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Wisconsin engineer

APRIL 2007 VOLUME 111, NUMBER 3

Bearing down on biofouling

Keeping boats clear of aquatic buildup p. 10

CoE differential tuition: p. 2
Did *your* vote count?

wisconsin engineer

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COVER STORY

Photo by Jamie Tabaka: Rodolfo Perez examines the hull of a Hoofers sailboat for signs of biofouling.

FEATURES

COMMENTARY

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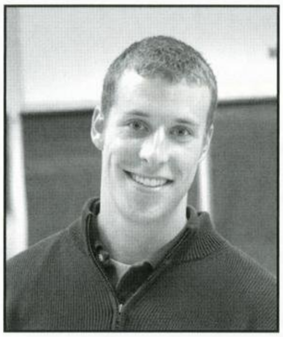

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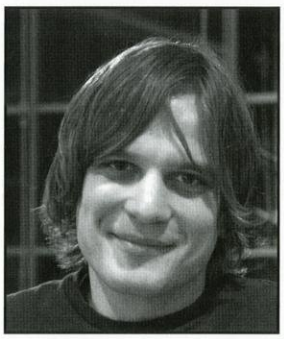
Writing Editor



Mike Verner
Writing Editor

Differential tuition process needs re-engineering

On April 11, Polygon held a vote on the issue of a differential tuition for students admitted to the College of Engineering at UW-Madison, raising the cost to students by $700 a semester. The UW Board of Regents requires student input for any sort of tuition hike, and Polygon, as the student representation for the College of Engineering (CoE) has been tasked with providing this input.

Over the past decade, state funding for UW-Madison has been steadily declining. At the same time, the cost of educating engineers is on the rise. Keeping pace with ever-evolving technology required for lab courses, the need for faculty salaries that compete with industry and planned additions to engineering curriculum all contribute to this increasing cost. These diverging forces are leading to a serious deficit in funding that threatens the quality of education that CoE students will receive.

The differential tuition plan was designed by Dean Peercy and the rest of the dean's office to help meet the need for additional funding. According to their calculations, the tuition increase should provide the CoE with approximately $3,000,000 in additional funds per semester.

The dean's office plans to use this funding primarily to hire new faculty (50 percent), improve our labs and machine shop (20 percent), improve student services such as computer-aided-engineering and engineering career services (15 percent) and make additions and changes to the course curriculum (15 percent).

The intentions of the dean's office are good and the funding deficit is a very serious problem. However, we feel that the way the administration is obtaining the student input requested by the Board of Regents leaves much to be desired. Last year, a committee of student leaders on campus was selected by Dean Peercy to head the newly formed "CoE Differential Tuition Committee." These students were tasked with promoting the tuition hike to students prior to the Polygon vote in April. Since formation, the committee has held several meetings with the presidents of engineering student organizations and one public listening session about the plan.

These efforts strike us as too little, too late. If the dean's office truly wanted student input, it should have been more proactive earlier in the process to inform students about the issue at hand. At press time, many in the CoE were still unaware that a tuition hike was being discussed, much less that it was days away from being voted on. A differential tuition has been an issue for several years, yet the first meeting open to the public was held just weeks prior to the proposed vote.

Furthermore, characterizing Polygon as a representative organization for the entire student body of the CoE is somewhat deceiving. Polygon is a collection of the student organizations within the CoE, so while they represent the collective opinion of the student organizations on campus, all affected students may not have been heard. The idea expressed by the Differential Tuition Committee is that students who are not members of organizations should have sought out an organization and made their voice heard. However, publicity for the proposed vote was virtually nonexistent.

We feel that the Differential Tuition Committee should have been tasked not with promoting the tuition hike, but with publicizing it. The student body should be informed about the reasons behind the proposed tuition increase, and then allowed to decide for themselves whether or not they support it. While a college-wide vote would require careful planning and execution, it would not use a large amount of resources. It would also gauge the opinion of the student body more effectively to fulfill the Board of Regent's requirement for student input.

By the time this issue is printed the Polygon vote will have already taken place. We hope that the student organizations voting will cast their vote against the proposal, not because we oppose the plan, but because a more legitimate forum for assessing student support should be used.

What do you think about the proposed differential tuition?

Let us know at wiscengr@cae.wisc.edu.

COLLEGE OF ENGINEERING
UNIVERSITY OF WISCONSIN-MADISON

THE UNIVERSITY of WISCONSIN MADISON

ECMA ASM

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Photo by Aaron Arnold & Jamie Tabaka

UW-Madison's Supermom

A wife, a mother, an electrical and computer engineer

By Victoria Yakovleva

As a wife and a mother of a 7-year-old boy, Irena Knezevic takes on the role of counselor, tutor, cook, nurse and disciplinarian. On top of all that, she is an assistant professor of electrical and computer engineering at UW-Madison. While most mothers struggle to balance home and work life, Knezevic has mastered this juggling act.

Born and raised in Serbia, she was exposed to a different type of family life than many of us are accustomed to in the U.S. There, families have a difficult time supporting themselves on just one income; so everyone works, including the women. Upon coming to the United States in 1999, Knezevic recognized that "there are definitely cultural differences" between women here and women in Serbia.

"When I was growing up, I didn't think that it was that big of a deal that I was a girl," Knezevic says. Living in the United States, however, has made her realize the lack of women in science and engineering—a reality that becomes apparent the moment you enter a Physics 201 classroom.

She never thought that her gender would affect her standing in the field of electrical and computer engineering. She just wanted to pursue what she enjoyed.

"I've always been a geek.... I've always liked math," Knezevic says. With her first exposure to physics in sixth grade, Knezevic realized "early on that physics was exactly to [her] taste; it was a perfect combination of math and science."

She proceeded to earn her undergraduate degree in physics at the University of Belgrade in Serbia. Upon graduation, she realized that there's more money for research in the States, and so she went to Arizona State University in 1999 for her graduate studies.

That same year, she married; the following year, she had her first child.

Remarkably, the birth of her son did not hinder Knezevic from getting her Ph.D. In fact, it kept her focused and efficient–it taught her how to prioritize. She learned how to be productive during the day so that she could spend time with her son during the evening. After completing her Ph.D., Knezevic began work at UW-Madison.

"The good side about engineering, especially if you're a woman in engineering, is that the opportunities for you to get a faculty position right after a Ph.D. are much greater than anything else such as physics, where traditionally you shouldn't try without at least one post-doc," she says. Though it is "always a very lucrative option" for engineers to go into industry, it never appealed to Knezevic.

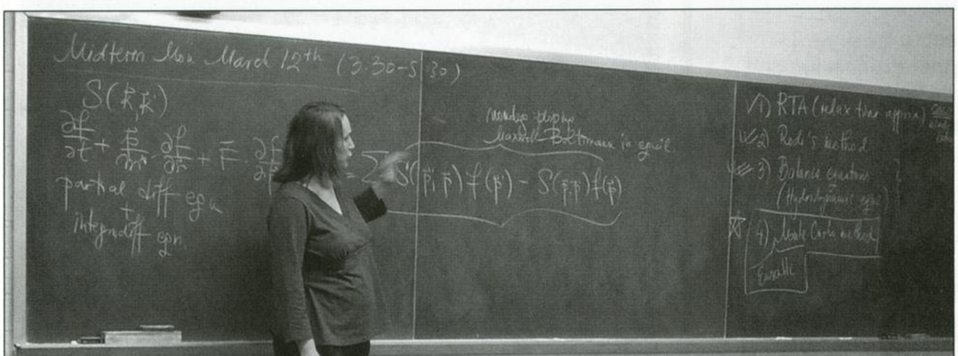


Photo by Anna Mielke and Pete Penegor

Knezevic presents the Monte Carlo method to her transport and semiconductor devices class.

Now, with almost three years of experience at UW-Madison, Knezevic continues to advance in her field. In 2006, she was granted the NSF CAREER Award. This award bestowed her with a 5-year, $400,000 grant for her work in theoretical modeling and simulation of short structures in very small timescales.

"The NSF CAREER Award is good because it's an honor and also good because it's money, which is probably even better," Knezevic says.

Currently, she is teaching a "high-level graduate course" on transport in semiconductor devices. If you pass by room 3349 of Engineering Hall on a Monday, Wednesday or Friday afternoon, you are likely to hear her prominent voice project throughout the hall. Her vibrant enthusiasm, punctuated hand gestures and eccentric articulation ensure that no student in her class ever dozes off.

Though the class is typically taught every other day from 2:30 to 3:30, Knezevic sometimes has to cut her week short. She is currently six months pregnant, so she sometimes needs an extended weekend. To compensate, she conducts an extended lecture on Mondays from 2:30 to 4:30 (now that's one heck of a power lecture!).

"Sometimes [the class] is a bit fast; but there's a lot to go over so it sort of has to be," Jeremy Kirch, a fifth-year senior currently taking Knezevic's class, says. "The homework is a bit too difficult for me, but that's good. It's challenging, which I like," he says.

On top of his duties as a student, Kirch also works in Knezevic's Nanoelectronics Theory Group (NTG).

The NTG is involved with simulating and theoretically modeling electronic devices such as lasers, nanowires and transistors. In such devices, there is a flow of charge carriers known as electrons and "holes," which represent the absence of electrons. (Picture the bubbles in a glass of soda rising from the bottom to the top, with the liquid taking the place of the bubbles; the bubbles are the holes and the liquid is the electrons.)

In order to measure the effectiveness of electronic devices–that is, how efficiently the electronic devices switch from "on" to "off" ("on" being when the current is flowing and "off" being when the current is not flowing)–the charge carriers' ability to conduct current must be simulated. The simulation involves tracking the path of the charge carriers across an electronic device using an equation that the carriers obey, known as the Boltzmann equation. This of course involves extensive knowledge of math and physics, which is why Knezevic is so passionate about it.

Kirch has been working with Knezevic since the beginning of last summer. During this time, he has been working on setting up the Virtual Nanoelectronics Lab (VNL).

"The purpose of [the VNL] is so that either graduate students, or anyone else who is interested in the work that's done here, can come in and see what's being done," he says. "The project in itself might not be the interesting thing; it's more the content, what the programs are that [the people of this lab] make."

Though Kirch has a lot of freedom in what he does, occasionally he has to ask Knezevic if the site is going in the direction she was hoping for.

"Typically [Knezevic] is fairly busy. But when I go in, she always has time to at least talk about things. Whenever I stop by, I am able to sit and ask her questions and she will give me advice," he says.

A wife, a mother and a professor who always has time for her students? That certainly qualifies for "Supermom" status. we

Author bio: Victoria is a freshman at UW-Madison who intends to major in biomedical engineering. This is her third article for the *Wisconsin Engineer*.

Courtesy of Irena Knezevic

Knezevic spends time with her son, Nikola, at a park on the west side of Madison.

