SYNERGY

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Al Feng's ultrasonic frog: Beckman researcher leads team that makes groundbreaking discovery

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Diane Beck is a new Beckman faculty member but is already beginning a new interdisciplinary research project *page 11*

Beckman alumnus Steve Sullivan has contributed to more than 40 films as head of Research and Development at Industrial Light and Magic *page 7*

Joe Lyding's career has been built around the scanning tunneling microscope but his contributions go far beyond developing new technology or innovative research *page 5*

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The effects of exercise on brain function and flexible electronics are just two of the Beckman Institute research projects making news worldwide *page 9*

The Little Frogs With the BIG Sounds

Tau Hua Creek in Central China. [Photo courtesy of Al Feng]

The scientists' surroundings were picturesque in daylight but especially hazardous at night: mountain runoff water rushing between steep, forested banks that hindered moonlight from reaching the many rocks and boulders dotting the creek bed. But it wasn't the beauty of the central China resort area or a possible misstep leading to injury that occupied Albert Feng's mind. It was a mounting sense of frustration.

Feng and his fellow researchers had used helmet lights and flashlights to navigate the rocks in Tau Hua Creek's cool, noisy waters for almost a week, recording instruments in hand, listening in vain for the mating calls of a unique species of frog known as Amolops tormotus. They had located the small, tan amphibians whose Chinese name means sunken ear frog among rocks in the creek, and waited patiently night after night in that summer of 2000, hoping for a chorus of what scientists refer to as advertisement calls from the males.

Finally, one night the scientists heard sharp, musical sounds they took to be coming from birds – an assumption, it turned out, the locals had also made when they heard those same calls. As the sounds of the creek's other creatures began to die down in the late-night hours, the bird-like calls stood out to the bored researchers. Their curiosity aroused, they temporarily abandoned the quarry that brought them halfway around the world and headed to the creek bank where the sounds were coming from.

"The first thing we noticed is these aren't birds because they are calling from the ground," Feng said. "They turned out to be frogs. Next thing we know, those are our frogs."

The team got its recordings, but with them came a surprise. The readouts of the frog calls showed unlimited variations and the frequencies on the high end appeared to extend into the ultrasound range – a discovery that contradicted the biology textbooks. Amphibians weren't thought to produce ultrasound (frequencies greater than 20kHz), except perhaps as a fluke byproduct of other communication. The results produced a paper, a story in *Nature*'s online "Science Update" and media

Amolops tormotus is a frog species found only in two regions of China. Tau Hua Creek in central China, habitat to Amolops tormotus, was a noisy and wild locale for Beckman researcher Al Feng to conduct his experiments.

attention from NPR to the BBC for the little frogs capable of producing limitless sound patterns and ultrasonic harmonies. What they didn't show was how far in the ultrasonic range the calls were, or answer the larger question: were the ultrasonic calls just a byproduct of an ordinary mating call or were they used for communication, as is the case with only a few groups of animals in nature.

Fast forward to May of 2002. Feng and his team return to the area, focusing their efforts on detecting ultrasonic calls from the Amolops. This time they brought with them German biologist Hans-Ulrich Schnitzler, a preeminent expert in ultrasound recording of animals in their natural habitat who focuses on bats with ultrasonic echolocation capabilities. The return visit provided a repeat pattern of initial frustration followed by some truly unexpected findings, thanks to Schnitzler's equipment and adventurous spirit. The results of their research, detailed in a 2004 journal article by the researchers, showed that both songbirds from the area and the Amolops produced ultrasound, with the frogs' calls extending into the high ultrasonic range.

Then in May of 2005, lugging state-of-the-art, PC-based recording equipment created by Schnitzler, Feng and his associates returned to the Huangshan Hot Springs to determine for good whether the little frog with no visible ears could prove the textbooks wrong. What they found should open up a new way of thinking about ultrasonic communication among vertebrates.

A few years before, Cornell biology professor Kraig Adler had directed Feng and his UCLA colleague Peter Narins to Amolops tormotus because it did not have external eardrums like all other frog species; rather, it possessed the unique anatomical feature of an ear canal with recessed eardrums. That fact alone made the Chinese frog worthy of further investigation for a researcher like Feng, whose focus at the Beckman Institute for Advanced Science and Technology is on the neural basis of sound pattern recognition in frogs and bats. Amolops tormotus, or concave-ear torrent frog, are located in just two regions of China, both of which feature bodies of water. The rainy season in the frog's habitats is known to turn meandering creeks into boisterous venues for wildlife – creating such a cacophony, in fact, that Feng and his colleagues often had to shout to one another in order to be heard.

In the spring of 2002, it wasn't the silence of the Amolops that was frustrating the team, but one of Huangshan's downpours that prevented any serious research work getting done. Feng, the team's leader, decided to call it a night. But Uli, as the outdoorsy Schnitzler is known, reveled at the idea of some rain-soaked research and set off to record bats in a nearby cave with equipment that detects ultrasound up to 128 kHz. A few minutes later, an animated Schnitzler returned with some astounding news. The Amolops were in full refrain, and their calls were off the ultrasonic charts.

