SYNERGY

SPRING 2007 BECKMAN INSTITUTE FOR ADVANCED SCIENCE AND TECHNOLOGY ISSUE 5

The Science of the Brain: A Beckman Perspective Page 2

Thanks to the work of staff, students, and faculty, thousands of visitors were treated to equal parts science and fun during Beckman Institute Open House 2007. Page 5

Motorola researcher and Beckman alumnus Chen Liu sees a new era dawning in the area of information technology. Page 8

Beckman faculty member Scott Carney is a Renaissance man: scientist, professor, weightlifter, and bicycle enthusiast. Page 10

ILLINOIS BECKMAN INSTITUTE

The Science of the Brain: A Beckman Perspective

The HALT project at Illinois studies the effects of exercise on cognition.

Whether it involves "mental fitness" or "brain training" or developing a healthy mind, the general topic of cognitive health is a trendy one these days. It's an area where science and popular culture overlap, and Beckman Institute researchers have been thrust into the middle of this timely discussion.

Advances in technology, such as improved imaging techniques, are providing exciting new insights into brain function and physiology. The topics of how we can improve cognitive functions such as memory and learning, maintain cognitive processes as we age, or even reverse cognitive loss due to disease have become as widely discussed in the popular culture and media recently as they have been in the scientific community for the last decade or so.

Sometimes the news stories, headlines, and product ads don't always carry the caveats and cautionary notes sounded by researchers. Beckman faculty members have been leading researchers in the areas of cognitive health and neuroscience for many years, and are often called upon by the national media for their expertise.

Some of the media spotlights have shone on so-called brain training programs, while others have taken an overall look at what the current scientific literature is telling us about our brains, cognition, and health. We asked several Beckman faculty members whose research is highly engaged in these areas for input on what the research tells us about what is known, what is suggested, and what is not yet proven regarding cognition and neuroscience. We looked at four (sometimes overlapping) topics: the growth of new brain cells (neurogenesis), the cognitive benefits of exercise, brain training, and transfer of skills (whether improvement from training on one task transfers to improvement on other tasks), and issues surrounding the loss of cognitive function due to aging and diseases like Alzheimer's.

Neurogenesis

For many years, science told us that the growth of new brain cells was a finite process – once we reached our 30s, neurogenesis stopped. In the past decade or so, the evidence (much of it coming from Beckman researchers) has tilted toward a theory that new neurons can be formed in certain regions of the brain.

> "We've done a pretty job of doping out, and by we I mean not my group but the collective wisdom in the field, situations under which neurogenesis either occurs or can be made to occur. The real question now is can we take advantage of it. " – *William Greenough*

Along with the change in thinking about neurogenesis, Beckman neuroscientists have produced research on brain plasticity suggesting that brain morphology and, consequently, cognition can actually be shaped by activities like exercise or environmental factors such as culture. Research involving exercise or fitness has become paramount to both discussions.

"There are very few studies that examine fitness training effects on human brain structure and function. Most of them have been done by us," said Beckman's Art Kramer, a leading researcher with colleague Ed McAuley in the area. "They do suggest positive effects, both in terms of how well the brain functions and in brain structure – how much of it you have using measures of change in brain volume."

Kramer, a Professor of Psychology and Director of the Biomedical Imaging Center at Beckman, said there is also a large and increasing literature on research done with animals that shows both learning and memory improvements and neurochemical changes in the brain with improved fitness.

"Both the animal and human research is pretty solid with respect to fitness effects on brain structure, brain function, neurochemistry, learning and memory, and cognition," Kramer said.

Exercise has become an important tool for researchers studying its effects on neurogenesis and cognition. In March, *Newsweek* magazine reported on a paper published in the *Proceedings of the National Academy of Sciences* that it said took exercise-induced neurogenesis found in animals and "extended that principle to humans for the first time."

Kramer said the study's results are narrower than that description.

"What this study showed was that a measure of cerebral brain volume which has been related to neurogenesis in the dentate gyrus in mice as a function of improvements in aerobic fitness is also associated with fitness improvements in a small, middle-aged group of humans – that is the measure of cerebral blood volume, not neurogenesis," Kramer said. "So, we still do not have a direct measure of exercise-induced neurogenesis in humans."

William Greenough, Co-chair of Beckman's Biological Intelligence research initiative, has been publishing peer-reviewed papers showing experience effects on brain plasticity since 1972 and was the first to show in a 1985 paper that more new glia (non-neuronal brain cells that provide protection and support for neurons) were formed in animals in enriched environments. He said the results reported in the PNAS paper confirmed what has been shown in animals for many years by a co-author of that paper (Fred Gage) and others.

Greenough said rather than thinking that exercise creates new neurons, exercise should be thought of as a mediating factor in neurogenesis.

"Exercise can tweak the rate at which some brain areas make neurons," Greenough said. "What is still up in the air is whether, with the right exercise, you can turn on a region that's not normally making neurons."

Even though neurogenesis has been correlated with improved cognitive function, a causal relationship has not yet been shown. NeuroTech group member Justin Rhodes is creating multi-generational mice models for future research efforts that will, among other projects, test whether exercise can produce learning improvement without the production of new neurons.

"We know that there are areas of the brain that continuously generate new neurons throughout adulthood and one of those areas is the (hippocampal dentate gyrus)," Rhodes said. "It turns out that exercise produces a tremendous increase in the number of new neurons that are found in that area."

Rhodes' research will try to isolate the neuronal factor by blocking the formation of new neurons, and then exercising the mice to see whether they still show learning improvement.

"If you exercise the animals and they're not able to produce neurons and they still show the improvement in learning, then that shows that new neurons are not necessary for new learning improvement," Rhodes said. "But if it blocks the learning then you know that they are necessary. That's a way that we can really test a causal mechanism."

Research has shown where neurogenesis takes place in the brain: in the dentate gyrus of the hippocampus and in the olfactory bulb.

"Every (other area) is highly debatable. But those two areas, not debatable," Kramer said. "And those new neurons are born as a function of exercise."

