SYNERGY

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LEADING AN IMAGING REVOLUTION

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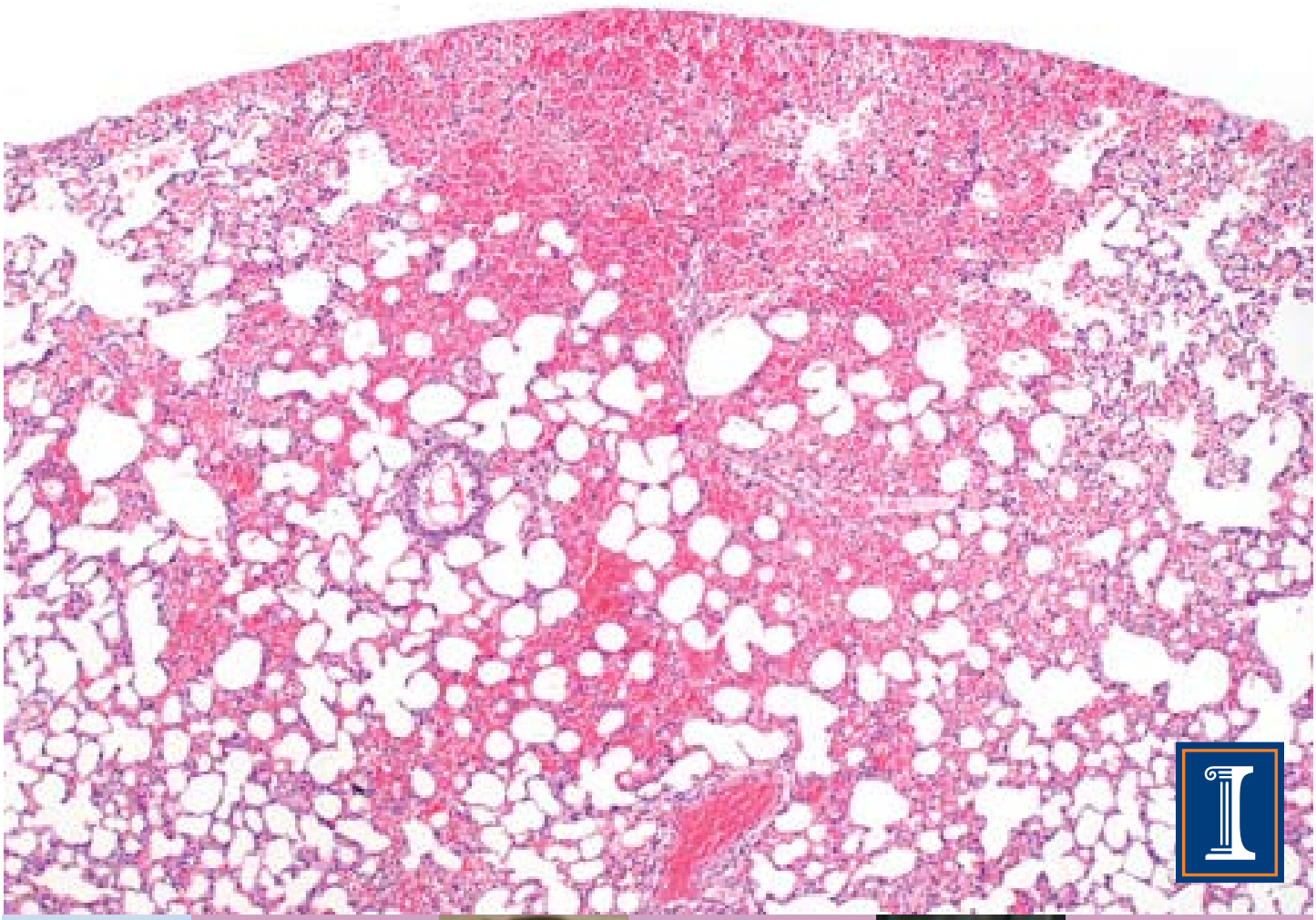

Some Beckman Institute discoveries are on their way to the marketplace. Read about Beckman researchers who have also taken on the title of entrepreneur.

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Beckman Alumni Profile: Ben Schaeffer applied some of his experiences working at Beckman's Integrated Systems Laboratory toward his current position on Wall Street.

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Faculty Profile: Beckman researcher Todd Coleman uses his expertise in electrical engineering and computer science to explore the human brain.

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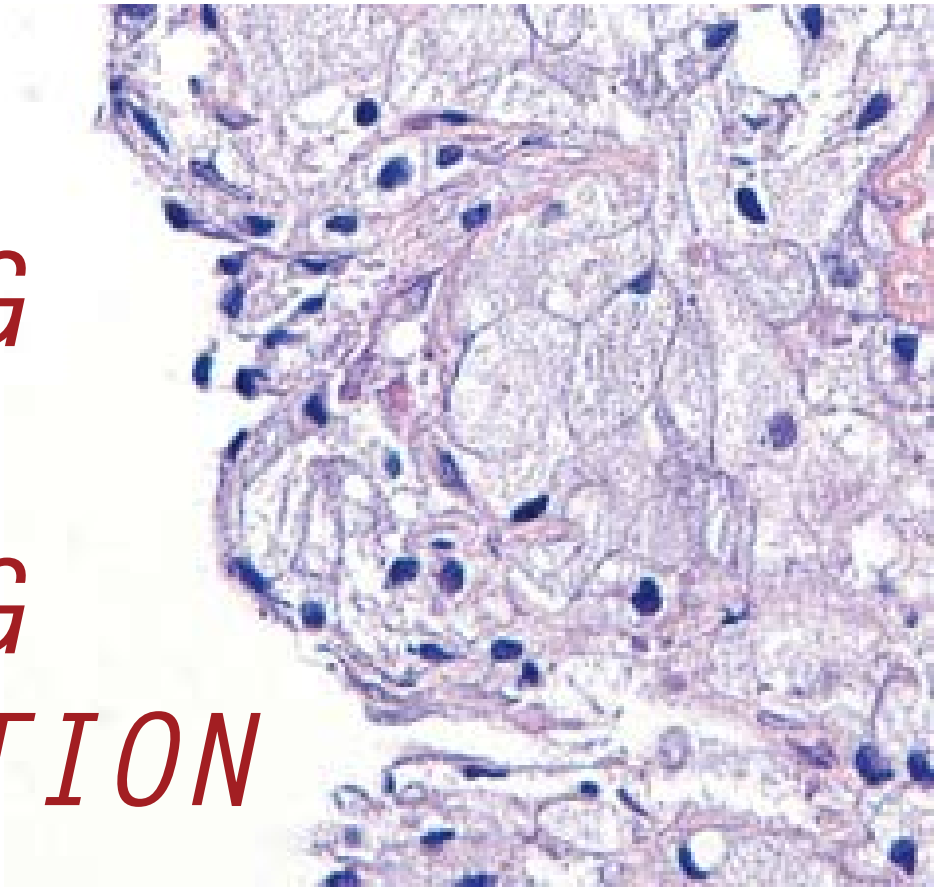
LEADING AN IMAGING REVOLUTION



Beckman Researchers Creating New Biomedical Imaging Methods for Screening Breast Cancer, Other Diseases

Using sound and light, mathematical equations, chemistry, and computer processing power, Beckman Institute researchers will be giving doctors new tools and patients peace of mind through the development of fast, accurate, and powerful medical imaging technologies for diagnosis and treatment of cancer and other diseases.