"About 15 minutes later he came back and said 'come on up, you guys have to come up, these guys are calling like *crazy*." Feng said. "And not only that, the call frequencies were extending furthest into the ultrasonic range. It went beyond the capacity of Uli's equipment. He said 'I cannot believe that this can happen.'"

The German biologist was shocked, as was Feng.

"Bats can do this, dolphins and whales, among underwater mammals, can do this.

The discovery goes beyond one little frog in China. It has the potential to change not only the way scientists think about amphibians, but other species as well.

But in the vertebrates, it was typically known that they are limited to these small groups of animals that can perform this," Feng said. "Frogs definitely would not be taken into consideration as a remote possibility. So this came as shocking news to us. We were stunned, in fact."

The team had another new bit of research to report, but was still left with the question of whether this remarkable ultrasonic capability was a byproduct or actual communication. Schnitzler went back to his lab to custom build a PC-based recording device and an ultrasonic microphone to capture sounds that would then be digitalized using a converter and saved as wavefiles. The device Schnitzler created not only could record at the high ultrasonic range Amolops was capable of, but also could play back those recorded sounds for use as a stimulus.

Another expedition in the summer of 2005 followed and, using digital wavefiles of Amolops advertising calls, Feng's team played the calls through loudspeakers. They got "immediate" feedback, Feng said.

The group was able to see, from real-time readouts, the stimulus calls were quickly followed by antiphonal, or prominent, responses, thus demonstrating a temporal relationship between the playback calls and the calls that followed. Some of the responses were in the audible range and some in the ultrasonic range, but the fact a chorus was formed based on an ultrasonic stimulus left no doubt about the purpose of the sounds. The frogs were in fact using ultrasound for communication – and at very high frequencies.

The discovery goes beyond one little frog in China. It has the potential to change not only the way scientists think about amphibians, but other species as well. Feng said this discovery means that ultrasound communication will be likely be found in other creatures once scientists are open to the possibility. "We'll reevaluate everything."

That reevaluation could include investigating the calls of a species of warbler songbirds found along the same streams as the Amolops.

"In the 2002 paper we found some birds in the same region of China produce some sounds in the ultrasonic range," Feng said. "I would not be surprised if this bird also uses ultrasound to communicate. If frogs make this adaptation, it makes sense that other creatures in the area (also do). We have seen evidence like this, the parallel evolutions where different species converge into a similar solution."

Feng said bats use ultrasonic communication in order to avoid cluttering the communication channels, but for frogs and birds to develop the same function is extraordinary.

"They shift the hearing to the upper frequencies in order to get around the sounds produced by other creatures," Feng said. "This frog is unusual in that regard. The (frogs and birds) converged on the same solution. We have seen that before but this is probably a novel form of parallel evolution because this is totally unexpected."

Feng said the Amolops' development of ultrasonic capability probably came about as a result of having to communicate in the noisy environment of rushing waters. In their 2002 *Naturwissenschaften* article, the team reported that calling was more active when temperature and humidity were high, and found

that "ambient noise from the stream at the calling sites was intense, especially after a heavy rainfall."

"Clearly there are several ways to get around the noisy background," Feng said. "One of them is to shift the frequency beyond the spectrum of the background noise. This is seemingly what this particular species is doing."

The various expeditions culminated with a report in the March 16th issue of *Nature*, "Ultrasonic Communication in Frogs", by Feng, Narins, et al.

The Amolops males were also found to have a "rich vocal repertoire" and each individual male had his own distinctive call.

Feng believes ultrasonic communication explains why Amolops developed ear canals and recessed eardrums. He said that in order for the frogs to receive very high frequencies they must have thin eardrums (larger eardrums couldn't vibrate at those frequencies), but that thinness also makes the eardrum vulnerable. So an ear canal developed, leading to the recessed eardrum. At the same time, the recessed eardrum puts the eardrum much closer to the inner ear, reducing the mass of the middle ear bones that mediate transmission of sound energy from the eardrum to the inner ear for sound detection.

It was that recessed eardrum that caught Feng's attention to begin with. Feng came to China to study a frog with an unusual morphology. He left it this past year with a new perspective on what animals are capable of. The various expeditions culminated with a report in the March 16th issue of *Nature*, "Ultrasonic Communication in Frogs", by Feng, Narins, et al.

But this most recent report is not the end for Feng, or other researchers willing to walk through the same door. Now that Amolops has been found to have this capacity, what other species can also communicate at the ultrasonic level? Feng expects the work of his team to spur other research.

"I'm sure it will because now we really have to change the complete modus operandi of (this research)," he said. "This is no longer the domain of limited groups of animals."

But in order to find out which animals, it takes the right equipment.

"This is the thing: unless you have a device to look for this, and if you don't look for this, you'll never find it," Feng said.

And it takes the right amount of patience. Feng still remembers those nights back in 2000 waiting in the rocks of Tau Hua Creek for the calls that never came. "That was very frustrating because we came all this way to find them, wanting to study them and they didn't show any overt behavior."

