way that prior knowledge appears to influence concept formation. Finally, work was done on creating an abstract framework for formalizing explanations in conceptual knowledge and an initial investigation of the properties of this framework has begun.

● The year 1998 saw much progress in research at the Beckman Institute that utilizes magnetic resonance imaging (MRI). One main component of this research involves creating new methods for utilizing MRI technology. A new state-of-the-art 1.5 Tesla magnetic resonance imager was installed in the **Biosensors Group** in November. Funding for this machine was obtained from the National Institutes of Health Shared Instrumentation Program with Professor Andrew Webb as the Principal Investigator. Research programs planned with the new system include the design of a closed loop MRI system, the synthesis and testing of new contrast agents, the use of constrained reconstruc-

tion techniques for magnetic resonance, and in vivo testing of ultrasound mediated hyperthermia. The system will also be used extensively for studying brain function in animal models, which will act as an adjunct to the other main project involving MRI, the Human Functional Brain Mapping Project. This project involves using functional magnetic resonance imaging (fMRI) techniques to assess the functional status of specific brain regions in humans performing various cognitive tasks.

- Major progress was made in the Human Functional Brain Mapping Project during 1998, as numerous lines of research were initiated to understand the brain systems underlying memory, face processing, language, emotion, attention, and executive control. This project links a group of cognitive neuroscientists (professors Marie Banich, Neal Cohen, Susan Garnsey, Arthur Kramer, and Gregory Miller) and engineers (professors Zhi-Pei Liang and Andrew Webb). A special focus of the project are studies that investigate how the brain's processes are modulated dynamically—by memory, learning, or the allocation of attention.
- With regard to memory, research conducted at the Beckman Institute has shown that cortical regions of the brain dedicated to the processing of faces are shaped by experience, becoming differentially active when processing famous versus nonfamous faces. Studies of attention have shown that activity of frontal cortical regions are modulated on the basis of to-be-attended dimension of an item (e.g., paying attention to its color rather than its meaning), whereas activity of posterior regions are modulated by both the attended dimension (e.g., an item's color), as well as the unattended

dimension (e.g., its meaning). A pilot project has begun to identify those components of the language system that are modulated by acquisition of a second language. This last project arose from a University of Illinois Center for Advanced Study Initiative on Mind, Brain, and Language, co-organized by Marie Banich, that culminated in a two-day conference of international researchers that was co-sponsored by the Beckman Institute.

• 1998 also witnessed continued development of MR engineering capabilities. Work here on new algorithms for more robust motion correction and image reconstruction routines are a key element of discussions now underway for a collaborative effort by the Beckman Institute, the University of Illinois College of Medicine in Chicago, and GE Medical Systems. This collaborative effort holds the promise of permitting the program eventually to include high-field MRI studies in Chicago.

In other developments, funds have recently been received to install a newly developed turn-key fMRI system, one of only ten sites in the country with this integrated hardware-software package, designed to enhance and standardize the presentation of stimuli and acquisition of brain images. Funds have also been obtained to monitor a subject's eye movements in the MR scanner simultaneously with the acquisition of brain data, permitting researchers to take advantage of the Beckman Institute's cutting edge eye movement research technology. This set of new capabilities sets the stage for even more exciting developments in the coming year.

• The Intelligent Hearing Aid Project, which has been ongoing for several years, uses biologically inspired computational and signal processing algorithms to overcome the problem of most conventional hearing aids, which is that they amplify all acoustic signals, both those that are relevant and those that are not. In past years, the interdisciplinary team on this project (professors Albert Feng Robert Bilger, Douglas Jones, Charissa Lansing, William O'Brien, and Bruce Wheeler) created algorithms for the localization of a particular sound from multiple sound sources, as well as a means of optimally canceling all the interfering sources. In 1998, the algorithms were improved by resolving phase ambiguities in arriving sound waveforms with the result that localization of interfering sources is more robust. Second, the team has created a complementary algorithm, which optimally cancels nondirectional noise sources. A second patent application on the improved sound localization and cancellation technologies was recently filed with the US Patent Office. Work is presently in progress to implement the algorithms to real-time prototypes for use with human subjects in the laboratory.

• In 1998, there was much growth in research on the fabrication of new sensors that can be used with biological systems or are based on principles of adaptability in biological systems. A new three-year \$3.5 million project began in June at the Beckman Institute to investigate microfluidic devices and phenomena and to develop next generation fabrication schemes. The Defense Advanced Research Projects Agency (DARPA)-funded project includes researchers from Electrical and Computer Engineering (David Beebe, PI), Theoretical and Applied Mechanics (Hassan Aref, Ronald Adrian), Chemical Engineering and Chemistry (Jeffrey Moore, Deborah Leckband),







as well as researchers from the University of California at Santa Barbara (Carl Meinhart) and Stanford University (Juan Santiago). Some of the researchers are developing models and experiments aimed at building microscale passive fluid mixers to provide rapid, low shear mixing for biomolecular systems. Others are working towards novel uses of polymers in microfluidics systems to prevent protein adsorption and to provide novel functional systems based on materials that respond to stimuli. A third group is developing new diagnostic tools to facilitate study of microfluidic systems.

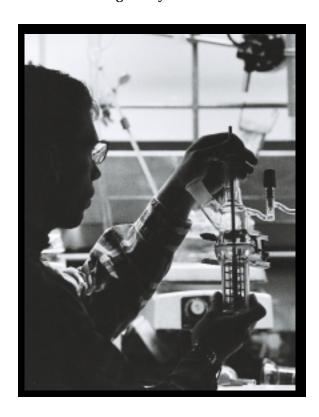
A related project which began in 1998 was phase II of a major grant from DARPA entitled "Integrated Mesoscopic Cooler Circuits (IMCCs): A Transforming Technology of Robust Ultra-efficient Environmental Control for Warriors of the 21st Century." Among the 12 faculty on this project are Beckman faculty member Mark Shannon, associate director of the project, as well as professors Narayana Aluru and David Beebe. The goal of this project is to combine new layered mesoscopic fabrication techniques with a scaleefficient vapor-compression cycle to create a system of light-weight microcoolers. The mesoscopic processes under development combine innovative polyimide/thin film layering technologies with silicon-based electromechanical device fabrication. An important potential application is the cooling of combat personnel operating in hot climates. Other potential applications include cooling of microelectronics and infrared sensors in harsh environments and thermal control of a wide range of biological systems.

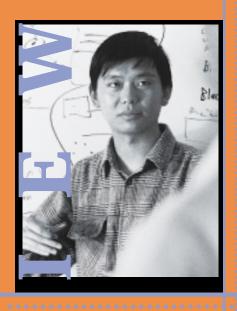
As a forum for discussing issues related to these two projects as well as others at the Beckman Institute, the Institute sponsored a conference in May, entitled "Frontiers of Mesoscale Systems and Microfabrication," which involved approximately 130 researchers from across the country who gathered to discuss novel miniaturized systems and methods. The symposium covered topics ranging from bioMEMS to commercialization issues to nontraditional fabrication techniques, and included representatives from academia, industry and government.

 A group headed by Beckman researcher David Clayton received a University of Illinois Critical Research Initiative (CRI) award, with Beckman researchers Jim Black, William Greenough, and Yuqing Li, and affiliates Martha Gillette and Jeff Mogil, to create a distributed laboratory for behavioral testing of genetically altered mice. Evaluating the behavioral significance of genes using transgenic and gene inactivation methods is complicated by the fact that multiple effects of gene manipulations may occur. Inactivation of a gene, for example, might impair learning—not because the gene is involved in the learning process, but because the gene is critical to normal vision. The CRI laboratory will use a test battery approach to examine the functioning of basic systems and to define more precisely the nature of behavioral alterations caused by genetic modifications. Areas of study include learning and memory, bodily "clocks," basic neural development, models of human psychopathology, and modulation of pain systems.

Work at the Beckman Institute during 1998
 led to exciting breakthroughs in understanding

the molecular bases of memory and learning. Professor William Greenough and his colleague Dr. Ivan Jeanne Weiler discovered that the fragile X mental retardation protein (FMRP), the absence of which causes mental retardation, was synthesized at the synapses that interconnect nerve cells in the brain. Subsequently, they have shown that FMRP acts to promote synthesis of other proteins at the synapse and that the absence of the protein, in both humans and a mouse model of the disorder, leads to malformation of synapses and to accumulation of more synapses than normal. The goal of this work is to find ways to bypass the absence of FMRP in patients who exhibit this genetically inherited disorder. Indicating the importance of this work, Greenough was awarded the 1998 William Rosen Research Award by the National Fragile X Foundation "for outstanding achievement in the field of fragile X syndrome."