Beckman researchers are imagining and creating exciting new technologies that could in the near future perform non-invasive breast biopsies – using light in one method and sound waves in another – or differentiate between non-cancerous and cancerous mammary tissues through an advanced ultrasound method. Institute faculty members from different disciplines are seeking to arm physicians, clinicians, and other medical personnel with more detailed information on the physical structure of cells and the cellular processes involved in disease, knowledge that could improve patient care in numerous ways.

Among their efforts are the creation of real-time imaging techniques for diagnosis that will give physicians visual information at the moment of screening rather than waiting days or even weeks for lab results, taking away at least some of the stress patients feel when potentially facing a serious disease. These technologies will also give doctors performing biopsies and operations more detailed images, down to the cellular and in some cases molecular level, allowing for much more precise surgical procedures that remove cancer cells, for example, while leaving healthy tissue intact.

Some of these advancements have come through the improvement of current imaging methods like ultrasound (US) and magnetic resonance imaging (MRI) and some through the development of novel imaging techniques like a new optical-based system created at Beckman. These researchers are at the forefront of an imaging revolution that will in the next few years lead to earlier, more accurate diagnosis of disease, and more effective procedures for treating those diseases.

While the approaches and applications may vary and the researchers have different backgrounds, many are applying themselves to breast cancer screening methods. Several Institute researchers are part of a Beckman seed proposal for developing molecular scale imaging technologies for imaging breast cancer and are collaborating on projects with medical institutions, including some who are working with Carle Foundation Hospital's Mills Breast Cancer Institute. Others are applying their methods toward other cancers and disorders, and all say the technologies can someday be used for numerous biomedical applications.

Beckman researchers Stephen Boppart, Michael Insana, William O'Brien, and Rohit Bhargava recently participated in short video interviews to discuss their innovations in bioimaging and the impact their work could have for doctors and patients. Short summaries of the researchers are on the following pages, as well as links to the video interviews.

STEPHEN BOPPART

BIOIMAGING SCIENCE AND TECHNOLOGY GROUP

As a medical doctor and professor of Electrical and Computer Engineering, Bioengineering, and Medicine at Illinois, Stephen Boppart works at the very heart of technology development for medical applications.

Boppart is director of the Biophotonics Imaging Laboratory at Beckman, where he has developed novel methods and technologies for biological imaging. An important part of his research has been the development of non-invasive or minimally invasive methods for generating high-resolution, real-time images of biological tissue at the cellular and molecular level for disease diagnosis at earlier stages and in greater detail than current methods.

A focus for Boppart is diagnosis of breast cancer through the use of an imaging technique called optical coherence tomography (OCT) that provides micron-scale images of subsurface biological tissue. In the OCT-based system Boppart's lab developed, a beam of near-infrared light is focused on the tissue and the resulting reflections are measured by their intensity and position to provide a high-resolution image in real time. While the possible applications of this technology are many, the potential of using the OCT system for what are called "optical biopsies" for breast cancer is a major thrust of Boppart's research and technology development efforts. Boppart is currently using the OCT system at Carle Hospital's Mills Breast Cancer Institute in Urbana.

In his **video interview**, Boppart talks about the advantages the OCT-based system offers over other methods, the results of clinical trials and reactions to the system, as well as future goals for this exciting new technology.

MICHAEL INSANA

BIOIMAGING SCIENCE AND TECHNOLOGY GROUP

Michael Insana is not only heads the Bioimaging Science and Technology group at Beckman but also a leader in developing novel ultrasonic instrumentation and methods for biological imaging. Insana is part of a Beckman seed proposal with four other Institute collaborators – Thomas Huang, Zhi-Pei Liang, Stephen Boppart, and Rohit Bhargava – for developing molecular scale imaging technologies for imaging breast cancer.

Insana, interim head of the Bioengineering Department at Illinois, is interested in biomedical imaging and biological modeling and instrumentation. His research focuses on "the development of novel ultrasonic instrumentation and methods for imaging soft tissue microstructure, elasticity and blood flow" toward understanding the "basic mechanisms of lesion formation, disease progression, and responses to therapy."

One project of Insana's lab is development of applications for imaging the elasticity of breast tissue, a diagnostic technique that will allow noninvasive visualization of soft tissue stiffness. A current project in Insana's Ultrasonic Imaging Laboratory measures the elasticity of cancer tissue using sonographic imaging, a technique that converts high-frequency sound waves into a picture on a video monitor. Their goal is to dynamically optimize diagnostic capabilities for different examination types and patient physiologies and therefore significantly improve diagnosis of breast cancer, a disease that affects one in eight American women.

In his **video interview**, Insana talks about the role his research plays in advancing bioimaging technology, especially sonographic imaging, as well as the importance of elasticity imaging for diagnosing breast cancer, how this technology can track tumors, and the advantages it offers to patients.

WILLIAM O'BRIEN BIOACOUSTICS RESEARCH LABORATORY

William O'Brien, Director of the Bioacoustics Research Laboratory at the Beckman Institute, is pushing ultrasound imaging methods in new directions, including the development of an innovative method for breast cancer screening.

O'Brien's research involves ultrasound-tissue interactions, including a major effort to understand and develop quantitative ultrasound imaging (QUS) approaches.

The work is dedicated to real world solutions as O'Brien and his collaborators seek to advance ultrasound technology for medical applications, including developing QUS technology as a reliable, fast, and inexpensive method that has advantages over conventional qualitative medical ultrasound for diagnosing disease. They write that QUS imaging "relies heavily on signal processing techniques to extract information about underlying tissue microstructure" and that to fully exploit its potential, digital signal processing methods are needed.

While working to improve the technique, O'Brien and his collaborators have already applied QUS to detect and diagnosis both malignant tumors and non-cancerous ones such as a mammary tumor called fibroadenoma, an important innovation for breast cancer screening.

O'Brien also applied the technique toward the detection of cervical ripening – a disorder which leads to preterm births, the second leading cause of infant mortality in the United States. The technique gives doctors an imaging method that provides real-time information on cervical ripening, an advancement that could be a breakthrough in preventing preterm births.

In his **video interview**, O'Brien explains the advantages, such as real-time diagnostics, that QUS imaging technology offers over conventional, qualitative medical ultrasound techniques, describes the method's ability to differentiate tumors, and talks about other applications of this approach.

ROHIT BHARGAVA BIOIMAGING SCIENCE AND TECHNOLOGY GROUP

Rohit Bhargava's research is focused on developing chemical imaging methods for medical and research applications. His truly innovative work is leading to new imaging techniques that provide for better diagnosis of human cancers.

Bhargava's work contributes a chemical information component to the field of bioimaging. By developing these methods, Bhargava says that researchers and technicians are able to look at how both structure and chemistry change over time when they evaluate an image.

While the original chemical imaging methods were created elsewhere, Bhargava's work has taken the technology to a new level, creating techniques that allow imaging in a matter of seconds as opposed to older methods requiring several days. Bhargava said the method is valuable for evaluating the technology for diagnosing cancer, for use as an analytical tool for tissue engineering, and for studying fundamental scientific problems.