Exercise and Cognition

The effects that exercise can have on cognition has blossomed into such an important area of study that *Newsweek* magazine featured "Exercise and the Brain" as the cover story for its March 26, 2007, issue. A series of "Health for Life" articles led off with a story on how exercise can boost brainpower. Kramer, Greenough, and Beckman colleague Charles Hillman were quoted, with Hillman's study of grade schoolers adding another answer in the affirmative to the question of whether exercise benefits mental performance.

"People have been slow to grasp that exercise can really affect cognition, just as it affects muscles," Hillman said.

Of all the research results on cognitive interventions, the effects of exercise on cognition have proven most compelling. That's according to Kramer, who has been researching and reporting on this and related issues for many years, and is often called on by media such as *Newsweek* and *CBS* for his expertise.

Kramer has led several investigations that have strongly suggested beneficial cognitive effects from exercise. Kramer and colleague Stanley Colcombe did a meta-analysis of 18 intervention studies involving the cognitive effects of aerobic fitness on older adults that was published in in 2003.

> "There are very few studies that examine fitness training effects on human brain structure and function. Most of them have been done by us." – *Art Kramer*

Kramer said that paper and other analyses of various types of studies, including epidemiological ones, point to the positive cognitive effects of aerobic exercise.

A report by Kramer, lead author Colcombe, and others in 2006 titled Aerobic Exercise Training Increases Brain Volume, found that "cardiovascular fitness is associated with increases in the volume of brain tissue in aging humans. Furthermore, the results suggest a biological basis for the role of aerobic fitness in maintaining and enhancing central nervous system health and cognitive functioning in older adults."

Those benefits, Greenough said, are good only if exercise is maintained.

"Many of the effects of exercise that appear to be beneficial require that exercise be continued," Greenough said, adding that animal research shows that while exercise plays a role in forming new neurons, the brain's ability to keep them also has a lot to do with environment.

"It's been shown that if the animals are where they can be in either an enriched environment or not, or where they can have access to exercise or not, exercise seems to control more of the production of neurons," he said. "The retention of neurons seems to be better explained by the enriched environment. It's as if they are produced on speculation. If things work out right they get used and they get incorporated into the wiring diagram and stay."

Kramer said much of the research in this area began with work done by Waneen Spirduso at the University of Texas at Austin, who was reporting as long ago as 1975 on the topic of fitness and cognitive function.

Rhodes said the research line is still a young one. But, thanks to the continuing development of imaging techniques, increased knowledge of genetics, and more funding, the literature is growing rapidly as to the impact of exercise on cognition.

"There are many things that change with exercise," Rhodes said. "That's why it's so difficult to find out which one of those changes is actually casually related to the enhancement of cognitive performance. Of course, that's what everyone wants to know, because if we can figure that out we might be able to figure out therapies that can enhance learning in a more direct way."

Thanks to research led in large part by University of Illinois faculty, researchers are learning more about the effects of exercise and fitness with each new study.

Kramer said this much is already known: "The fitness literature is pretty clear that you get fairly broad effects on different aspects of cognition from fitness training with fairly modest amounts of improvement in fitness."

Skill Transfer or Does "Brain Training" Really Work?

Computer programs and other materials promising improved brainpower through "brain training" techniques are increasingly popular. But do they, in fact, increase general cognitive functions such as decision making and memory processing through "brain exercise" programs that can costs hundreds of dollars?

For Kramer, the research so far isn't convincing.

"The question is, can people really transfer cognitive skills learned in the laboratory or from commercial computer-based training program to skills and tasks in everyday life such as remembering a shopping list, driving an automobile in traffic, and rapidly learning a set of new skills in a job setting. And the answer, for the most part, is such transfer of training has not been convincingly demonstrated," Kramer said.

It turns out that researchers can see improvements in the specific tasks people are tested on. But that is different than taking specific improvement on task performance and generalizing to overall improvement in cognitive skills.

One study cited as answering the question in the affirmative and published in the Aug. 2006 issue of the *Proceedings of the National Academy of Sciences* tested the program from the Posit Science Corporation.

The PNAS paper contains a conflict of interest statement that said all of the paper's authors had a financial connection to the company. The company's founder, chief scientific officer, and paper co-author, Michael Mezenrich, is a professor at the

University of California at San Francisco, a member of the National Academies of Science, and a well-respected researcher into the neural origins of higher brain function.

The company's Web site states that its program is "proven to improve memory and processing speed" but Kramer says claims about transfer of improvement in cognitive function from a commercial program or laboratory training experiment to everyday cognition have yet to be convincingly shown.

A large clinical trial called Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) was designed to train groups of participants between the ages of 65 and 96 in cognitive skills like memory, speeded processing, and reasoning while a control group received no training. The overall goal of the trial was to "link specific cognitive and perceptual interventions to broader behavioral outcomes."

The research, reported in the Dec. 20, 2006, issue of *JAMA* found that some of the subjects, trained on specific skills such as identifying and locating visual information quickly, showed long-term cognitive improvements on those specific tasks as much as five years later.

Beckman researcher Elizabeth Stine-Morrow said the results on the long-term effects were surprising, but the evidence for transfer of those skills outside the lab was limited.

"What's interesting about that finding is that it's very provocative to show that you have this little modest training–that is very, very narrow–and then five years later you're still showing effects," Stine-Morrow said. "From our point of view it must have changed something about the way those individuals have engaged experiences or have done things in their daily lives to retain these skills.

"The investigators did show some transfer, but the transfer was to self-reported ratings of difficulty in performing everyday activities. What they showed the five-year gains on were the very task specific performances."

Stine-Morrow said the ACTIVE study is valuable for showing plasticity and for adding to the literature on skill or task improvement.

"You can change mental abilities and can change how older adults perform in these different tasks," she said. "All the effects are very narrow and we see that in the literature on expertise. If you look at what experts can do, expert chess players, expert bridge players, expert pilots, they can do exactly what they've been trained to do and what they practice every day."

Denise Park studies how different interventions could improve cognitive health as Co-director of the Center for Healthy Minds at Beckman. While transfer of skills is not yet borne out by the research, Park says that interventions such as learning new skills have shown the potential to improve cognitive performance.

"Acquisition of new skills is important," Park said. "The brain is based on connections. Novelty forges new pathways."

