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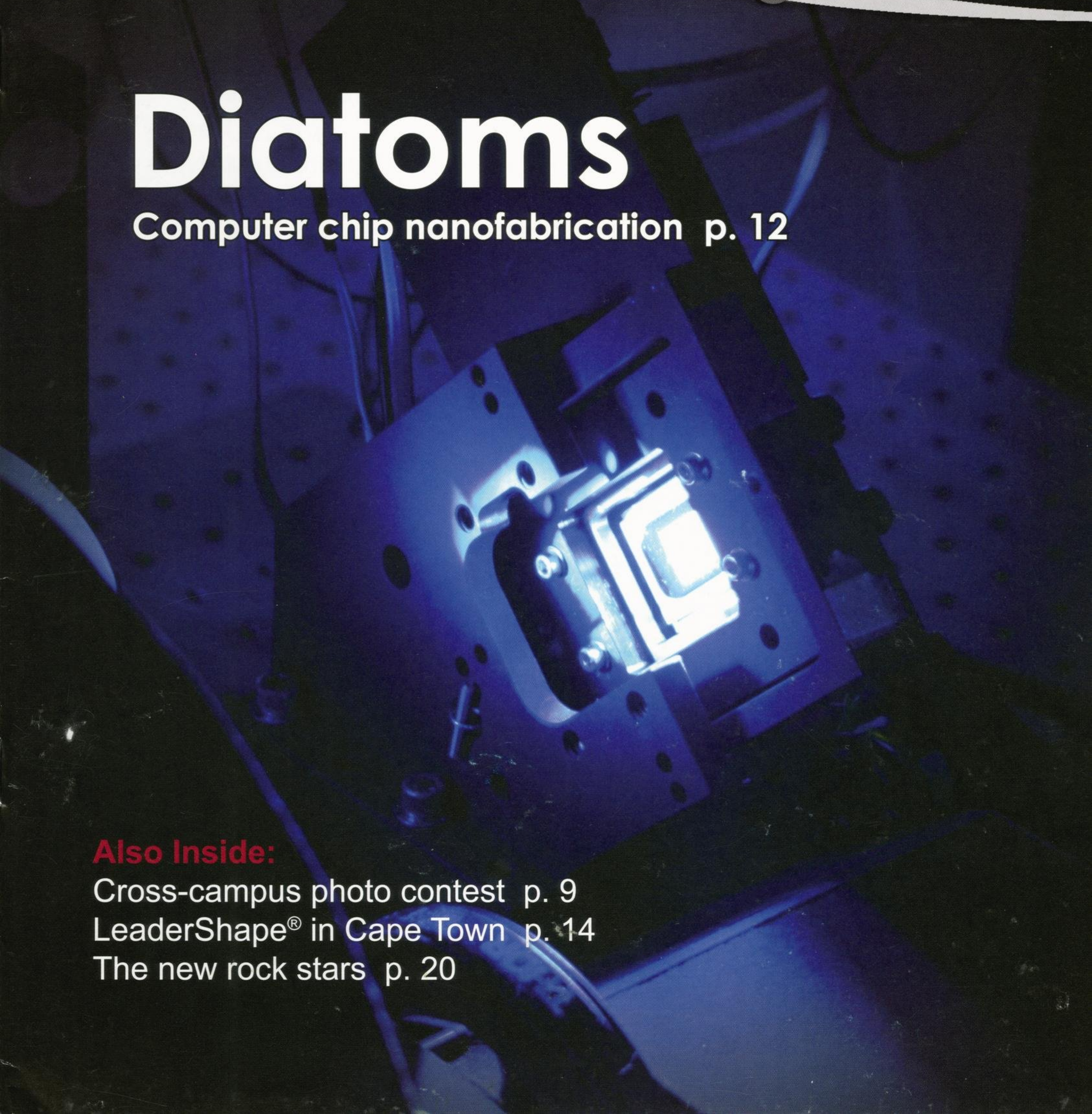
Wisconsin Engineer

APRIL 2008 VOLUME 112, NUMBER 3



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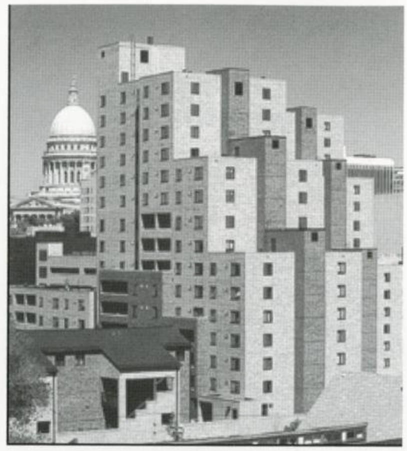

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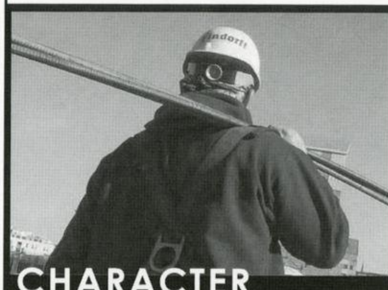

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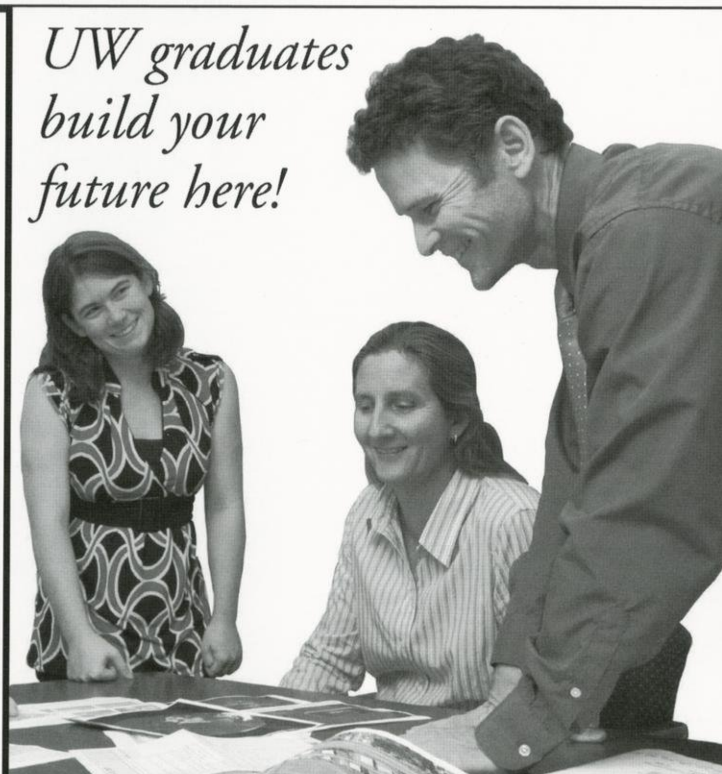

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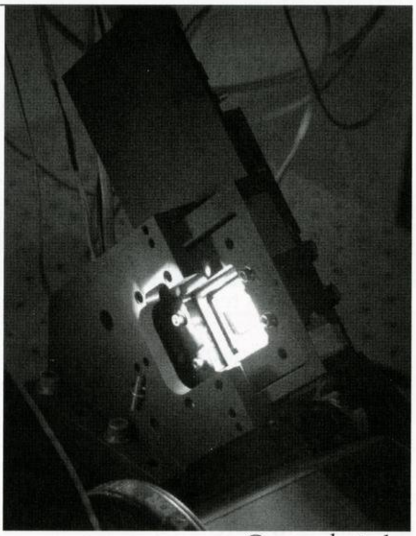

Cover photo by Harley Hutchins

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Victoria Yakovleva
Writing Editor

If it ain't broke, don't fix it

"If it ain't broke, don't fix it" is a popular idiom in the world of engineering, politics, athletics, you name it. In general, it makes sense—why worry about something that is working just fine? Yet, like expressions so often do, it has worn out its meaning over time. A recent experience of mine, however, has reminded me of what this expression really means and has, as a result, refreshed my outlook on the field of engineering.