But the team's dedication paid off – that and a willingness to look and listen where no one had before. Feng said the locals were surprised to learn the unique sounds they heard at night were coming from frogs.

"They thought they were little birds," he said. "All of us thought the same thing too. They're hard to find if you don't look for them."

But they did look for them, often by ignoring the advice of workers at the Huangshan Hot Springs hotel who warned of the creek's possible dangers. It could be raining on the hilltops, they said, and someone in the creek might not know it until floodwater was crashing down on them. Watermarks on the boulders 10 feet high and more above the creek bed testified to what happens when Tau Hua Creek floods.

But the danger or frustration isn't what Feng remembers most about his quest to understand why one little frog in China has distinctive ears.

"This was a fun trip, particularly when exploring an unknown, that's always fun," he said. "There's always a reason why things are different and when you finally understand it, it's just a rewarding experience.

"You explore an unknown and are finally able to explain it. That's just tremendous satisfaction for me." □

MESSAGE FROM THE DIRECTOR

I'm pleased to introduce the inaugural issue of *Synergy*, the Beckman Institute for Advanced Science and Technology's new quarterly newsletter. *Synergy* was developed to highlight current research and help you get to know the people behind it. As you will see, new and ongoing projects such as those featured in this issue are putting the Beckman Institute in the spotlight around the world.

As always, the primary mission at the Beckman Institute is to foster work of the highest quality at the interface of the physical, computational, engineering, biological, neurological, behavioral, and cognitive sciences. Our research initiatives continue to prosper and push the limits, leading to exciting breakthroughs of global proportions. It is truly a place where great minds meet.

Additionally, we recently held an open competition to seed new research directions in engineering and the physical, social and life sciences. The competition brought many new ideas to the table and from them we chose 11 new proposals to fund. These proposals are very promising and we hope they will form the building blocks of a new research initiative at the Beckman Institute. You can find more information about the seed proposals on our website.

I hope this – and upcoming – issues of *Synergy* illustrate how the people and research at the Beckman Institute are making an impact.

Enjoy!
Pierre Wiltzius
Director

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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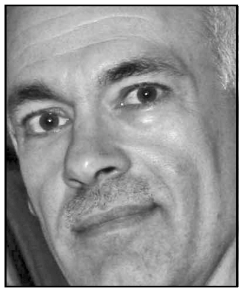
Lyding Leads By Example



Risky moves, creative research strategies, and enjoying the work are not only what Joe Lyding practices; they are also what he preaches.

Joe Lyding came to Illinois in 1984 to work with the legendary John Bardeen and explore a research path that seemed paved with potential. As a young professor and researcher Lyding started off growing crystals for the two-time Nobel Prize winner and colleague John Tucker as part of their group's focus on charged density waves.

A year later Lyding heard an invited talk at a professional meeting about a revolutionary new instrument for atomic scale microscopy and everything changed. He had never heard of the scanning tunneling microscope (STM) that IBM researcher Gerd Binnig was describing, but his initial reaction was "wow." His second was that he had to make one of his own.

It took a year and numerous after-hours visits to a student machine shop before Lyding was actually able to build an STM, finishing just a month in fact before Binnig and colleague Heinrich Rohrer won the Nobel Prize in Physics for discovering the technology. But once the 12-foot tall, four-foot wide instrument was finished to Lyding's satisfaction, the University of Illinois had one of the few STMs in the world and Lyding had a new career path.

"Once we got atomic resolution, I just dumped what I was doing before and jumped into that," Lyding said. "It was kind of a risky move for an assistant professor but it worked out."

Lyding's accomplishments attest to the wisdom of his decision. His discoveries in the areas of microscopy and micro- and nanoscale research and technology are known throughout the fields of physics, materials science, and engineering.

A year after building that first STM, Lyding was mowing his lawn when an idea for an ultra-stable version popped into his head. His design of a series of interconnected ultra-high vacuum STMs served as one of the cornerstone technologies of the Beckman Institute for Advanced Science and Technology during its early years, and today's refined versions remain a key part of various interdisciplinary research projects. This new design has been copied worldwide and has been licensed by the University of Illinois for commercial production

Lyding's career as a researcher has been intertwined with the STM, which provides both visualization and manipulation at the micro- and nanoscale. But he has used the technology to branch off in many directions, including collaborations involving transistor technology and development of an atomic resolution patterning technique.

It's possible none of it would have happened if he had stuck with his original work on electrical measurements of charged density waves.

"I was already publishing in the other area and there was sort of a clear track toward getting tenure," Lyding said. "But jumping out of that safety net into the fire was fun, it was exciting, and challenging. To be honest with you, that's where the action is. The safe route is boring."

Lyding takes the same approach to teaching students and working with postdoctoral researchers and graduate students in his group. Risky moves, creative research strategies, and enjoying the work are not only what Lyding practices; they are also what he preaches. And it's a message that has been soaked up over the years.

Scott Schmucker was at the top of his class at Case Western Reserve University, and had his pick of the top engineering graduate schools in the country, including his first choice of Stanford. That was until he visited with the Lyding group and decided to go in another direction.