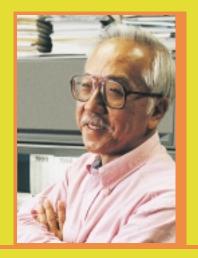


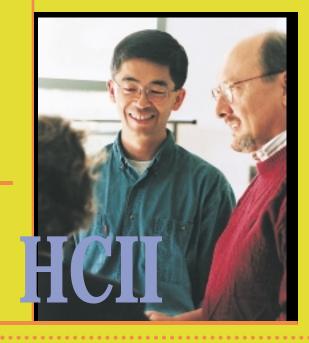


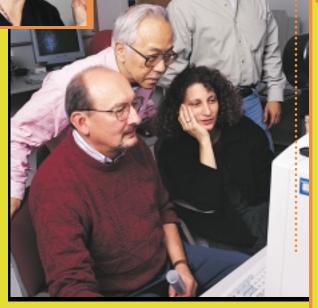
HUMAN-COMPUTER INTELLIGENT INTERACTIO











A broad objective of the Human-Computer Intelligent Interaction

Main Research Theme is to combine synergistically machine

intelligence and human

intelligence for the Solution

of complex scientific, engineering,

and societal problems.

To this end, basic and applied research are carried out on issues related to the interaction among humans, computers, and the physical environment. Research topics include multi-modal human computer interfaces, multimedia databases, intelligent information processing, advanced displays, smart sensors, and robotics. A main characteristic of the HCII MRT is that technologists and human factors scientists collaborate closely to ensure that HCII systems are human-centered. Several major multidisciplinary research programs are underway and made significant progress in 1998. Three of the largest are: "Advanced and Interactive Displays," sponsored by the Army Research Laboratory; "Automated Situation Awareness," sponsored by the Naval Research Laboratory; and "Computer Companion," sponsored by the Yamaha Motor Corporation.

Other research programs include MRI image reconstruction and registration, human perception in complex environments, constructing 3D object geometrical models from video, omnifocus camera, six-legged robots, mobile multimodal learning robots, human wayfinding, and pilot training and decision making. Complementing these research grants, a major NSF Research Infrastructure grant provides the much needed experimental facility for research in multimodal and multimedia signal processing and visualization.

Members of the HCII MRT participate in the activities of professional societies. Several held key positions (including General Chair and Special Session Chair) on the Organization Committee of the IEEE International Conference on Image Processing (October 4-7, 1998, Chicago). In conjunction with this conference, a very successful International Workshop on Very Low Bitrate Video Coding was held at the Beckman Institute immediately following the IEEE meeting. HCII MRT members collaborate closely with industry and the military and are heavily involved in international standards activities, including JPEG2000, MPEG-4, and MPEG-7.

—Thomas Huang and Arthur F. Kramer (acting), Co-chairs

Highlights

- During the past year, the group of Beckman Institute researchers involved in the Army Research Laboratory's (ARL) Federated Lab for Advanced and Interactive Displays has made a number of significant contributions to basic and applied research relevant to the development of the next generation of advanced displays. For example, researchers under the direction of professors Caroline Hayes (University of Minnesota since February 1998) and Patricia Jones have continued to develop battle planning and management tools, which have begun to transition to private industry and military laboratories and facilities. The human factors group, including professors Arthur Kramer, George McConkie, and **Christopher Wickens**, has made substantial progress in our understanding of human navigation with a variety of 2D and 3D terrain visualization methods; and has continued to develop techniques for the on-line assessment of aspects of human attention and perception. The engineering group led by Professor Thomas Huang and Dr. Robin Bargar of the **National Center for Supercomputing Applications** has continued to develop hardware and software for multimodal displays, including integrated speech, gesture, and sonification. In the coming year, each of these groups will further integrate their knowledge and products in the context of the Integration Support Laboratory, which will serve as a model testbed for technical and scientific explorations of integrated display concepts.
- The Integration Support Laboratory (ISL) was opened in 1998 at the Beckman Institute. It has been

- funded as part of the ARL Federated Lab project, and is currently managed by Dr. Robin Bargar. The ISL allows researchers to perform experimental integration of advanced technology research and to conduct controlled experiments concerning humanmachine interaction with the integrated technologies. The ISL is designed to provide researchers with the capability for loose coupling of algorithms, data, and technologies from diverse laboratories. These technologies include human-centered sensors and advanced interactive displays, high-dimensional and dynamical computational models, and distributed software and hardware systems to support real-time information processing. The ISL addresses a growing need that has been identified in university, government, and industrial research facilities, by enabling the loose coupling among emerging research and off-the-shelf technologies for efficient configuration, testing, and prototyping of integrated systems.
- Fox is an intelligent computer assistant that is being developed as part of the ARL Federated Lab for Advanced and Interactive Displays. Fox allows Army battle staff planners and decision makers to save time in critical situations by rapidly generating and evaluating thousands of plan options using genetic algorithm technology. It quickly identifies a few "best" plan options, then hands them over to the battle staff to allow them to make their own assessments and modifications. In 1998, evaluations of Fox were conducted at Fort Huachuca, Arizona, and at the Army training school in Fort Leavenworth, Kansas. The tests demonstrated that users aided by



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interaction with computers more enjoyable





Fox explore significantly more battle plans. Fox is being developed jointly by Professor Caroline

Mayer at the University of Minnesota; her student
Carolyn Fiebig at the University of Illinois; Robert
Winkler of the Army Research Laboratory in Aberdeen, Maryland; and Hayes's former student Major
Jerry Schlabach, now at INSCOM in Belvoir, Virginia.

• As part of the ARL Federated Lab for Advanced and Interactive Displays, the goal of the CoRAVEN ("Collaborative RAVEN") project is to create a prototype cognitive tool for Army intelligence officers, as well as engage in empirical study of the intelligence planning and monitoring process. The CoRAVEN prototype tool integrates Bayesian Belief Network,

spatial representation, and sonification technologies into a flexible tool for Army intelligence analysts to support planning and monitoring data in simulated battlefield scenarios. In addition, in 1998, the CoRAVEN project explored issues in collaborative support and in psychological studies of judgment under uncertainty. The research team working on the CoRAVEN project includes professors Patricial Innes, David Wilkins, James Sintezes, and Dr. Robin Bargar from the Beckman Institute, and Professor Campline Hayes, at Minnesota.

• In 1998, Professor Christopher Wickens's research, funded in part by the ARL Federated Lab, has continued to address the frame of reference

with which complex spatial data should be presented to the user. This issue can be addressed across a variety of domains: the pilot or air traffic controller understanding the location of traffic, weather, or terrain: the soldier or battlefield commander understanding the location of terrain and progress of enemy movement; or the scientist understanding the structure of data or abstract information. Such presentation may be egocentric —when the user is "immersed" in the database; or it may be exocentric—when the user is outside, looking in. In the latter case, the viewpoint may be from an angle, creating 3D perspective, or from directly above, creating a 2D map. Based upon the perceptual and cognitive operations that are carried out as users interact with such data bases, the research has identified a series of principles of task-display dependencies, which can allow the designer to choose the optimal viewpoint or frame of reference.

 Professors Janet Sniezek's and David Wilkins's research groups have begun a four-year project sponsored by the Navy Research Laboratory, titled "Automated Situation Awareness." The goal of this effort is to automate decision making and situation awareness for damage control on the next generation of Navy ships. A research prototype under development uses a combination of data from experts on damage control and machine learning techniques to replace human judgment and decision making. The scope of the solution encompasses modelbased crisis recognition, model-based predictive validation, automated casualty response, and a supervisor interface console. A special advantage of the multidisciplinary approach is that the humancomputer interaction aspects of automated decision

making and situation awareness is guided by psychological experimentation. By understanding the manner in which humans assess the many dimensions of a crisis and apply their knowledge for effective decision making, it is possible to incorporate human expertise into the system as well as make the system understandable to human operators. The proposed solution is for a ship of the future that is equipped with more intelligent damage control sensors and actuators than are currently present on ships. Prototypes of these sensors and actuators are being placed on an experimental floating research laboratory, the *ex-USS Shadwell*, to test the solution ideas represented in this project.