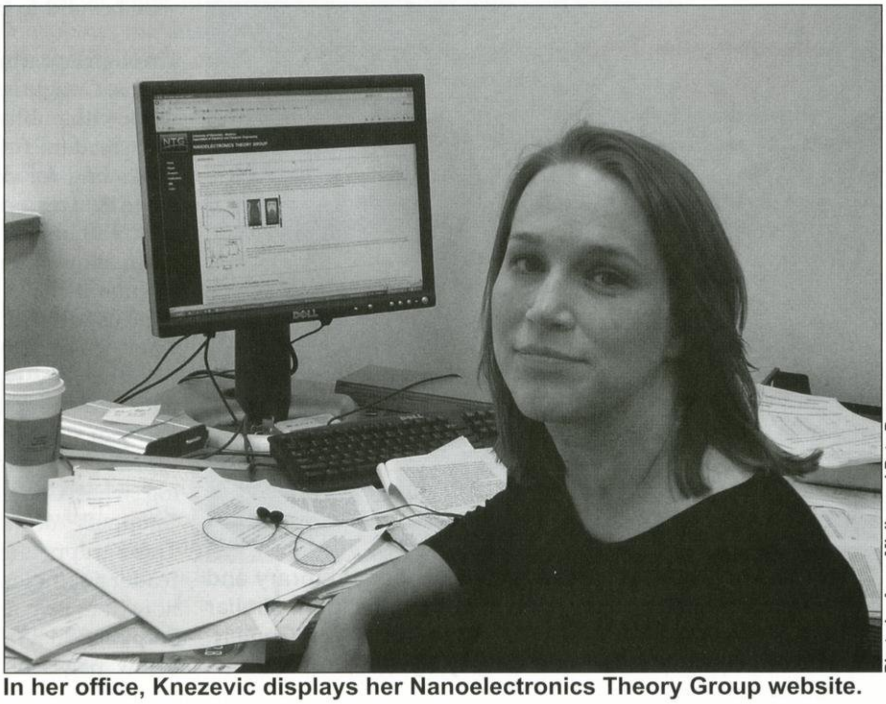


Photo by Anna Mielke and Pete Penegor

In her office, Knezevic displays her Nanoelectronics Theory Group website.

The world's library

at your fingertips

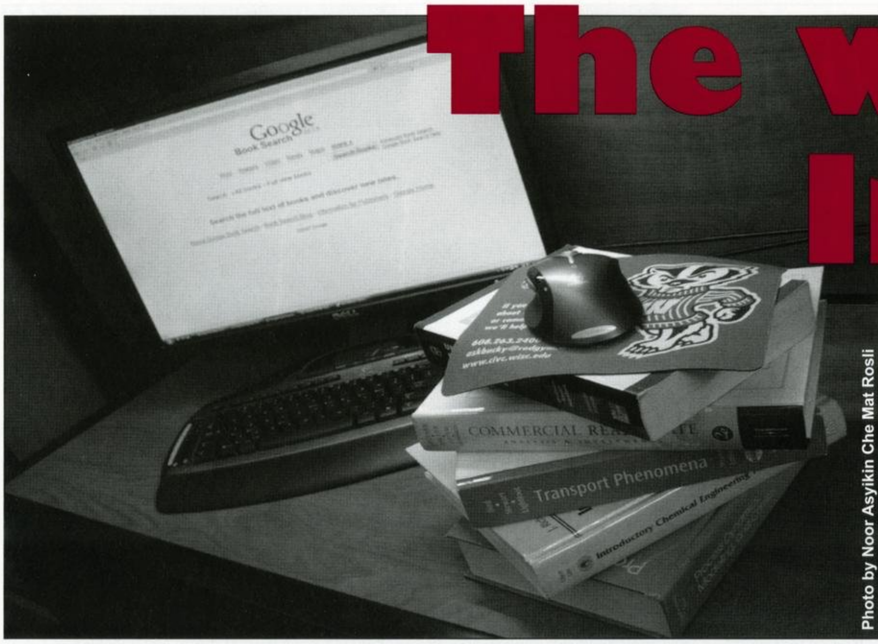


Photo by Noor Asyikin Che Mat Rosli

UW-Madison joins forces with Google to establish an online book database available to the public

By Elizabeth Grace

Gmail, Google Earth, Google Images, videos, maps, news, and just when you thought Google couldn't do anything more – Google Book Search. Starting in 2005, the project set out with the mission to make it easier for people to access materials that they may not find in other ways. It provides access to out-of-print books, books in all languages and other documents that can otherwise be hard to find.

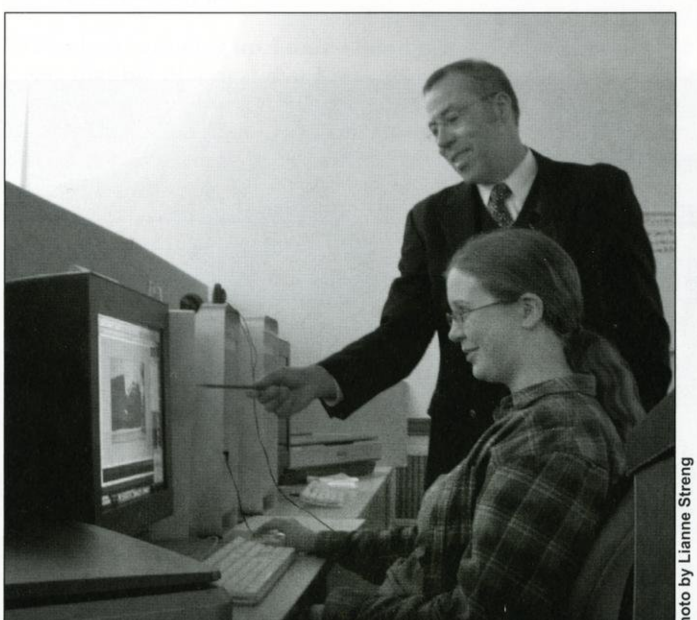


Photo by Lianne Streng

Kelly Giles, a graduate student in the School of Library and Information Studies, uses document digitization similar to that of the Google Library Project. Edward Van Gemert, interim director of the General Library System, looks on.

Through its partner programs, Google hopes to work with publishers to help readers find new books and for publishers to find and develop new authors. The program allows publishers to submit books under their copyright. If they want to contribute to the site, they can post their books for purchase on the Google Book Search site while offering what Google calls "snippets" of the book. These snippets give the reader a sample view of how the text appears. Snippets may include a few pages of a text, a few chapters or even the full document. Most significantly, this database is free to use and growing rapidly.

Contributing to this rapid growth are the partnerships Google is forming with universities across the nation. UW-Madison became the eighth such university to join the effort.

"Google's staff is very committed to the Google research project, and the [number] of resources put into it is astounding," Edward Van Gemert, Interim director of the UW-Madison General Library System, says.

Van Gemert, who has been working closely with Google on this project, says that the internet giant's dedication to their work is evident by the doubling of their work force each year; part of this is because of the Google Book Search project. Google staffers work to reposition and add value to content by preserving old documents provided to them by resources such as UW-Madison.

UW-Madison has one of the oldest regional depositories in the United States: the Wisconsin State Historical Society. The Society has documents dating back to 1789, including government and historical writings.

The Google Library Project is helping to preserve this public domain through digitization.

"This effort truly exemplifies the vision of the Wisconsin Idea–the notion that the boundaries of the university are limitless." - Edward Van Gemert

"The value the Google staff place on our content and the work we do is astounding," says Van Gemert. This includes documents primarily and most significantly involving the history of engineering (patents and discoveries), history of medicine and history of science. Documents from the areas of decorative arts and materials culture, as well as state genealogical information, come from fields unique to our university and will be digitized.

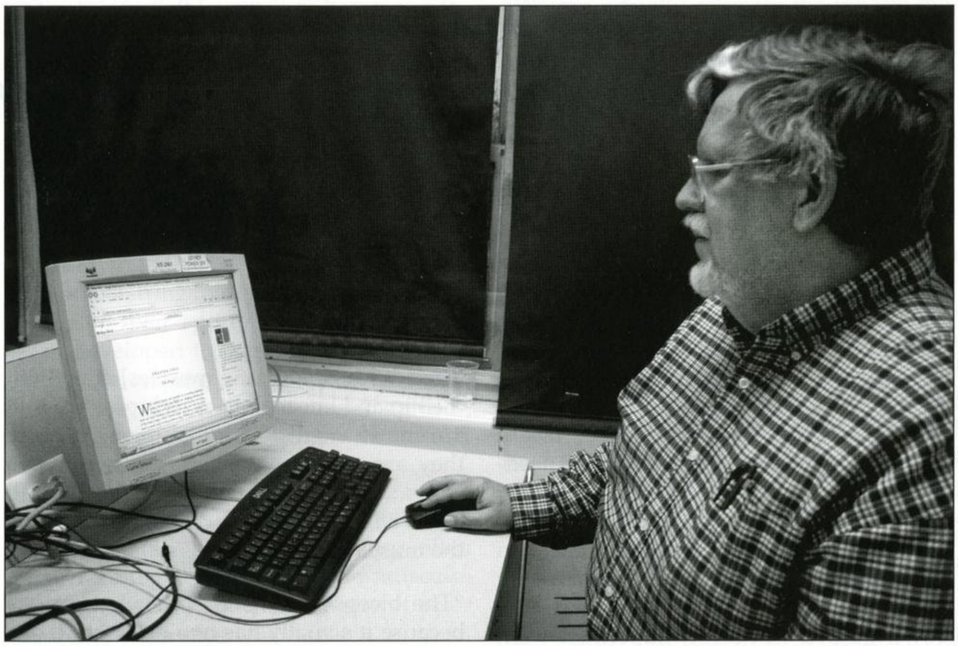


Photo by Noor Asyikin Che Mat Rosli

Paul Ross, director of the Technical Communication Certificate internship program, uses Google Book Search to easily access information about his favorite authors.

"This effort truly exemplifies the vision of the Wisconsin idea–the notion that the boundaries of the university are limitless," Van Gemert, says on the UW-Madison Libraries' website on the digitization project.

Despite the fact that no money changes hands, both sides will benefit greatly from this project. Google wants to develop an enormous database of knowledge and information through the use of ground-breaking technology, while UW-Madison wants to strengthen our university by taking part in a revolutionary process.

However, it's more than just these two sides that will benefit from this exchange of information. Paul Ross, director of the technical communications certificate internship program at UW-Madison, feels that all those involved in academia, specifically literary and historical studies, will receive the most benefit from the book search. Ross has used the Google Book Search to research anything from works by his favorite authors, to primary documents on the history of science.

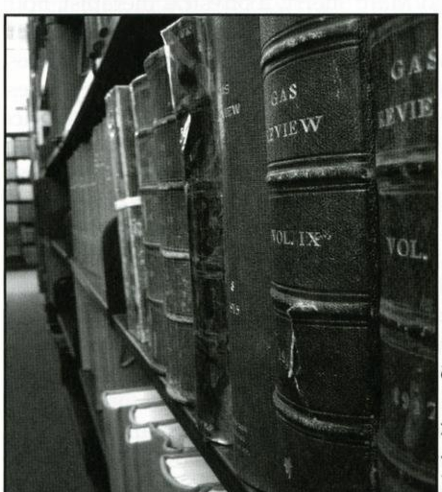


Photo by Lianne Streng

Shelves of books will become accessible at the touch of a button on Google Book Search.