It began with a research study in which I participated. The study consisted of me lying in an MRI scanner for a good two hours, with my brain being imaged as I performed certain mentally aggravating tasks. What motivated me to participate—on top of the $75 pay—was my extreme curiosity about the happenings of my brain.

After writing my aneurysm story in the November 2007 issue, I realized how uncontrollable things in the brain are. Even if I'm doing everything right—eating healthy, exercising and so on—something can still go wrong. And, if it does, I want to know before it's too late to fix it.

Before the research study, I had to fill out a series of forms. Among the questions I encountered was one asking me whether I wanted to be informed if anything of concern was spotted on my MRI scan. I couldn't believe that a box for "no" was even present. Were there people that didn't want to know if there was something out of the ordinary about their brain? Never having been swayed by the "ignorance is bliss" proverb, I marked "yes."

One afternoon a couple weeks after, I received an unexpected phone call from a man who was in charge of the research study. In a terribly serious tone, the man told me they recently got back my scan from Radiology and that something was spotted that was of serious concern—a cell mass in the pineal gland of my brain. It was urgent that I get it checked out immediately, he said.

Thus began a month-long domino effect of chaos in my life. After weeks of phone calls between my primary doctor in Milwaukee and various neurologists, as well as a consultation and second MRI scan—both of which were scheduled during my spring break—I finally found out that I didn't have a tumor. It turned out to be a cyst in my pineal gland—the cause of which is unknown. The cyst is currently non-threatening, but as a precaution, I was advised to get another MRI scan in six months, followed by another every year.

Though the experience was undoubtedly stressful, it made me realize how important it is to not just wait until things break. A lot of the time, people don't draw attention to things until they do—be it a bridge, a relationship, or a part of the body. All too often we figure that if a bridge still holds cars, a boyfriend or girlfriend still lingers around, and we feel no physical pain, then everything is A-okay. Only when something goes terribly wrong—possibly irreversibly wrong—do we realize something needs to be fixed.

Though we shouldn't worry about things that aren't causing us problems, things are much easier fixed before they break. Aneurysms are easier blocked off from main blood flow before they've ruptured, tires are easier pumped with gas before they've gone flat and plants are easier revived before they've completely dried out. I'm not saying that we should over inflate tires and overwater plants, but part of making sure things run smoothly is monitoring and analyzing.

In the world of engineering, this kind of maintenance is especially important. Though a lot of us enter the field because we enjoy building and breaking things, we can't overlook the testing part of our job. To build something and then not regularly test to make sure everything is functioning properly would be awfully negligent. So though this part of the job may seem tedious and bothersome, we need to treat it with as much significance. That's why there's another important idiom—"better safe than sorry." WE

Victoria Yakovleva

COLLEGE OF ENGINEERING
UNIVERSITY OF WISCONSIN-MADISON

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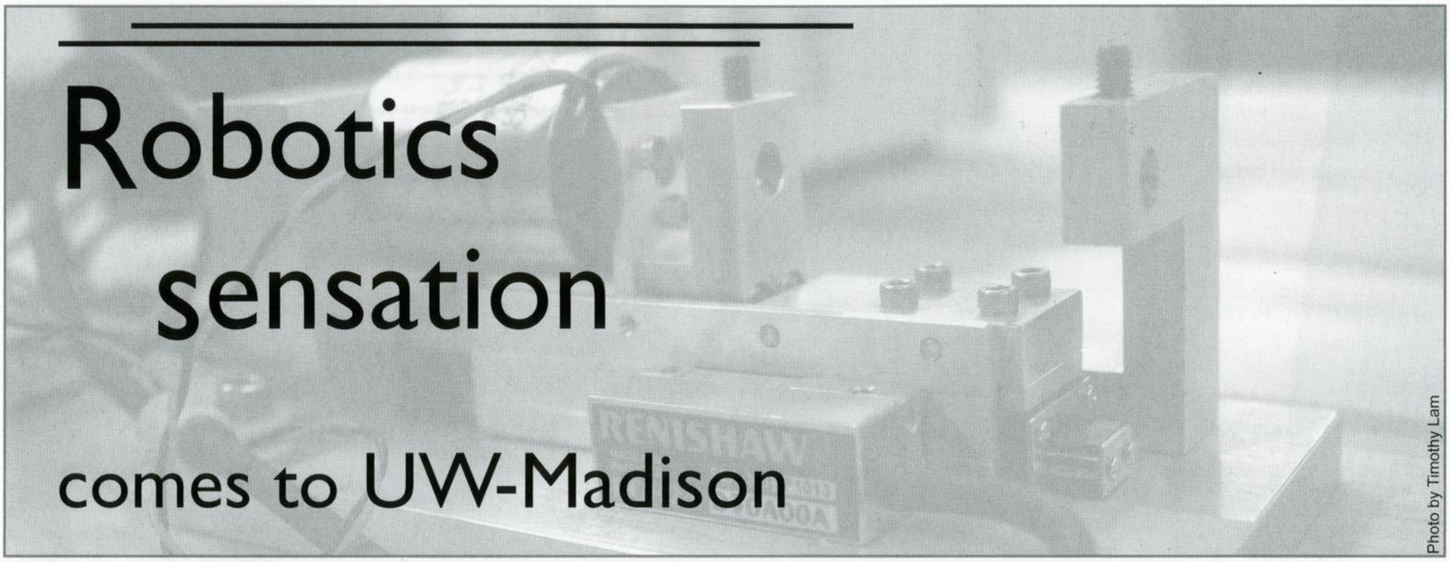

Robotics sensation comes to UW-Madison

Photo by Timothy Lam

By Amanda Wingren

As children, most engineers live in a world of pulling things apart and putting them back together, questioning how things work and withstanding ridicule for their affinity for math and science. So what happens to the engineers that were not natural-born fiddlers but instead followed their interests and used this knowledge to change the world around them?

Professor Michael Zinn is an engineer who is interested in the fundamentals of engineering. He stands on the forefront of robotic research in the United States, working with minimally invasive haptics robotics. By enabling surgeons to operate directly with robots, Zinn is working to form intimate contact between the two.

Haptics robotics is a field where the surgeons are actually holding and directing the robots during surgery. The robotic catheter is one such example, since it is directed using a three-dimensional force field through the body to the heart and replaces the manual catheter (a thin, flexible tube that is manually fed through the body to the heart). The robotics Zinn worked with were used to treat a heart condition called atrial fibrillation, where the electrical impulses in the heart tissue become disorganized and cause an irregular heartbeat.

In college, Zinn had no specific focus and found himself drawn to robotics, a field which incorporates a wide breadth of knowledge in the engineering field, ranging from computer systems and electrical engineering to the more mechanical, physical elements of engineering. After graduation from MIT, Zinn worked with an aerospace company on space shuttles and satellites before deciding to pursue a Ph.D. at Stanford University.

Zinn worked with Hansen Medical, a company he helped start, while writing his dissertation at the Stanford Robotics Lab. As the director of systems and controls at Hansen Medical, Zinn was able to work in a cutting-edge robotics lab to design a robotic catheter system for cardiac surgery. This system creates a more informed environment for surgery; the robots feed information from within the body to an external screen, giving the surgeons vital, detailed information regarding specific case surgery.

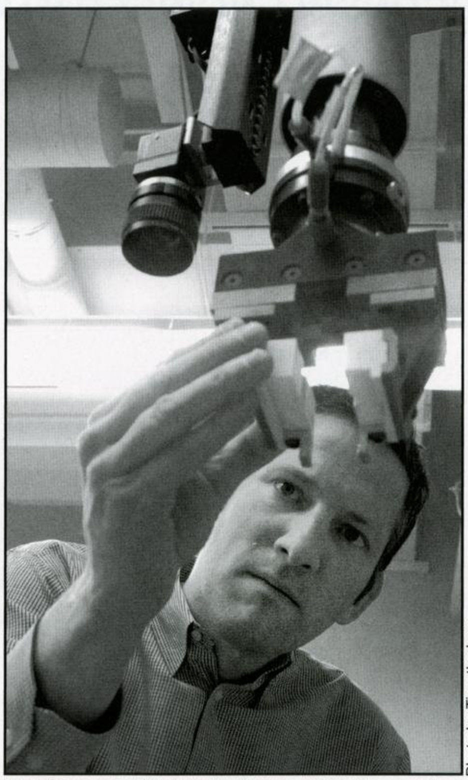

Photo by Timothy Lam

Professor Michael Zinn examines the Adept-1 Robot.