"When I met with Professor Lyding and the members of his research group my plans for graduate study changed completely," Schmucker said.

Like his teacher, Schmucker's switch in plans proved successful. Lyding teaches a course each semester on nanotechnology in which he asks his students to think and act like researchers. As part of a discussion on selective etching of nanowires, Lyding asked his students if anyone could come up with a way to remove a gold catalyst without destroying the nanowire. Schmucker proposed a sacrificial layer that could be etched, thus removing the catalyst but leaving the nanowire intact.

"That was just an amazing idea," Lyding said. "I said to the whole class 'you all are witnesses that I think this is an important idea that should be submitted as an invention disclosure.'"

Unfortunately, a research group at Northwestern beat Schmucker to the punch by proposing a similar solution in a *Science* article that appeared shortly before his proposal was finished. But the story demonstrates the kind of experience students get with Lyding.

Schmucker said Lyding brings "an understanding that any fresh perspective could yield a solution, be it from a Nobel Laureate or an undergraduate student. Not only does Professor Lyding regularly encourage his students to bring their own ideas into the classroom, it is often expected."

Mark Hersam, an assistant professor of Materials Science and Engineering at Northwestern, first met Lyding when the Beckman researcher served as Hersam's undergraduate academic advisor. Hersam earned his master's degree at Cambridge – on a British Marshall Scholarship attained with Lyding's aid – but it was his undergraduate experiences with the professor that drew Hersam back to UIUC for his Ph.D. He served as a research assistant and collaborator with Lyding until earning his Ph.D. in 2000. Hersam said students feel comfortable with Lyding.

"Joe is very down-to-earth and approachable," Hersam said. "His demeanor is the same in almost all situations – whether it is in class teaching undergraduates or on the basketball court at Kenney Gym. In addition, Joe expresses complicated ideas in a clear and logical manner, which makes his lectures exceptionally understandable."

Lyding's style when it comes to explaining research is such that Hersam said he doesn't remember Lyding ever receiving a clarification question from the audience following a lecture at a professional meeting. "Clearly, Joe is a gifted teacher at levels, from undergraduates to Ph.Ds."

Perhaps that ability comes from Lyding's teaching philosophy.

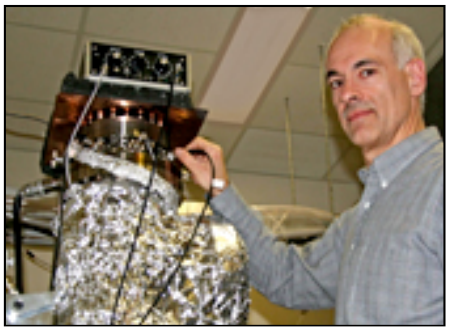
"I think it's far more important to think about what the students need than what I need," Lyding said. "I'm satisfied with my career, I've had a good time, and enjoy what I'm doing. But I get a lot of satisfaction out of seeing the students excel. My philosophy is they are going to excel if they're happy, and in order for them to be happy they need to be empowered."

Josh Ballard has a Ph.D. in physical chemistry and collaborates with Lyding as a Beckman Fellow. Ballard said Lyding's love of doing research makes him an excellent role model when it comes to inspiring younger students and postdocs.

"You can see that he really enjoys the science that he's doing by the fact that he makes such an effort to spend time in lab, which he doesn't have to do," Ballard said. "You can see that you can go on in life after being a student and a postdoc and can still continue enjoying science."

Ballard said that quality makes Lyding different than most high profile researchers.

"He's different in that he's made a choice to spend time in lab," Ballard said. "I think he really enjoys not only writing research proposals and papers but doing the nitty gritty stuff."



Joe Lyding, standing next to the STM in his lab at Beckman, earned an excellent teacher rating in 2005 while his research efforts have led to breakthroughs such as single-molecule absorption spectroscopy.

Hersam said Lyding is different in another way.

"Joe is the most humble professor that I have ever met," Hersam said. "In an era when universities are increasingly populated with prima donnas, Joe quietly goes about his business and lets the high quality of his work do the talking."

Lyding's students and postdocs like Ballard say the approach works.

"I came here based on the reputation for producing high quality science, but the intangibles of working for, or rather I would like to say with him, have far exceeded any thing I would have expected," Ballard said.

While he loves doing research, Lyding said teaching is still the most important work that goes on at a university.

"This is a university and the key output of this university is trained students at all levels," he said. 'At a major research university, producing highly-trained M.S. and Ph.D. graduates is the most important thing."

Lyding certainly has been successful in sending young scientists off to high-level positions in academia and industry. Three of his former students have tenured positions.

"It's very satisfying," Lyding said. "They've all gotten tenure at other places and are demonstrating success that has mostly to do with themselves, but I think also has something to do with the experience that they have at Illinois."

Lyding and Beckman colleague Karl Hess collaborated on a project involving hydrogen/deuterium desorption from silicon surfaces and its potential impact on transistor technology. The original idea came to Lyding much like the one for the ultra-stable STM – a sudden insight – during a casual conversation with Hess.