"Up until about 1900, there is a lot of great information about the history of science. There is great stuff for the history of science and the history of ideas. For example, you could look at global warming based on past weather patterns available online," Ross says.

So tonight after you check your Gmail, locate satellite images of your backyard and read the most up-to-date news ticker, feel free to expand your knowledge. Out-of-print essays by your favorite authors or snippets of print from various editions of your textbook are now just a click away. WE

Author bio: Elizabeth Grace is a junior majoring in English and technical communications at UW-Madison.

Straining for answers:
Understanding hamstring injuries

By Marshall Stringfield

He looked almost like Superman. He wore flashy red sprinter's shoes and matching shorts over bright blue spandex. He was "faster than a speeding bullet" and many saw him as just a blur as he flew down the straightaways. Then one day it happened. He rounded the turn coming into the home stretch when a look of tremendous pain shot across his face. The crowd gasped in horror; Superman went down. Laying there clutching his leg, he howled in pain. What could have crippled this superhero so suddenly? As you might have guessed, it was a hamstring injury. But the real question is: what causes it?

The hamstring, in layman's terms, is the big muscle in the back of the leg. Muscle strains happen when the fibers tear at the junction of muscle and tendon. However, when compared to other muscles in the human body, the hamstring is unique.

"The hamstring consists of three muscles called the semitendinosus, the semimembranosus and the biceps femoris," Bryan Heiderscheit, assistant professor of orthopedics and rehabilitation, explains. "All three of [the hamstring muscles] cross both the hip and knee joints, which puts them at a somewhat greater risk of injury because they are really controlling motion at two joints… so motion at either one joint or both joints will influence the demands placed on the muscles."

"The biceps femoris is somewhat unique because it actually has two heads to it: one which spans both the hip and the knee and the other which spans just the knee," Heiderscheit says. He went on to explain that it is responsible for 70-80 percent of hamstring injuries, which could be a result of any of three mechanical factors.

"First, the biceps femoris has relatively short muscle fibers. Second, it has innervations from two different nerves. Third, the moment arm at the knee is different than the other two muscles," Heiderscheit says.

No one is precisely sure what causes the injury, but the UW Neuromuscular Biomechanics Lab is laced up and trying to figure it out.

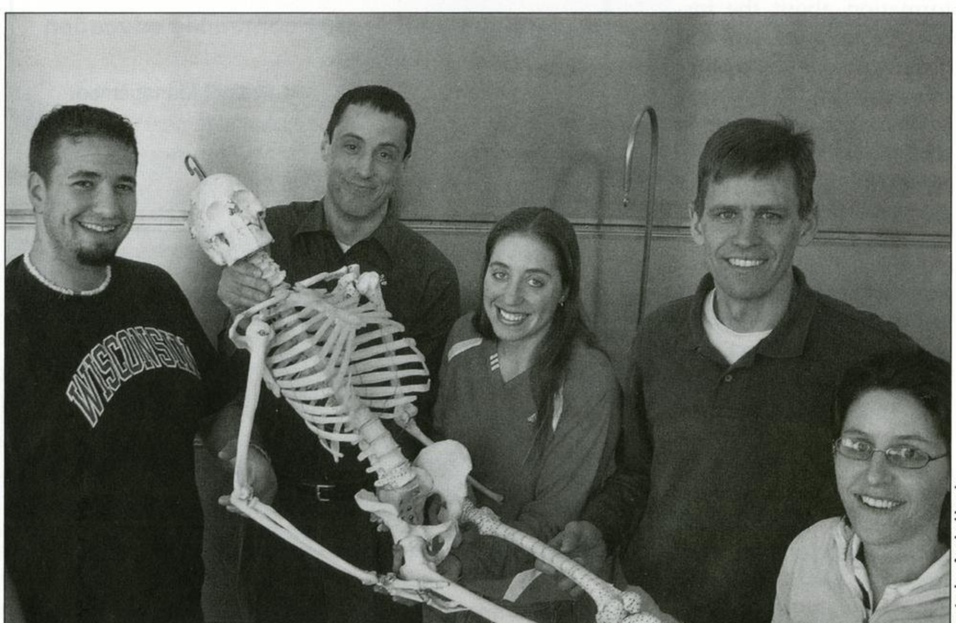


Photo by Andy Hardy

From left: Christopher Westphal, Bryan Heiderscheit, Amy Silder, Professor Darryl Thelen and Liz Chumanov are pictured above.

The UW Neuromuscular Biomechanics Lab joins the research forces of three lab groups from biomedical engineering, mechanical engineering and clinical rehab. Their mission: "Establish a scientific basis for the clinical treatment and prevention of impairments that limit locomotor performance."

"We can actually estimate the muscle mechanics while the individual is sprinting and assess when they're at risk for injury." - Darryl Thelen

The Lab has many different projects, but the reason for their research, besides sponsorship from NFL charities and The Aircast Foundation, could be answered by sports enthusiasts everywhere: hamstring injuries occur more often than any other sports related injury.

The Lab's research into the hamstring stemmed from a project that was originally conducted by Thomas Best, a physician, and Marc Sherry, a physical therapist, both at the UW Health Sports Medicine Center. In addition to the high frequency of cases, they were observing high re-injury rates, extended recovery times and persistence of "nagging" symptoms. Sherry developed what was, at the time, a novel rehab program.

To test the program, they brought in individuals who had recently injured their hamstrings. Half of the participants went through this unique new program while the others went through traditional rehab. Almost immediately, those in the modified program began performing hamstring exercises in order to promote remodeling of the muscle. At the same time individuals also worked to strengthen core muscles such as the abdomen and lower back.

The research study reduced re-injury rates to almost zero compared with nearly 50 percent from the traditional rehab program. This new program also showed evidence of reducing recovery time. The problem was they didn't know exactly what was happening at the muscle level or how they were getting such dramatic improvements. The next step, naturally, was to evaluate what differences were occurring in these individuals.

"When we started to look at was actually known about the hamstring, we ended up going way back to the beginning because we realized that there was hardly any objective evaluation of the mechanics of the hamstring," Heiderscheit says. So, the first project was to determine what the hamstrings do and how they function in high-speed running in healthy individuals.

However, studying the muscle's mechanics and length changes directly can be difficult. Engineers, to your marks…

"Fundamentally, a strain injury would mean there is excessive strain within the muscle," Darryl Thelen, UW-Madison associate professor of mechanical and biomedical engineering, explains. "[However], there is no direct way of measuring strain in biological tissue, so we have to look at indirect techniques of estimating what the strains are."

Get set…What better way to study a sprinting related hamstring injury, than with sprinters? At UW Health Sports Medicine Center, mechanical engineering PhD student Elizabeth Chumanov and biomedical engineering PhD student Amy Silder, place approximately 50 rubber markers with reflective tape on volunteer subjects. They then attach electrodes to the surface of shaved patches of the body to measure electrical activity within the muscles.

Go! Individuals then begin sprinting on a specialized treadmill that is capable of 30 mph with a 35 percent incline. A system of eight optical digital cameras records the markers' reflections. This monitors the individual's position in space, helping to determine the kinematics of the body.

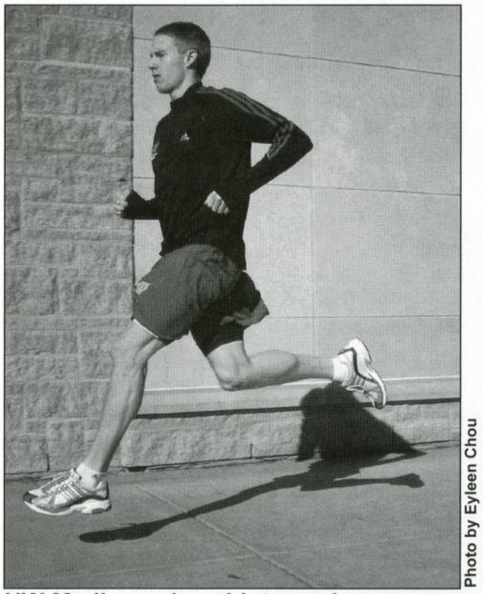
The Lab hasn't hit the tape yet, though. In addition to determining the cause of injury, researchers are working to understand the relatively high re-injury rate associated with hamstring injuries.

"An athlete who's endured at least one hamstring strain is likely to experience repeat injuries," Thelen says.

"One-third of all hamstrings become re-injured after returning to sport," Heiderscheit says. So what differentiates that re-injured third from the remaining two-thirds? That is apparently the trophy-winning question the lab is currently facing. But with all these questions, how exactly is research being accomplished?

By studying athletes who have previously had a hamstring injury and been cleared to return to their sport, other methods have been developed to learn more about hamstring remodeling and re-injury. With the help of magnetic resonance imaging (MRI), the lab can quantify the amount of residual scar tissue from the previous injury.

"We've learned that even individuals who are five or six months post-injury often have residual scar tissue at the musculotendon junction, which is the site of prior injury," Thelen says.



UW-Madison decathlete and computer engineering student Joe Detmer jogs outside the Shell.

Thelen is also applying new dynamic imaging techniques to this problem. This method requires an individual to use a device that loads, or applies stress to, the hamstring while in the MRI scanner. Encoding the motion of individual pixels, using phase contrast imaging, the lab can monitor and measure image pixel motion to calculate strains within the muscle.

By combining motion-capture data and studies of sprinting biomechanics with data about muscle fibers, tendon stiffness and muscle geometry from cadavers, and using some clever computational techniques, Thelen is able to develop a computer simulation of a person sprinting.

"We can actually estimate the muscle mechanics while the individual is sprinting and assess when they're at risk for injury," Thelen says.

Although simulations only create modeled estimates, they provide a wealth of information.

"If we capture the kinematics of the system and the muscle activity we can feed those as inputs into his model and make some more covert estimates of calculations on the specific fiber length changes, tendon length changes, whole muscle changes and even forces present within the muscle without having to directly measure," Heiderscheit says.

"It's been pretty well shown in animals and human tissue that when muscle is taken to a greater length it's at a greater risk of injury," Heiderscheit explains. "From that data we were able to determine regions in the gait cycle, [foot-to-foot contact of the same limb] when the hamstring is most likely to be at risk for injury."

Specifically, Heiderscheit and Thelen believe that athletes are most likely to injure a hamstring during the late-swing phase of the gait cycle–when your leg is out in front of you and the knee is extended.

"That's when the hamstring is loaded and stretched and seems to be most susceptible to injury," Thelen says.

Combining all the information they have learned, researchers are now developing ways to prevent initial injury, as well as rehab programs that will speed recovery, minimize residual scar tissue and reduce the probability of re-injury.