One facet of Bhargava's research seeks to create an automated method for determining whether certain kinds of prostate cells have the potential to cause life-threatening cancer. Current methods provide, at best, a correct diagnosis one-half of the time for the more than 200,000 men diagnosed with prostate cancer each year. Creating an automated technology with chemical imaging techniques could provide more accurate diagnoses for prostate cancer, and prevent unneeded surgery.

Bhargava said the most important question facing medical personnel in this area is how to determine which patients will get the truly risky kind of prostate cancer versus those who have prostate cancer that is unlikely to cause death.

In his **video interview**, Bhargava talks about his method that incorporates chemistry into bioimaging, how the techniques will help medical personnel in making assessments about cancers, how the automated method works, and the ultimate goals of this project.

Beckman at the Research Park

Taking Discovery to the Marketplace

"Everybody there is on the same team in some sense. They want to see you succeed."

– Scott White on the University's Research Park.

Their motivations for trying to turn scientific discovery into a viable business enterprise are as different as their inventions. For Scott White, it was impatience with the standard business model. For Narendra Ahuja, it was partly a desire to follow his funding agencies' wishes, even if that meant going it alone. For Magnus Andersson it was the challenge.

The reasons why these Beckman Institute researchers took a plunge into the exciting and sometimes frightening world of the start-up company are varied and personal. A deep belief in the science behind the discovery was foremost, they say, but whatever the reasons, the journey from research scientist to start-up entrepreneur is not an easy one.

White, who along with Beckman colleagues Jeff Moore and Nancy Sottos pioneered self-healing materials, led a successful effort this year to start a company that is seeking to turn their groundbreaking discoveries into marketable applications.

"I would say this experience has been the best education I've had in 20 years of working at the University," White said. "There are books out there where you can read about it but they don't really give you what you need to know on a daily basis.

"It's been a lot of fun and a lot of stress. There are so many things coming up on a daily basis that you've never had experience dealing with. You have to go with your gut and talk to people who have something to say, and then do it."

White and other campus researchers who are looking to take their discoveries to the market are much better off than someone in their position 15 or even 10 years ago. After failing to capitalize on valuable technologies that came out of University research, Illinois officials began pursuing technology transfer and intellectual property rights issues more aggressively in the late 1990s. The Office of Technology Management (OTM) at the University of Illinois was restructured in 2002, with more staff added, just about the time that the Research Park located on the south end of campus started to take shape.

Steve Wille, a Technology Manager at OTM who maintains an office at Beckman, said U of I researchers can now go from discovery to patent to start-up, all with the help of University or University-related resources.

Those resources include the Office of Technology Management, which facilitates technology transfer to the public, including

help with issues like disclosure and the patent process. Illinois Ventures LLC is a start-up services company that offers help to would-be entrepreneurs regarding issues of financing. Finally, the University's Research Park site, home to more than 70 high-technology firms, plays host to EnterpriseWorks (EW), a 43,000 square-foot building that serves as the University's start-up business incubator.

"All of that is right here, right now," Wille said. "It makes it so easy for the researcher."

Beckman Institute Director Pierre Wiltzius said helping researchers turn discovery into an application and potentially a product is now part of the Institute's mission, with Associate Director Van Anderson overseeing that area.

"That is explicitly part of his job description, being the liaison to OTM and making sure the researchers – the faculty, the students and also the Fellows and research staff – making sure that they are really fully aware of how the process works." Wiltzius said. "The process starts with disclosure to figure out whether there is something there or not and beyond that there are different paths: there is licensing it to an outside company, a third party, and getting royalties, and then there is the path of forming a start-up."

Several Beckman researchers who chose to start their own company have taken advantage of the Research Park and Enterprise Works. Ahuja has had a company called Vision Technology Inc. at the Research Park for several years while other Beckman faculty members involved in companies there include researchers like Jont Allen from Mimosa Acoustics and Yoram Bressler of InstaRecon. Numerous Beckman researchers were involved with the Intelligent Hearing Aid project, an innovation that was sold to a global hearing technology company called Phonak that had a presence at the Research Park when the hearing aid was being developed.

More than 50 companies have used the EnterpriseWorks facility in getting off the ground. White, who along with Sottos, Moore, other collaborators and investors including Illinois Ventures, founded Autonomic Materials, Inc. (AMI) in 2008. He said locating at EW and the Research Park is "crucial" to his company's early success.

"Access to the University is one of the strong suits for us," White said. "The rents and facilities are in line with what a start-up company can afford. Everybody there is on the same team in some sense. They want to see you succeed. They will bend over backwards if you need something, some expertise; it's a really nice set-up. They are there to help you succeed."

Larry Evans, a veteran of the chemical industry, joined AMI as CEO in July. Andersson and Gerald Wilson were the first two employees of AMI when the company was launched earlier this year. AMI is seeking to incorporate their self-healing technology as an anti-corrosive additive for coatings for large steel structures and, eventually, coatings for consumer products. With three employees and a cutting edge product, AMI is the definition of a high-tech start-up.

> "There is very much a research aspect and an educational aspect (to the Beckman Foundation mission) but it is also supposed to support activities that might lead to development of new technologies..."
>
> – Beckman Institute Director Pierre Wiltzius

"It was Gerald and I who started this and we had to build a lab, we had to drive the technology forward, and just do what it takes," Andersson said.

"When you're a small start-up company like this, the operative word is multi-task," White said. "Everybody does everything because you're talking to investors one day and the next day you're mixing chemicals in the lab, then the next day you're planning out the next ten year's budget. Everybody has to be involved in every aspect of everything."

Evans, whose experience had him working mostly at large companies like AstraZeneca, said sometimes division of labor in a start-up needs to be done on the fly, such as when he took a phone call about information technology.

"I said just a second let me put my Director of Information Technology on and I looked over at Gerald and said, 'Gerald you want to take it?'" he said with a laugh.

For Andersson, a native of Sweden who worked first as a postdoctoral researcher with Beckman's Autonomous Material Systems group and then as a research scientist, the opportunity to join AMI was something he could not pass up.

"This was the challenge of a lifetime," Andersson said. "You know, it's sink or swim. When I first started there we didn't even know if we could go beyond three months. I've worked at Beckman for a lot of years and given tours and, with Scott, would meet with companies. It's just such a cool technology to be able to take that into the world. I knew the technology but the rest is just a blank piece of paper."

Perhaps that blank piece of paper is what scares off many researchers from going the start-up route. After waiting for something to develop with large, established companies, White finally chose to begin his own firm.

"I didn't see the progress in moving this technology from these great labs and writing these great papers and having everybody say this is great to something applied," White said. "As an engineer, that's the culmination of what I do. I want to go out to Lowe's or wherever and see a self-healing adhesive or paint. And it's frustrating not to see this make it there because *it works*."

Ahuja, a member of Beckman's Artificial Intelligence group, first went the patent route about a decade ago with his NiCam Imaging System that allows all of the objects in view to be in focus regardless of their distance from the camera. Ahuja said that at that time, the University declined to help fund the patenting process so he financed it himself and began a company to market the product.

Since then another camera system, the Hemview, has come out of the work in Ahuja's Vision Computing facility at EnterpriseWorks. The HemView boasts a 360 degree field-of-view in a hemispherical dome and is able to produce real-time, seamless images of an entire room scene, a feature which makes it advantageous for monitoring purposes, for example. It could replace a multi-camera set-up, such as security systems that require several regular pan/tilt cameras that may not capture all of a scene because they are pointed at one area.