There are very few companies in the United States that make robotics due to the cost-sensitive research. "It was a robotic Ph.D.'s dream," Zinn says of his work with Hansen Medical.

Hansen Medical went public after approximately four years, and the startup company went from a small robotics lab to a medium-sized company that also deals with other issues such as production and sales/marketing. Zinn decided to leave shortly after the company went public and joined the mechanical engineering staff at UW-Madison.

At UW- Madison, Zinn has plans to continue his research with minimally invasive robotics. Zinn is in the process of setting up his own lab and has plans for a collaborative research project with Hansen Medical. He hopes to extend his research into the deeper problematic details of robotic design that a smaller company may not be able to fund. His research places emphasis on the sensory aspect in hopes of improving the performance and flexibility of robots. The research Zinn conducts at UW-Madison allows him more freedom than a small company would. He collaborates with Professor Nicola Ferrier, who specializes in visual control and imagery of robots.

"In some ways, I'm working harder than I did in the early days of the startup [at Hansen Medical], but I've also got this incredible flexibility. You're working for yourself—you're your own harshest critic, so to speak. But it's been great so far," Zinn says.

Zinn is also teaching ME 240: Dynamics with Professor Ferrier. Dynamics is a course that is concerned with the accelerated motion of particles and is fundamental to engineering. Zinn claims that it is more fun than he thought it would be and says, "Even in something as dry as dynamics, there are things that are very interesting… there are these cool physical phenomena about how something works."

"You're working for yourself—you're your own harshest critic, so to speak."

-Professor Zinn

Zinn says that understanding the material is much more important than grades; a bombed quiz won't matter in a year and definitely won't matter in ten.

"The first few classes give you most of what you need for industry. So focus on learning the material, don't take it so seriously—enjoy it," Zinn says.

Although he has only been on campus for one semester, Zinn is already largely involved in campus life—from the setup of his robotics lab and collaboration with other mechanical engineering professors to teaching eager young engineers the fundamentals of their major.

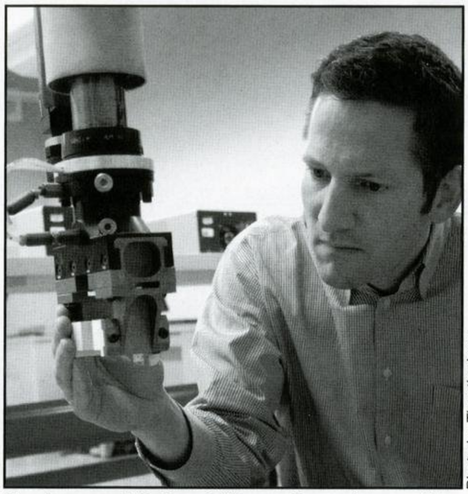

Photo by Timothy Lam

Professor Michael Zinn plans to continue his research with minimally invasive robotics.

"He really seems to care about his students, and he tries to be fair and make the material fun," Bob Hocraffer, an engineering sophomore, says shortly after observing a Dynamics demonstration involving a bouncy ball, a bowling ball and the conservation of momentum.

Zinn believes that if you follow what you enjoy doing, everything else will fall into place.

"In the path that you follow, you do what you want to do, what you're interested in, and things will work themselves out. Just enjoy what you're doing and don't live too much for the future. If you're always looking towards the future, then you're not really enjoying what you're doing now." WE

Author bio: Amanda Wingren is a sophomore studying mechanical engineering. This is her first semester with the magazine.

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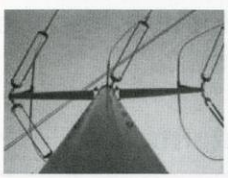

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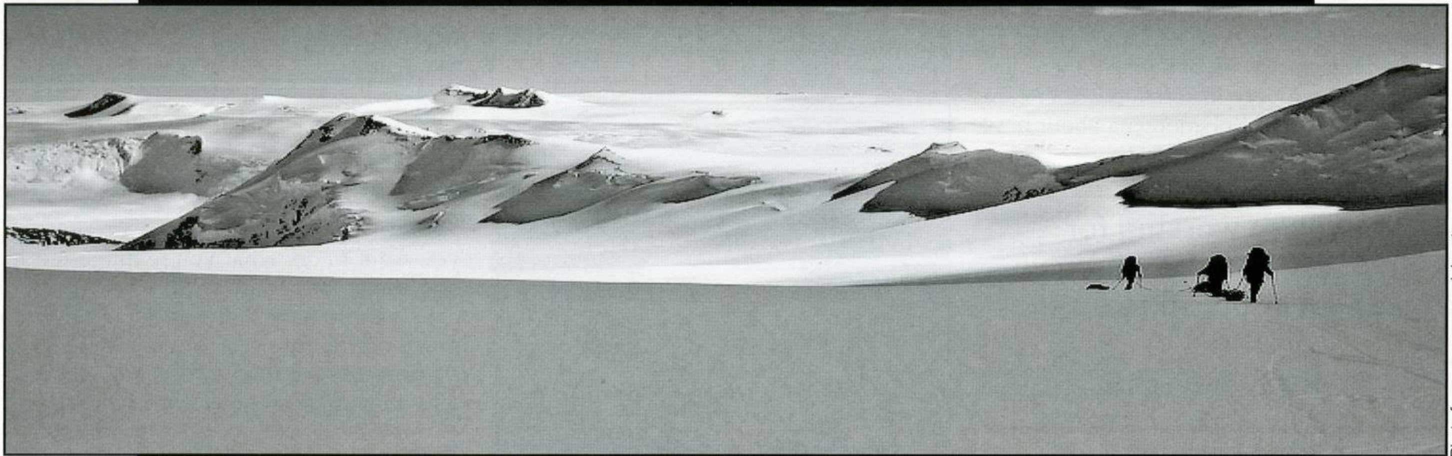

Photo from www.exposedplanet.com

By Lynn Singletary

UW-Madison students and faculty spend their winters dreaming of tropical climates and the day they can finally break out the sandals. But even with Madison's record snowfall this year, these blustery conditions feel tropical to a team of engineers from UW-Madison who recently returned from a two-month visit to Antarctica. Living in tents at the bottom of the world, where the average temperature is -31 C and the sun only shines for half the year, left these researchers yearning for the warmth of a Wisconsin winter.

In 2003, UW-Madison was approached by the National Science Foundation (NSF) to build a drill that would collect ice cores 122 millimeters in diameter and 4,000 meters long and hopefully reveal some of the mysteries behind the planet's climate change—UW-Madison's Ice Coring and Drilling Services (ICDS) was born. The team of six staff engineers began work on the design for the Deep Ice Sheet Coring (DISC) drill almost immediately.

ICDS engineers studied plans from similar projects in Russia and Europe as the basis of design but also added several new innovations of their own. Different combinations of drill rotation speeds, pump speeds and cutter configurations were examined to determine optimal drilling parameters for the DISC drill.

"You can't predict the future if you don't know about the past… "

-Dr. Shturmakov

Arguably the most important design component of the DISC drill is the drill fluid. Not only is it used as a lubricant, but it is also the exact density of the ice. This is an important feature because it equalizes the pressure pushing in on the hole which would otherwise have a tendency to collapse.

"The drill is like a long cookie cutter; it has a long tube with a cutter on the bottom. It cuts out a whole column of ice, and after the column is about three meters into the tube, it comes back up and the ice is pushed out of the tube," Charles Bentley, principal investigator for the DISC drill project, says.