So if you wish you could get back into those sprinting shoes, then you're in luck.

"We're still looking for anyone who has strained their hamstring or anyone who can run fast," Silder says.

So although our superhero might not be able to finish the season, he can still save the day helping future athletes stay healthy. WE

Author Bio: Marshall Stringfield is a senior majoring in industrial and systems engineering with a certificate in technical communications. This is his third article for the *Wisconsin Engineer*.

BEARING DOWN ON BIOFOULING

UW-Madison team works to eliminate aquatic buildup

By Jaynie Sammons

From pirates to Navy seals, not even the most experienced of sea-goers has been able to permanently protect his ship from the buildup of pesky water-loving organisms, properly known as biological fouling. This costly problem, titled in shorthand as "biofouling", has troubled sailors and other sea-faring folk for as long as ships have sought to cross the depths of the ocean. A team at UW-Madison has taken on the task of finding an effective method of antifouling--a term used to describe the prevention of buildup.

Although the expression is used to describe any unwanted mass of aquatic micro- and macro-organisms on a surface, biofouling is most commonly used in reference to ships. Organisms such as bacteria, barnacles and seaweed are just a few of the undesirable creatures that can attach themselves to a ship's hull.

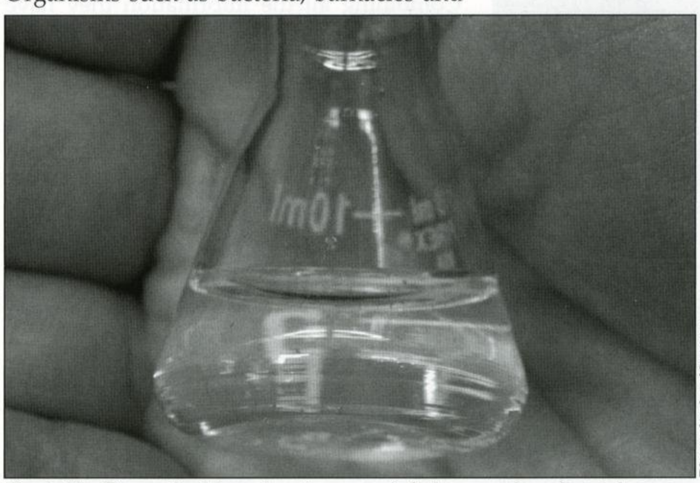


Photo by Ian Hanson

Rodolfo Perez holds a beaker containing undeveloped mussels that will be used in testing the prevention of biofouling.

Seeking any substrate (generally an artificial surface, such as a ship hull, pier, buoy or even an air conditioning pipe) that is in constant contact with water, the organisms cause problems when they start to form in masses. The mass eventually becomes large enough that it creates resistance as the ship passes through the water, resulting in decreased maneuverability and fuel efficiency.

Besides the negative economic effects, biofouling is also a nuisance to clean. The buildup is foul in smell, and keeping the ships free from organisms is not cheap; divers are constantly trying to maintain cleanliness.

Here in the Lake Michigan area, zebra mussels are of largest concern; they are an extremely invasive organism that dominates the food chain. They originate from the Caspian Sea region but have slowly made their way to the Great Lakes via trans-oceanic vessels. Zebra mussels have significantly decreased the population of the microscopic food supply, and their tissues accrue pollutants that are harmful to the environment. If not controlled, the zebra mussel 'plague' could spread to the New England area and cause even more problems for the fishing industry.

In the past, copper-based paints have been used on boats' hulls to successfully prevent biofouling, but studies have found it to be detrimental to the environment. Evidence of this includes female organisms growing male parts and other less than desirable side effects. Although the paint is not officially banned, its usage is highly frowned upon for obvious reasons.

Four years ago, Marc Anderson, professor of civil and environmental engineering at UW-Madison, decided it was time to explore new options. He toyed with a few ideas, drawing inspiration from various sources. He claims the self-cleaning lotus plant sparked his interest as a possible solution; however, not enough light reaches the boat's hull to make this option viable. He then considered a Teflon-like surface, but went back to brainstorming when he was unable to get the material to stick to the ship.

Finally, in September 2003, Anderson went to his colleagues Daniel Noguera, also a UW-Madison professor of civil and environmental engineering, and Dean Tompkins, UW-Madison associate scientist of environmental chemistry and technology, with what would become the ideal proposal: attaching electrodes to the ship's surface in order to 'zap' the biofouling organisms.

"I thought about, 'what if we could create very strong mini-electric fields as we had made our own nano films as electrodes,'" Anderson says. They would create a "moving field, always pulsing, to trick the organisms into detracting."

He contacted the Navy for funding, realizing that its ships would reap huge benefits if the proposal eventually became a reality. Then in January 2004, Rodolfo Perez was asked to join the development team. A graduate student in the department of civil and environmental engineering, Perez says working with Anderson, Noguera and Tompkins is like having "three bosses and one employee," since he conducts the biological testing and is guided by the three environmentalists.

To date, the testing has been steady and successful. The prototype electrodes are made of titanium and are placed very close together–only 8 to 100 microns apart. The voltage drop across each is huge, resulting in equally large field strength. The pulsing electrodes are controlled from an outside power source, where the voltage as well as the time on and off for each electrode is monitored.

"When I started to do some literature searches on this idea, I noticed that other folks had the idea of huge fields but with large, continuous voltages. That idea had been done, but what about small, discontinuous voltages with the electrodes close together to give a large field? Voila! Pulsed electric fields," Anderson says about his thought process.

The electrode prototype was first designed by a team at Penn State University, but the UW-Madison researchers have been working to make improvements. The electrodes that are currently being used are called Interdigitated Electrodes (IDE). The series of parallel strips form a structure similar in appearance to two combs with their prongs facing each other, and with each of the combs wired to an electrical source.

Although idyllic, placing the electrodes all along the entire ship's hull is not an option because it would be far too expensive and may not be necessary. Instead the ultimate plan is to place groups of platelets along the hull and test different patterns for effectiveness. The team has been studying what field conditions are best for coding, or as Perez puts it, "We are designing the best geometry for keeping antifouling conditions. There is no general configuration."

But Perez adds that for right now, "We're not thinking to put these things straight onto a ship, since cost issues would make it completely unfeasible. Rather, we're working on developing plates with similar features, but easier to scale up. These electrodes are used to prove the concept; their straightforward applications are more related with smaller devices such as sensors."

Photo by Ian Hanson

Perez prepares a slide for experimentation in the Water Science and Engineering Laboratory.

The team started their work by looking at what happens when surfaces are stationary and have been comparing different fields. The Navy has taken an active interest in this topic, and is funding 40 different research groups. Research is presented to the organization at annual meetings. The UW-Madison team soon hopes to work with different organisms outside of barnacles, and have been invited to submit a proposal to combat basic organisms.

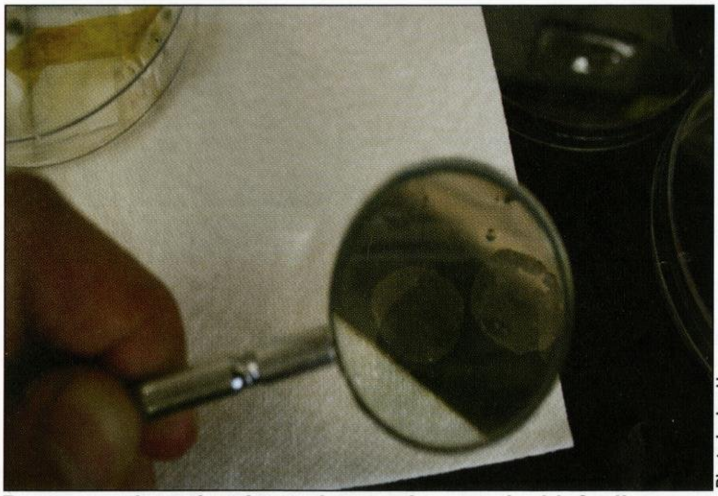


Photo by Ian Hanson

Perez examines the electrodes used to zap the biofouling organisms.

The UW-Madison team, led by Perez, has made exemplary progress since their original proposal. The long-term benefits from this antifouling technique could result in extreme cost reductions for not only aquatic transportation, but for any surface in constant contact with water.

Through the collaboration with other universities doing similar testing, the use of electrodes for antifouling purposes is more than a mere possibility. With national environmental concern skyrocketing, there is little doubt that support for this project will increase. For now, Perez and his team will continue conducting research and testing. Perhaps someday, Perez will be able to add "biological fouling eliminator" to his already impressive resume. WE

Author bio: Jaynie Sammons is a junior in industrial and systems engineering and is also working towards a certificate in technical communications. This is her first semester writing for the *Wisconsin Engineer*.

wisconsin engineer

Cross-Campus Photo Contest

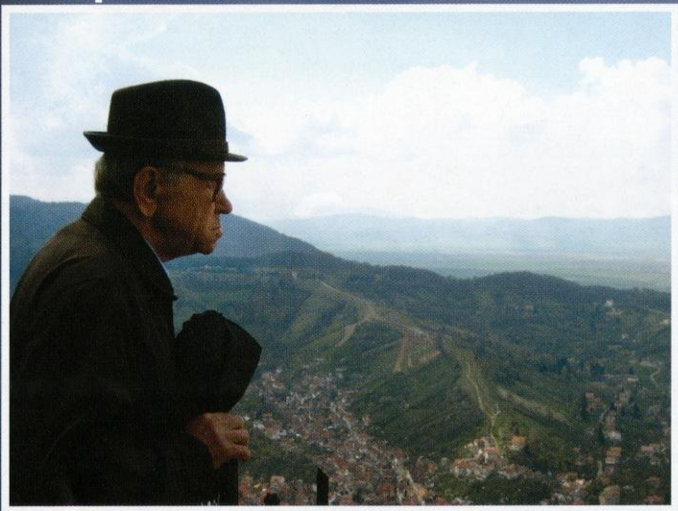
Grand Prize Winner

Looking Through by John R. Brossman

A digital image taken using the afocal photography technique with a Schmidt-Cassegrain telescope.