"Those cameras have this sort of flashlight mode, where they see only so much," Ahuja said. "Imagine that flashlight expanding to cover the entire hemisphere and now nothing is beyond it. What we have is a seamless single image of everything. But this camera records everything. You can come back and search it for whatever. It will replace several different cameras."

Ahuja began his research with the NiCam through grants from the National Science Foundation and the Department of Defense and it was partly due to their suggestion that the work be marketable that he took the start-up path. Ahuja is currently

demonstrating the company's latest camera technology to potential investors. He said the fact that the University has a research park for fledgling companies may inspire reluctant researchers to take that step toward commercializing their inventions.

"The very fact that it's there makes people cross that hurdle of just doing it," he said. "Sometimes you say there is one more thing to do and you will not do it. But now there is a space and the people there are very helpful. I think they are truly helping."

The Office of Technology Management's Web site said it is "responsible for identifying, evaluating, protecting, marketing, and licensing IP developed on the University campus." Wille said OTM determines whether an invention or innovation is "patentable and marketable" and Illinois Ventures determines whether it will fund the technology or not. The Research Park's Web site said it can "help tenants with low-interest loan programs, workforce development training grants and in finding venture equity financing."

Wille added that all of the technology transfer resources – OTM, Illinois Ventures, and the Research Park – work together with the University's Office of the Vice President for Technology and Economic Development (OVPTED) that oversees and facilitates the transfer and commercialization of University-based technologies and intellectual properties. Wille said people from the different resources have regular meetings and share reports on new technologies.

"We definitely communicate a lot," he said. "Part of our mission is to make sure we're there when (the researchers) need us."

Andersson said being at EnterpriseWorks reminds him of his time at Beckman.

"Both places are just amazing: the infrastructure, the facilities, the people, they are both really, really great places," he said. "And they are so tailored to you – they say we can get it for you; people listen to you."

White remains a very active researcher on campus and at Beckman.

"I want to make sure the Beckman Institute gets the credit for being supportive of me in doing this endeavor," White said. "We have a facility-use agreement here that allows us to come up and use equipment and things like that. They are very supportive. The link to the Beckman gives AMI immediate credibility out there."

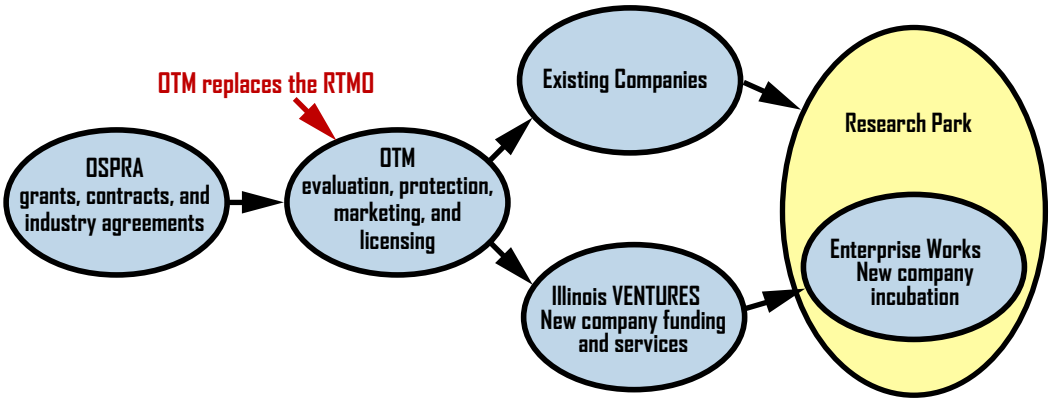
Wiltzius said technology development for the marketplace is very much in line with the Arnold Beckman philosophy.

"If you look at what the mission of Arnold and Mabel's Foundation is, it is also explicitly developing technology," he said. "There is very much a research aspect and an educational aspect but it is also supposed to support activities that might lead to development of new technologies, in particular in the field of the physical sciences broadly defined. He would certainly be proud of the things that are happening here."

White talked to many people, including Wiltzius, before starting his company. Wiltzius was asked if he had any advice for researchers considering the start-up route.

"It's hard work; don't go into it lightly because it's going to take up a lot of your time," he said. "But it can be very exhilarating and very exciting. You really are at the genesis of something that might change the lives of many people. Seeing how sometimes very abstract or complex topics that we research in our labs do connect to the lives of people and do connect with the real world is something that I find the older I get, the more important that becomes to me."

The University of Illinois' Seamless System of Resources



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Editor: Sue Johnson, johnso16@illinois.edu
Writer: Steve McGaughey, smcgaugh@illinois.edu
Design & Videography: Rick Valentin, rnv123@illinois.edu

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Contact information:
Office of External Relations
Beckman Institute
405 N. Mathews, Urbana, IL 61801
www.beckman.uiuc.edu

FROM BECKMAN TO WALL STREET:

Schaeffer Leverages Cube Experience into High-powered Position

Ben Schaeffer got his Ph.D. from the University of Illinois and some valuable real-world experience at the Beckman Institute before leaving his Midwestern roots behind for the opportunity and bright lights of Wall Street and New York City. Schaeffer left a huge mark at Beckman as the primary author of the software code that powers the Cube, the immersive virtual reality environment operated by the Institute's Integrated Systems Laboratory (ISL). Schaeffer now works on Wall Street as a quantitative analyst in the field of computerized securities, but he hasn't forgotten his alma mater or the people who helped shape his experience at Beckman and Illinois. The Office of External Relations recently asked Schaeffer about his experiences at Beckman and Illinois, his successful career, and other topics in an e-mail question-and-answer session.

First, could you tell us about your personal background, where you grew up and went to high school, your degrees, and how you ended up at Illinois?

I grew up and went to high school in Evansville, Indiana. My degrees are B.S. in Mathematics from the University of Chicago and Ph.D. in Mathematics from the University of Illinois at Urbana-Champaign. My thesis advisor was Carl Jockusch, and I studied mathematical logic.

I was told that you alone wrote the code (Syzygy) that powers the Cube and that can also be used for other platforms for PC and PC-cluster-based virtual reality environments and other graphical applications. I was also told that it was unusual for someone to do both the math and the code for software like that, so it was a big accomplishment. Is that something you're most proud of from your time at Beckman and Illinois? Did it aid your future career, either getting the job you have or in writing other codes? If you wanted to say more in depth about the process that resulted in Syzygy, that would be great also.

As a teenager, I'd done a lot of computer programming. At the end of the Ph.D., I got interested in doing something practical (as opposed to purely theoretical) and decided that working with computers might be a good skillset to develop. One of my big hobbies was painting, so doing something artistic appealed to me as well, and it turned out that the Beckman (via NCSA) was a big center for Virtual Reality (VR) at the time, with (Beckman faculty member) George Francis teaching a class in mathematical visualization that stressed VR. This was a unique opportunity and I pursued it, taking George's class, along with a number of first year computer science (CS) grad classes while writing my thesis. After graduation, I worked for Daniel Reed in his Pablo Group and got valuable exposure to the supercomputing world. In that context, I saw some of the preliminary work people were doing with scalable display walls and realized that a PC cluster architecture made sense for CAVE environments as well. The potential cost savings were incredible, and, indeed, the first visualization cluster for the "Cube" cost about $50K, compared to the $1.5 million for a SGI Onyx2. You don't often see a factor of 30 cheaper!