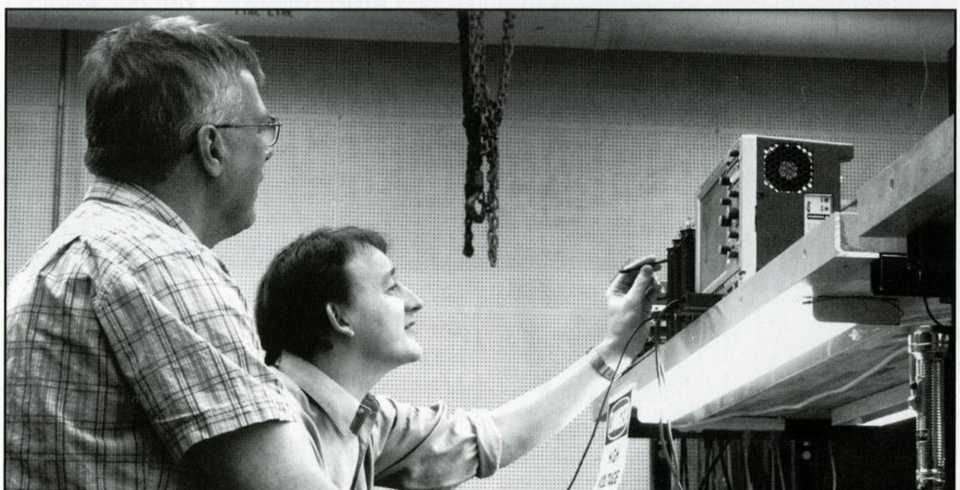

Photo by Preston Judkins

Paul Sendelbach and Nicolai Mortensen monitor equipment that controls the Deep Ice Sheet Coring drill.

DISC project members, from left, Paul Sendelbach, Jay Johnson, Bill Mason, Dr. Alex Shturmakov, Scott Haman and Nicolai Mortensen.

Once the drill was completed, it was sent to Greenland in 2006 for preliminary tests. The drill was then brought back to Madison for some last minute improvements before it was shipped to Antarctica on a C130 airplane flown by members of the Air National Guard and chartered by NSF.

"Logistics just made more sense to do the test run in Greenland. It was cheaper and closer to home, and we didn't really care. We just needed cold ice that was about 1,000 meters deep," Dr. Alex Shturmakov, project manager of the DISC project, says.

The location selected for the drilling lies along the western part of the continent along the West Antarctic Ice Sheet (WAIS) Divide. Most of Antarctica is somewhat like a desert due to so little snow fall each year; this makes for ice cores with thin layers that are more difficult to interpret. At the WAIS Divide site, however, snowfall is abundant and has been that way for quite some time.

An ice divide is comparable to a watershed divide; the divide separates opposing flow directions of ice on an ice sheet. Ice coring is typically done above ice divides to minimize potential horizontal movement of bedrock beneath the ice sheet. It is often a good idea to drill slightly off the current ice divide to ensure that migration of the divide over time does not adversely affect the ice record.

The WAIS Divide ice core will provide the first climate and greenhouse gas records in the Southern Hemisphere comparable to the Greenland ice cores. Because the time resolution and duration of drilling at the two sites are so similar, comparisons of environmental conditions between the northern and southern hemispheres is possible. Researchers will also be able to study the greenhouse gas concentrations in the paleo-atmosphere with more detail than was previously thought possible.

The drilling of these ice cores is only the beginning of a very long process. When the ice is first drilled, it is very brittle and must be handled carefully. The ice must rest to avoid cracking before being shipped back to the United States for research purposes.

After the cores have rested, they are shipped in special ice core boxes back to the National Ice Core Lab (NICL) in Colorado where NSF makes the final decision in the research process. Sections of the ice core are very expensive and also highly coveted since there is so much that can be discovered about the Earth's climate by examining isotopes and escaped gasses from the ice.

"Basically it's all about climate change and global warming. You can't predict the future if you don't know about the past, so we're trying to get a very good record of the last 100,000 years," Shturmakov says.

It will likely take another three drilling seasons before the core reaches its goal depth of 4,000 meters deep, and this portion of the project is complete. However, this won't be the end of drilling excursions in Antarctica. The ICDS engineers, supported by NSF, are already making plans to prepare for drilling into the bedrock an additional 4 meters.

It could be years before any conclusions are drawn based on the ice cores from Antarctica, which is why these ICDS engineers were hired by UW-Madison specifically for the DISC drill project in 2003. It has become an integral part of their lives, and though they aren't involved in the research process, it is their dedication to drilling that makes the project a success.

"We have an exceptional team of people," Shturmakov says. "You can have excellent equipment, but the project would be unsuccessful if you didn't have a great team of people that really live with that equipment." WE

Author bio: Lynn Singletary is a sophomore majoring in civil and environmental engineering. This is her third article for the magazine.

A novel approach to e-business

Photo by Wai Keat Tan

By Carter Franz

Roughly a decade ago, when the dot-com bubble was nearing its climax, apprehension and uncertainty in industry was also reaching a boiling point. How was this rapid onset of e-business and e-commerce going to affect the way we do business? Should we even worry about it? Looking at the landscape of the present day, the answer is obvious.

"[Companies] intuitively knew this was something that was going to transform their industry. They did not know to what extent, but knew it would be big," Raj Veeramani, a founder of UW-Madison's E-Business Consortium, says.

Around this time, Veeramani and his colleagues queried ways in which UW-Madison could lend its vast resource and research base to help industry find the role e-business would play in their future. Their answer was in the E-Business Consortium, currently in its tenth year of operation.

"[UW-Madison] deals with issues in a holistic manner and provides an unbiased point of view." With the competitive nature of industry, finding someone to call an ally is not easy. "As a university we provide an unbiased view. People feel the info they are hearing is the best," Veeramani says.

At the time, each company had been trying to utilize the web in different ways. As these companies began talking with each other, they realized all these different industries could learn from one another. "There were a lot of issues and pressures to which answers were not known. The consortium was a way for industry to tap into the intellectual capital of the university," Veeramani says.

But what could an energy provider learn about business practices from a shoe distributor? "That is what is unique about the consortium. It is a collaborative, non-competitive environment," Lisa Bruckschen, a graduate student majoring in industrial engineering at UW-Madison, says. Her focus area for the consortium is the Supply Chain Management Group—one of five divisions.

The company's fields are all across the board. "We have manufacturing, telecommunications, service, distribution and many more. We bring them together and facilitate the exchange of knowledge and best practices related to emerging technologies and e-commerce," Bruckschen says.

Other focus areas of the consortium include sales, marketing and customer service, IT strategy and information security, web strategy and marketing, and radio frequency identification (RFID).

The heart of the consortium is the peer group meetings, which number over 50 every year and are conducted for the five focus groups. Early on, the consortium also decided to take on a more regional focus so that all companies were able to attend the peer group meetings.

"The peer groups are how we fulfill our mission and promise," Veeramani says. "Peer groups bring companies together on a regular basis to engage and facilitate discussion sessions. They learn how different companies are doing things. The meetings are very valuable to participants and a portion of the meeting is more open forum. Companies can pick the brains of others. They tend to be very practical types of discussions, not academic. The hope is that everyone walks away with actionable ideas."

Actionable ideas are exactly what it will take to be successful in the coming decades, regardless of a company's specialty. The newest generation of college graduates must be prepared to tackle the challenges of a globally interconnected market place. Being able to adapt to rapid onsets of change will require the constant regeneration of knowledge and best practices, and the UW-Madison E-Business Consortium sets out to assist in that process. "It is the cross pollination of ideas, and the wisdom of the group that allows companies to climb the learning curve," Veeramani says. WE

Author bio: Carter is a sophomore studying civil engineering. He does fundraising for Engineers Without Borders. This is his first semester with the magazine.

Photo by Wai Keat Tan

Members of the UW-Madison E-Business Consortium discuss information security.