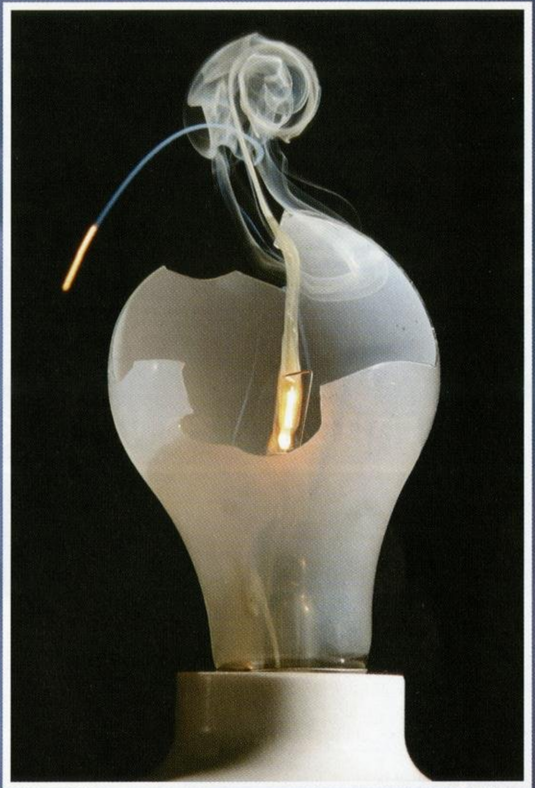
Category winners

People



Transylvanian Trance by Talia Esser

Random



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Reactor reduction

Miniaturizing nuclear micro-batteries

By Ryan Denissen

What if it were possible to build robot sensors the size of ants, or millions of tiny satellites that spread like space dust and communicate with each other as well as larger satellites? The technology to build these miniature machines and sensors already exists but the obstacle preventing these tiny devices from becoming reality is that no one has been able to develop an adequate microscopic power source.

James Blanchard, UW-Madison professor of engineering physics, has found a way to jump this final hurtle through the use of nuclear micro-batteries. These batteries "take energy from decaying isotopes and convert that to electrical energy," Blanchard says.

Isotopes can release energy in the form of alpha particles, beta particles or gamma rays. Alpha particles occur when the isotope ejects two protons with two neutrons or "essentially a helium nucleus," says Blanchard. Beta particles are simply free electrons that are released from the isotope's nucleus. Gamma rays are not particles but rather electromagnetic radiation similar to X-rays. Nuclear batteries can be designed to produce energy from either alpha particles or beta particles.

Blanchard and his team have recently focused on batteries that use the energy from alpha particles. When these particles are released, they lodge within a nearby material converting their energy to heat. This heat is then converted to electricity in much the same way that a thermocouple converts heat to voltage in digital thermometers.

Other miniature technologies could be used to generate power such as fuel cells or chemical batteries. "The main reason [nuclear batteries] are used is their long life," Blanchard says, as evidenced by their 25-year lifetime in NASA space probes.

Only one thing was keeping the researchers from creating applicable thermoelectric nuclear micro-batteries: they required micro-insulation.

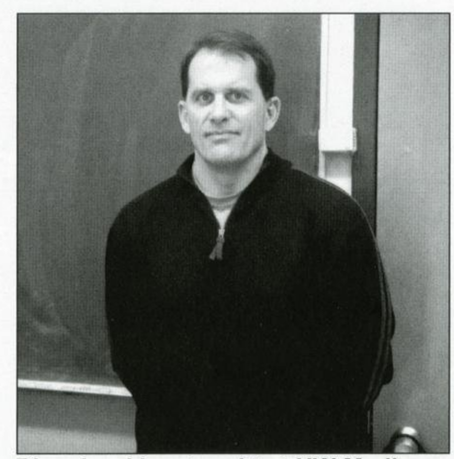


Photo by Ross Kaplan

Blanchard has taught at UW-Madison since 1988 and received a UW distinguished teaching award in 2002.

"Thermoelectrics are more efficient the hotter they run…insulation becomes more important at small scales," Blanchard says. This is because the surface area to volume ratio is very high, causing rapid heat loss. The challenge is developing insulation for batteries smaller than the letters on this page.

Blanchard and his team have invented a new type of insulation that has broken through this barrier. This insulation uses tiny pillars made of a polymer called SU-8 to connect thin sheets of silicon. The empty space between the silicon sheets is evacuated making conduction only possible through the pillars. SU-8 is a poor heat conductor, and coupled with the pillars' relatively small cross-sectional area, the result is very little heat loss through conduction. This high resistance to conduction forces heat to slowly radiate from one silicon sheet to the next; thus improving insulation properties significantly.

Rui Yao, a graduate student working with Blanchard, constructs this new insulation through lithography. First, a layer of specially formulated, epoxy based SU-8 is spread over the silicon substrate. The consistency of this type of SU-8 "is like honey," Rui says. After evenly spreading a film of SU-8, the sample is baked for five minutes to increase the film's density. Next, a stencil that exposes only the desired pillar locations is placed on top of the SU-8 layer, and the sample is exposed to ultraviolet light. The unexposed SU-8 is then wiped off while the areas exposed to the light have hardened and remain. The SU-8 pillars that give this insulation its unique properties have now been formed. Lastly, another silicon substrate is placed on top, and the sample is cooked to bond the two substrates and complete the insulation.

Blanchard's team of researchers has verified the effectiveness of this insulation with computer models as well as experimen-

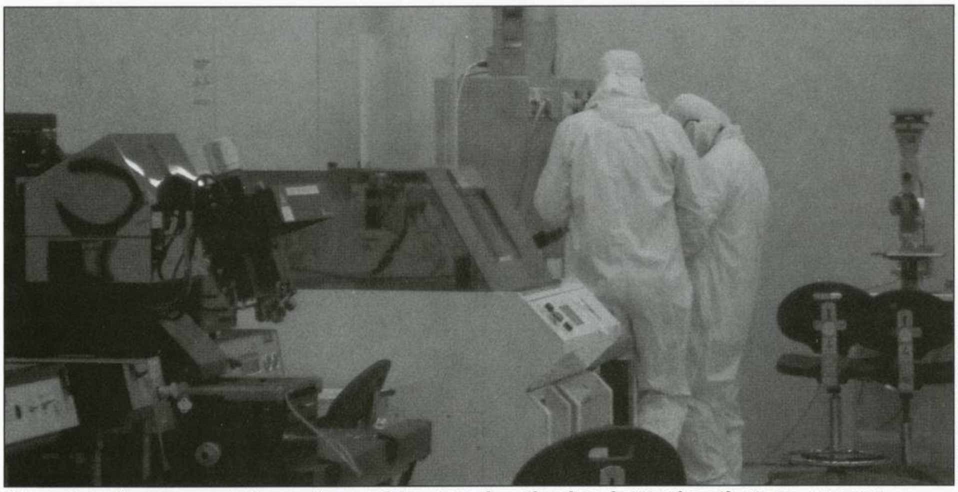


Photo by Ross Kaplan

Blanchard's research team is working on developing batteries that can power Micro-Electro-Mechanical Systems (MEMS). These systems can be used to harness the power of the microprocessor and perception of the microsensor.

tally with prototypes. These prototypes have been made as thin as 50 micrometers, "we would like to get to 20 micrometers," Blanchard says.

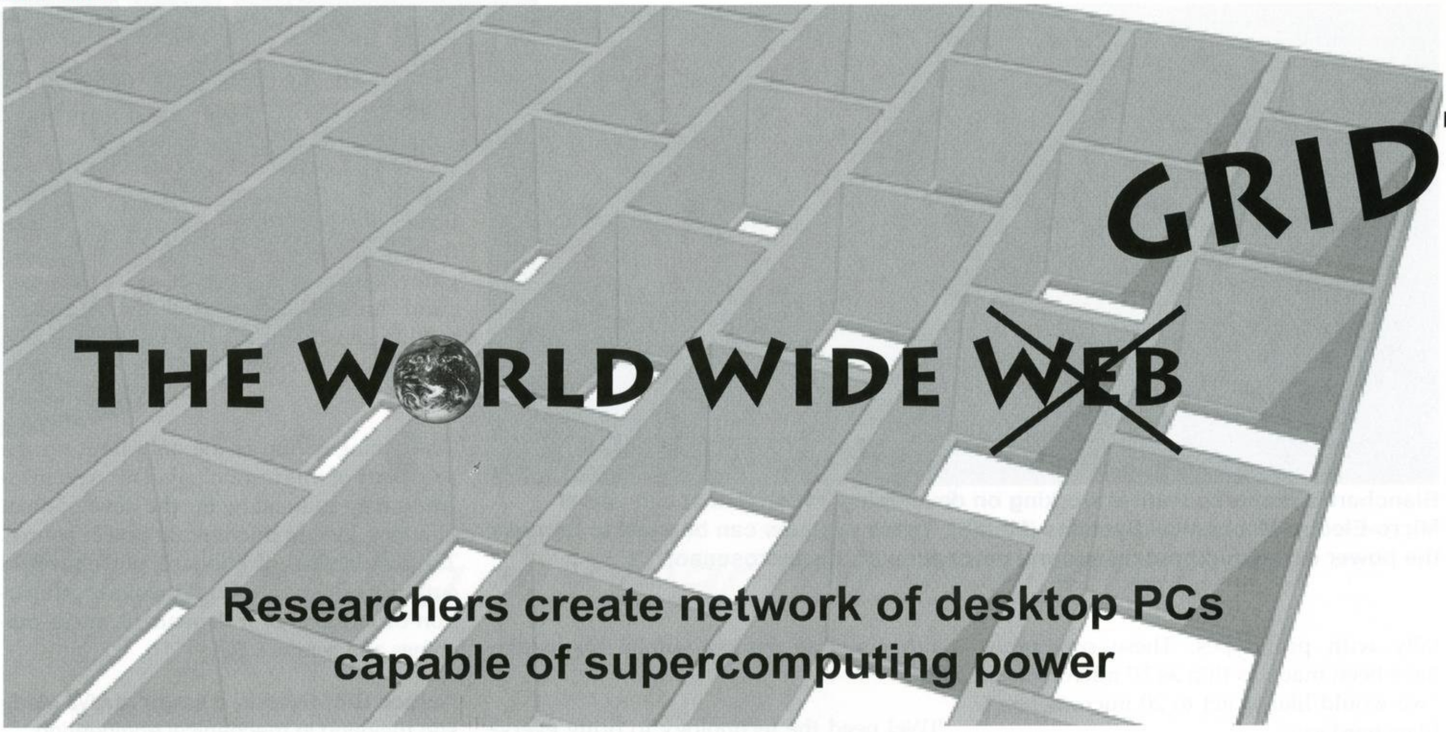
Though the future looks optimistic, challenges remain. The researchers must develop an effective way to package the batteries and miniature devices within this insulation.

"[We] need the technology to bring everything together," Yao says. Once a method is developed, these micro-batteries will provide long lasting power on a microscopic scale.

Potential applications of nuclear micro-batteries are endless. The most exciting prospect of this technology would be the batteries' ability to power integrated micro-machines and sensors. For example, diabetes patients could have devices implanted that sense diabetic shock and immediately inject a dose of insulin to quickly reduce their blood sugar. Military intelligence gathering capabilities could also greatly expand through the use of miniature robotic motion sensors and listening devices that are capable of changing locations on their own.

One's imagination is the only limit on the prospects of this technology. This new insulation may soon allow for the development of a long lasting micro-scale power source. The availability of onboard power would cut the leash holding back the mass production of millions of independent micro-machines and sensors. WE

Author Bio: Ryan is a senior at UW-Madison majoring in mechanical engineering.



The World Wide ~~Web~~ Grid?