 Beckman researchers (educational psychologists George McConkie, James Levin, and Michelle Perry; electrical and computer engineers Thomas Huang and Stephen Levinson; linguists Jerry Morgan and Georgia Green; and computer scientist Jerry DeJong) have been working since 1997 on a project funded by the Yamaha Motor Corporation, Japan, to conduct basic research that will lead to the development of "computer companions." This research has explored a number of different ways to make the interaction with computers more enjoyable, including the integration of multimodal inputs and outputs, recognition of the user's emotional state, the development of different interactional styles for the computer, models of learning, and new ways to interact with Internet resources. In 1998, a system was developed that can detect the emotional state of the user based on visual and vocal cues. Additional research has also discovered that certain gestures, positions, and eye movements are indicators of the user's emotional and cognitive states. New visualization techniques

have also been developed for displaying information from the Internet in the most comprehensible ways.

- **Professor Stephen Levinson and his group** are testing experimentally a novel theory of cognition by building an autonomous intelligent robot. Their theory comprises three equally important principles. First, they believe that cognition, as manifest in humans, requires a well integrated sensorimotor periphery. This is essential for the development of a semantic representation of reality from which all other levels of linguistic structure derive. Second, for intelligent behavior, the widely accepted role of computation in the sense of Turing is of secondary significance to the primary mechanism of associative memory. And, finally, the contents of the associative memory must be acquired by the interaction of the machine with the physical world in a reinforcement training regime. The reinforcement signal comes from three sources: autonomous exploration by the robot, instruction of the robot by a teacher as to the success or failure of its behavior, and instruction of the robot by the teacher in the form of direct physical demonstration of the desired behavior (e.g., overhauling the robot's actuators). Such instruction must make no use of any supervised training based on preclassified data. Nor may the robot use any predetermined representation of concepts or algorithms. The result should be a robot, trained as described above, of sufficient complexity to be able to carry out simple navigation and object manipulation tasks in response to naturally spoken commands. The robot is to acquire language along with its other cognitive abilities in the course of its training.
- Professor Jean Ponce's research group continues to explore the geometric aspects of computer vision and robotics problems. In 1998, a focus of

- the vision work was on automating the construction of geometric object models from images; a method for constructing 3D spline models from a few photographs has been developed. Another technique that bypasses the 3D reconstruction process directly to create real-time graphical animations from image sequences has also been proposed, and new statistical estimation methods are boosting its performance. Work on shape representation continues, with exciting developments in the analysis of the critical changes in the appearance of a surface as it deforms and moves in space. In robotics, the prototype of the reconfigurable gripper developed in Professor Ponce's group has become operational and it has been used for several manipulation experiments. New developments involve a collaboration with Beckman Fellow Dr. Srinivas Akella that are aimed at developing novel part-sorting devices and algorithms for manufacturing applications, and a collaboration with Professor David Kriegman on mobile robot navigation.
- Professor Zhi-Pei Liang's research group made significant progress along several lines of research in 1998. Notably, the group has developed a maximum-entropy, generalized series-based, imaging method for fast dynamic imaging. This method can effectively incorporate a priori information into the imaging process, resulting in up to a ten-fold improvement in imaging speed for many magnetic resonance imaging applications. The group has also proposed a new image similarity measure that can accurately predict the relative position of images with large contrast difference. This measure is a major step forward in solving the long-standing, challenging problem of automatically registering images acquired from different imaging modalities.



During the past year, the group of Beckman Institute

Researchers have developed battle researchers involved in the Army Research Laboratory's

planning and management tools,

Federated Lab for Advanced and Interactive Displays

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private industry and military

and applied research relevant to the development of the

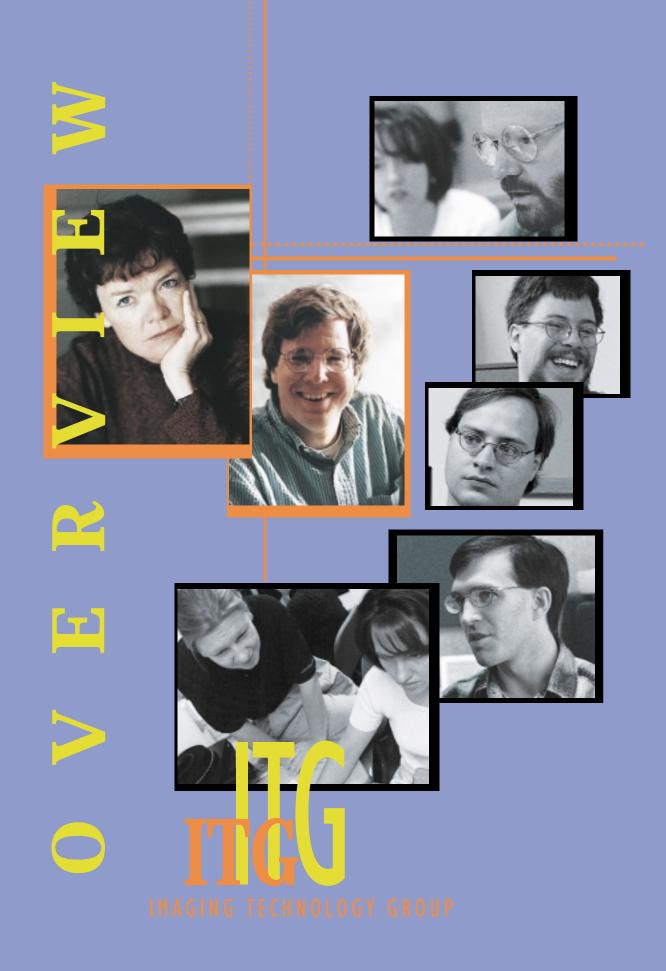
laboratories and facilities.

next generation of advanced displays.

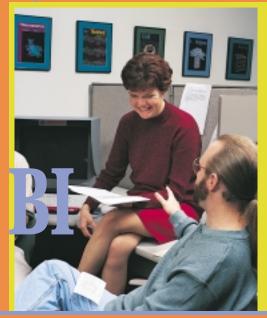
• In 1993, motivated by activities in international compression standards (MPEG-4), professors Thomas Huang and Mike Orchard organized a workshop on Very Low Bitrate Video Coding at the Beckman Institute. Due to the enthusiastic response and overwhelming interest in this subject matter, it was decided that workshops on this topic should be held regularly, and that they would be organized by an International Steering Committee. Three such workshops followed; they were held in Essex, England; Tokyo, Japan; and Linkoping, Sweden. In 1998, at the beginning of MPEG-7, the 5th workshop on VLBV returned to the Beckman Institute. The twoday workshop consisted of invited panel discussions and contributed poster papers. The topics of the five panels were image and video feature extraction and segmentation; video representation, coding, and indexing; 3D modeling and virtual reality; applications;

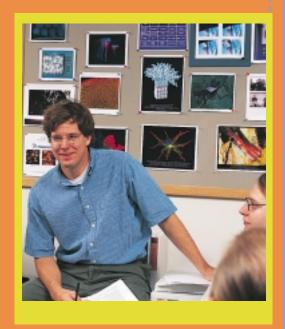


- and MPEG-7 issues. Approximately 100 researchers from all over the world participated in this workshop. The discussions at the meeting and resulting proceedings (which include position papers from the panelists and the contributed poster papers) will help shape the future of international video compression standards.
- Funded by a Critical Research Initiative grant from the University, a new research program on "Electronic Commerce" began formulation in 1998. This effort is spearheaded by Dr. Michael Shaw and involves faculty members from the Beckman Institute, Department of Computer Science, College of Commerce and Business Administration, and the College of Law. A broad range of technical, commercial, and legal issues will be studied.









In January 1998, the Beckman
Institute visualization facilities were
reorganized into the Imaging
Technology Group with
two directors: Bridget Carragher,
director of the facility since 1992,
and new director Clint Potter.

The primary mission of the group is to provide Beckman researchers with state-of-the-art imaging facilities. This service mission is accomplished through two facilities: the Microscopy Suite and the Visualization, Media, and Imaging Laboratory (VizLab). A secondary focus of the group is to develop advanced imaging technologies, primarily in the area of microscope control and automation.