"I asked him 'has anybody tried deuterium in transistors' and he jumped out of his chair," Lyding said. "It was one of those type moments. It was sort of perfectly obvious to him."

As a result of that work several major chipmakers have either used deuterium in production or in the advanced development of their latest technologies.

The STM was part of that research project, as well as the key component in a recent project with Martin Gruebele for single-molecule absorption spectroscopy. Lyding said the STM allows researchers to visualize the actual effects of technologies or methods that theorists can only speculate might work in areas of nanoscience and nanotechnology. He said STM technology allows researchers to make and test future applications and ideas and get fundamental information about how they work. One project currently in the initial stages involves putting molecules and carbon nanotubes on silicon and using opto-electronic materials like gallium arsenide as possible precursors for making molecular scale transistors.

"That's what the STM allows you to do," Lyding said. "We can make now things that are way over the horizon but could become extremely important as silicon technology runs out of gas."

Transistors made of single molecules or carbon nanotubes may be in the future, but Lyding's group is visualizing their potential today. Nowadays the STMs are the size of a person's thumb and University machinists fashion the hardware according to Lyding's specs. But the approach is still the same.

"What I tell my students is what you need to do is have fun because the best ideas you're going to have are going to come out of your creativity," he said. □

Sullivan Goes From Beckman to

MAKING MOVIE MAGIC

A decade ago Steve Sullivan was a research assistant at the Beckman Institute on the lookout for job opportunities when he decided against a career in academia or one of the traditional industry outlets for an engineer with a brand new Ph.D. Instead, he chose to go to Hollywood.

As head of research and development at Industrial Light & Magic, Beckman alumnus Steve Sullivan is a key player in the world of movie special effects. (Photo courtesy of ILM)

As an electrical engineer, Sullivan's dreams of making it in the movie business differed from the standard Hollywood formula. Sullivan wanted to work behind the camera and knew the computer vision techniques he focused on at Beckman could provide real-world solutions to moviemakers who in the 1990s were grappling with how to apply new digital technologies to some of the problems inherent in traditional filmmaking.

But like many a Tinsel Town dreamer, Sullivan was hit with a spark of inspiration emanating from the screen. He was watching a TV documentary about the making of *Jurassic Park* and instantly realized that computer vision techniques could replace the laborious and restrictive camera location methods the show was describing for creating special effects.

"It was talking about how movies have this problem of matchmoving and figuring out where the cameras were and objects were and that is computer vision," Sullivan said.

Sullivan began talking to people in the industry and telling them about computer vision techniques that could solve special effects problems. In 1996 he landed a job with a graphics company in Los Angeles called Rhythm and Hues that did work for the movies.

"So that's how I got into the industry." Sullivan said. "I was applying exactly those things that had I worked on at Beckman."

But his dream job was to work at George Lucas' famed special effects company Industrial Light and Magic, located in northern California. That desire was realized in 1998 and since then the Beckman alumnus has been, well, living large: winner of an Academy Award for technical achievement, soon-to-be White House honoree, and, oh yes, recipient of a kiss from actress Charlize Theron.

Not the usual perks for someone with a Ph.D. in Electrical and Computer Engineering from the University of Illinois. But then Sullivan is not your typical electrical engineer, according to Jean Ponce of the Artificial Intelligence group. Ponce served as teacher, academic advisor and mentor to Sullivan when he worked in Ponce's Computer Vision and Robotics group at Beckman.

"He was this kid from Missouri with a funny haircut. But he wanted to do something with himself," Ponce said.

Ponce said ambition wasn't the only thing that separated Sullivan from his peers.

"Steve was an interesting guy, and a fun person as well," he said. "He had a gift for person-to-person relationships that I think is rare for a Ph.D. student because they focus on their work. But Steve had other interests."

Sullivan's early graduate studies were in areas like medical imaging and robotics before later focusing on topics such as image-based modeling and 3-D tracking that would play a role in his future career. He joined Industrial Light and Magic just as the movie industry was looking to incorporate the kind of computer vision techniques he learned as a research assistant for Ponce.

At that time, computers had widely been used to create special effects. But the moviemaking process was still hampered by the age-old methods of calculating camera angles and positions by hand, while filming the effects separately from the rest of the film and then integrating them, sometimes clumsily, into the movie.

> "Look for applications outside of what you know. I'm the poster child for that. Paying attention to what other fields' problems are . . . it's a great way to do something that's brand new."

Sullivan was a pioneer in writing algorithms for computer-vision software for automatic camera-tracking. The computer vision matchmoving method measures two-dimensional and 3-D objects in images (a process called photogrammertry), and then reconstructs them for integration with special effects. The technique is a more efficient and robust process for creating special effects and gives them a much more realistic look than before.

Today, computer vision methods like matchmoving and photogrammertry have become the standard as special effects and moviemaking in general underwent a revolutionary change in the last few years with the advent of digital technology. Sullivan said computer vision frees filmmakers to shoot the movie they want because the special effects can be integrated seamlessly once filming is done.

"It changed the kinds of stories that can have effects in them," Sullivan said. "They can take it for granted now that you can put effects anywhere you want to put them."