Cognitive Loss Due to Aging, Disease

One of the most exciting potential benefits of exercise-induced neurogenesis is the possibility of slowing or even reversing cognitive loss due to aging or diseases like Parkinson's and Alzheimer's.

Greenough said more neuroscience research is going toward alleviating diseases like Alzheimer's.

"More and more work is going to be directed to clinical problem areas like Alzheimer's and Parkinson's," he said. "We've done a pretty job of doping out, and by we I mean not my group but the collective wisdom in the field, situations under which neurogenesis either occurs or can be made to occur. The real question now is can we take advantage of it."

Taking advantage would mean targeting neurogenesis toward certain areas of the brain so that new neuron growth would slow or perhaps even reverse cognitive loss due to disease or aging. Since new neuron growth has been shown to take place almost exclusively in the dentate gyrus of the hippocampal formation and the olfactory bulb, new methods for targeting the "right" regions for neurogenesis would be crucial for more widespread effects on behavioral ability.

The hippocampus is central to memory processing, so increasing neurogenesis in that region could lead to improved memory. Greenough said there are many other brain regions and functions that could potentially be important in fighting disease and cognitive loss.

"There is some data, and this is really very important, saying that the corpus striatum can make new neurons under some conditions but not under resting conditions," he said. "That has enormous implications for Parkinson's disease because that's the principal structure where you have secondary cell loss underlying Parkinson's disease."

Greenough said researchers should also look at the potential found in glial cells, which serve to protect and support neurons.

"My attitude is we shouldn't ignore the other cytogenesis that's going on," he said. "Number one, there is the possibility that certain kinds of glial cells, under some conditions, seem to be able to change themselves into neurons. In addition, the glial cells and other cells actually put out trophic factors that can help the survival of neurons."

Greenough said enough research exists to show that intervention strategies targeting disease could work.

"There are two ways you can look at a therapeutic intervention for disease," Greenough said. "One is that it provides resilience so that the disease has less impact once it comes. So you're sort of getting the nervous system ready in advance. The other is more of a repair mode, that is, take the diseases as they are, and do something that will fix it. There is enough evidence in the literature to suggest that both modes exist and have a reality with regards to exercise as an intervention in the Parkinson's arena."

Again, the fitness factor appears to play a key role in lessening the effects of cognitive loss.

"What the research suggests, not uniformly but very consistently, is that if you're fit at time 1 with everything else being equal – equal education, socioeconomic status, many, many other factors – that you will have better cognition, better memory, better decision making at time 2, and the probability of you being diagnosed with Alzheimer's or vascular dementia will be diminished," Kramer said.

SYNERGY is a quarterly publication of the External Relations office of the Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign. Each issue will spotlight the people and science that make the Institute one of the premier facilities for interdisciplinary research in the world.

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Cover images: Cover images by the Beckman Institute; Pages 2, 4 photos of HALT participants by Elise McAuley; pages 5,6 photos by the Beckman Institute; page 8 photo of Chen Liu by Nancy Brokopp; pages 8, 9 Intelligent Hearing Aid photos courtesy of Al Feng; page 10 photo by the Beckman Institute.

BECKMAN INSTITUTE OPEN HOUSE 2007

Opening the Doors to Beckman Research

Thousands of visitors came to the 2007 Beckman Institute Open House, March 9-10, 2007.

The 2007 Beckman Institute Open House was a big hit with the thousands of visitors who crowded the building March 9th and March 10th, perusing almost 30 exhibits put on by Beckman faculty, students, and staff. Popular exhibits could be found in the atrium, the basement, and on the second and third floors of the Institute. More than 300 faculty members, students of all levels, and Institute staff volunteered to make Open House a success.

On Friday's opening day, schoolchildren from across the state took part in Open House while Saturday was a day for many families to explore the world of Beckman Institute research. In a fashion typical of the interdisciplinary research approach at Beckman, exhibits from fields as different as psychology and physics or biology and engineering were displayed side by side during Open House. Neuroscience researchers at the Drugs, Exercise and the Brain display in the atrium had visitors shoot basketballs while wearing "drunk" glasses, while next door materials science researchers at the Stretchable Silicon exhibit used an interactive approach to illuminate this amazing new technology. As usual, the CAVE, the driving simulator, and the flight simulator were popular, while visitors were fascinated by new displays such as ants that use their powerful jaws to propel themselves through the air and a system that converts the written word into three-dimensional graphical scenes.

The Open House was also a fun and eye-opening experience for the Beckman faculty, staff, and students who created and worked at the exhibits. Here are some comments from some of the volunteers:

Beckman Fellow **Magnus Andersson** knows just how to handle an Open House crowd. Magnus, a postdoctoral research associate with the Autonomous Materials Systems group, was group leader for the AMS exhibit on self-healing polymers presented in their third floor laboratory.

"In a crowd like that you can always see the naughty kid. You take the naughty kid and put safety goggles and a lab coat on them. Then they do anything you want them to do. You just pick out the bad one have them be your little helper and they love that."

Open House 2007 was the second go-round for Magnus.

"I love it. It's so much fun and it's a great opportunity to show off our lab. But in addition, it's a great opportunity to train our students and get them to really understand what we are doing. We have 14 students on shifts in the lab and they are just taking turns explaining to the kids what we're doing and showing them the demos and walking them through the lab. When you can explain it to kids that means you really understand it."

Joseph Spagna is a postdoctoral researcher who is taking part in a Beckman seed proposal project that studies the powerful jaw mechanisms of the trap-jaw ant as inspiration for, as the seed proposal states, "design principles for generating, storing and releasing large amounts of force using small, simple materials." Spagna and other team members at the group's exhibit in

room 1005 had a colony of the ants in a dish for visitors to check out, as well as videos of their amazing striking power. Spagna said the ants definitely had a 'wow' factor for visitors.

"They really like the videos and the word they use to describe the live ants is that they are big. They're really surprised at how big they are. Other words that have been used are stinky because the colony has some dead bugs in there with the ants, and interesting because people are really surprised to see something jumping using its mouth."

Spagna said he also received some good questions from the visitors.