Researchers create network of desktop PCs capable of supercomputing power

By Adam Anders

Imagine nearly 200 years of data processing done in just a year and a half. Now imagine this being done at over 50 sites across the country and the world.

The Open Science Grid (OSG) does just that, putting the power of thousands of computers to work on everything from microbiology to astronomy. The Grid is composed of 50 independent sites for a total of about 20,000 CPUs in the U.S., South America and Asia. Each site has desktop or rack-mount computers linked together with specially designed software that allows large computational tasks to be distributed across available computers. UW-Madison has about 1,500 computers on the Grid, half of which are desktop workstations.

"The computers that we use aren't really that different than desktop computers," Dr. Alain Roy, software coordinator for OSG and UW-Madison associate computer science researcher, says.

Universities, research groups and national laboratories who want to use the OSG resources must become members of the OSG virtual organization and be approved by the board of directors. Users are then able to upload data or programs to specific OSG facilities for processing. The sites operate independently, allowing each to divide its total computing power between its users. In general, sites join the OSG because they are willing to share their computing power when they are not busy in exchange for the same services when they are.

A unique aspect of the OSG is that, although the Department of Energy and the National Science Foundation have provided $30 million for expansion, there is no money set aside to buy new computers. The money is used to connect preexisting standard computers–not servers or supercomputers like some other networks. Dr. Roy says that the Grid does not require special computers, but works by "sharing community hardware."

The idea of grid computing has been around since the 1970s and has been increasing in popularity ever since. UW-Madison has its own smaller grid known as GLOW, the Grid Laboratory of Wisconsin, which is utilized for a variety of fields including high energy physics and genomics.

"It looks like Open Science Grid in miniature," Roy says. The idea of sharing computing resources allows groups to save money by using other computers during times of peak processing needs, while sharing their computers during slow times. OSG is similar to projects like SETI and Einstein@Home, where home users can add

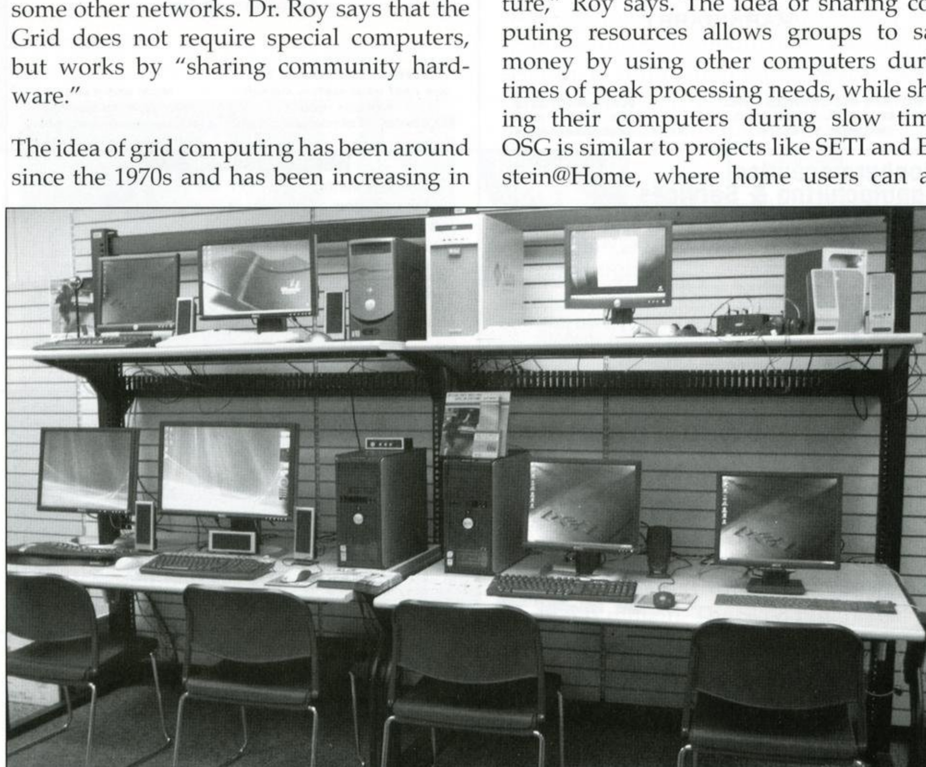


Photo by Jamil Farah Hanaa

Standard workstations across campus link together to create UW-Madison's computing grid, one of 50 similar sites that form the Open Science Grid.

their own computing power to the network. However, unlike the other two, OSG is not limited to running one specific program; it can run anything that a user uploads.

The benefits of a potentially limitless network do not come without a certain amount of risk. Since the uploaded programs and data are run through other computers, there are more entry points for computer hackers. This discourages some companies, such as those producing pharmaceuticals, from joining the network for fear of having proprietary information stolen. Although most researchers at universities and labs are wary of potential leaks, the odds of this happening remain small and do not deter most users.

The OSG provides many groups at the university with a valuable computing asset. The high energy physics department uses the grid to process data from the Compact Muon Solenoid, which will be used to investigate unproven theories of modern physics.

"Wisconsin OSG computers have provided 1.7 million CPU hours, mostly for CMS," Dan Bradley, senior systems programmer for high energy physics, says. In the last year and a half, the OSG has allowed many groups from all over the world to analyze this data efficiently.

Imagine nearly 200 years of data processing done in just a year and a half. Now imagine this being done at over 50 sites across the country and the world.

Grid computing provides an efficient and cost-effective way for scientists and researchers to process the large amounts of data that modern experiments require.

UW-Madison has long been a leader in grid computing and looks to continue by devoting $1.2 million a year toward the expansion and improvement of the OSG.

"Our goal is to expand the number of sites and users, and I think we'll have no problem doing that," Roy says. WE

Author Bio: Adam Anders is a sophomore majoring in electrical engineering and physics.

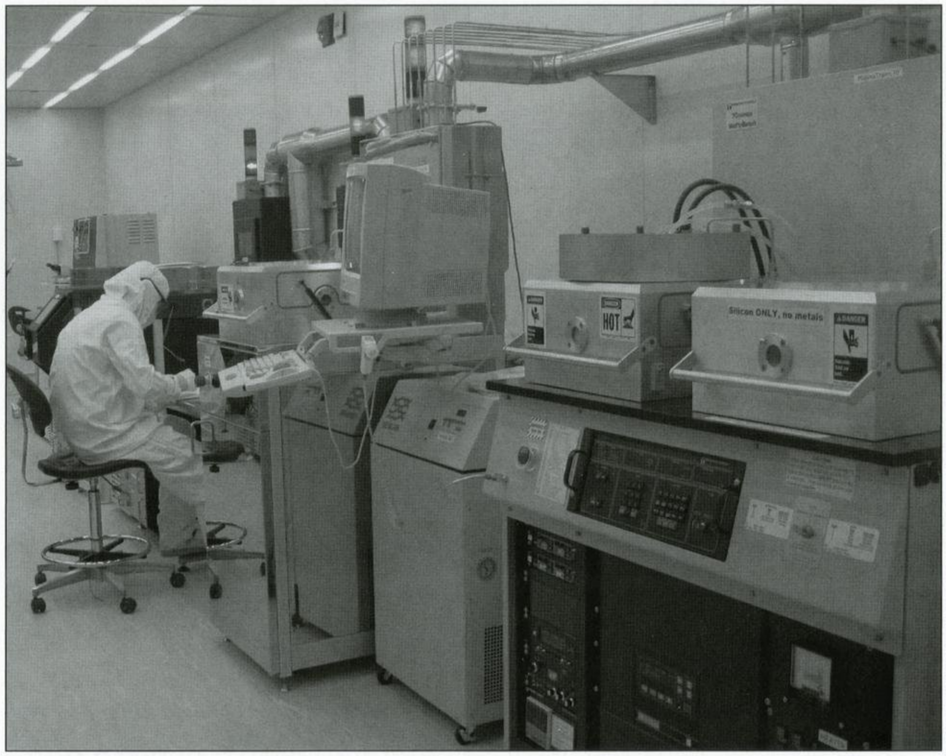


Photo by Nurhuda Adam

The Open Science Grid allows researchers like Chi-Chun Liu, a UW-Madison graduate student, to process vast amounts of data more efficiently.

Crazy for consumer tech

A look inside the 2007 show

By Matt Treske

Imagine the feeling experienced walking into a local Best Buy, Circuit City or similar large-scale retail electronics vendor. Upon entrance you are greeted with an ever-present aura of fascination inflicted by high ceilings lined with brilliant fluorescent lights, aisle upon aisle of beeping, blinking and dazzling electronics and a sense of chaos among the vast number of employees and customers grazing throughout the main show floor.

If you were to take this feeling and multiply it by the number of seconds in a day you will have just barely scratched the surface of the thrill that greeted visitors of the 2007 International Consumer Electronics Show in Las Vegas, Nevada.

The International Consumer Electronics Show (CES) is the largest consumer electronics show on the planet. An annual event that takes place every year in January, this year's show spanned three buildings in Las Vegas from January 8 to the 11: The Las Vegas Convention Center, Sands Expo and Convention Center/The Venetian and the Las Vegas Hilton. The 2007 CES was the biggest show to date.

According to press releases following the cessation of the 2007 show, over 140,000 attendees were welcomed to an electronic extravaganza boasting 1.8 million square feet of exhibit space. Contributing to consistency of this enthralling event were the 2,700 consumer electronic vendors who showed up to flaunt their latest and greatest achievements and breakthroughs in product lines for the upcoming year.

The most buzzed about item on the floor, and perhaps even the entire show, was LG's BH100 home media player capable of playing both HD-DVD and Blu-Ray discs.