In 2001, Sullivan won an Academy Award in Technical Achievement for development of the ILM Motion and Structure Recovery System (MARS) and two years later, he was named Director of Research and Development at ILM. Sullivan and ILM continue to break new ground in movie special effects. One of their major goals is to create the first completely digital, realistic human actor.

"We do basic R&D to make sure that's going to be possible when the movie comes along," Sullivan said, "but you won't see that come out on the screen until the right movie comes along."

Sullivan said another big project, in concert with the LucasArts video game company, is to develop a virtual reality, game-based method of collaborative moviemaking. Sullivan said this new project could be as important as computer vision in changing the way movies are made. The program would allow writers, directors and other players to engage in virtual storyboard sessions that could let them know, among other things, exact camera shots and positions prior to shooting the scenes.

"This is really about tools for the director and tools for the artist to work collaboratively with each other, rather than assembly-line fashion, which is what they do now," Sullivan said. "The same way you might have a multi-player video game where you have characters running around in this computer graphics world and you have a certain viewpoint on that, a director could work in that style to make their movie."

Changing the way movies are made and contributing to special effects blockbusters like *Minority Report* and the *Star Wars* saga is a dream career for many. But Sullivan has some very down-to-earth advice for those students who would like to follow in his footsteps.

"First, take as much math as you can possibly get," Sullivan said. "You'll never regret that. It's very easy to learn programs or new systems when you're out in the workforce but very, very difficult to learn new math on the job."

Sullivan also says that anyone interested in working on computer games should become part of the development process.

"Get an evaluation copy or buy a license for one of these 3-D packages and try making visual effects on your own," he said. "You have to try it to really understand it."

Thirdly, he said, "look for applications outside of what you know.

"I'm the poster child for that. I had no idea this would apply to visual effects but just by

paying attention to what other fields' problems are, even if you don't know the solution, it's a great way to do something that's brand new."

Sullivan said his time at Beckman paid off in that regard.

"That was what was really great about Beckman is you were exposed to all these different disciplines that may have, on the surface, very little to do with each other," he said. "But down at the bottom they are solving a lot of the same problems. I think being at Beckman four years gave me that awareness and appreciation for other fields."

Sullivan said there was a "very direct relationship" between what he worked on at Beckman and his current work.

"Matchmoving, image-based modeling, those are exactly the things I worked on at Beckman in the AI group there," he said.

"Then there's the second-level stuff that is just as important," he added, "all the classes I took at the U of I as part of the Ph.D. course work like control theory and optimization, numerical analysis. Things at the time that maybe I wasn't so interested in but had to take as part of the degree. But they turned out to be extremely important, if only for some of the fundamental concepts like knowing if something is possible or knowing that things are related in a certain way is useful today. I don't think I'd have that perspective had I not gone through that course and worked in that group."

Sullivan enjoys the various rewards and honors he has received, including the Academy Award in 2001 when he received the peck from Charlize Theron.

"It was great," he said with a laugh. "I have no reservations on that. That was really fun."

Sullivan will be part of an ILM contingent going to the White House to be honored by President Bush with the National Medal of Technology, an award given to Arnold Beckman in 1988. The National Medal of Technology is the highest honor awarded by the President of the United States to those who have made outstanding contributions to America through technological innovation.

"Talk about the right place at the right time," Sullivan said. "(The National Medal of Technology is) going to George and ILM for the scope of all their technology advances over the years, but it's great to be involved in something like that."

Ponce said he tells his classes and audiences at talks that some people may not consider computer vision useful. The he tells them about Sullivan.

"I show a picture of him with one of the *Stars Wars* robots and say his success has nothing to do with me. It's his success, but the fact that this kind of work can lead to a career and impact on movies and industry is great."

Ponce mimicked his audiences' customary response with a reaction that would make a special effects guru proud: his eyes widen and he says, "They are like 'ahhhhhhh.'" □

The Chronicles of Narnia from 2006 is just one of more than 40 films Steve Sullivan has worked on since joining Industrial Light & Magic in 1998. (Photo courtesy of ILM)

A sampling of Beckman Institute research projects receiving national media attention in January and February of 2006:

Detection of DNA on Nanotubes Offers New Sensing, Sequencing Technologies

February 17, 2006. **Michael Strano** of the Beckman Institute has new research showing that carbon nanotubes can be used to target specific DNA sequences.
UI News Release | PhysOrg.com | M&C Science and Nature | Nanotechwire

Training Benefits Brains in Older People, Counters Aging Factor

February 16, 2006. New research by the Beckman Institute's **Kirk I. Erickson** and **Art Kramer** shows that training re-ignites key areas of the brain, offsetting some age-related declines and boosting performance.
UI News Release | Senior Journal | Hindustan Times | Medical News Today | Journal Times | Senior Journal

To Concentrate, Cut the Noise

February 14, 2006. **Denise Park**, co-director of the **Center for Healthy Minds** at the U. of I.'s Beckman Institute, says if you have to concentrate, it wouldn't hurt to turn off the radio, TV or other unnecessary noises.
Washington Post