"Some people have asked about the force– how much force the ants generate–and I like that question because I know the answer. People have asked what we try to do with the ants, what are the applications we are coming up with. Some of the things we're thinking about are small energy storage and release devices for specific applications like micro suturing devices and really small actuators. I do enjoy it. It's a project that people can really grasp. It has a charismatic animal, so it's one of the more fun things to do."

Amit Patel took part in his first Open House. He is part of the AMS group which used an animation video to help explain how self-healing polymers work.

Charles (Chas) Conway is a staff member with the Imaging Technology Group (ITG) who did Open House demonstrations of two projects he's been a part of at ITG. Conway has worked on ITG's popular Bugscope educational outreach project and the NASA-funded Virtual Microscope project. Chas said he has been working on Bugscope since it began and Open House is a good way to let people know what is going on with that and other ITG projects.

"We are really starting from scratch in making a redesign and making Bugscope a lot better. So we're just starting to debut that now. Hopefully we're planting some seeds for some new Bugscope connections."

Conway has worked three Open Houses now but this was his first stint at the ITG exhibit in the atrium.

"With the Virtual Microscope we do get a lot of people who are just looking but I've been amazed at how many people will take the time to sit down and listen. I can teach them things about integrated circuits or bugs and they learn a little bit as they go by and a lot of people seem to really enjoy that. Hopefully they'll realize that we're doing some things that they've only seen in movies."

Eric Leshikar has now been through two Beckman Institute Open Houses as a graduate student with Denise Park's Productive Aging Laboratory. This year he helped guide visitors through the lab's exhibition in room 1624, explaining some of the research that goes on there. Eric said there is a definite difference in the crowds between Friday's opening day and Saturday's finale.

"Open House is very interesting because it is like a tale of two worlds. The Friday crowd usually is a lot more middle school to high school students and Saturday's are more family oriented. They both have different sorts of goals. For example, on Saturday generally we have a lot of the families come in, so we get a lot more questions on those days. The parents are trying to build up scientific curiosity in their children."

Amit Patel is a graduate research assistant with the Autonomous Materials Systems group who explained how self-healing polymers work with the help of an animation video. Amit's strategy for conveying the science to lay persons instead of his usual peer audience was to tell them how a self-healing polymer could, for example, self-repair a scratch on their car.

"It's a little bit of an adjustment, but people pretty much get it. There are ways of connecting with them by explaining how applications they use in everyday life would benefit a lot from self-healing."

This was Amit's first Open House. He said it was a positive experience and one that he'll take back into the laboratory. "It's nice to see people get excited about what you do. When you are stuck in the lab you can get a little depressed when things don't work. When you do these types of events where people actually see what you do and get excited about it, it is a morale booster."

Joe Spagna, a post-doctoral researcher, talks to an Open House visitor about the trap-jaw ants.

Honors & Awards

MURI Grants go to Projects Headed by Beckman Researchers


Kramer


Moore

Beckman faculty members **Art Kramer** and **Jeff Moore** are principal investigators on two separate projects that were among the winners of a coveted Multi-University Research Initiative (MURI) grant competition announced by the Department of Defense in March.

The two projects were among 36 winners selected from 129 proposals in a technical competition that, according to the DoD, is "highly competitive" because the multi-million dollar, multi-year awards "provide greater sustained support than single-investigator awards." The total amount of all the MURI awards is $207M in research funding over five years, distributed to 67 universities in the United States and Canada.

Kramer, who is Co-chair of the Human-Computer Intelligent Interaction research initiative at Beckman, is the PI on a MURI project that includes MIT, the University of Minnesota, and Penn State, in addition to the University of Illinois. The grant was for the topic of "Capitalizing on Research on Animal and Human Brain Plasticity to Enhance Warfighter Training and Performance." The grant is through the Office of Naval Research.

Moore is a faculty member in the Autonomous Materials Systems group and professor in the departments of Materials Science and Engineering and Chemistry at Illinois. He is PI on a project titled "Mechanochemically-Active Polymer Composites" that also includes the University of Texas at Austin and Duke. The grant is through the Office of Army Research.

The awards are for up to five years and are for projects that the department says "typically involve a team of researchers with expertise in a variety of disciplines in order to accelerate both research progress and transition of research results to application."

The winning projects were selected after a competition that solicited proposals in 29 topics important to the DoD. Winners were selected by a merit review panel of experts from the pertinent science and engineering fields

Rogers Earns Two Honors


Rogers

Beckman Institute faculty member **John Rogers** has earned two important honors this academic year.

Tau Beta Pi, the national engineering honor society, has named Rogers as the 2007 recipient of the Daniel C. Drucker Eminent Faculty Award. The Drucker Award goes to Engineering college faculty members at the University of Illinois who have "received national or international acclaim for dedication to academic excellence through teaching and research and have made exemplary contributions to the understanding of their fields."

The award is given in honor of Daniel C. Drucker, Dean of the College of Engineering from 1968 to 1984, and a worldwide expert in the areas of applied mechanics and materials. The honor includes a $3,000 award and a bronze plaque.

Rogers has also earned the honor of being named as a Fellow of the American Physical Society. Rogers earned the Fellow status for "contributions to the fields of flexible electronics, optical fiber devices, nanolithography and picosecond ultrasonics."

The honor is given to only a few scientists each year. The By-Laws of the American Physical Society state: "Each year, no more than one-half of one percent of the then current membership of the Society are recognized by their peers for election to the status of Fellow in The American Physical Society." Some of Rogers' research interests include the science and engineering of so-called soft materials like polymers and biological tissues, as well as work on carbon nanotubes and on a stretchable form of single crystal silicon.

O'Brien honored with William Fry Award


O'Brien

Beckman's **William O'Brien** was presented with the 2007 William J. Fry Memorial Lecture Award, one of the highest honors given by the American Institute of Ultrasound, at the group's annual convention in New York City in March.

O'Brien, who heads the Bioacoustics Research Laboratory at Beckman, was recognized at the convention as "an individual who has significantly contributed in his or her particular field, to the scientific progress of medical diagnostic ultrasound" by the award. In addition to being a full-time faculty member at Beckman, O'Brien is the Donald Biggar Willet Professor of Engineering at Illinois, and holds professorships in Bioengineering and Nutritional Sciences. His research involves the "mechanisms by which acoustic energy interacts with biological and non-biological materials (physical acoustics), and applications of quantitative acoustic imaging in biology, agriculture, material science and medicine."