> Learn some useful skills. These will let you support yourself and give you opportunities. Learn some things that don't seem practical too. Otherwise, you won't have the breadth of knowledge and flexibility needed to try new things and take risks.
>
> – Ben Schaeffer's advice to students.

My involvement with Beckman began when Rachel Brady and Hank Kaczmarski hired me into the ISL to work on software for what would become the Cube. I remember sharing the "PC cluster VR" scheme with them in that first interview and discovered they were already thinking about the same thing. It really was amazingly fortuitous. At the time, I was convinced that the VR niche was potentially quite big, assuming that costs could be brought down, and thought this was a great opportunity to work on something that could really have an impact. In retrospect, it was a really wonderful experience to work on a new technology (that we weren't really sure would work as well as it did), and I'm proud to have turned out a product that served a need at the university. However, the VR niche (vis-a-vis society) has turned out to be much smaller than I thought it would be. It's pretty clear that the larger trend in computer interfaces (those used by millions of people) is smaller (think cell phones and handhelds) not bigger (like VR). Once I saw this clearly, it started to seem like time to move on.

The segue to a new career direction was a little unexpected. The main trick in writing Syzygy was writing reliable, high quality, and high performance real-time distributed systems code. Making the quality of the PC cluster display equal that of the Onyx2 (and, incidentally, making the whole thing reasonably user friendly) wasn't easy. It turns out that real-time distributed systems programmers are in high demand on Wall Street for writing computerized trading systems. So, those particular skills, combined with my math background, led me to my current job as a quantitative analyst at Lehman Brothers (a "quant" in the local slang). Regarding

Syzygy, I'd say that I "invented it" and wrote the original functional system. However, Camille Goudeseune and Jim Crowell deserve substantial credit as co-authors/co-developers. They are impressive scientists/engineers and contributed substantially to the final product. I was lucky to work with them.

What other accomplishments would you like to mention from your time at Beckman/Illinois?

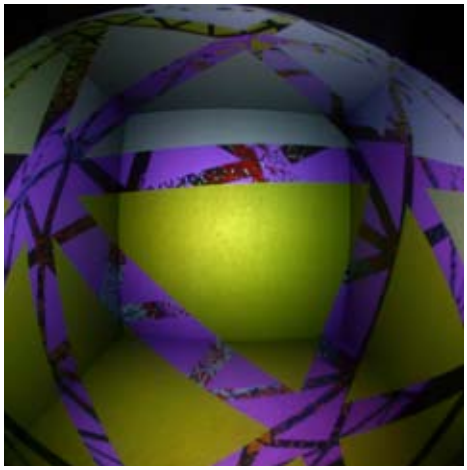
Hank Kaczmarski did a very good job of collaborating with artists in the university community. In particular, I enjoyed working with Yu Hasegawa-Johnson and Luc Vanier on dance performances. With Hasegawa-Johnson, we did a "long distance collaborative dance" between Champaign and Los Angeles. And with Luc, we did a performance at the Krannert Center along with an installation at the Krannert Art Museum. Later, Hank took Syzygy and built a permanent museum exhibit in the Art Museum. So, in general, I was very pleased to be involved with arts/technology cross-disciplinary work.

Could you talk about the Beckman/Illinois people who influenced you, and the ways in which they helped you; people such as perhaps George Francis, or Hank, or whoever you care to mention.

George Francis was a big influence. His visualization class helped me get back into programming after a long hiatus. Also, he became a valued collaborator later when I was with the ISL, and he used Syzygy and the ISL VR facilities for a number of his summer classes for undergrads. These are part of some sort of "research experience" campus program, I think. In any case, George devotes quite a bit of energy and talent to mentoring young people and really deserves a lot of credit for service to the University.

Hank is someone I respect tremendously and feel very fortunate to have worked with. First of all, he is a down-to-earth person and extremely loyal and hard working. Second, he is a real genius with manipulating/managing physical stuff ... electronics, displays, shipping stuff here and there, you name it. The hack he pulled off getting the Cube frame and screens into the Beckman basement is simply beyond belief. One of my favorite things regarding working at ISL was his can-do, no-excuses, hard-working attitude and I hope that rubbed off on me a little bit.

I'd like to say how much I appreciated my ISL colleagues Camille Goudeseune and Jim Crowell. They both taught me a lot about programming. I'm a much better programmer for having worked with them. Jim, being a psychologist, taught me about human perception, how to be always open to doing things in a new way, and turned me on to the Python language. Camille amazed me with his ability to create gadgets of all kinds, showed me that good error handling/error messages are critical parts of programming, and, in general, was a relentless force in writing code professionally, in the right way. The greatest thing about working at Beckman was being able to interact with top notch people such as these.



What is your job title at Lehman Brothers and how long have you been there? Could you describe as much as you are able what you do there? How did your experience at Illinois and Beckman prepare you for your current position?

I'm a quantitative analyst at Lehman Brothers (a "quant"). Been there about 2 years. I work with algorithmic trading systems (so computerized trading of securities).

Beckman prepared me for this job in a number of ways: being able to produce results under time pressure; having to create a working "production" system; being able to analyze project requirements, do a design, and carry things through to their conclusion. But, most importantly, being in academia allows one to explore new technologies and new kinds of software. Following things through to their logical conclusions (making lots of mistakes along the way and going into dead ends) is a real luxury that isn't always present in the business world. Also, the freedom and opportunity to create (be it in software, some technology, some math theorem) is precious. Taking real advantage of these opportunities gives one condensed practical experience and a real edge in any technology intensive/ intellectual capital intensive business going forward.

How did you become interested in math and computer science? Is there one area, such as working with graphics, that intrigues you more than others?

I became interested in computers via computer graphics and video games when I was 10-years-old, so, in a sense, the VR was returning to my first love. But I've always liked to do a number of different things. It sounds corny, but for a long time, I got into a search for "truth", which led naturally to mathematical logic (which is also called "the foundations of mathematics" by some) and to leave more applied pursuits (like computer programming) behind. And to have really followed that search to a conclusion (not *the* conclusion of course), being exposed to a number of the world's real experts, was a real privilege. More recently, I've been interested in probability, stochastic differential equations, and modeling, really more applied than pure mathematics, which is a real switch for me, since I'm back to being interested in math again, and active in there again, but it's a new area for me. So, in general, always learning and always moving on.

Do you live and work in Manhattan? If so, how are you enjoying living and working there compared to life on the prairie? Any great memories from your time at Illinois?

I work at the Lehman Brothers headquarters in Times Square. My wife and I live near downtown Brooklyn. The transition was a little tough for me since I've been a midwesterner almost all of my life and lived in Champaign in particular for 13 years. Champaign is low to the ground, relatively empty (not densely packed), and very quiet. NYC is the opposite. So, for the first year, I found myself listening to an iPod whenever I was out, to drown out the chaos/newness, which was a little intimidating. But, after that, I suddenly adjusted, got rid of the iPod, and enjoy paying attention to the city environment when I'm out.