Capsules Can Release Drugs on Demand

February 14, 2006. **Sahraoui Chaieb**, a faculty member in the **Biological Sensors** group, has created temperature-sensitive capsules that can release drugs on demand.
Innovations Report | Science Daily

Studies Show That Exercise Improves All Sorts of Brain Functions

February 6, 2006. "The way I think about it is that fitness changes the building blocks – the structure and function – that support numerous cognitive abilities," says U. of I.

psychology professor **Arthur Kramer**, director of the Beckman Institute's **Biomedical Imaging Center.**
Austin American-Statesman

'Five-second Rule'

February 3, 2006. Think twice before you pick up that dropped Super Bowl snack. A few years ago, the "five-second rule" was put to the test at the Beckman Institute's **Microscopy Suite** and it was found that food had a significant amount of bacteria on it after less than five seconds on floors that had been purposely contaminated.
Sacramento Bee

Researchers Find Ties Between Activity and Health, Happiness

January 29, 2006. Physical activity not only tends to make senior citizens more fit, but also might improve their quality of life, and on a long-term basis, Beckman Institute faculty member and UI kinesiology professor **Edward McAuley** said recently.
The News-Gazette

DNA-wrapped Carbon Nanotubes Serve as Sensors in Living Cells

January 26, 2006. Single-walled carbon nanotubes wrapped with DNA can be placed inside living cells and detect trace amounts of harmful contaminants using near infrared light, report researchers including **Michael Strano**; affiliate faculty member in the **Nanoelectronics and Biophotonics** group.
UI News Release | Eurek Alert | Science Daily | PhysOrg.com | Daily Science News | Innovations Report | Medical News Today | Medgadget.com| Nanotechwire.com |United Press International | Nanotechnology News | Monsters and Critics.com | Digital Silence | AZoNano.com |Middle East North Africa Financial Network | Photonics.com | Medical Technology Business Europe | Live Science

Fitness Counteracts Cognitive Decline from Hormone-replacement Therapy

January 24, 2006. Women pondering hormone-replacement therapy also should consider regular exercise. A new study done by **Kirk Erickson**, HPP faculty member **Arthur Kramer**, and other Beckman researchers suggests that being physically fit offsets cognitive declines attributed to long-term therapy.
UI News Release | Eureka Alert | Innovations Report | United Press International | Science Daily | Monsters and Critics.com

New Theory Explains Electronic and Thermal Behavior of Nanotubes

January 19, 2006. Researchers, including **Computational Electronics** faculty member **Jean-Pierre Leburton**, have made an important theoretical breakthrough in the understanding of energy dissipation and thermal breakdown in metallic carbon nanotubes. Their discovery will help move nanotube wires from laboratory to marketplace.
UI News Release | California Computer News | Monsters & Critics.com | Science Daily | Nanotechnology News | New Kerala | United Press International | Web India 123 | PhysOrg.com | Innovations Report | Nanotechnology Now | EurekAlert | Small Times | Nanotechwire.com | CCN Magazine | PressZoom | LinuxElectrons | AZoNano.com

Self-healing Materials

January 17, 2006. **Advanced Chemical Systems** faculty member **Scott R. White** is collaborating with Duke University engineering professor Adrian Bejan on plans for self-repairing skins for airplanes and automobiles.
News & Observer (Raleigh, N.C.) | Space.com

Can You Prevent Alzheimer's Disease?

January 16, 2006. **Human Perception and Performance** faculty member and Psychology professor **Arthur Kramer** is among the researchers studying the relationship between cardiovascular fitness and cognitive health.
Time Magazine

Scientist Creates Flexible Electronics

January 16, 2006. It is expected that the flexible electronics device may be applied in a variety of uses, ranging from biological tissues to integrated robot sensors. **Nanoelectronics and Biophotonics** faculty member **John Rogers** is a co-author of a paper on the subject that appeared in the journal *Science*.
Donga (Seoul) | Science News

Nature Materials Journal Cover Designed by ITG for Rogers Group

January 2006. The cover of the January 2006 issue of *Nature Materials* accompanies an article by **John Rogers**' research group on stamp-printable micro/nanostructures. Chas Conway and Ben Grosser helped lead author Matt Meitl photograph and prep the cover image in ITG's Visualization, Media, and Imaging Laboratory.
Nature Materials

Ambassador To U.S. Wants Bilateral Relations Strengthened

January 14, 2006. On a visit to Illinois that included a tour of the **Beckman Institute**, Angolan ambassador to the United States of America, Josefina Pitra Diakite, said there is still much room for the growth of relations between the two countries, despite the current level of politico-diplomatic understanding she regarded as good.
AngolaPress

Researchers Model Nano-size Battery to be Implanted in Eye to Power Artificial Retina

January 12, 2006. A multi-institutional, multidisciplinary team directed by **Eric Jakobsson** of the **Computational Electronics** group, is developing a nano-size battery that one day may be implanted in the eye to power an artificial retina.
Nanotechwire.com | LinuxElectrons.com | PhysOrg.com | Chemie Information Service | Electronic Engineering Times | Nanotechnology.com | Sandia National Ls News Release | AVS | MedGadget | NSTI | Medical Technology Business Europe | Albuquerque Tribune | Sit News | Windsor (Ontario) Star

Research Ties Fitness to Better Brain Function

January 9, 2006. "The way I think about it is that fitness changes the building blocks – the structure and function – that support numerous cognitive abilities," says **Art Kramer**, **Human Perception and Performance** group faculty member and director of the **Biomedical Imaging Center** at Illinois.
Los Angeles Times | The Times-Dispatch (Richmond, Va.)