Martinez, Nelson AAAS Fellows


Martinez


Nelson

The American Association for the Advancement of Science has named Beckman Institute faculty members **Todd J. Martinez** and **Mark E. Nelson** as AAAS Fellows, an honor given for their efforts to advance science or its applications that are deemed scientifically or socially distinguished.

Martinez and Nelson were two of 10 University of Illinois at Urbana-Champaign faculty members given the distinctive honor, and join an international class of 449 AAAS members as Fellows.

According to the AAAS Web site, it is the world's largest general scientific society, with 262 affiliated societies and academies of science that serve 10 million individual members. AAAS's flagship publication, *Science* magazine, has the largest paid circulation of any peer-reviewed general science journal in the world, with an estimated total readership of one million.

Martinez is a professor in the Department of Chemistry, researcher at the Frederick Seitz Materials Research Laboratory, and a member of Beckman's Theoretical and Computational Biophysics group. Martinez was named a Fellow for his "contributions to the development of the ab initio molecular spawning method, and applications to fundamental photochemical reactions where electron-nuclear separability breaks down."

Nelson is a professor in the Department of Molecular and Integrative Physiology and a member of Beckman's NeuroTech group. Nelson was chosen for "contributions to neuroethology, particularly the neural mechanisms and computational principles that animals use to actively acquire sensory information in complex, dynamic environments."

From Beckman to Motorola: Liu Envisions New Era

In this lab we have a bunch of scientists in EE and CS, but we find more and more situations where we need to collaborate with linguists and psychologists.
– Chen Liu

Chen Liu came to Beckman to help launch the Intelligent Hearing Aid project, an effort that saw the successful development of a new kind of hearing aid.

As a principal research scientist at one of the biggest technology companies in the world, Chen Liu has a window into the future. That future, according to the former Beckman Fellow, gets closer every time we perform a search or download a file to our computers.

Liu

When the transistor age ushered in electronic signal processing in the 1950s and eventually led to the information technology era of today, it created a vast mountain of data that continues to accumulate in servers and hard drives worldwide. Liu said the next information technology phase is now being built around two key elements: managing all that data and putting it to use, especially in the area of artificial intelligence.

"We are entering an era of how to deal with this data, to use, search for, and retrieve data. To get access to data anywhere, anytime," Liu said. "The trend will be pattern recognition, machine learning, and data mining.

"Another thing is the intelligence area. Both in academia and industry we are doing things like intelligent cars, intelligent homes. In my lab we develop user interfaces, with a focus on phones, but also on very general research. We definitely need students with new knowledge, like in artificial intelligence and machine learning."

This, of course, means more opportunities for students in the new data era Liu describes. Those opportunities, he says, won't just be for computer science or engineering majors.

"When we enter this data era, psychology is definitely a big component of that," Liu said. "In this lab we have a bunch of scientists in EE and CS, but we find more and more situations where we need to collaborate with linguists and psychologists."

A student interested in these areas should listen up. Consider that Liu is someone who knows firsthand about being in the right place at the right time and about taking advantage of opportunity. Through his own efforts and a little serendipitous luck, Liu made the most of a one-time chance at the Beckman Institute and eventually earned a coveted position at Motorola Labs.

In 1995 Chen Liu was more than 6,500 miles from Illinois, thinking about how to use the capability certain animals had to pick out individual sounds from a noisy environment in his auditory signal processing research. At the same time a Beckman Institute researcher was pondering how to translate that same ability into something useful for human beings.

It now seems natural for the two quests to become one, but at the time Liu was in Israel doing doctoral work at the Technion-Israel Institute of Technology. He was searching the scientific literature for researchers who could help find a way to deal with the so-called "cocktail party" problem in audio signal processing.

Liu's aim was to localize and extract a single sound in the presence of multiple interfering sounds – in other words, the kind of environments often found at a cocktail party. That search led him to Beckman's Al Feng, and to an abrupt change in his life.

"Professor Feng was known worldwide as a specialist in auditory signal processing, especially in directional hearing," Liu said. "So I contacted him and he said 'wow we happen to be initiating this kind of project.' So it was just perfect timing and a perfect match."

The match turned out to be perfect for both parties. Feng had a postdoctoral research associate to help launch the nascent Intelligent Hearing Aid project, and Liu had a new career path in the United States.

The Beckman Institute got the Intelligent Hearing Aid project started with an initial grant, but there was pressure early on to keep the research and funding on track. Liu said it was a challenge from the very beginning.

"The cocktail party problem was very challenging," Liu said. "It had been attacked by researchers from around the world for more than four decades. We ventured on a new approach and we had to start from scratch."

The project started with some equipment and space at Beckman, an algorithm inspired by Feng's seminal research into how frogs delineate sounds in a noisy environment, and Liu. It eventually grew into an interdisciplinary effort involving more than a dozen people and encompassing researchers from electrical and computer engineering, speech and hearing science, and molecular and integrative physiology. The group built an anechoic chamber, testing and recording facilities, and improved and added to the original algorithm.

The Intelligent Hearing Aid project produced high-performance, biologically-inspired signal processing algorithms that used two directional microphones to extract the desired signal from a noisy environment for use in hearing aids. The rights to the technology were eventually sold to hearing aid manufacturer Phonak.

Feng was the team leader while Liu, who got a Fellows appointment a year into the project, continued to serve as a lead researcher and engineer.

"Chen Liu is an outstanding research scholar, with phenomenal drive, energy and creativity," Feng said. "His postdoctoral stint at Beckman made it possible for us to formally launch the Intelligent Hearing Aid project. He is a tireless and meticulous researcher, and his work ethic is exemplary.

Chen Liu is an outstanding research scholar, with phenomenal drive, energy and creativity. – *Al Feng*

His success in developing the biologically-inspired computational algorithm paved the way for expansion of the project and subsequent development of other hearing aid and important enabling technologies."

Liu said the project's future success was not guaranteed.