Highlights

• Environmental Scanning Electron

Group received a major Research Instrumentation grant from the National Science Foundation for the purchase of an environmental scanning electron microscope with a field emission gun. The system is capable of imaging under wet and low vacuum conditions and will facilitate the examination of wet, oily, dirty, outgassing, and nonconductive samples in their natural state without significant sample preparation. This system is a unique instrument on campus and will be used by over twenty user groups. In addition, the ITG received a sponsored university research grant from IBM to provide for remote and automated access to this instrument.

e Light Microscope Facility Upgrades: The capabilities of the light microscope facilities have been extended as a result of major hardware and software acquisitions. Quantitative image analysis tools for applications such as stereology, neuron tracing, quantitative densitometry, morphometry, receptor binding, gel analysis, and grain counting are now available. The new addition to the Microscopy Suite's collection of light microscopes is a Zeiss SV-11 stereoscope. This microscope is well suited for the examination of specimens that are too large to be viewed using a conventional research microscope, such as plant structures, oocytes, and embryos. A set of laser tweezers was added to the inverted fluorescence light microscope; this device

allows users to manipulate microscopic particles, such as cells, organelles, beads, or macromolecular complexes. A heating stage was also acquired to facilitate experiments with live cells and organisms.

- Scanning Probe Microscope Upgrades: An electric force tip holder was acquired for the atomic force microscope (AFM). The new tip holder allows the user to scan samples while applying a voltage between the sample and the tip. New software features include particle analysis and automatic tip quality analysis. Most recently, pulsed force mode AFM has been added that will allow users to collect topographic, adhesion, and local stiffness data simultaneously.
- New Digitizing Capabilities: A 3D digitizing system has been added to the Visualization, Media, and Imaging Laboratory that provides the capability to digitize and model macroscopic objects. Two new flatbed scanners were also installed to provide both high resolution and large format capabilities.
- Automated Tissue Processor: A new addition to the Microscopy Suite is a tissue processor that provides an option of automatic processing of specimens for electron microscopy. It helps to decrease the use of chemicals that are expensive and often harmful, as well as the amount of hazardous waste.
- Chickscope: The Chickscope project is an inquiry-based learning and teaching program for K-12 classrooms. Chickscope is a web-based program that allows students to study chicken embryo development using a variety of educational resources, such as inquiry-based curriculum materials, interactive modules on egg mathematics, and a remotely controlled magnetic resonance imaging (MRI) instrument. Over thirty classrooms took part in the development of this project. Partial support for

Chickscope was provided by the Lumpkin Foundation and the Illinois Board of Higher Education. (http://chickscope.beckman.uiuc.edu)

- Automated Electron Microscopy: This NSFsponsored project supports the development of technology for the automated acquisition of images from a transmission electron microscope. The project is a collaboration between the Imaging Technology Group and several Beckman Institute researchers, including Brendan Frey, a 1998 Beckman Fellow.
- Outreach: In 1998, a weekly Imaging Technology Group forum series was initiated to provide an opportunity to learn about the tools, techniques, and technologies available within the group. Thirty-six forums were presented during the year and included presentations from members of the Imaging Technology Group, users of the facilities, and members of the Beckman Institute and University of Illinois campus and local communities. In addition, a technical report series was initiated to document the techniques and applications developed within the Imaging Technology Group. Twelve technical reports were published during 1998.
- University Non-credit Course: In the fall, the Imaging Technology Group taught a University non-credit course. The course provided a hands-on overview of the imaging technology activities at the Beckman Institute. Students learned about a wide variety of microscopes and techniques, advanced automated instrument control, advanced animation and video editing techniques, and virtual reality.

-Bridget Carragher and Clint Potter, Co-directors



INFRASTRUCTURE:

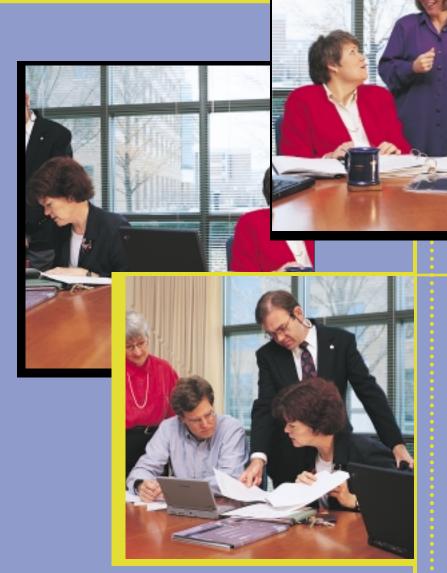
Responding to Increased Demands











The past several years
have seen tremendous
growth at the Beckman
Institute in terms of the number of affiliated faculty, the
amount of external funding,
and the diversity of
the research programs.

For example, in 1993 there were 106 faculty members from 17 academic departments affiliated with the Institute. This number increased to 147 faculty in 1998, and these faculty now come from over 25 departments on the campus. The Institute's external funding also increased from \$14,512,877 in 1993 to \$24,877,611 in 1998.

With this increase in external funding, many new multidisciplinary research programs have been initiated. These include the Army Research Laboratory's Federated Laboratory for Advanced and Interactive Displays; a large effort on mesoscale systems funded by DARPA; a Multidisciplinary University Research Initiative program in dendritic polymers funded by the Army Research Office; and several research grants funded as part of the Knowledge and Distributed Intelligence program of the NSE

This rapid growth of people, funding, and programs has, not surprisingly, placed a strain on the Institute's existing infrastructure, much of which was put in place when the Institute opened in 1989. Therefore, in 1998, my staff and I focused much of our time on responding to the increasing demands placed upon the infrastructure, and reinforcing it where necessary.

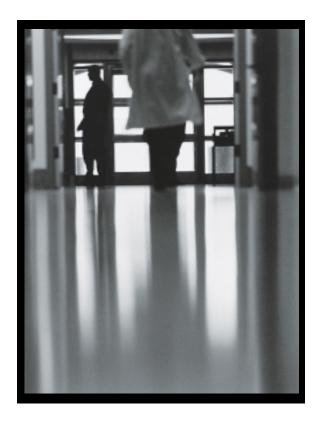
In the facilities area, Mr. Witchnel Smith, Assistant Director for Operations and Systems Services, and his capable staff have spent a great deal of time remodeling various labs and offices in the Institute to accommodate both the new staff and programs. A scale-up laboratory was built for the dendritic polymers program, which allows for the preparation of up to kilogram quantities of these interesting new materials. The first clean room was also constructed in the Institute for use in device assembly in the mesoscale program. Suitable space was also prepared to house a new NSF-funded environmental scanning electron microscope and a new state-of-the-art

1.5 Tesla magnetic resonance imager funded by the National Institutes of Health. A large-scale computer imaging laboratory, known as the Integration Support Laboratory (ISL), was created for the Army's Federated Lab program. In addition to these efforts, a number of Institute laboratories were renovated to better facilitate ongoing activities. And, finally, many enhancements were made to some of our laboratories to ensure a safer research environment.

The Beckman Institute continued the upgrade of the building backbone network in 1998 to sustain a leading edge network capability for the Institute's researchers. Ms. , Manager of Systems Services at the Institute, and her staff are replacing the old shared repeated Ethernet network (10Base2) to every office with a new, dedicated, switched Ethernet network (10/100BaseT) to every desktop. An asynchronous transfer mode (ATM) backbone was installed with high-speed connectivity to the campus backbone. The building ATM backbone provides direct connectivity to the very high performance Backbone Network Service (vBNS), and the Metropolitan Research and Education Network (MREN), which are both high-speed regional networks. The creation of ISL required the new network infrastructure to transfer large video images in real time between an eye tracker and the ISL for research on eye movement and human visual perception. The new network infrastructure has increased visualization performance for the Theoretical Biophysics Group by decreasing the animation times of their molecular models. The Imaging Technology Group is utilizing the new network infrastructure to increase speed and performance of visualization and microscopy, including the World Wide Laboratory project for remote instrument control and imaging. These groups have also proposed to expand research

projects to other universities and research institutions via the ATM connection to the vBNS, the Internet2, and the MREN.

Systems Services is also responsible for developing a family of Oracle database applications to maintain the vast array of information that is critical to the daily operation of the Institute. The first database module, FACTS (Faculty Activity Tracking System), is currently tracking information about the over 1,100 faculty, staff, students, and visitors who are members of the Institute. The database team is in the process of developing the second module of the database family referred to as BASE (Business Affairs System Environment). This module is designed to track and manage the daily activities of the Business Office, including procurement, billing, reconciliation, and reporting. The BASE application will also ensure that the operations of the Institute will be Year 2000 compliant.