In Love With Reality Truly, Madly, Virtually

January 8, 2006. **Hank Kaczmarski** and **Rose Marshack** of the **Integrated Systems Laboratory** discuss virtual reality in the CANVAS project at the Krannert Art Museum.
New York Times | International Herald Tribune

Illinois Scientists Studying How Life Emerges from Inanimate Matter

January 8, 2006. How life emerges from the interplay of inanimate matter is the goal of a new $5 million grant from the National Science Foundation. Among those whose

work is funded by the grant is chemist **Zaida Luthey-Schulten**, a part-time faculty member of the **Theoretical and Computational Biophysics** group.
CHICAGO TRIBUNE

A HEAD FOR MUSIC

January 8, 2006. In an essay, **Richard Powers**, a professor of English at Illinois and an affiliate faculty member of the **Cognitive Neuroscience** group, considers recent research on Mozart, Beethoven and the public fascination with unsolved medical mysteries.
NEW YORK TIMES

IMPROVING AIRCRAFT SAFETY

January 5, 2006. For the past three decades, **Chris Wickens** of the **Human Perception and Performance** group, has been working to improve the display of visual information in airplane cockpits.
APS OBSERVER

ARE YOU LOSING IT? MIDLIFE FORGETFULNESS MIGHT JUST BE A PART OF AGING

January 3, 2005. **Human Perception and Performance** faculty member **Denise Park** is quoted in article about the memories of middle-aged people as compared to older adults.
OCALA.COM

EXERCISE BENEFITS SEDENTARY SENIORS

January 1, 2006. Illinois researchers have found that formerly sedentary seniors who began exercising experienced physical and psychological benefits. The study is co-authored **Edward McAuley**, a part-time faculty member in the **Human Perception and Performance** group.
BALTIMORE SUN | MEDICINENEWS.NET (ITALY)

FACULTY PROFILE

Diane Beck, a member of the Cognitive Neuroscience group at Beckman, joined the Institute in 2005 with a focus on the limitations of the visual system.

It didn't take Diane Beck long after arriving at the Beckman Institute for Advanced Science and Technology to start doing some truly interdisciplinary research.

Beck, a full-time faculty member in the Cognitive Neuroscience group, focuses on how our cognitive processes and neural structures both enable and limit our visual representations of the world.

"I'm interested in the sort of things like why is it when we're looking right at someone but, say we're deep in thought or busy doing something else, that we fail to see them," she said. "This suggests we have this limitation that we can only process a certain amount of information at the same time."

Beck came to Beckman and the University of Illinois in the fall of 2005 chiefly, she says, because of "the number of fantastic faculty here that I have common interests with.

"I would call myself somebody interested in visual cognition and the brain. There's fantastic visual cognition people here and fantastic brain and cognition people here, so it was a perfect place for me."

After only a few months at the Institute, Professor Beck is already expanding her interests to include a collaboration with Electrical and Computer Engineering Professor Fei-Fei Li. Beck and Li, a full-time Beckman faculty member in the Artificial Intelligence group, are starting a research line that involves using computer vision techniques to analyze fMRI data. The project began when Beck and Li talked at a Beckman social gathering about working together and then came up with the idea during lunch at the cafe – in other words, a classic tale of how interdisciplinary collaborations often begin at the Institute.

"A nice thing is that because she's a computer vision person, she actually brings a lot of mathematical sophistication that is less common in the field of fMRI because they look at data a little bit differently," Beck said. "This is a good one for Beckman because it wouldn't have happened if it weren't for the Beckman Institute. It's because she's five doors down that I'm even talking to her."

Beck is diversifying the Institute's research portfolio in another way by introducing an imaging method called transcranial magnetic stimulation (TMS) to Beckman's Biomedical Imaging Center. She said TMS allows researchers to disrupt activity in certain regions of the brain as a complementary technique for use with functional MRI.

"Then you'll get an idea of whether that brain region was at least in part responsible for the behavior," she said.

A native of Wellington, New Zealand, Beck and her family moved to Southern California when she was 12. She got her

> "I'm interested in the sort of things like why is it when we're looking right at someone but, say we're deep in thought or busy doing something else, that we fail to see them."

Ph.D. in psychology from the University of California at Berkeley in 1998 and was a postdoc at Princeton University and University College London, where she began her current work in the limitations of the visual system. But her future research work at Beckman could be going in new directions. Even her collaboration with Li began with an idea about one research project before the concept for applying computer vision techniques to fMRI data came up.

"So we decided to go down that road, which is completely different from how we started," Beck said. "It is an amazing thing that just having people in the same place is such a good idea." □