"After four months of hard work, during the Christmas of 1995 I finally hit on a new approach and my preliminary tests showed that the idea was doable," Liu said. "It was based on a hypothetical binaural hearing network structure.

"For the next two more years we kept working, based on the fundamental idea, by improving the algorithms, adding new breakthroughs, and solving implementation issues. Before I left Beckman, we had reached the performance of successfully localizing six simultaneous, equally loud sound sources and extracting only one sound – the capability psychologically observed in the human beings. That was achieved on a computer for the first time."

Liu joined Motorola in 1998 after a stint as a Beckman Fellow, and after watching the Intelligent Hearing Aid project become a success.

"It was an unforgettable three years for me," Liu said. "It was one of the most intense growing periods in my research life."

Liu is now the principal staff research scientist with the Human Interaction Research Lab at Motorola Labs in Schaumburg, Illinois. His group works on aspects of automatic speech recognition, such as robustness, acoustic model training, and multilingual speech recognition. The technology has been incorporated into various Motorola products, including cell phones, home set-top boxes, in-vehicle products, and voice servers.

In addition to having a project go from concept to success on his resume, Liu had the experience of working in an interdisciplinary fashion while at Beckman.

"One thing about the Beckman Institute is the freedom, especially for a Beckman Fellow," Liu said. "You don't need to worry about funding; you're free to do whatever you want. It's really a rare, precious opportunity for a young scientist.

"Another thing is the interdisciplinary collaborations at the Beckman Institute. A good example is the Intelligent Hearing Aid project. We had faculty members from vastly different fields and we achieved great success. I think it shows the uniqueness of the Beckman Institute."

In other words, Beckman is the kind of place where young scientists are being prepared for the next technology revolution. The data and know-how are there, Liu says, for this new era to evolve, just as the information technology age has evolved in the last half-century. Now it's just a matter of making it happen.

"In science fiction 20 or 30 years ago there were things that are now realistic," Liu said. "All the theoretical and fundamental things have already been laid out and are coming to fruition. There are a lot of things which are technically doable."

For today's students interested in being a part of this new era, Liu has some advice. "Broaden your view, try to get various experiences, and think impossible thoughts."

Those are principles that worked for him.

FACULTY PROFILE

Scott Carney a Theorist at Beckman, Engineer at Home

Physics and the Art of Bicycle Maintenance

In many of his research projects at the Beckman Institute Scott Carney is the one who, as he puts it, "does the long division" i.e., the equations that collaborators turn into software for powering applications such as new imaging technologies.

When he's not doing the math or spending time with his family, Carney is usually involved in a lifestyle that can only be described as highly active. He has taken home prizes from weightlifting and strongman contests, ridden his motorcycle all over the lower 48 states, and is, to put it mildly, a bicycle enthusiast. For Carney, bicycles flip a psychic switch: working on them means going from theoretician to engineer while riding them is a form of meditation.

"At work I'm a theorist but at home I'm an experimenter," he said. "I've got the bike shop at home and do my own maintenance and build my own wheels. It's sort of the ultimate engineer's hobby because it's essentially like building very small suspension bridges."

Then there's the riding itself.

"For me it's a great time to just think," Carney said. "I decompress and leave my work behind. I'm an academic, so it's not like my life is really stressful, but it's still pretty intense at times. So I leave this intense environment and I've got 10 or 15 minutes of pedaling and sort of running that out of my system before I get home to my wife and my son."

Carney is a full-time member of Beckman's Bioimaging Science and Technology group and director of the Optical Science group who focuses on the mathematical physics that undergird small-scale imaging and microscopy. His research includes pioneering work that demonstrated for the first time inverse light scattering for near field microscopy.

"What I do is figure out how to take measurements and turn them into usable representations," Carney said. "The way I do that is by understanding the physics of the measurement taking process."

A recent collaboration between Carney and Beckman colleagues Stephen Boppart, Dan Marks, and Tyler Ralston resulted in the development of a new imaging technique for optical microscopy that can generate sharp 3-D images from blurry, out-of-focus data. The technique, called Interferometric Synthetic Aperture Microscopy (ISAM), could mark a sea change for traditional optical microscopy with its non-invasive, high-speed, cross-sectional imaging capability.

Carney is excited about the potential of the technique, but is also pleased that its genesis was in a graduate level physical optics class he was teaching. Ralston, who was in Boppart's group at the time, was taking the class.

"One of the things that I'm very proud of in that class is that I require students to do a project, and my standard for success is that it they do something that is publishable," Carney said. "It doesn't have to be published, but I should look at it and say 'yeah we could turn that into a paper.' So Tyler really reached out for that standard and achieved it. It was his student project that semester that was the beginning of ISAM."

Carney, who has won outstanding teacher awards in addition to his research accomplishments, said he was trained as a physicist but thinks of himself as an engineer.

"I'm really a theoretical physicist," Carney said. "I like to say that today's engineering is yesterday's physics. Engineering research is just taking what were once considered the cutting-edge results of the natural sciences and finding applications for them."

Carney does find a place for engineering when it comes to bicycling, and not just in his shop.

"Of course I do it because I enjoy it, but I recommend it, especially to our students because it's the right engineering solution," he said. "If you simply look at the costs to yourself and to society at large of operating a motorcycle or car or truck or SUV, everyday, to travel two miles to work, it's insane. Whereas the bicycle is the proportionate response, it's the right thing, it's the flyswatter to kill the fly."

For Carney, that even applies during the harshest winter weather. He rode his bike into work the week a blizzard went through the area in February.

"Most sane people stop riding when there is six inches of snow on the road but I just get out the mountain bike with the big knobby tires," Carney said.