Wisconsin engineer

Cross-Campus Photo Contest

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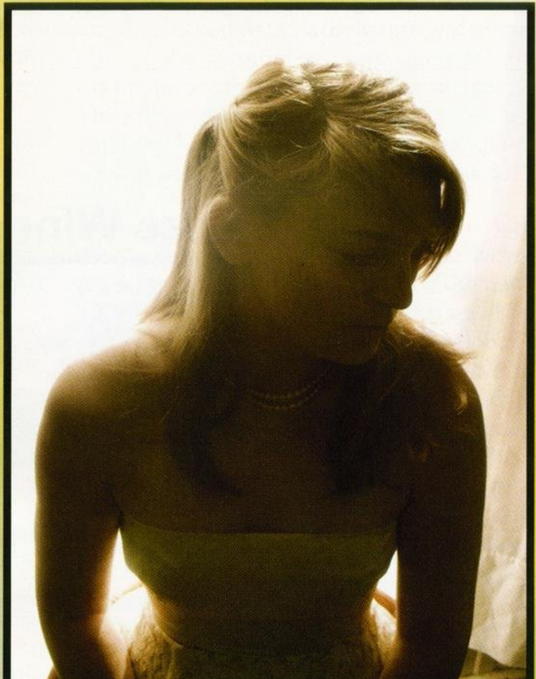

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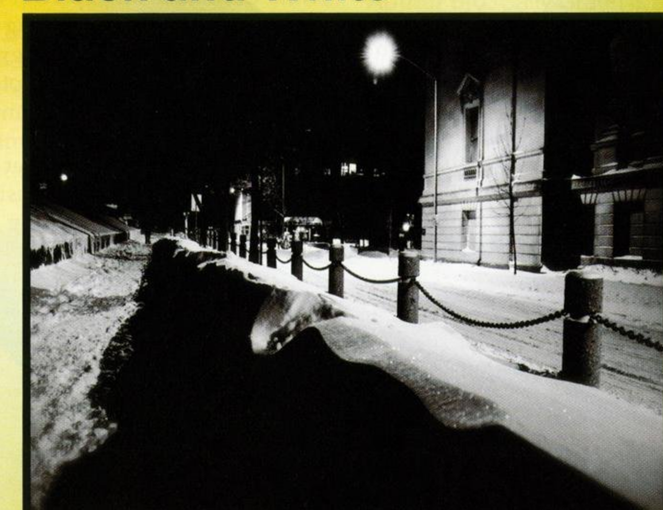

By Matthew Hintz

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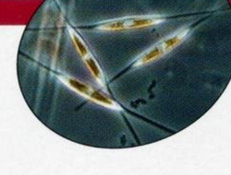
Thanks to all photographers and voters.

Engineering + Biology = Computer Chip Breakthrough



Biologists and engineers work with a unicellular algae, known as the diatom, for computer chip nanofabrication.

By Sally Green

Engineer: a person who uses scientific knowledge to solve practical problems.

Biologist: a specialist in the science of life and of living organisms, including their structure, function, growth, origin, evolution and distribution.

These two fields of study form a natural pairing for Michael Sussman, professor of biochemistry at UW-Madison, and Franco Cerrina, professor of electrical engineering at UW-Madison. "You can't get much more interdisciplinary than what we've been doing," Sussman says.

"We do something together that we couldn't do alone," Sussman says. As engineers, the importance of teamwork is regularly stressed; however, Sussman was referencing something slightly different. He has been working with Cerrina to discover industrial applications for a unique biological organism—the diatom.

Diatoms are unicellular algae encased in cell walls made of silicate, a form of silicon. In engineering, silicon is used in the nanofabrication of computer chips. Sussman understands the chemistry and mechanisms behind researching the diatom's structure, while Cerinna is an expert in the nanofabrication process. By combining both of their concentrated scientific backgrounds, they were able to recognize the potential use of diatoms in computer chip manufacturing.

"The chips are getting smaller and smaller and higher and higher density," Cerrina says. However, engineering technology has already reached its smallest possible chip. The speed cannot be further increased unless a new method of production is designed.

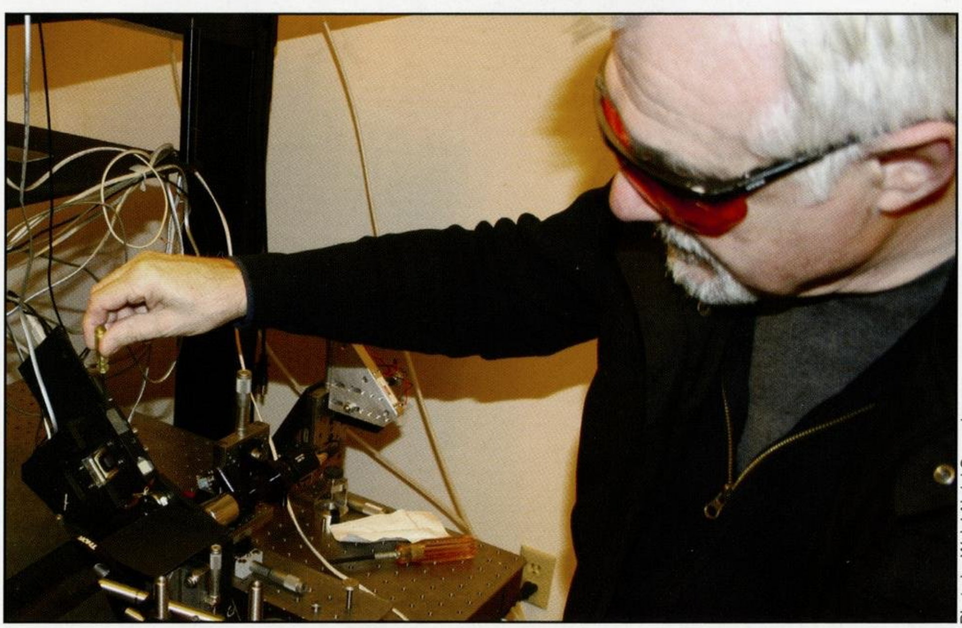


Photo by Wa'el Abdel Samad

Professor Franco Cerrina explains the electrical aspects of diatom research.

"You can do it yourself and that is what we are doing today. You develop the techniques yourself and make things smaller and smaller… Or you can take something that already knows how to make small things and use it as a tool," Cerrina says.

"Synthetic biology. Let's assume that we know system biology. Can we use that to build new things?" Cerrina says of how the idea was initiated. These diatoms are able to "make little machines—little structures in dimensions that engineers have trouble with," Sussman says. "We are hoping that we can discover how they do that."

"No one has been able to genetically modify [the diatoms], to manipulate them and use them," Sussman says. When a team at the University of Washington was able to sequence the diatoms, Sussman knew he was part of an amazing research project. "This group of organisms is so far out there," Sussman says. "In this case, prior information is useless." The diatom is the first silicate-requiring organism that has ever been studied.

How exactly did this discovery take place? Cerrina, Sussman and their teams built a microarray synthesizer to make DNA chips. Then they decided to starve the organisms of silicate to see which genes get turned on and which get turned off. It is "an easy way to figure out which genes are involved in the [nanofabrication] process," Sussman says.

The organisms were similarly starved of nitrogen, carbon and other important components that have been previously studied on known systems. "Out of the 10,000 genes, 2,000 genes were affected by one of those conditions," Sussman says. "Out of the 2,000 genes, we identified 75 genes that were specifically impacted by silicate starvation... 67 of them have no sequence seen before." Since this is the first researched organism that requires silicate, they think an entire world of silicate chemistry is yet to be discovered.

A second investigation performed at UW-Madison was to find out where in the cell the genes specific to the silicate process exist. It is hypothesized that they are in the cell wall since this is the silicate's location. In order to test the theory, the diatom protein was modified by fusing half with a glowing jellyfish protein.

"It glows in the cell wall," Sussman says. "We are going in the right direction." Next on the agenda is to mutate the genes, create imperfect cell walls and overexpress the organisms to see how they react, a process known as "reverse genetics."