The dramatic increase in external funding over the past several years has significantly increased all of the activities in the Beckman Institute Business Office, from the actual processing of the grant applications through purchasing and personnel appointments. In addition, the large size and complexity of many of the multidisciplinary grants has required additional administration and monitoring on the part of the Business Office. Mr. Gary Anderson, Manager of the Institute's Business Office, and his staff have put in many long hours to ensure that the office continued to run smoothly even with this increase in work load. The new BASE database system, as well as the addition of several new staff members to the Business Office, will help ensure that it continues to meet the needs of the Institute's research staff.

The Beckman Institute's Office of Publications and Special Events also had a very busy year. Ms. Judy Jones and her staff assisted Beckman researchers in organizing several major conferences and workshops in 1998. Several of them, including the Frontiers of Mesoscale Systems and Microfabrication symposium and the workshop on Very Low Bitrate Video Coding are discussed in detail earlier in this report. This office also coordinated the Institute's annual Open House, which was held again in March as part of the College of Engineering Open House. Several thousand people attended the event, which has become an important part of the Institute's outreach efforts.

As one can see, these are very exciting and busy times at the Beckman Institute. The Beckman Institute administration and support staff are very proud of the roles they play in supporting the world class research staff which makes the Institute what it is today.

—Jennifer Quirk, Associate Director for External Affairs and Research

FACTS & FIGURES BECKMAN INSTITUTE





BECKMAN INSTITUTE FUNDING¹

Funding Awarded to Beckman Institute Faculty Administered by the Beckman Institute²

	FY94	FY95	FY96	FY97	FY98
DEPARTMENT OF DEFENSE	1,378,174.00	1,283,925.00	2,942,604.00	3,018,926.00	4,244,105.00
National Institutes of Health	773,704.00	1,083,260.00	1,841,717.00	1,907,009.00	2,024,355.00
National Science Foundation	1,446,208.00	1,296,212.00	1,782,607.00	3,447,156.00	1,823,786.00
OTHER	527,396,00	922,840.00	1,016,751.00	1,645,026.00	817,864.00
TOTAL	4,125,482.00	4,586,237.00	7,583,679.00	10,018,117.00	8,910,110.00

FUNDING AWARDED TO BECKMAN INSTITUTE FACULTY ADMINISTERED BY OTHER DEPARTMENTS³

DEPARTMENT OF DEFENSE	2,377,930.00	1,811,671.00	4,435,872.00	4,524,577.00	6,475,573.00
National Institutes of Health	3,713,473.00	4,057,225.00	4,982,368.00	4,752,157.00	5,614,090.00
National Science Foundation	3,994,211.00	5,400,368.00	1,754,112.00	3,176,276.00	1,837,054.00
OTHER	2,348,406.00	2,170,321.00	2,240,345.00	2,218,587.00	2,452,133.00
TOTAL	12,434,020.00	13,439,585.00	13,412,697.00	14,671,597.00	16,378,850.00

 $^{^{1}}$ In addition to the sources itemized in the chart, funding for the Institute is received from the following:

- $1. \ The \ state \ of \ Il lino is \ to \ the \ University \ of \ Il lino is \ and \ allocated \ through \ individual \ departments:$ 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 Research Assistantships

Beckman Institute Equipment Competition

 $^{^2} All\ interdisciplinary\ grants\ with\ faculty\ investigators\ from\ multiple\ departments\ are\ administered\ by\ the\ Beckman\ Institute.$

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

ASES MOLECULAR & ELECTRONIC NANOSTRUCTURES

Faculty by Beckman Institute Group

Advanced Chemical Systems Group • Paul W. Bohn: Chemistry • Theodore L. Brown: Emeritus, Chemistry • Bruce W. Fouke: Geology • Jiri Jonas (Institute Director): Chemistry • Jeffrey S. Moore: Chemistry • Stephen G. Sligar: Biochemistry • Computational Electronics • Narayana R. Aluru: General Engineering • Karl Hess: Electrical and Computer Engineering • Jean-Pierre Leburton: Electrical and Computer Engineering • Richard M. Martin: Physics • Umberto Ravaioli: Electrical and Computer Engineering • Molecular Biophysics Group • Antony R. Crofts: Microbiology • Eric G. Jakobsson: Molecular and Integrative Physiology • Shankar Subramaniam: Molecular and Integrative Physiology • Photonic Systems Group • David Brady: Electrical and Computer Engineering • Martin Gruebele: Chemistry • Nancy Makri: Chemistry • Eric Michielssen: Electrical and Computer Engineering • Scanning Tunneling Microscopy Group • Ilesanmi Adesida: Electrical and Computer Engineering • Joseph W. Lyding: Electrical and Computer Engineering • Theoretical Biophysics Group • Laxmikant V. Kale: Computer Science • Todd J. Martinez: Chemistry • Klaus J. Schulten: Physics • Robert D. Skeel: Computer Science • Very Large Scale Integrated Circuits Group • Sung-Mo (Steve) Kang: Electrical and Computer Engineering

MOLECULAR & ELECTRONIC NANOSTRUCTURES M&ENS

Major Awards

Paul Bohn

Fellow, American Association for the Advancement of Science

Martin Gruebele

Sloan Fellowship, Alfred P. Sloan Foundation University Scholar, University of Illinois Senior Editor, *Journal of Physical Chemistry* Editorial Board, *Journal of Chemical Physics*

Karl Hess

Center for Advanced Study Professor, University of Illinois

Steve Kang

Science and Technology Award, Korea Broadcasting System

Nancy Makri

Fellow, American Association for the Advancement of Science

Todd Martinez

Career Award, National Science Foundation Research Innovation Award, Research Corporation

Eric Michielssen

Valued Service Award, Applied Computational Electromagnetics Society

Umberto Ravaioli

1998 Advisors List for Excellence in Advising, College of Engineering, University of Illinois

Patents and Patent Applications

(Beckman Institute faculty in boldface)

Steve Kang: "Methods, Apparatus, and Computer Program Products for Synthesizing Integrated Circuits with Electrostatic Discharge Capability and Correcting Ground Rules Faults Therein, Issue Date: August, 1998, Patent No. 5,796,638.

Steve Kang: "Scalable Broadband Input-queued ATM Switch Including Weight Driven Cell Scheduler," Allowed: December 1998.

Jeffrey Moore, D. S. Thompson, and L. J. Markoski: "A New Method for the Synthesis of Thermally Stable Polyetherimide Monomers and Polymers with Controlled Degree of Branching and Easily Modified Endgroups," File date (year only): 1998.

Grants Awarded

(Only Principal Investigator listed)

Ilesanmi Adesida: Department of Defense/Navy, "Ultra High Speed INP-based E/D Hemt Analog to Digital Converters," 01-Mar-98 to 28-Feb-01.

Ilesanmi Adesida: Department of Defense/Air Force, "Metallization and HFET Fabrication in AIGAN/GAN Materials," 01-May-98 to 28-Feb-00.

Paul W. Bohn: Department of Education, "84.200: Graduate Assistance in Areas of National Need," 15-Aug-98 to 14-Aug-01.

David Brady: Department of Defense/Army, "Interferometric Digital Imaging," 01-Mar-98 to 31-May-99.

Martin Gruebele: National Institutes of Health, "Submillisecond Laser5 T-jump Induced Protein Folding," 01-May-98 to 30-Apr-02.

Karl Hess: Department of Defense/Navy, "Electron Transport in Semiconductor Heterostructures and in Mesoscopic Systems," 01-Mar-98 to 30-Nov-00.

Karl Hess: Department of Defense/Army, "Multi-scale Approach to Semiconductor Device Simulation Combining Semi-classical and Quantum Transport Regions," 01-Aug-98 to 31-Jul-01.

Karl Hess: National Science Foundation, "Descartes: A Distributed Center for Advanced Electronics Simulation," 01-Oct-98 to 30-Sep-99.

Eric Jakobsson: National Science Foundation, "An Integrated Computational Environment for Studying Ion Movement in Biological Systems," 01-Oct-98 to 30-Sep-01.

Jiri Jonas: National Science Foundation, "Experimental Studies of the Dynamic Structure of Liquids," 01-Dec-98 to 30-Nov-99.

Sung Mo (Steve) Kang: Semiconductor Research Corporation, "Computer-aided Design of Reliable Deep Submicron VLSI Circuits," 01-Mar-98 to 28-Feb-99.