A sampling of Beckman Institute research receiving national media attention:

Cell Simulation

April 13 – As the director of the Theoretical Computational Biophysics group at Illinois, Klaus Schulten's team helped write the book on molecular dynamics simulations, which give a better understanding of the inner workings of a cell's micro-machinery.
The Why Files.org

Bugscope

April 11 – Thanks to "Bugscope," an electron scanning microscope at the U. of I.'s Beckman Institute for Advanced Science and Technology, students at Shiloh Pointe Elementary in Cumming, Ga., can peek at extreme close-up views of the insect world at their school computer labs - for free.
cumminghome.com

Flexible Electronics

April 9 – Flexible electronic structures with the potential to bend, expand and manipulate electronic devices are being developed by researchers at Illinois, including John A. Rogers, a Beckman researcher and professor of materials science and engineering, and at the U.S. Department of Energy's Argonne National Laboratory.
Medical News Today

Multitasking and Aging

April 9 – According to Art Kramer, a Beckman researcher and professor of psychology at Illinois who studies how aging affects cognitive abilities, the ability to multitask peaks when people are in their 20s.
New Scientist

Computer Simulation of HDL

April 5 – Computer simulations conducted at the Beckman Institute by a team of scientists including physics professor Klaus Schulten, biochemistry professor Stephen Sligar, and pre-doctoral fellow Amy Shih are allowing experts to study the characteristics of high-density lipoprotein or HDL, the so-called "good" cholesterol.
American Scientist

Linear and Parallel Carbon Nanotubes as Transistors

April 5 – Arrays of thousands of perfectly linear and parallel carbon nanotubes have been turned into transistors by Beckman researcher and U. of I. materials science and engineering professor John Rogers and his co-workers.
Nature

U of I Partners with Sandia Labs on Research Initiatives

April 4 – The University of Illinois and Sandia National Laboratories signed a memorandum of understanding (MOU) on April 3 which outlines their mutually beneficial research efforts. Areas specifically covered in the MOU include nanoscience, cognitive neuroscience, information technologies, water technologies, high-performance computing, energetics/combustion, complex systems/system-of-systems, and high-frequency imaging and communications.

Treating Brain Disorders

April 3 – Many neurocognitive researchers are worried that that clinicians and patients might opt for questionable computer-based approaches to treat brain disorders when low-tech solutions, such as surveys and medicines, are more effective. William Greenough, Beckman researcher and a professor of psychology and of bioengineering at Illinois, said, "The fact that something changes the brain in a measurable way is not sufficient to show that it is treating a symptom or a disorder."
Nature

Enzymatic Fuel Cells

April 2–"The elimination of noble metals is saving cost, but (using enzymes) also widens the range of fuels that can be used," says Paul Kenis, a Beckman researcher and chemical engineering professor at Illinois.
Science News

Fitness and Academic Performance

April 2 – In a study of grade-school students, Beckman affiliate and U. of I. kinesiology and community health professor Charles Hillman found that the most fit kids also did the best on statewide standardized tests, "even when factors such as socioeconomic status were taken into account."
Chicago Sun-Times

Changes in the Adolescent Brain

March 30 – Brain scans have shown that the brain shrinks in volume between adolescence and adulthood, but research at Illinois involving rats has provided the first evidence that some brain cells may not survive the transition, says Beckman affiliate and U. of I. psychology professor Janice Juraska.
Huntington News

Ancient Fabric Tweaked for Modern Use

March 29 – Chang Liu, a Beckman researcher, Willett Scholar and a professor of electrical and computer engineering at Illinois, and graduate student Jonathan Engel have fabricated the world's smallest chain-mail fabric.
UPI

Exercise, Aging and Memory

March 27 – Aerobic exercise has helped elderly people more easily switch between mental tasks, concentrate better and improve their short-term memory, says Beckman researcher and U. of I. psychology professor Arthur Kramer.
USA Today

Mechanics Meets Chemistry in New Way to Manipulate Matter

March 21 – Researchers at the Beckman Institute and University of Illinois have found a novel way to manipulate matter and drive chemical reactions along a desired direction. The new technique utilizes mechanical force to alter the course of chemical reactions and yield products not obtainable through conventional conditions.
Nature

The Chemistry of Flat Soda

March 27 – Flat soda tastes different from fresh, and U. of I. chemistry professor and Beckman researcher Kenneth S. Suslick has the pictures to prove it.
Photonics Spectra

Analytical Chemistry and Applied Spectroscopy

March 20 – Advances in engineering and precise microfabrication, rather than quantum leaps in technology, drove the instrument improvements on display at this year's conference on analytical chemistry and applied spectroscopy held in Chicago last month, says Rohit Bhargava, a Beckman researcher and professor of bioengineering at Illinois.
Chemical & Engineering News

Exercise and the Brain

March 19 – Exercise does more than build muscles and help prevent heart disease. New science shows that it also boosts brainpower - and may offer hope in the battle against Alzheimers. The Newsweek cover story features quotes from Beckman researchers Arthur Kramer and William Greenough and Beckman affiliate Charles Hillman.
Newsweek

O'Brien Honored by AIUM

March 14 – The American Institute of Ultrasound in Medicine has awarded William O'Brien, a Beckman researcher and U. of I. professor of electrical and computer engineering, the 2007 William J. Fry Memorial Lecture Award for his contributions to medical diagnostic ultrasound.
Medical News Today

Nanoelectrodes

March 14 – U. of I. researchers led by Min-Feng Yu, a Beckman affiliate and professor of mechanical science and engineering, have taken a step toward nanotech-based medicine, creating nanoelectrodes intended to go inside human cells to analyze their condition.
Medical News Today

Submarines Get Fish-like Sensors

March 13 – Thanks to a row of sensory organs along their sides, fish can avoid obstacles, swim in schools and seek prey, even in dark water. Now, inspired by those "lateral lines," researchers have developed an array of artificial sensors for underwater vehicles. Equipped with an artificial lateral line, a submarine or submersible robot could potentially move through the water like a fish, detecting targets and avoiding collisions. "We are trying to develop a new type of sensor for subs that can detect underwater events, currents and obstacles without conventional sonar and lights," said U. of I. electrical and computer engineering professor and Beckman researcher Chang Liu.
Discovery Channel

Super Small Nanoelectrodes can Probe Microscale Environments

March 9 – Investigating the composition and behavior of microscale environments, including those within living cells, could become easier and more precise with nanoelectrodes being developed at the University of Illinois. "The individual nanotube-based probes can be used for electrochemical and biochemical sensing," says Min-Feng Yu, a Beckman affiliate and U. of I. professor of mechanical science and engineering.
U of I News Bureau