What about these possible computer chips that may be formed by "reprogramming" the diatoms? In what kind of computer will they be used? "It is not going to be a computer in the way that we know a computer," Cerrina says. "[The diatoms] will be nanofabricators... The plan is to teach these diatoms to fabricate the shape that we want, not the shape that they want." The process is analogous to taking a machine that is designed to make sunglasses and reprogramming it to create reading glasses.

iGEM: Summer Research Competition

Synthetic biology is an emerging area of interest to a spectrum of undergraduate (and graduate) engineering students. If you are in computer, industrial systems, chemical, biological, or biomedical engineering, you may enjoy the unique, research-driven learning opportunity presented by the UW-Madison iGEM team. The team is an interdisciplinary group of students that spends each summer tackling exciting collaborative research projects at the interface of engineering and biology. Many of the projects focus on engineering bacteria and other organisms to create new materials, processes, and capabilities in biotechnology. No previous biology experience is required. Our team travels to the jamboree at MIT in the fall to compete against other teams, to share results, and to meet students and faculty; this event is fun and is the highlight of the annual competition. Financial support for the summer and for the trip to MIT is available.

Interested students should contact Franco Cerrina (fcerrina@wisc.edu) and Doug Weibel (weibel@biochem.wisc.edu) for more information.

"We are trying to make biological systems to mimic engineering systems," Cerrina says. "We are trying to find the set of instructions to make the diatom work."

Finally, the scientists will want to modify the diatom's set of instructions for purposes of computer chip production.

"It's a new time that requires collaboration." Natural science needs people who are comfortable in thinking outside of their own area. "Engineers are very good at this," Sussman says. WE

Author bio: Sally Green is a junior in chemical engineering. When she is not studying or working, she can be found playing sports, reading or traveling.

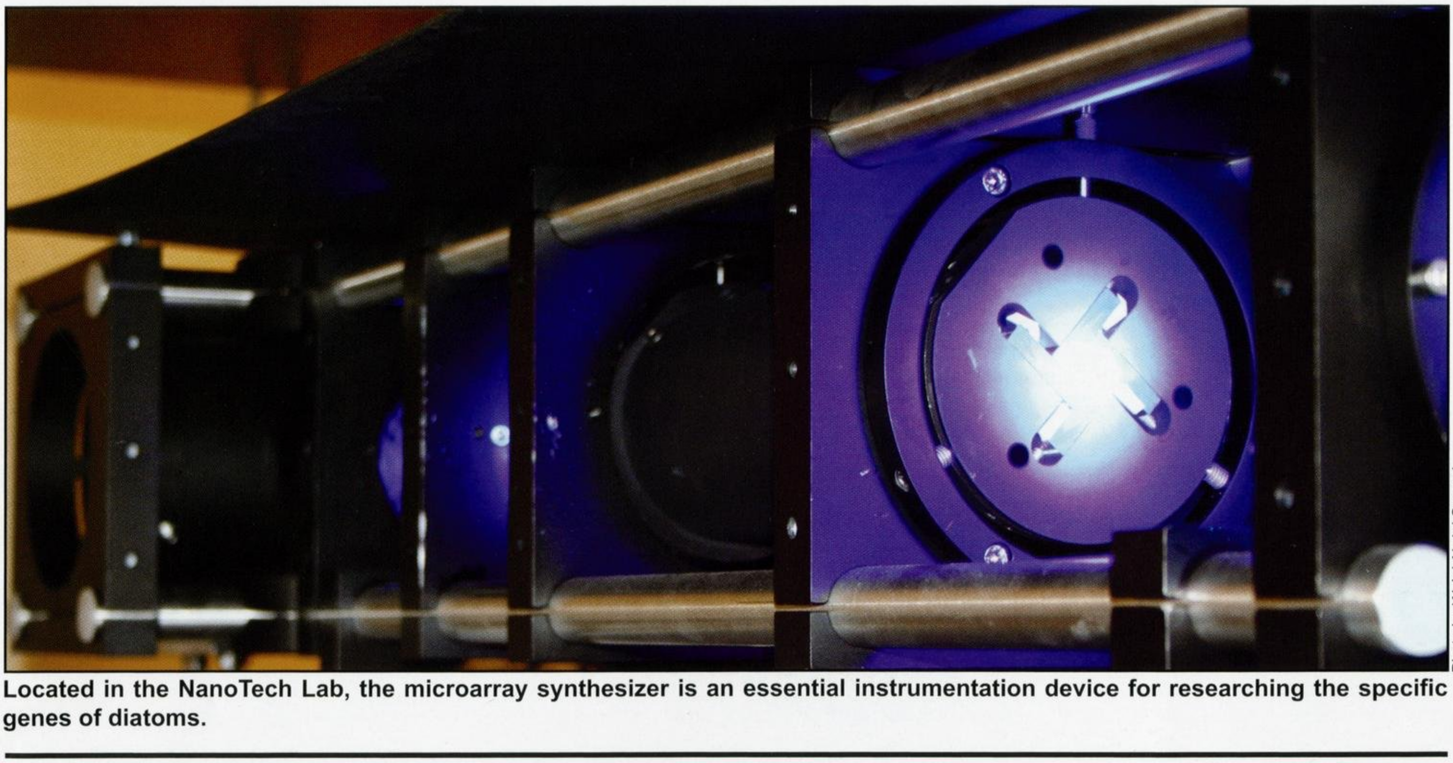
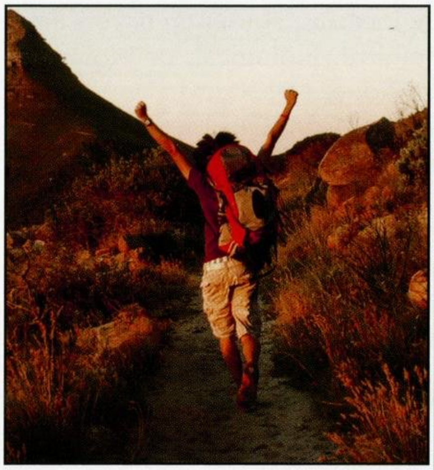
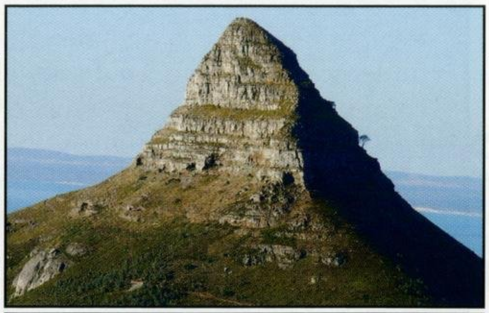
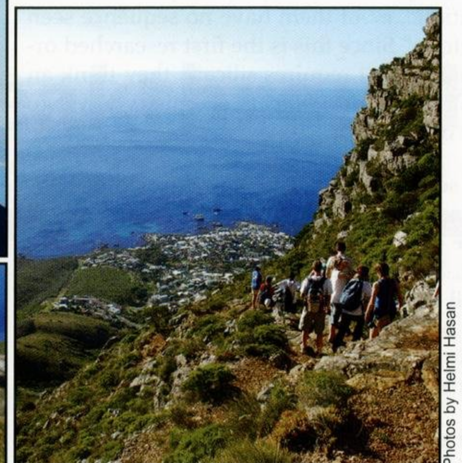


Photo by Wa'el Abdel Samad

Located in the NanoTech Lab, the microarray synthesizer is an essential instrumentation device for researching the specific genes of diatoms.

LeaderShape®: Challenging What Is, Looking To What Could Be



Photos by Helmi Hasan

By Elizabeth Grace

This past winter break, 30 UW-Madison students attended the 10th annual LeaderShape® conference in Cape Town, South Africa. The trip marked the first time American students have attended the conference overseas, as well as worked with international students. The UW-Madison LeaderShape® crew teamed up with students from the University of Cape Town (UCT), hoping to develop leadership skills while also learning to work with people from different cultures.

Kathy Prem, program coordinator for the trip, attended and facilitated the conference in South Africa. "One of the things that the program really explored was different leadership styles and how to be a leader in the face of adversity and how to create a very inclusive, supportive environment for people to play their roles... They were really looking at what it might mean someday to work for a global company, and they learned that their perspective may be one of many," Prem says.