Sung Mo (Steve) Kang: Semiconductor Research Corporation, "Single-clock Low-power Circuit Techniques," 01-Sep-98 to 31-Aug-99.

Sung Mo (Steve) Kang: Epiworks, "Epiworks Testing Agreement," 01-Sep-98 to 31-Aug-00.

Joseph W. Lyding: Department of Defense/Navy, "Nanoelectronics: Low Power, High Performance Components and Circuits (ASU)," 30-Apr-98 to 29-Nov-98.

Todd J. Martinez: National Science Foundation, "Career-nonadiabatic Effects on Chemical Reaction Dynamics in Gas and Condensed Phases," 15-Feb-98 to 31-Jan-99.

Jeffrey S. Moore: National Science Foundation, "Barrel-like Molecular Architecture from Folded Oligomers," 01-Mar-98 to 28-Feb-99.

Jeffrey S. Moore: Chromatography Research Supplies, Inc., "Dendrimer Growth From Surfaces," 01-Jan-98 to 12-Dec-98.

Jeffrey S. Moore: National Science Foundation, "Supramolecular Structuring of Hydrogels and Transient Polymer Networks," 15-Jun-98 to 31-May-99.

Jeffrey S. Moore: NASA, "Development of Polyetherimides for Modification of Engineering Thermoplastics," 21-Aug-98 to 20-Aug-99.

Jeffrey S. Moore: American Chemical Society, "Molecular Construction of Receptor Arrays and Ligand Sequences for Self-assembled Nanostructures," 01-Sep-98 to 31-Aug-00.

Umberto Ravaioli: Semiconductor Research Corporation, "Full Band Monte Carlo Models for Advanced Transport Semiconductor Simulation in Silicon," 01-Aug-98 to 31-Jul-99.

Klaus J. Schulten: National Institutes of Health, "Resource for Concurrent Biological Computing," 01-Aug-98 to 31-Jul-99.

Selected Publications

(Beckman Institute faculty in boldface)

• Arafa, M., Wohlmuth, W., Fay, P., and Adesida, I. (1998), "Effect of Diffraction and Interference in Submicron Metal-semiconductor-metal Photodetectors," *IEEE Transactions on Electron Devices*, 45/1, pp. 62-67.

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- Aluru, N. R. (1998), "A Point Collocation Method for Meshless Analysis of Microelectronic and Microelectromechanical Devices," *Proceedings of the Sixth International Workshop on Computational Electronics*, p. 54057.
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- Zhang, Y., Terrill, R. H., and Bohn, P. W. (1998), "In-plane Resistivity of Ultrathin Gold Films: A High Sensitivity Molecularly Specific Probe of Mercaptan Chemisorption at the Liquid-metal Interfaces," *Journal of the American Chemical Society*, 120/38, pp. 9969-9970.
- Zhang, Y., Terrill, R. H., Tanzer, T. A., and **Bohn**, **P. W.** (1998), "Ozonolysis Is the Primary Cause of UV Photooxidation of Alkanethiolate Monolayers at Low Irradiance," *Journal of the American Chemical Society*, **120**/11, pp. 2654-2655.
- Marks, D. L. and Brady, D. J. (1998), "Three-dimensional Source Reconstruction with a Scanned Pinhole Camera," Optics Letters, 23/11, pp. 820-822.
- Zhang, Z., Huang, L.-S., Shulmeister, V. M., Chi, Y.-I., Kim, K.-K., Hung, L.-W., Crofts, A. R., Berry, E. A., and Kim, S.-H. (1998), "Electron Transfer by Domain Movement in Cytochrome bc1," *Nature*, 392/6677, pp. 677-684.

- Kuras, R., Guergova-Kuras, M. and Crofts, A. R. (1998), "Steps Toward Constructing a Cytochrome b6f Complex in the Purple Bacteria Rhodobacter Sphaeroides: An Example of the Structural Plasticity of a Membrane Cytochrome," *Biochemistry*, 37/46, pp. 16280-16288.
- **Gruebele**, **M**. (1998), "Intramolecular Vibrational Dephasing Obeys a Power Law at Intermediate Times," *Proceedings of the National Academy of Sciences USA*, **95**/**11**, pp. 5965-5970.
- Gruebele, M., Sabelko, J., Ballew, R. M., and Ervin, J. (1998), "Laser Temperature Jump Induced Protein Refolding," *Accounts of Chemical Research*, 31/11, p. 699.
- Grupen, M. and **Hess**, **K.** (1998), "Simulation of Carrier Transport and Nonlinearities in Quantum-well Laser Diodes," *IEEE Journal of Quantum Electronics*, **34/1**, pp. 120-140.
- Ipatova, I. P., Chikalova-Luzina, O. P., and Hess, K. (1998), "Effect of Localized Vibrations on the Si Surface Concentrations of H and D," *Journal of Applied Physics*, **83/2**, pp. 814-819.
- **Jakobsson**, E. (1998), "Using Theory and Simulation to Understand Permeation and Selectivity in Ion Channels. Methods," *A Companion to Methods in Enzymology*, **14**, pp. 342-351.
- Scott, H. L., Jakobsson, E., and Subramaniam,
 S. (1998), "Simulation of Lipid Membranes with
 Atomic Resolution," *Computers in Physics*, 12/4,
 pp. 328-334.
- Ballard, L., Yu, A., Reiner, C., and **Jonas**, **J**. (1998), "A High Pressure, High Resolution NMR Probe for Experiments at 500 MHz," *Journal of Magnetic Resonance*, **133/1**, pp. 190-193.

- Kim, Y. J. and **Jonas**, **J.** (1998), "Dynamics of Complex Phthalate Liquids I: Structural Effects of Molecular Framework," *Journal of Physical Chemistry*, **102**, pp. 2767-2777.
- Fonseca, L. R. C., Jimenez, J. L., and **Leburton**, J. P. (1998), "Electronic Coupling in InAs/GaAs Self-assembled Stacked Double-quantum Dot Systems," *Physical Review B*, **58**/**15**, p. 9955.
- Fonseca, L. R. C., Jimenez, J. L., Leburton, J. P., and Martin, R. M. (1998), "Self-consistent Calculation of the Electronic Structure and Electron-electron Interaction in Self-assembled InAs-GaAs Quantum Dot Structures," *Physical Review B*, 57/7, pp. 4017-4026.
- Kale, L. V., Bhandarkar, M., Brunner, R., and Yelon, J. (1998), "Multiparadigm, Multilingual Interoperability: Experience with Converse," *Lecture Notes in Computer Science*, **1388**, pp. 111-122.
- Kale, L. V. (1998), "Programming Languages for CSE: The State of the Art," *IEEE Computational Science and Engineering*, **5/2**, pp. 18-26.
- Stroming, J. W., Kang, Y., Kang, S. M., and Huang, T. S. (1998), "New Architecture for M4R Shape Coding," *IEEE Transactions on Circuits and Systems*, Part II, **45/5**, pp. 556-562.
- Huh, Y., Song, Y., and **Kang**, **S. M.** (1998), "A Study of Hot Carrier-induced Mismatch Drift: A Reliability Concern for VLSI Circuits," *IEEE Journal of Solidstate Circuits*, **33/6**, pp. 921-927.
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- Makri, N. and Thompson, K. (1998), "Semiclassical Influence Functionals for Quantum Systems in Anharmonic Environments," *Chemical Physical Letters*, **291**/1-**2**, pp. 101-109.
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- Ben-Nun, M. and **Martínez**, **T. J.** (1998), "Electronic Energy Funnels in Cis-trans Photoisomerization of Retinal Protonated Schiff Base," *Journal of Physical Chemistry A*, **102/47**, p. 9607.
- Ben-Nun, M. and Martínez, T. J. (1998), "Direct Evaluation of the Pauli Repulsion Energy Using Classical Wavefunctions in Hybrid Quantum/ Classical Potential Energy Surfaces," *Chemical Physical Letters*, **290**/1-3, pp. 289-295.
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- Hu, X., Damjanovic, A., Ritz, T., and **Schulten, K.** (1998), "Architecture and Mechanism of the Light Harvesting Apparatus of Purple Bacteria" (invited review), *Proceedings of the National Academy of Sciences of the USA*, **95/11**, pp. 5935-5941.
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BIOLOGICAL INTELLIGENCE