Here are four wonderful memories … First, going to the comic book store on Green St. in Campustown every Wednesday to pick through the new comics. It was a constant in my life during my time in C-U. Next, watching the Illini almost win the NCAA basketball title in some downtown Champaign sports bar. Third, thinking back to my first few years in grad school, being on fellowship over the summer and just sitting around day after day studying mathematical logic and not doing too much else, the air conditioning in the shared grad student office and the distinctive "Omega series" in logic books, with their yellow-orange covers. Fourth has got to be all the mornings when I show up to work and take the Cube for a spin, just feeling the experience, in the seemingly infinite blackness of that basement room...

Do you have any advice for students or others who may want to follow a similar path to the one you followed?

Learn some useful skills. These will let you support yourself and give you opportunities. Learn some things that don't seem practical too. Otherwise, you won't have the breadth of knowledge and flexibility needed to try new things and take risks. Always make sure to build and do instead of talking about building and doing. Don't leave a job unfinished, especially the last 5% that takes the majority of the work.

FACULTY PROFILE

"They all told me to take this hard core math that I learned earning my Ph.D. and apply it toward helping out mankind. So I told myself 'well now I have a job waiting on me so let me do something completely different and have some fun.'"

– Todd Coleman

Todd Coleman holds a cap with electrodes in this photo taken at his lab in the Beckman Institute (Photo by Robin Scholz, The News-Gazette)

Coleman Uses Engineering to Study Neuroscience

Todd Coleman had gone from a science and engineering magnet high school in Dallas to earning bachelor's degrees in both computer engineering and electrical engineering at Michigan. What course his educational path would take him in graduate school at MIT he wasn't exactly sure going in, but it's a safe bet he didn't expect to be solving mysteries of the human brain.

"When I went to MIT I didn't know if I was going to go the hard core computer science route or the hard core electrical engineering route," Coleman said.

Coleman, a member of the Human-Computer Intelligent Interaction (HCII) research initiative at the Beckman Institute, chose electrical engineering for his Master's and Ph.D. but his most recent path followed a different course, one geared more toward the human part of the human-computer equation.

Coleman's Master's and Ph.D. thesis advisor at MIT was Muriel Medard, a Professor of Electrical Engineering and Computer Science and former faculty member at Illinois. By the time Coleman earned his Ph.D. from MIT (and the offer of a faculty position at Illinois), Medard was urging him to try something different before starting the life of a professor and researcher.

"She said that would give me more time to mature as a thinker, to work on a completely different class of problems," Coleman said. "So I decided to try and pursue something biological."

That "something biological" turned out to involve neuroscience. Delaying his teaching career at Illinois for a year, Coleman did a postdoctoral stint with Emery Brown, a doctor and nationally-known Professor of Computational Neuroscience from MIT's Department of Brain and Cognitive Science and the Neuroscience Statistics Research Laboratory at the famed Massachusetts General Hospital. The experiences led him into completely new research areas, ones that fit in well with his appointment as a researcher in HCII's Artificial Intelligence group.

Coleman came to Illinois in 2006 where, as an Assistant Professor of Electrical and Computer Engineering, much of his research involves computational neuroscience, or using statistical and computational approaches to understand brain function. He seeks to understand how the brain represents information by investigating how neuron "spike trains" encode information and has begun to design novel, non-invasive brain-machine interface applications.

"We know that neurons generate these little flickers of energy called action potentials and it's basically the timing at which they generate all these spikes that is carrying all the information," Coleman said. "What I am interested in understanding is how is information about the environment, or information about intent, or information about sound, how is that specifically encoded in the timing of the spike trains and I like to use statistical principles to do that."

Coleman, along with his students and collaborators and Beckman colleagues Tim Bretl and Ed Maclin have begun to address brain-machine-interface problems by using non-invasive EEGs to record the brain's electrical signals of test subjects during task performance. They then create statistical models of these neural datasets and signal processing algorithms that "decode" what the subject's intent was; from these come signals that can be used to guide a cursor to aid someone, for example, in searching for a location on a map, or someday perhaps, in using a prosthetic limb.

Coleman's methods use adaptive querying techniques inspired by data compression, optimal control, and feedback information theory principles that explicitly take into account the user's behavior. This approach – as opposed to most current brain-machine interfaces – includes the user's brain as part of a dynamic system.

"The user, by virtue of the visual feedback from what he sees, is going to control this process by what he thinks," Coleman said. "What we're really trying to espouse is: what are the first principle approaches as to how we can really look at this as a closed-loop dynamical system where there's feedback? Just the whole idea of having the brain in the loop for these brain-machine interfaces opens up so many different opportunities."

Coleman said modeling human cognition in this context is challenging. "It's a non-trivial task for a number of reasons but we're chipping away at it slowly but surely."

Coleman said he was inspired to add a biological/application component to his research by friends from Michigan who were also studying in Boston while he was at MIT.

"They were doing M.D./Ph.D.s or doing biological imaging. They all told me to take this hard core math that I learned earning my Ph.D. and apply it toward helping out mankind," Coleman said. "So I told myself 'well now I have a job waiting on me so let me do something completely different and have some fun."

Coleman said Medard and Brown were also important influences on him.

"Emery and Muriel are two of my closest mentors now," he said. "Both Emery and Muriel are very down-to-earth, normal people who value family and treat people as human beings. Everyone calls them on a first name basis; the human component is very strong in both of them and I admire them for that."

HONORS & AWARDS

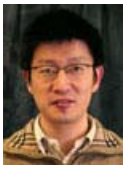
Moore Elected to AAAS

Beckman Institute researcher **Jeffrey Moore** has earned the prestigious honor of election to the American Academy of Arts and Sciences, along with University of Illinois Chancellor Richard Herman and other luminaries from the arts, academia, and government. Moore, a faculty member in the Autonomous Materials Systems group and the Murchison-Mallory Professor of Chemistry at Illinois, will be honored at a ceremony on Oct. 11 at the academy's headquarters in Cambridge, Mass. Other new members this year include U.S. Supreme Court Senior Associate Justice John Paul Stevens, two-time cabinet secretary and former White House Chief of Staff James A. Baker III, Academy Award-winning filmmakers Ethan and Joel Coen and Milos Forman, Emory University Provost and historian Earl Lewis, Darwin biographer Janet Browne, Pulitzer Prize-winning novelist Edwards P. Jones, and blues guitarist B.B. King.

Brown Wins Mosher Award

Beckman Institute Founding Director **Ted Brown** has been named as the 2008 winner of the American Chemical Society's Mosher Award. The Harry and Carol Mosher Award is presented by the Santa Clara Section of the American Chemical Society (ACS) to recognize and encourage outstanding work in chemistry, advance chemistry as a profession, and recognize service to ACS. Brown is the Beckman Institute's Founding Director, serving as its first director until his retirement in 1993. He has also won many awards honors over the years, including being honored as a Fellow of both the American Association for the Advancement of Science and the American Academy of Arts and Sciences.

Fang Named to List of 35 Top Young Innovators



Nicholas Fang, a member of Beckman's 3-D Micro and Nanosystems group, has been selected as one of this year's 35 Top Young Innovators by Technology Review, the world's oldest technology magazine. Fang, a professor of Mechanical Science and Engineering, and fellow Illinois faculty member Martin Burke were chosen by the editors of Technology Review, published by the Massachusetts Institute of Technology, for the award which honors people under the age of 35 whose innovative work in technology and business has a profound impact on today's world.