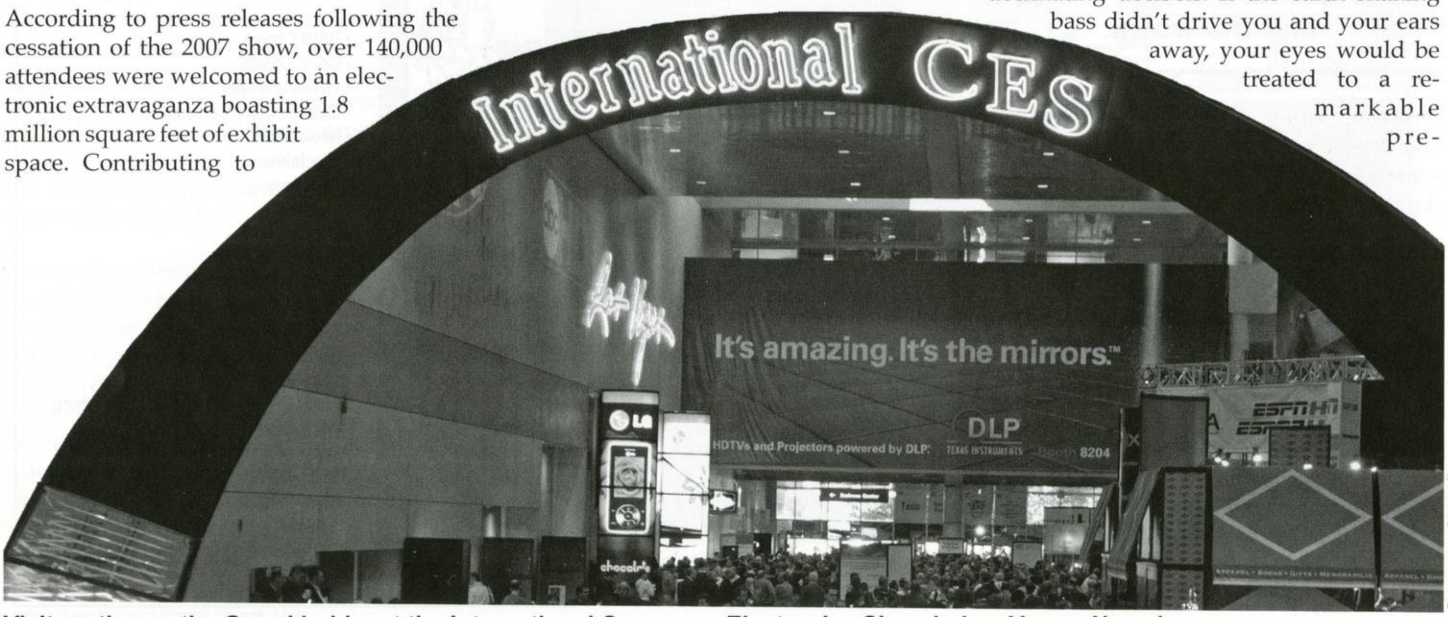
The meat and potatoes of the 2007 CES was found in the Las Vegas Convention Center (LVCC). Nearly all of the 2,700 exhibits could be found within its several halls and lobbies. This is where the action was to be found. If time were of no issue, visitors were also able to visit a handful of emerging technology exhibits at the Sands Expo and Convention Center or check out the International Gateway at the Hilton.

Upon entrance to the 2007 CES visitors would find it wise to begin their journey by getting a glimpse of what the future will hold for the consumer electronic industry by entering the Grand Lobby. The Grand Lobby is a tech enthusiast's vision into the world of the trade organization that hosts the Consumer Electronics Show, the Consumer Electronics Association (CEA).

Although the lobby was littered with smaller kiosks, visitors would find it hard to miss the impressive "Best of Innovations" display or the ESPN/CEA Grand Lobby Stage.

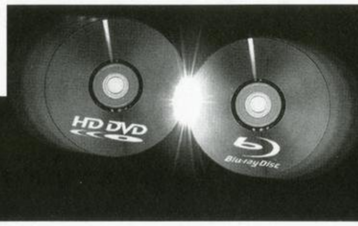
Taking a left out of the Grand Lobby, visitors found themselves either welcomed or scared away by one of the LVCC's most peculiar wings. The North Hall was the focal point for automotive advancements in mobile technology. Depending on the demographic of the visitor, the North Hall may have been a make or break segment of the 2007 CES.

A younger and progressive audience was immediately treated to an extravagant presentation of incredibly powerful, window-decimating decibels. If the earth shaking bass didn't drive you and your ears away, your eyes would be treated to a remarkable pre-



Courtesy of http://www.cesweb.org

Visitors throng the Grand Lobby at the International Consumer Electronics Show in Las Vegas, Nevada.



Courtesy of http://blog.scifi.com

Two new media formats, HD-DVD and Blu-Ray, are battling for consumer approval.

sentation of various mobile automotive gadgets including speakers, global positioning systems and LCDs.

Retreating back through the Grand Lobby and into the enormous Central Hall, sights of astonishingly sleek photographic tools, impossibly large televisions and increasingly sexy media centers accompany the mesmerizing reverberation of the crispest audio equipment on the planet. It was the Central Hall that was home to both the inspirational demonstration of seemingly infinite television size and high definition resolutions and was also the key battle ground for the next generation media format conflict between HD-DVD and Blu-Ray (see "Discs of the Future," Feb. 2005). Perhaps the most impressive of displays in the Central Hall was not Westinghouse's Quad Full high-definition display running a resolution of 3840x2160 or even Sharp's 108" LCD television which eclipsed the previous maximum size of large plasma and LCD displays. No, the most buzzed about item on the floor, and perhaps even the entire show, was LG's BH100 home media player capable of playing both HD-DVD and Blu-Ray discs.

Continuing on their journey through the LVCC, enthusiasts would stumble into the southern end of the building, which was made up of South Halls 1 and 2. The ground floor was the home of numerous exhibits in the departments of home theatre, satellite and data networking. Although interest in the products and innovations located on the ground level was obvious by the intrigue of visitors on the floor, it would be impossible not to notice the grins and overhear the conversations of the impressed visitors coming down from upstairs.

South Halls 3 and 4, the upper level of the South Hall, were the main grounds of the computer hardware, home networking and electronic gaming exhibits. It was on this floor that interaction between visitors and new technology was most prevalent. To the swiftly expanding group of tech enthusiasts who declare themselves "PC Modders," this was the place to be. It was in the

A younger and progressive audience was immediately treated to an extravagant presentation of incredibly powerful, window-decimating decibels.

South Hall that all of the major computer component companies were teasing everybody with their upcoming line of products for the 2007 year. From bizarre computer cases and water cooling kits to never before seen system memory timings and processing power that is out of this world, it would be impossible not to crack a grin in the South Hall.

One of the newest technologies that has gamers drooling on their keyboards is Crytek's upcoming computer game Crysis. Crysis will be one of the first games to truly utilize the power of DirectX10 technology found in Microsoft's new operating system, Vista.

With a location in one of the world's most intriguing cities and an unprecedented amount of revolutionary exhibits that would humble even the largest of trade shows, the 2007 CES celebrated its 40th anniversary in record-breaking fashion. The thousands of products that made their debut at the show will no doubt soon be making their way into our living rooms and pockets. WE

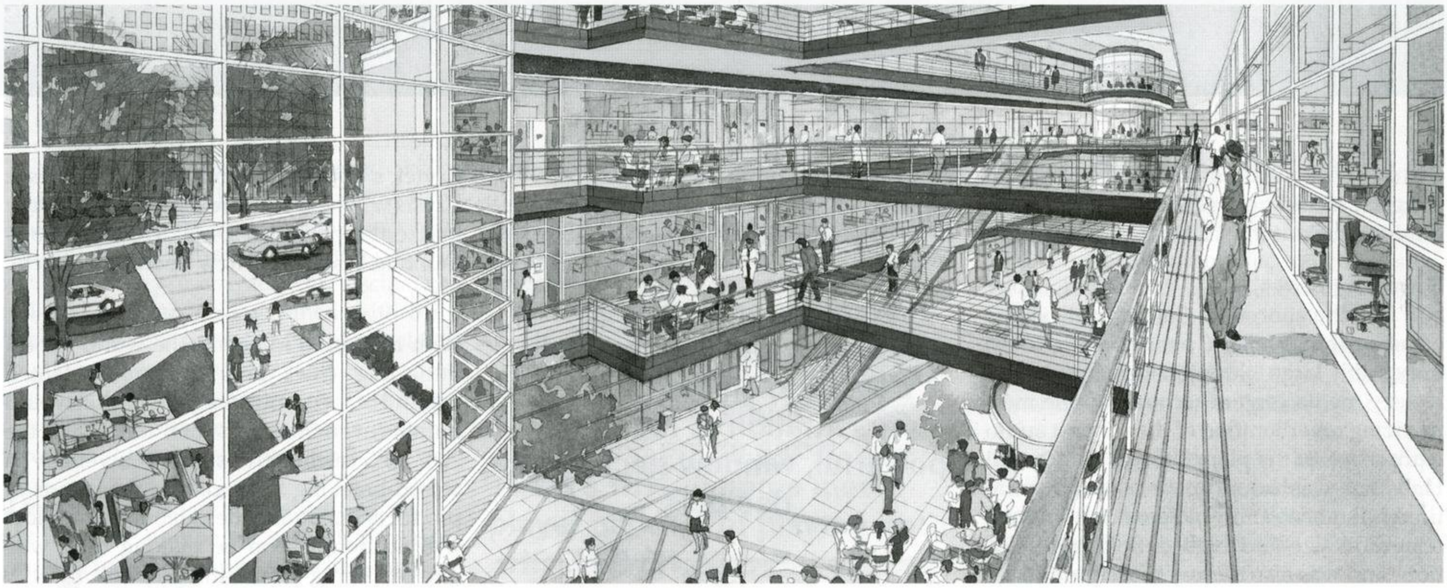
Author Bio: Matt Treske is a freshman engineering student in his second semester with the *Wisconsin Engineer*.

Photo by Franz Stadtmueller

What student wouldn't want to take home a 55" plasma HDTV from Hitachi? The TV was on display at the 2007 Consumer Electronics Show.

Double the discovery

Dual research centers planned for campus


Courtesy of http://discovery.wisc.edu

By Natalie Forster and Lynn Singletary

Everyone knows Wisconsin for its dairy farms and breweries, but does everyone know that a new brewery–of sorts–will be built right here in the heart of the UW-Madison campus? Sorry beer lovers, it's not a beer brewery. It's an idea brewery.

The Wisconsin Institutes for Discovery (WID), UW-Madison's newest hub for interdisciplinary research, will be built on the university block surrounded by University and Randall Avenue, as well as West Johnson and Charter Street. Construction is slated to begin in 2008. When completed in 2010, the new kid on the block will become UW-Madison's central research facility designed to promote collaboration, information sharing and the generation–or brewing–of new ideas in the biomedical field.

The WID was made possible by a $50 million donation from UW-Madison alumni John and Tashia Morgridge–the largest individual donation in the history of the school. The Wisconsin Alumni Research Foundation (WARF) and the state of Wisconsin both matched this donation. This $150 million undertaking will only be the beginning of possibilities for UW-Madison researchers.

The facility will house not one, but two institutes for discovery: the public Wisconsin Institute for Discovery and the private Morgridge Institute for Research. Although they will be separately funded, researchers from both institutes will have the opportunity to talk about their work and share ideas over a cup of coffee, as well as attend seminars together.

"There will be a lot of common interest. They will be working together in terms of thinking together," Marsha Seltzer, interim director of the Wisconsin Institute for Discovery, says.

An atrium, designed with socialization in mind, will connect the two buildings and serve as a communal place for collaboration, not only between public and private, but also between disciplines. This interdisciplinary collaboration is one of the central themes of the WID.

Part of the design includes the location of the building itself, which is critical to making this facility a nucleus of collaborative research. Its proximity to the engineering, chemistry, biochemistry, computer science and biotechnology buildings means that researchers, faculty and students alike will have convenient access to the new facility.