Faculty by Beckman Institute Group

Bioacoustics Research Laboratory • Floyd Dunn: Emeritus, Electrical and Computer Engineering • Leon A. Frizzell: Electrical and Computer Engineering • William D. O'Brien: Electrical and Computer Engineering • Biological Sensors Group • David J. Beebe: Electrical and Computer Engineering • Chang Liu: Electrical and Computer Engineering • Mark Shannon: Mechanical and Industrial Engineering • Jonathan V. Sweedler: Chemistry Andrew G.Webb: Electrical and Computer Engineering Bruce C.Wheeler: Electrical and Computer Engineering • Cognitive Neuroscience Group • Marie T. Banich: Psychology • Neal J. Cohen: Psychology Michael G. Coles: Psychology Emanuel E. Donchin: Psychology Wendy Heller: Psychology Gregory A. Miller: Psychology • Cognitive Science Group • Kathryn J. Bock: Psychology • Gary Bradshaw: Psychology William F. Brewer: Psychology Jennifer S. Cole: Linguistics Gary S. Dell: Psychology Adele E. Goldberg: Linguistics • Georgia M. Green: Linguistics • Peter N. Lasersohn: Linguistics • Kevin Miller: Psychology • Jerry L. Morgan: Linguistics • Gregory L. Murphy: Psychology • Brian H. Ross: Psychology Edward J. Shoben: Psychology
 Robert A. Wilson: Philosophy
 Magnetic Resonance Imaging and **Spectroscopy Group** Joan M. Dawson: Molecular and Integrative Physiology 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

Major Awards

Thomas Anastasio

James E. Heath Award for Excellence in Teaching, University of Illinois Visiting Scholar, Department of Cognitive and Neural Systems, Boston University

Albert Feng

Alexander von Humboldt Award
President-Elect, International Society for
Neuroethology
Treasurer, International Society for
Neuroethology
Member, Program Advisory Committee
for NIDCD, NIH
Member, International Hearing Aid Research
Steering Committee

Leon Frizzell

Fellow, American Institute for Medical and Biological Engineering

Michael Gabriel

Editorial Board, *Neurobiology of Learning* and *Memory* Editorial Board, *Neural Plasticity*

William Greenough

Swanlund Endowed Chair, University of Illinois
William Rosen Research Award, National
Fragile X Foundation
Distinguished Scientific Contribution Award,
American Psychological Association
William James Fellow Research Award,
American Psychological Society
Oakley-Kunde Award for Undergraduate
Teaching, University of Illinois

Gregory Miller

Editor, Psychophysiology

Gregory Murphy

Associate, Center for Advanced Study, University of Illinois

William O'Brien, Jr.

Achievement Award, IEEE Ultrasonics, Ferroelectrics, and Frequency Control Society

Mark Shannon

Andersen Consulting Award for Excellence in Advising, College of Engineering, University of Illinois

Jonathan Sweedler

University Scholar, University of Illinois

Andrew Webb

Advisor's List, College of Engineering, University of Illinois

Robert Wilson

Fellow, Center for Advanced Studies, University of Illinois Executive Committee Member, Society for Philosophy and Psychology

Patents and Patent Applications

(Beckman Institute faculty in boldface)

Carl D. Gregory, Clint Potter, and **Paul C. Lauterbur**: "Interactive Stereoscopic Magnetic Resonance Imaging System," Issue date: January 13, 1998, Patent No. 5,708,359.

David Beebe, C. Bullard, M. Philpott, and **Mark Shannon**: "Active Compressor Vapor Compression Cycle Integrated Heat Transfer Device," File date (year only): 1998.

Albert Feng, Chen Liu, Robert Bilger, Douglas Jones, Charissa Lansing, William O'Brien, and Bruce Wheeler: "New Dual-channel Extraction Algorithm/System for Hi Fidelity Signal Localization, Characterization, and Interference Suppression," File date (year only): 1998.

Grants Awarded

(Only Principal Investigator listed)

David J. Beebe: Department of Defense/Air Force, "Engineering Solutions for Robust and Efficient Microfluidic Biomolecular Systems," 23-Jun-98 to 22-Jun-01.

David F. Clayton: National Parkinson Foundation, "Toward a Transgenic Mouse Model of Parkinson's Disease," 01-Jun-98 to 31-May-99.

Michael Gabriel: National Institutes of Health, "Neural Coding of Context in Instrumental Learning," 01-May-98 to 28-Feb-99.

Michael Gabriel: National Institutes of Health, "Neural Mediation of Context-appropriate Behavior," 01-Aug-98 to 31-Jul-01.

Michael Gabriel: National Science Foundation, "A Database System for Neurological Pattern Analysis," 15-Sep-98 to 31-Aug-99.

William Greenough: National Institutes of Health, "Role of Beta-amyloid Precursor Protein in Head Injury," 22-Sep-98 to 21-Sep-99.

Arthur Kramer: National Institutes of Health, "Aging and Dual-task Performance: Training Interventions," 01-Jan-98 to 31-Dec-98.

Yuqing Li: National Science Foundation, "Genetic Analysis of Mouse Cortical Development and Plasticity," 01-Apr-98 to 31-Mar-01.

Chang Liu: Department of Defense/Navy, "Integrated Capillary Microelectrode Arrays for Studies of Olfactory Response Pattern," 01-Jul-98 to 30-Jun-99.

Gregory A. Miller: National Institutes of Health, "Processing Deficits in Psychopathology," 09-Jul-98 to 08-Jul-00.

Mark Nelson: Department of Defense/Navy, "Workshop on Defining the Future of Biomorphic Robotics," 01-Oct-98 to 30-Sep-99.

William D. O'Brien: HHS-Misc., "Ultrasound Dosimetry in Human OB/GYN Examination," 01-Apr-98 to 31-Mar-99.

William D. O'Brien: National Institutes of Health, "In Vivo Ultrasonic Microprobe for Tumor Diagnosis," 01-Jul-98 to 30-Jun-00.

William D. O'Brien: Department of Defense/ Navy, "Portable Integrated MEMS Sonar Imaging System (Penn State)," 01-Sep-98 to 15-Apr-01.

Andrew G. Webb: Whitaker Foundation, "Design of New Functional Agents for Thermal Mapping Using MRI," 01-Sep-98 to 31-Aug-99.

Bruce C. Wheeler: National Institutes of Health, "Microstamping Proteins and Micropatterning Neurons," 30-Sep-98 to 29-Sep-00.

Selected Publications

(Beckman Institute faculty in boldface)

• Dow, E. R. and Anastasio, T. J. (1998), "Analysis and Neural Network Modeling of the Nonlinear Correlates of Habituation in the Vestibulo-ocular Reflex," *Journal of Computational Neuroscience*, 5/2, pp. 171-190.

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- Banich, M. T. (1998), "The Missing Link: The Role of Interhemispheric Interaction in Attentional Processing," *Brain and Cognition*, **36/2**, pp. 128-157.
- Banich, M. T. (1998), "Integration of Information between the Cerebral Hemispheres," *Current Directions in Psychological Science*, 7/1, pp. 32-37.
- *Trumbull, J. D., Glasgow, I. K., Beebe, D. J., and Magin, R. L. (1998), "Integrating Microfluidic Systems and NMR Spectroscopy: Preliminary Results," 1998 Solid-state Sensor and Actuator Workshop, Hilton Head, South Carolina.
- Tang, H. and **Beebe**, **D. J.** (1998), "Sensory Rehabilitation: A Microfabricated Electrostatic Haptic Display for Persons with Visual Impairments," *IEEE Transactions on Rehabilitation Engineering*, **6/3**, pp. 241-248.
- Griffin, Z. M. and **Bock**, **J. K.** (1998), "Constraint, Word Frequency, and the Relationship between Lexical Processing Levels in Spoken Word Production," *Journal of Memory and Language*, **38/3**, pp. 313-338.
- Bradshaw, G. L. (1998), "Patterns of Flight Testing During the Invention of the Airplane," *Proceedings of the 29th Annual Society of Flight Test Engineers*, September, Reno, NV.
- **Brewer, W. F.**, Chinn, C. A., and Samarapungavan, A. (1998), "Explanation in Scientists and Children," *Mind and Machines*, **8**/**1**, pp. 119-136.