Ahuja Wins HP Labs Innovation Award

Beckman Institute researcher **Narendra Ahuja** won a coveted 2008 HP Labs Innovation Research Award, it was announced Thursday. Ahuja is a full-time faculty member in Beckman's Artificial Intelligence group and a professor in the Illinois Department of Electrical and Computer Engineering. Ahuja is one of 41 winners of the award, which is designed to encourage open collaboration with HP Labs on projects that result in mutually beneficial, high-impact research. HP reviewed more than 450 proposals from 200 universities in 28 countries before selecting the 41 projects from 34 different institutions. The title of his project is "3-D Reconstruction of Dynamic Real-World Objects and 3D Motion Aided Gesture Recognition."

Huang named as Academia Sinica Academician

Human-Computer Intelligent Interaction Co-chair **Thomas Huang** has been named by Academia Sinica as an Academician for 2008. Academia Sinica is a world-renowned research institution founded in China in 1928 and based in Taiwan that seeks to promote and perform scholarly research in the sciences and humanities. Huang was honored along with seven others in the Division of Mathematics and Physical Sciences. Academia Sinica has a total of 250 Academicians and almost 1,000 principle investigators working at its 24 research institutes and seven research centers. Huang is a member of the Image Formation and Processing group at Beckman and Professor of Electrical and Computer Engineering at Illinois.

Lleras Receives NSF CAREER Award

Alejandro Lleras, a member of the Beckman Institute's Human Perception and Performance group, was the recipient of a coveted Early Faculty CAREER award from the National Science Foundation. Lleras, an Assistant Professor in the Department of Psychology, received a $400,000 award as part of the honor.

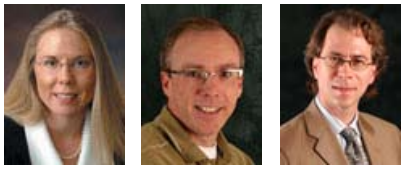
Sproat Named University Scholar

Beckman Institute researcher **Richard Sproat** has been named a University Scholar by the University of Illinois. The University Scholars program "recognizes excellence while helping to identify and retain the University's most talented teachers, scholars and researchers." Sproat is a full-time faculty member in Beckman's Artificial Intelligence group and a professor in the Department of Linguistics and the Department of Electrical and Computer Engineering.

Rogers Named MRS Fellow

Beckman Institute researcher **John Rogers** has been chosen by the Materials Research Society (MRS) as a member of its inaugural class of MRS Fellows. Rogers, who is a member of Beckman's 3-D Micro and Nanosystems group, is a Founder Professor of Engineering and faculty member in the University of Illinois departments of Materials Science and Engineering and of Chemistry.

Self-healing Researchers Honored with SciAm 50 Award



Beckman Institute researchers **Nancy Sottos**, **Jeff Moore**, and **Scott White** *(pictured respectively, left to right)*, who pioneered self-healing materials, have earned a 2007 SciAm 50 award from *Scientific American* magazine. The awards are given annually to innovators in business, policy, and research for work in a wide variety of areas, such as fuel alternatives and neurological insights. Their research was chosen by *Scientific American* for a 2007 SciAm 50 Material World award for their biologically-inspired development of synthetic materials that can self-repair cracks and other breaks. The *Scientific American* article on the Material World awards states that "the new material can repair minor cracks up to seven times at each location, improving on the group's previous system." In describing this year's award winners, *Scientific American* writes that "sometimes new technologies actually live up to some of the wildest expectations for them" and "What they have done is decidedly new."

RECENT BECKMAN INSTITUTE RESEARCH
IN THE NEWS

Let Video Games Read Your Mind
August 22 – A lightweight headset that allows players of computer games to move items on the screen with their thoughts could well benefit far more than just game fanatics, says Monica Fabiani, a Beckman researcher and U. of I. psychology professor. "Often, when companies make products that are comfortable and easy to use by the public, interesting applications on the medical side" follow, she said.

USA Today

Evolution Tracked Through Ribosomes
August 22 – A new study of the ribosome, the cell's protein-building machinery, sheds light on the oldest branches of the evolutionary tree of life and suggests that differences in ribosomal structure between the three main branches of that tree are "molecular fossils" of the early evolution of protein synthesis. Elijah Roberts, a Beckman affiliated graduate student, was the lead author of the study that confirmed and extended the early work of U. of I. microbiology professor Carl Woese. Beckman researcher and Illinois chemistry professor Zaida Luthey-Schulten is a co-author of the study.

RedOrbit.com

Inattentional Blindness Dangers Demonstrated
August 8 – Experiments conducted by U. of I. psychology professor Daniel Simons and colleagues at the Beckman Institute demonstrated the dangers of "inattentional blindness."

Bicycling Magazine

Pervasive Computing
August 7 – Beckman faculty member and U. of I. Computer and Electrical Engineering professor Thomas Huang and three other researchers explain that for computing to become all-pervasive and useful, it must adapt to people's natural way of living, communicating, and working.

Innovations Report

Stretchable Silicon Camera Next Step to Artificial Retina
August 6 – As reported in the Aug. 7 issue of the journal Nature, Beckman Institute's John Rogers and his collaborators have developed a high-performance, hemispherical "eye" camera using an array of single-crystalline silicon detectors and electronics, configured in a stretchable, interconnected mesh. The work opens new possibilities for advanced camera design. It also foreshadows artificial retinas for bionic eyes similar in concept to those in the movie "Terminator" and other popular science fiction.

U of I News Bureau

Protein Folding
August 5 – Researchers led by Beckman faculty member and U. of I. chemistry professor Martin Gruebele and Martina Havenith of Ruhr-University Bochum used newly developed Kinetic Terahertz Absorption Spectroscopy to gain a better understanding of water's role in protein folding.

Science Daily

Autonomic Materials
August 1 – Scott White, a Beckman researcher and U. of I. professor of aerospace engineering, is the founder of Autonomic Materials, a company in Champaign that is developing self-healing coatings for ships, oil rigs, and other structures.

News-Gazette

Shannon Testifies Before Congress
July 25 – Beckman researcher and U. of I. engineering professor Mark Shannon, the director of the Center of Advanced Materials for the Purification of Water with Systems, testified before a House energy and environment subcommittee this month in support of a bill focusing on water development, demonstration projects, education and outreach, and technology-transfer activities.

Energy & Environment

Nanotube Mesh Boosts Plastic Electronics
July 24 – A team of researchers from the U. of I. and Purdue University have overcome a major obstacle in producing transistors from networks of carbon nanotubes, a technology that could make it possible to print circuits on plastic sheets for applications including flexible displays, and an electronic skin to cover an entire aircraft to monitor crack formation. "These findings represent the culmination of four years of collaborative efforts between the Illinois and Purdue groups," said John A. Rogers, a Beckman researcher. "The work established the fundamental scientific knowledge that led to this particular breakthrough and the ability to make circuits."

Chemistry World

Ultrasonic Frogs Can Tune Their Ears to Different Frequencies
July 22 – Beckman Institute researcher Albert Feng and his collaborators have discovered that a frog that lives near noisy springs in central China can tune its ears to different sound frequencies, much like the tuner on a radio can shift from one frequency to another. It is the only known example of an animal that can actively select what frequencies it hears, the researchers say.