Bee Social Activity Tied to Gene

March 7 – A gene involved in egg production also helps honeybees exhibit some crucial social behaviors that distinguish them from solitary insects, researchers report. The research marks an important technical breakthrough, because it was the first time that RNA interference has been used to manipulate the behavior of bees in the field, as opposed to in the laboratory, says Gene Robinson, a Beckman affiliate and an entomology professor at Illinois. "This technique promises to be extremely helpful in identifying the no-doubt many other genes involved in regulating division of labor," Robinson predicted.
The Scientist

Wisdom Trumps Youth in Airplane Pilot Study

Feb. 27 – In an essay co-written with Dr. Joseph Sirven of the Mayo Clinic, U. of I. psychology professor Daniel G. Morrow, a researcher at the Beckman Institute and at the Institute of Aviation, said the rapid aging of the population means increasing numbers of older workers in critical occupations.
San Francisco Chronicle

Printable Electronics

Feb. 27 – A research group at Illinois led by John Rogers, a Beckman researcher and professor of chemistry, of materials science and of engineering, is combining the use of semiconductor nanomaterials and printing techniques for new approaches to three-dimensional heterogeneously integrated systems.
Nanowerk

Bigger Older Brains (MP3)

Feb. 23 – Beckman Institute researcher Arthur Kramer speaks with Ira Dreyfuss about the connection between exercise and increases in the brain's white and gray matter in older adults.
HHS Health Beat

New Stamping Process Creates Metallic Interconnects, Nanostructures

Feb. 21 – Creating high-resolution metallic interconnects is an essential part of the fabrication of microchips and other nanoscale devices. Researchers at the University of Illinois at Urbana-Champaign including Beckman researcher Nicholas X. Fang have developed a simple and robust electrochemical process for the direct patterning of metallic interconnects and other nanostructures.
University of Illinois News Bureau

A New Process for Making Iron Nanospheres

Feb. 20 – Using a process that creates bubbles as hot as the surface of the sun, chemists at Illinois are reporting development of a new method for making hollow hematite (iron oxide) nanospheres. Chemistry professor and Beckman researcher Kenneth S. Suslick and Jin Ho Bang, a graduate research assistant in the chemistry department, describe the synthesis of these iron nanoparticles in a report scheduled for the Feb. 28 issue of the *Journal of the American Chemical Society*.
PhysOrg.com

The Upside of Aging

Feb. 19 – "Semantic memory is relatively resistant to the effects of aging," says U. of I. psychology professor Arthur Kramer, who is a researcher at the Beckman Institute. Semantic memory includes vocabulary, which increases with age so reliably (at least in people who continue reading) that a younger person should never challenge a sharp 75-year-old to a crossword puzzle. Also: The Biology Behind the Benefits
The Wall Street Journal

Disposable Sensor for Detecting Hazardous Uranium Ions

Feb. 19 – Researchers at Illinois led by chemistry professor and Beckman researcher Yi Lu have developed a simple, disposable sensor for detecting hazardous uranium ions, with a sensitivity that rivals the performance of much more sophisticated laboratory instruments.
AZoNano

Bubble Fusion Still Questioned

Feb. 13 – A professor who contends that nuclear fusion can be generated in a tabletop experiment has been cleared of research misconduct by Purdue University. But the refusal of university officials to answer any questions and their lack of detail in a statement released last week has left scientists to pore over the words like Kremlinologists, looking to divine meaning in what was said and what was not. Critics of the researcher said some wording in the statement suggested that the university had disregarded concerns and accusations raised by non-Purdue scientists and instead had concentrated on one seemingly small issue: whether it was improper for the professor to have left his name off two scientific papers. "The Purdue administration apparently narrowly focused the committee's charge and avoided the question of whether the research was doctored," said Kenneth S. Suslick, a Beckman researcher and chemistry professor at Illinois.
The New York Times

Virtual Microscope Wins Award

Feb. 9 – ITG's Virtual Microscope has been awarded a NASA Software Award by Michael Griffin, NASA's Administrator. The award recognizes significant technical contributions to NASA, and is made under the authority of the National Aeronautics and Space Act of 1958. The Virtual Microscope is part of NASA's Virtual Lab, and provides free software to the world for high-resolution, multi-dimensional image viewing and analysis. To date, it offers 90 specimens from light, electron, and scanned probe microscopes, and the application has been downloaded over 40,000 times. Congratulations to the Virtual Microscope team for this award.

A Molecular Cause for One Form of Deafness Found

Feb. 8 – Scientists exploring the physics of hearing have found an underlying molecular cause for one form of deafness, and a conceptual connection between deafness and the organization of liquid crystals, which are used in flat-panel displays. "We found the structure of the bundles changes dramatically when normal espin is replaced with espin mutants that cause deafness," says Gerard Wong, a Beckman affiliate and U. of I. professor of materials science and engineering, of physics, and of bioengineering.
Medical News Today

Mask-Based Multiphoton Photolithography

Feb. 8 – Using a mask-based approach, chemists at the University of Texas at Austin can rapidly fabricate whatever shape they want through multiphoton photolithography. "Two-photon lithography is extremely powerful because it enables the formation of unusual three-dimensional micro- and nanostructures that would be difficult or impossible to fabricate using other methods," says John A. Rogers, a Beckman researcher and U. of I. materials science professor. Rogers also has developed a mask-based approach to two-photon lithography that allows the formation of 3-D lattices in a single exposure step.
Chemical & Engineering News

Aging and Mental Training

Feb. 7 – A University of Florida study has shown that older adults who received just 10 sessions of mental training showed long-lasting improvements in memory, reasoning and speed of processing five years later. "Showing that training gains are maintained over five years is a stunning result," says Beckman researcher and U. of I. educational psychology professor Elizabeth Stine-Morrow, "because it suggests that a fairly modest intervention in practicing cognitive skills can have relatively long-term effects."
Hillsboro Argus

Exercising the Brain

Feb. 2 – Researchers say you can take measures to increase cognitive function and delay dementia, even Alzheimer's disease. "My advice: Travel, go to the theater, go to museums, take a dance class," says Denise Park, a U. of I. professor of psychology and researcher at the U. of I.'s Beckman Institute for Advanced Science and Technology.
Kiplinger's