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- Clayton, D. F. and George, J. M. (1998), "The Synucleins: A Family of Proteins Involved in Synaptic Function, Plasticity, Neurodegeneration, and Disease," *Trends in Neuroscience*, **21/6**, pp. 249-254.
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- Cole, J. (1998), "Deconstructing Metaphony," *Rivista di Linguistica*, **10**, pp. 69-98.
- Holroyd, C. B., Dien, J., and Coles, M. G. H. (1998), "Error-related Scalp Potentials Elicited by Hand and Foot Movements: Evidence for an Output-independent Error-processing System in Humans," *Neuroscience Letters*, 242/2, pp. 65-68.
- Coles, M. G. H., Scheffers, M. K., and Holroyd, C. (1998), "Berger's Dream? The Error-related Negativity and Modern Cognitive Psychophysiology," in H. Witte, U. Zwiener, B. Schack, and A. Döring, eds., *Quantitative and Topological EEG and MEG Analysis* (Jena-Erlangen: Druckhaus Mayer Verlag), pp. 96-102.

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- Spencer, K. M., Karni, O., Wijensinghe, R., and **Donchin**, E. (1998), "The Mental Prosthesis: Assessing the Speed of a Brain-computer Interface," *Psychophysiology*, **35**, p. S78.
- Zhang, H. M. and Feng, A. S. (1998), "Sound Direction Modifies the Inhibitory as Well as the Excitatory Frequency Tuning Characteristics of Single Neurons in the Frog Torus Semicircularis (Inferior Colliculus)," *Journal of Computational Physiology A*, **182/6**, pp. 725-735.
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- Kang, E. and **Gabriel**, **M.** (1998),"Hippocampal Modulation of Cingulo-thalamic Neuronal Activity and Discriminative Avoidance Learning in Rabbits," *Hippocampus*, **8**/**5**, pp. 491-510.
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- Heller, W. and Nitschke, J. B. (1998), "The Puzzle of Regional Brain Activity in Depression and Anxiety: The Importance of Subtypes and Comorbidity," *Cognition and Emotion*, **12/3**, pp. 421-447.
- Heller, W., Nitschke, J. B., and Miller, G. A. (1998), "Lateralization in Emotion and Emotional Disorders," *Current Directions in Psychological Science*, 7/1, pp. 26-32.

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- Lasersohn, P. (1998), "Events in the Semantics of Collectivizing Adverbials," in S. Rothstein, ed., *Events and Grammar* (Dordrecht: Kluwer Academic Publishers), pp. 273-292.
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M. Jones: Mechanical and Industrial Engineering • David J. Kriegman: Computer Science • Stephen E. Levinson:

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• Dan Roth: Computer Science • Michael J. Shaw: Business Administration • David C. Wilkins: Institute of

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Electrical and Computer Engineering •

Major Awards

Narendra Ahuja

Technology Achievement Award, International Society for Optical Engineering Associate, Center for Advanced Study, University of Illinois

Thomas Huang

Honored as a pioneer in signal processing at the *IEEE International Conference on Acoustics, Speech, and Signal Processing,* May 11, 1998, Seattle, WA

Interviewed for the *Oral History of the IEEE*Processing Society in commemoration of its
50th Anniversary. Parts of the interview
appeared in the book, Signal Processing:
The Emergence of a Discipline, 1948-1998,
by F. Nebeker, IEEE History Center, 1998.

Honorary Chair, *International Conference on Computer Vision, Pattern Recognition, and Image Processing*, October 23-28, 1998, Research Triangle Park, NC

Patricia Jones

Andrew P. Sage Best Paper Award, IEEE

Arthur Kramer

Fellow, American Psychological Association

David Kriegman

Young Investigator Award, National Science Foundation

Best Paper Award, European Conference on Computer Vision

Zhi-Pei Liang

Senior Member, IEEE

George McConkie

Fulbright Research Grant Senior Scholar Grant, Chiang Ching-kuo Foundation

Jean Ponce

Senior Xerox Award for Faculty Research, College of Engineering, University of Illinois

Kannan Ramchandran

Inaugural Award for Outstanding Young Faculty, Hang Magnuski Scholar Fund

Benjamin Wah

Technical Achievement Award, IEEE Computer Society

Fellow, Society for Design and Process Science First Vice President, IEEE Computer Society Robert T. Chien Professor of Engineering, University of Illinois

Stanley Wasserman

Who's Who in the World (1998-)

Patents and Patent Applications

(Beckman Institute faculty in boldface)

R. Dugad, K. Ratakonda and Narendra Ahuja: "Edge Image DWT Watermarking Method," File date (year only): 1998.

Thomas Huang: "Data Compression for Animated Three Dimensional Objects," Issue date: October 6, 1998, Patent No. 5,818,463.

B. Krongold, D. Jones, and **Kannan Ramchandran**: "Efficient Optimal Power Allocation Processes for Multicarrier Communications Systems," File date (year only): 1998.

J. Chou, I. Kozintsev, and **Kannan Ramchandran**: "Method of Information Communication over Noisy Channels with Feedback," File date (year only): 1998.

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Grants Awarded

(Only Principal Investigator listed)

Weng C. Chew: Raytheon TI Systems, "Fast Multipole Analysis of Large Antenna Arrays," 01-Jul-98 to 30-Jun-99.

Patricia M. Jones: Department of Defense/Army, "Advanced Visualization Techniques," 16-Mar-98 to 15-Nov-98.

David J. Kriegman: Department of Defense/Army, "Environment-independent Perception and Navigation for Tactical Mobile Robots: A Diktiometric Approach," 01-Sep-98 to 15-Aug-00.

Stephen E. Levinson: National Science Foundation, "Speech Synthesis Based upon Fluid Dynamic Principles," 01-Oct-98 to 30-Nov-99.

Pierre Moulin: National Science Foundation, "An Integrated Study of Image Estimations and Compression Problems," 15-Jan-98 to 31-Dec-01.

Kannan Ramchandran: Department of Defense/ Navy, "Sensor to Shooter," 21-Aug-98 to 20 Aug-99.

Dan Roth: National Science Foundation, "Learning to Perform Knowledge Intensive Inferences," 01-Sep-98 to 31-Aug-99.

Nadine Sarter: National Science Foundation, "Turning Automation into a Team Player: The Development of Multisensory and Graded Feedback for Highly Automated Flight," 01-Aug-98 to 31-Jul-99.

Christopher D. Wickens: NASA, "Attention Based Situation Awareness Support for Rotorcraft Operations," 15-May-98 to 14-Jan-99.

Christopher D. Wickens: Department of Transportation/FAA, "Pilot Expectancy and Attentional Effects for Hazard Awareness (FAA)," 16-Jul-98 to 15-Oct-99.

Selected Publications

(Beckman Institute faculty in boldface)

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 "A New Wavelet-based Scheme for Watermarking Image," *International Conference on Image Processing*, Chicago, IL, October, 2, pp. 419-423.
- Perrin, B., Ahuja, N., and Srinivasa, N. (1998),
 "Learning Multiscale Image Models of 2D Object Classes," *Proceedings of the 3rd Asian Conference* on Computer Vision, Hong Kong, January, pp. 323-331.
- Chen, F. C. and Chew, W. C. (1998), "Experimental Verification of Super Resolution in Nonlinear Inverse Scattering," *Applied Physics Letters*, **72**/**23**, pp. 3080-3082.
- Song, J. M., Lu, C. C., Chew, W. C., and Lee, S.W. (1998), "Fast Illinois Solver Code (FISC)," *IEEE Antennas and Propagation Magazine* (invited), 40/3, pp. 27-34.
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Srinivas Akella (1996) Michal Balberg (1998) Gregory J. DiGirolamo (1998) Brendan J. Frey (1997) Prahlad Gupta (1995) Tammy Ivanco (1997) Jose Jimenez (1996) Chen Liu (1996) Gregory J. Zelinsky (1995)

Selected Publications

(Beckman Institute fellows and faculty in boldface)

- Akella, S. and Mason, M.T. (1998), "Posing Polygonal Objects in the Plane by Pushing," *International Journal of Robotics Research*, 17/1, pp. 70-88.
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- Frey, B. J. and Kschischang, F. R. (1998), "Early Detection and Trellis Splicing: Reduced-complexity Iterative Decoding," *IEEE Journal on Selected Areas in Communications*, **16/2**, pp. 153-159.
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- Fonseca, L. R. C., **Jimenez**, J. L., **Leburton**, J. P., and **Martin**, R. M. (1998), "Self-consistent Calculation of the Electronic Structure and Electron-electron Interaction in Self-assembled InAs-GaAs Quantum Dot Structures," *Physical Review B*, **57**/7, pp. 4017-4026.

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