LeaderShape® is a student organization centered on the vision of positive changes in an academic community, on a business level and on a global level. Their mission is to become influential leaders on campus as well as to encourage others to take part in making a positive impact now and in their future careers.

The trip to South Africa was partially funded by Abbott Laboratories. "There are a lot of companies that want to give back to the campus in one way or another. This particular program is something that Abbott has been involved in before. They have had people deeply involved in the program and they feel it is great training for students," Prem says.

The program was also funded by UW-Madison College of Engineering alum, Gary Wendt. "He wanted the opportunity to offer engineers an international experience beyond study abroad, and combining the leadership aspect was important to him, too," Prem says. He was also able to visit and speak to the students in Cape Town and hear about why he felt this was so important.

LeaderShape® participant Sarah Steenblock said Wendt spoke to students about their future careers as engineers. "He did a good job of reminding us of the importance of little decisions to our vision," Steenblock says.

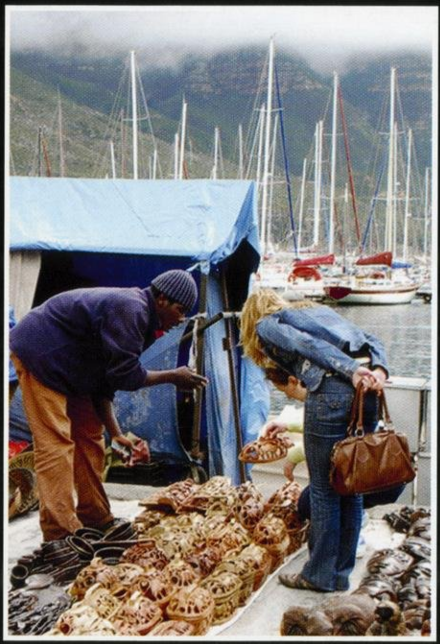
While in South Africa, students spent most of their time listening to influential speakers who described the importance of being a leader and advised them on how to step up into leadership roles. There were many themes addressed at the conference, such as "Challenging What People Call Impossible," "Challenging What Is, Looking at What Could Be" and "A Healthy Disregard of the Impossible."

LeaderShape® members also contributed to projects, such as clearing ponds of hyacinth to help local communities with their flooding problems. The task seemed daunting, but the students had a renewed energy and positive mentality while working. "[This] gave us a time to take all of the information and go back into the reality," Steenblock says.

To those involved, travelling to Cape Town was much more than just attending a conference. It was learning to communicate with people from different parts of the world, and how to make the world a better place. Students broadened their awareness of the challenges different countries face, while simultaneously expanding their perspective. Although UW students were still on a college campus much like UW-Madison's, they were able to experience the laid back Cape Town culture. "[They were] very inviting people, and [we realized] that humor is the same in every country," Steenblock says.

The program is currently looking at the outcomes of this past trip and analyzing how the students benefited from working abroad in order to determine whether another conference will be held overseas. If the key components fall into place, students and faculty from different parts of the globe can meet again and further discuss their unified visions of challenging what others might call the impossible. WE

Author bio: Elizabeth Grace is a senior studying English and Technical Communication.



Photos from LeaderShape® Trip to Cape Town, South Africa

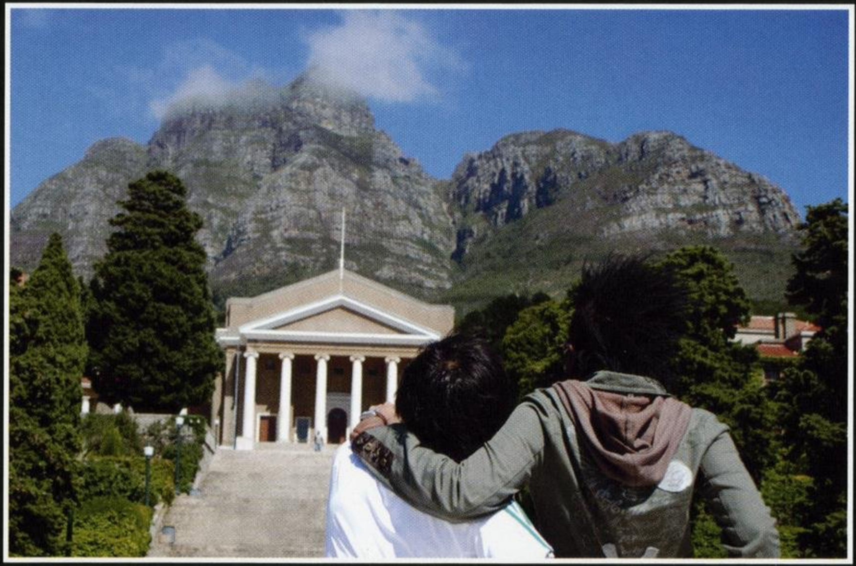


Photo captions (moving clockwise from top left): Jumping from left is Helmi Hasan, Ivan Serwadda and Ahmed Akhalwaya; Tourist viewing handmade craft items on Seal Island; Landing from rock jump from left is Helmi Hasan, Shaniel Lakhoo, Ivan Serwadda and Ahmed Akhalwaya; Seals warming in the sun; University of Cape Town dormitories; African penguin stands on the beach at Simon's Bay; Helmi Hasan and Nwabisa Letosha overlook Jameson Memorial Hall.

All photos taken by Helmi Hasan.

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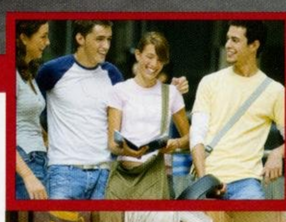

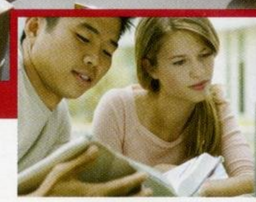

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Better, faster, clearer

By Mike Sargent

After you have removed all your magnetic accessories, you are asked to lie down on your back. A heart pressure measuring device and an emergency stop button are attached to your arm. Earplugs are then inserted into your ears and your head is compressed to ensure maximum stillness. Any slight movement will blur the scan. After 30 or so minutes of listening to a barrage of loud clicking noises that eventually mesh into a techno beat, the scan is complete. Yet, the results are unclear.

This is the unfortunate reality of present-day Magnetic Resonance Imaging (MRI) scans. A breast abnormality can't be deemed malignant or benign, a brain tumor in the center of the brain can't be verified and the presence of a fluid around a knee ligament is uncertain.

However, recent strides in modern technology have advanced the field of medical diagnoses and treatment. Some of these advancements in the field of medical imaging are currently being made right here on campus. While many engineers are looking to alternative methods for image processing, Walter Block, professor of biomedical engineering, is seeking to improve the current methods. Adaptations of current MRI technology show great promise in producing sharper images of the body in shorter amounts of time.

MRI requires polarization and stimulation of all hydrogen atoms in a patient's body. Perturbing the magnetization with a radio frequency signal shows the hydrogen location in relation to cell tissue. The hydrogen will return to equilibrium at different rates depending on its location in the body. These rates are processed and used to generate an image. MRI utilizes radio frequency energy on the scale of meters and processes them in millimeters through encoding of special position. While the encoding scheme is clever, it also drastically limits how many detectors can be used to speed the scan. MRI can take one to ten measurements at a time; conversely, a state of the art 64-slice CT-scanner can take 64,000 points of data in an instant.

Photo by Ross Tillman

MRI equipment, such as this small limb scanner, can be updated with Block's technology.

"With x-rays you see bone and some soft tissue… in MR you see much more contrast of tissue," Block says. This contrast can show arteries and tissue abnormalities. However, the encoding of spatial position is what slows down the MRI process. It can take upwards of a half hour to gather enough data to produce a high-quality three-dimensional image. With time at a premium, it may make sense in some cases to accept a lower quality x-ray image.