U of I News Bureau

ITG Image Earns Cover of Lab on a Chip
July 21 – The Beckman Institute's Imaging Technology Group (ITG) earned the cover of the July 2008 issue of Lab on a Chip for ITG staff member Janet Sinn-Hanlon's rendering of HeLa cells being captured and cultured on silicon cantilevers within microfluidic devices.

Hoddeson Profiles Bardeen
July 16 – Beckman Institute faculty member Lillian Hoddeson, the Thomas M. Siebel Chair in the History of Science at the University of Illinois, has written a feature story about famed Illinois professor and two-time Nobel Prize winner John Bardeen for Illinois Alumni magazine. Hoddeson, who has written a biography of Bardeen, profiles the theoretical mind behind the transistor in the May/June issue.

Illinois Alumni Magazine

First Simulation of Binding of Molecules to a Protein
June 30 – Beckman Institute researcher Emad Tajkhorshid has once again used computer simulation for a scientific breakthrough – this time he has provided insight into an important cellular recycling process in the body and shown, for the first time ever, a simulation of the binding of a molecule to a protein.

U of I News Bureau

Protein Drugs
June 30 – "Protein drugs have huge therapeutic potential, except they have almost no lifetime under normal physiological conditions," says Jeffrey Moore, a Beckman researcher and chemist at Illinois, who was commenting on another scientist's development of backbone-enhanced proteins.

Milwaukee Journal Sentinel

BECKMAN IN THE NEWS
CONTINUED

Silicon Photonic Crystals Key to Optical Cloaking
June 25 – Now you see it, soon you might not, researchers at the University of Illinois say. In computer simulations, the researchers, including Beckman affiliate Harley Johnson, have demonstrated an approximate cloaking effect created by concentric rings of silicon photonic crystals. The mathematical proof brings scientists a step closer to a practical solution for optical cloaking.

U of I News Bureau

Awareness Test
June 24 – An award-winning television ad for Transport for London called "Awareness Test," about cycle safety and featuring a moon-walking bear, has come in for criticism in some quarters for its remarkable similarity to a video created in 1999 by Beckman researcher and U. of I. psychology professor Daniel Simons for the Visual Cognition Laboratory at Illinois.

The Guardian

Inventing Water's Future
June 24 – "As dire as the growing problems are with a lack of enough clean water in the world, I have a great deal of hope that many of these problems can be solved by increasing research into the science and technology of water purification," said Mark Shannon, a Beckman researcher and professor of mechanical science and engineering at Illinois.

Forbes

Chasiotis Leads Team of Student MEMS Winners
June 5 – The student team from the University of Illinois at Urbana-Champaign, under the leadership of Professor Ioannis Chasiotis, won in the "Characterization, Reliability, and Nanoscale Phenomena" category by creating a design for the first MEMS platform able to perform creep and stress relaxation tests on polymeric, metallic, and biological nanofibers.

Sandia Labs

Estimating a Person's Age
May 30 – Computer engineers Yun Fu, a graduate student at the U. of I.'s Beckman Institute, and Thomas Huang, a Beckman researcher and professor of electrical and computer engineering at Illinois, have trained a computer system to estimate a person's age based on facial features.

PhysOrg.com

Social Interaction and the Brain
May 30 – According to Art Kramer, a U. of I. psychology professor at the Beckman Institute, social interaction might be one of the keys to keeping the brain in shape as people age.

The Courier News

Nanomembranes Get Tough
May 28 – A new chemical approach to making strong carbon films less than 5 nanometers thick could help speed their use in molecular sieves and flexible displays, according to researchers in the U.S. The tough nanomembranes made by the team, led by Beckman researchers Jeffrey Moore and John Rogers, come in a variety of shapes and sizes, including balloons, tubes and pleats.

Chemistry World

Photonic Crystals
May 23 – For decades, scientists have dreamed of computer chips that manipulate light rather than electricity. Unlike electrons, photons can cross paths without interfering with each other, so optical chips could compute in three dimensions rather than two, crunching data in seconds that now takes weeks to process. "You can take the light, criss-cross it and it doesn't interfere. It allows you to build more complex and compact architectures," said Paul Braun, a Beckman researcher and U. of I. materials science professor.

Wired

Exercise and the Brain
May 15 – "I think we still have limited knowledge of how to rank different kinds of exercises that humans could be asked to choose or engage in," said Bill Greenough, a U. of I. neuroscientist at the Beckman Institute. Greenough and his colleagues were among the first scientists to take an in-depth look at how exercise causes physical changes in the brain.

The Bulletin

Kramer's Research Spotlighted in New York Times
May 13 – A special New York Times section on wellness includes a feature story quoting Beckman Institute researcher Art Kramer about his work showing the power of exercise to improve brain function.

New York Times

Hsu's Research Efforts Featured in Science
May 8 – Beckman Fellow Ming Hsu has a paper appearing in Science that highlights his study of moral decision-making. Hsu's work is also featured in Synergy 9.

U of I News Bureau

Watkin Developing "Smart Helmets" for Injury Detection
May 8 – The work of Beckman Institute researcher Kenneth Watkin is profiled in the News-Gazette. Watkin is collaborating on a project that is developing "smart helmets" that can sense brain injuries.

News-Gazette

The Brain and Behavior
May 5 – "The clarity of how the brain controls behaviors is shown in sharp relief in songbirds," says David Clayton, a Beckman researcher and professor of cell and developmental biology at Illinois.

The Boston Globe

Exhibition Features Designs for the Disabled
May 1 – A current campus exhibition of designs and prototypes created with and for students with disabilities highlights the empathic design approach of Deana McDonagh, a Beckman Institute researcher and Professor of Industrial Design.

U of I News Bureau

Copper Nanowires Grown by New Process Create Long-lasting Displays
April 28 – A new low-temperature, catalyst-free technique for growing copper nanowires has been developed by researchers at the University of Illinois including Beckman affiliate Kyekyoon (Kevin) Kim. The copper nanowires could serve as interconnects in electronic device fabrication and as electron emitters in a television-like, very thin flat-panel display known as a field-emission display.

U of I News Bureau

Braun's Lab Demonstrates Bending Light
April 14 – Beckman researcher and U. of I. materials science and engineering professor Paul Braun has created 3-D optical waveguides out of photonic crystals that should make possible to trap light, slow it down and bend it around sharp corners, without fear of it escaping.

New Scientist

Silicon Circuits That Fold and Stretch
April 14 – "The notion that silicon cannot be used in such applications because it is intrinsically brittle and rigid has been tossed out the window," says John Rogers, a Beckman researcher and materials science professor at Illinois.

Chemical & Engineering News

Technique Takes Chemical Analysis to Femtogram Scale
April 14 – A laboratory technique developed by William King, a Beckman researcher and U. of I. professor of materials science and engineering, can describe both the structure and chemical composition of samples with a mass of less than one femtogram (one quadrillionth of a gram) using standard laboratory equipment.

Lab Technologist

Imitating Nature with Self-healing Materials
April 1 – Two research groups - one in the U.S. and one in the U.K. - have independently tried to create composite materials that mend themselves if damaged. The American initiative, led at the U. of I. by Beckman researcher and chemistry professor Jeff Moore and colleagues, focuses on the problem by adding extra components to composites.

The Economic Times