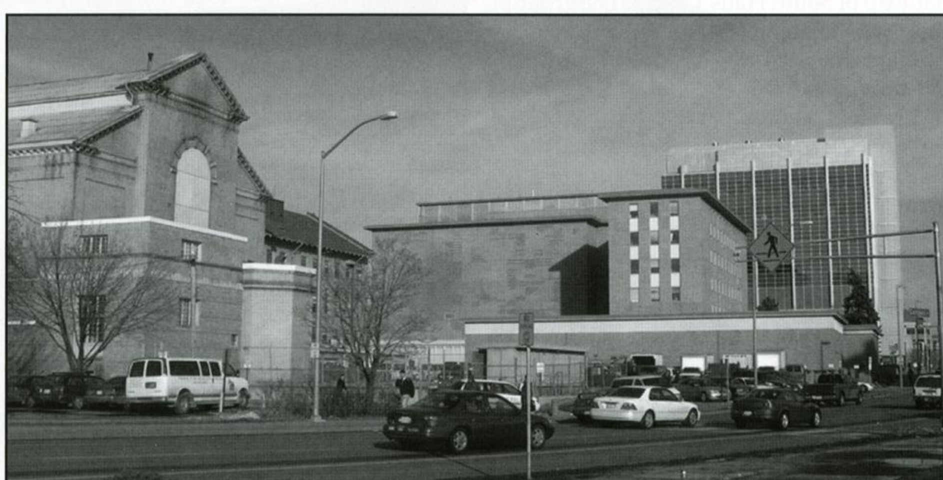
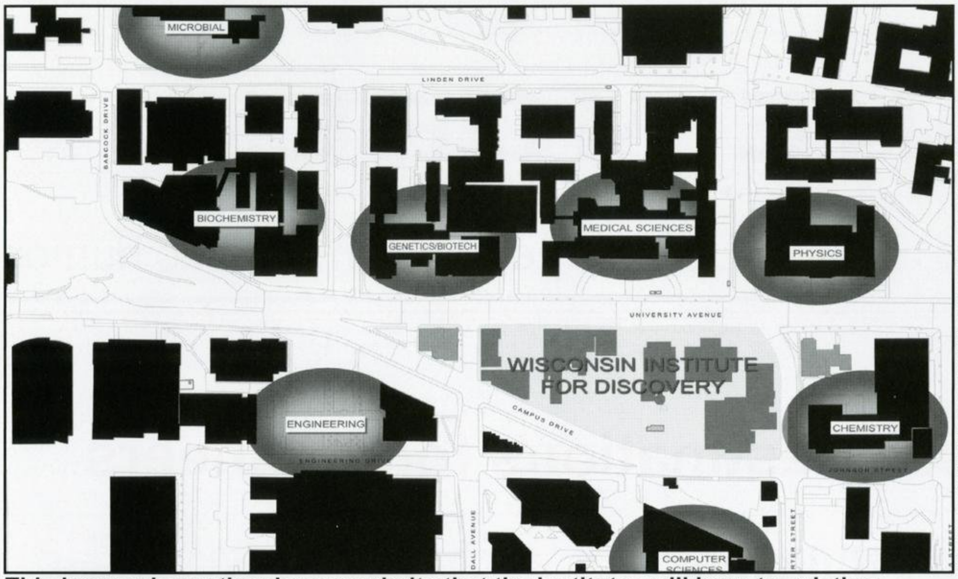


Photo by Muhamad Asyraf Yahaya & Azyyati Ahmad Hamizan

This view, from Union South, depicts part of the 1300 block of University Avenue that will be demolished to build the Wisconsin Institutes for Discovery.



Courtesy of UW-Madison Facilities, Planning and Management

This image shows the close proximity that the institutes will have to existing scientific facilities on the UW-Madison campus.

"It will be research that involves nanotechnology, biotechnology and information technology for the purpose of making discoveries that enhance human health and welfare," Seltzer says.

Eight research proposals in alignment with this goal have already been approved by the WID. Research topics include the early detection of disease, treatments for hyperactivity in children and the healing of chronic wounds. In a highly competitive process, a committee headed by Paul Peercy, dean of the College of Engineering, sifted through over 220 letters of intent from interdisciplinary research teams seeking funding from the WID. After surviving multiple rounds of competition and the scrutiny of several judging committees, eight final research ventures were chosen to receive Discovery Seed Grants. However, these are not necessarily the same research teams that will be housed in the WID building. In fact, not all WID research will be conducted in the new facility.

"The Wisconsin Institutes for Discovery will extend across campus. It's like a hub and spokes," Dean Peercy explains. "Research will be done where it makes sense."

In addition to reaching out across campus, the WID also intends to connect to the community by being highly involved in the education of current and future UW-Madison students. The institutes will encourage scientific education for the community through events, lectures and hands-on learning opportunities for K-12 students from around Wisconsin. Current UW-Madison students will also have the opportunity to attend seminars and lectures and assist with research, although no timetable classes will be held in the center.

Students in the College of Engineering can look forward to the possibility of many engineering-related research opportunities that build on concepts from other disciplines. According to Dean Peercy, engineering has always been built around the physical sciences. Some examples of engineering-related fields that are likely to be explored in conjunction with researchers from other departments are biomedical engineering, healthcare, energy supply and environmental sustainability.

The Wisconsin Institutes for Discovery promise to be a breeding ground for new ideas and a crossroads between disciplines all over campus.

"This is an exciting opportunity for the campus and the College of Engineering," says Dean Peercy.

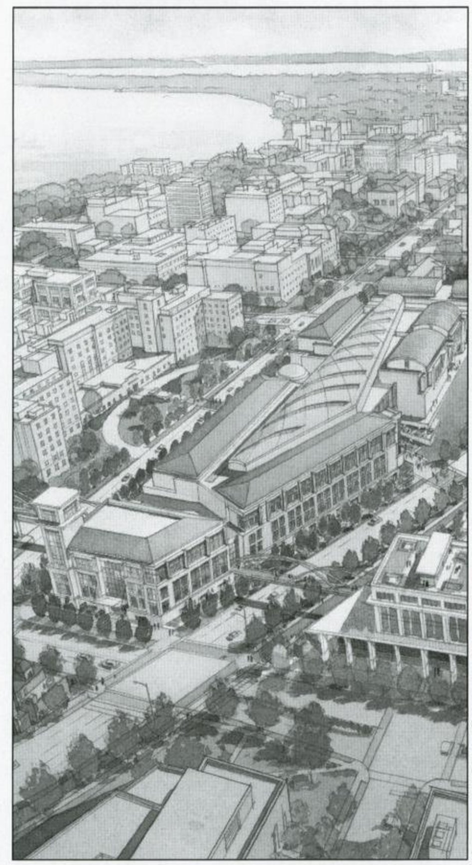
The Wisconsin Institutes for Discovery promise to be a breeding ground for new ideas and a crossroads between disciplines all over campus.

"We've got a great campus, so the idea is to bring the best and the brightest together and mix them up and see what they can do," Carl Gulbrandsen, chairman of the Morgridge Institute for Research Board and managing director of WARF, says.

At a university already well known for its prestigious researchers and award-winning discoveries, a new and improved interdisciplinary research center is a welcome addition. There is no end to the ways in which the Wisconsin Institutes for Discovery could improve the lives of people everywhere, proving to the nation that Wisconsin has more to offer than just dairy products and beer. WE

Author bios: Natalie Forster is a fifth year senior majoring in mechanical engineering. This is her third article with the *Wisconsin Engineer*.

Lynn Singletary is a freshman intending to major in civil engineering. This is her first article with the *Wisconsin Engineer*.



Courtesy of http://discovery.wisc.edu

An architectural rendering shows an aerial view of the proposed Wisconsin Institutes for Discovery.

For more information about The Wisconsin Institutes for Discovery, log on to http://discovery.wisc.edu.

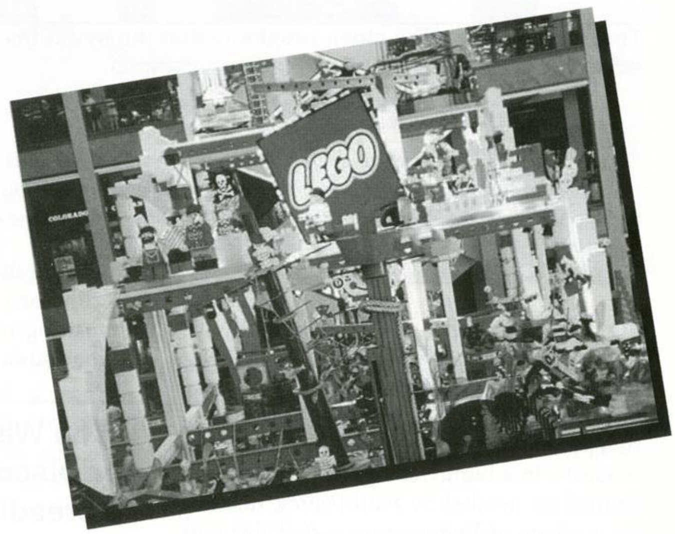
JUST ONE MORE

The finest in eclectic humor

By *Wisconsin Engineer* staff

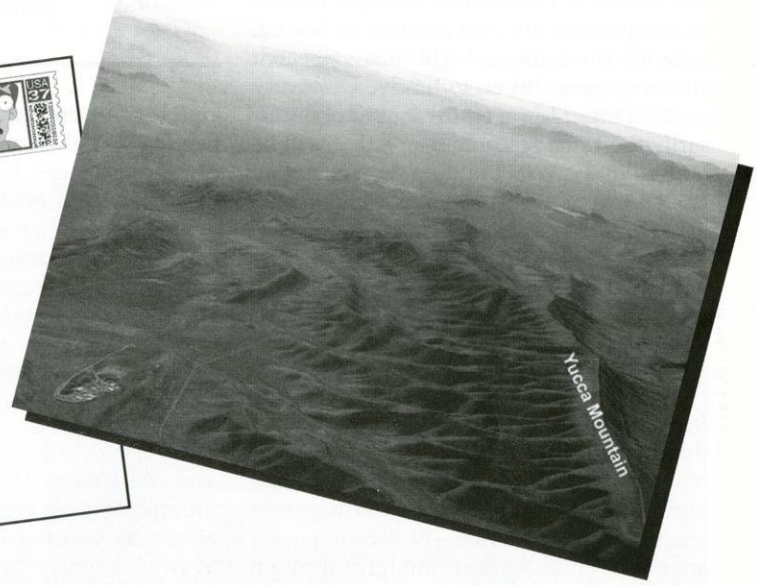
Top 10 spring break destinations for engineers

1. Engineering Centers Building
2. Mom's basement
3. Yucca Mountain
4. LEGOLAND®
5. Fermi National Accelerator
6. Silicon Valley
7. Smithsonian
8. Space camp
9. Area 51
10. Bed



Hi mom,
Having a lot of fun at Yucca Mountain.
Can you make me a doctor's
appointment for when I get home?
While tanning, I started to notice an
abnormal glow. Think it's bad. See you
when I get home!

Bart



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