Block's techniques have cut that half hour sampling time down to approximately five minutes. MRI requires generation of a three-dimensional image by taking data for every point at that image. Block creates acceleration with his new method through under sampling of data. However, this machine is able to collect a lot more data much faster. The collected data is then processed so that clearer images are produced. "We can use computers to visualize the body in any orientation we want. We aren't limited to the one orientation we get with the two-dimensional images today," Block says.

That's great, but what does this mean for the future of MRI? "We can take it out of the realm of the spine, knee and brain and take it into the abdomen, the heart…" Block says of medicinal advantages to his MRI process. Images are currently being produced based off of large contrast between tissues. If images are produced from finer contrast, then MRI can become a viable way of diagramming minute lesions on vital organs. As a result, hopefully MRI will be used as a means of catching certain conditions.

The new MRI method will also play a big role in prevention and treatment of breast cancer. Current MRI can only display a lesion in a breast. Upon detection, a doctor will typically do some sort of invasive testing to confirm if the lesion is cancerous or benign. This costs the hospital money and puts the patient under emotional and physical duress. However, Block believes that with a higher resolution image, a computer can use tissue characteristics to determine malignancy within seconds. Breast lesions are just the beginning of a broad spectrum of diseases for which direction and monitoring can be improved.

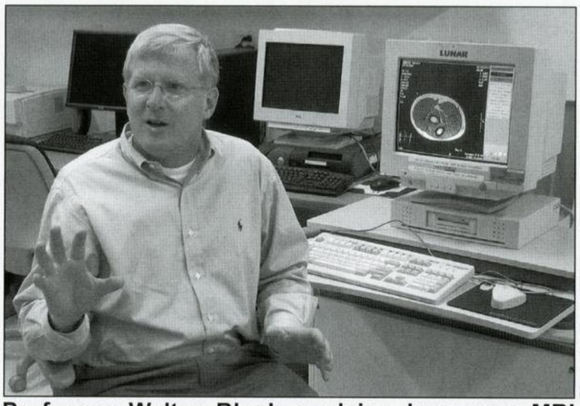

Photo by Ross Tillman

Professor Walter Block explains how new MRI technology has the potential to distinguish benign from malignant tumors.

Imaging research is moving away from pathology and shape to looking at images as a function of time or physiological parameters. "Medical images will often make a live person look the same as a dead person," Block says. Instead of showing images frozen in time, the faster MRI can show how the body is changing over time or reacting to treatments. Time issues with older MRI practices made this type of imaging costly and infeasible. The newer MRI has the potential to track the development of diseases and even show how a patient's body is degenerating over time.

Overall, Block has reformatted the process of acquiring and processing MRIs—not the hardware itself. Hospitals will not have to purchase new, expensive equipment. Faster MRI can often be implemented via a software upgrade on most MRI scanners. This is a very attractive means for hospitals to grow technologically with conservative budgeting. As more research is done on this technology, MRI will become a useful tool in patient diagnoses and treatment. However, as Block explains, its use and acceptance will be highly dependent on the preference of those working in the medical field. Clearly, the potential of this technology has yet to be fully realized. WE

Author bio: Mike is a junior majoring in civil engineering. This is his first semester with the magazine.

Disarming a viral time Bomb

Promising breakthroughs in the fight against Ebola

By James Kadunc

In the 1995 sci-fi thriller Outbreak, a deadly virus runs rampant through a small U.S. town, leaving death and destruction in its wake. The virus, nicknamed "Motaba," bears an uncanny resemblance to the real-life Ebola virus (EBOV). While Dustin Hoffman was able to eradicate the Motaba virus, save his ex-wife and win the day before lunch time, scientists have thus far been unsuccessful in controlling Ebola.

EBOV is a highly contagious virus known to cause a laundry list of symptoms known collectively as "Ebola hemorrhagic fever." It kills around 85 percent of those infected and currently has no cure or vaccine; in the right conditions, it has the potential to be the deadliest virus in the world. Thus far, outbreaks have been limited to a few parts of central Africa, so EBOV's death count pales to those of viral heavy-hitters like Smallpox. EBOV's severity has made it a prime candidate for a biological weapon. Its high death rate, lack of a cure, communicable nature and one-week incubation time give it the potential to spread through a population with savage results.

Research done on EBOV must be done in so-called "biosafety level 4" (BSL-4) facilities. BSL-4 facilities must have, among other things, extensive decontamination procedures for all occupants, multiple airlocks for entry and exit, a low air pressure, documented procedures for any outbreak that could occur and a highly trained staff. Only a handful of BSL-4 facilities exist in the U.S., making EBOV extremely difficult to study. The restrictions placed on BSL-4 labs hinder the research necessary to develop a vaccine. However, a team of researchers at UW-Madison is easing the restrictions by creating a less hazardous strain of the virus.

"We have a person that works in a BSL-4 lab in Winnipeg, but we needed something to work with here in Madison," Peter Halfmann, a graduate student in the UW-Madison department of pathobiological sciences, says.

Halfmann and his research colleagues in the Kawaoka Laboratory have uncovered a way to effectively "disarm" EBOV in normal human cells. By deleting VP30, one of Ebola's seven structural genes, researchers have been able to create a strain of EBOV virus that is only able to replicate in cells which themselves have been genetically modified to supply the missing gene. "Basically, we took one protein out of the viral genome and made a host cell line which has the protein incorporated into its genome," Halfmann says.

To accomplish this, researchers modified cDNA sequences recovered from EBOV. cDNA is obtained by artificially constructing the complementary strand of the virus' RNA. This cDNA can then be extracted, modified and eventually re-introduced into the virus. This process is favorable because any RNA extracted has already undergone any modifications that occur after transcription from the main strand. As such, the RNA is in its final form, free of non-coding regions and able to code directly to proteins. Additionally, the techniques used to do genome sequencing during development of the new virus can only be performed on DNA.

> **"Basically, we took one protein out of the viral genome and made a host cell line which has the protein incorporated into its genome."**
>
> **-Peter Halfmann**

Aside from its inability to replicate, the VP30-deficient virus looks and acts identically to the wild EBOV. It exhibits the same morphology as Ebola and expresses the other six of its genes, making it a perfect candidate for study in lower biosafety-level labs. When given the VP30 gene and allowed to grow, the new virus even exhibits the same replication behavior as the wild virus.

The modified EBOV has shown huge promise as a basis for a vaccine as well. Though there is currently a vaccine in testing, it doesn't directly incorporate EBOV genome. Vaccines of this nature introduce safety concerns and other complexities. A vaccine using fragments of the actual virus' genome has the potential to be much safer.

"This [vaccine] expresses the authentic EBOV. It looks like Ebola [and] has all the genes; it just won't replicate," Halfmann says.

In order to replicate the VP30-deficient virus, a genetically-modified host had to be developed. Researchers inserted the genetic sequence for VP30 into a living cell's DNA. This gave the cell the ability to create its own VP30 gene. The modified EBOV could survive and replicate in these modified host cells but in not in others.

Of particular concern to researchers is the genetic stability of the new virus. Though the genome is stable, once the VP30-less virus is introduced to a host that has been engineered to produce the VP30 gene, there is a possibility that the host cell's VP30 genetic sequence could recombine into the virus' RNA sequence, rendering a fully-functional, hazardous EBOV.

Halfmann says that there is "no sequence similarity for recombination to occur" and that "there is no selective pressure toward having a virus with the VP30 gene." In short, the biological state in which the virus is developed doesn't provide a favorable environment for recombination. Preliminary tests allowing the virus to go through a handful of generations have shown that the virus' RNA replicates without error and the genome is thus stable.

While much more research must be done before the genetically-modified EBOV can be studied in lower biosafety-level labs, it appears that a slew of new possibilities are on the horizon. WE

Author bio: James Kadunc is a sophomore majoring in chemical engineering and economics.

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The New Rock Stars

Photo by Tom Moran

Making big noise on campus

By Carrie Boecher

As snow falls heavily outside, UW-Madison senior Erik Sua sits on his living room couch, fixing the broken pedal of his bass drum. After the screws are tightened and the pedal is repaired, he's ready to start the jam session. Sua tosses a microphone to his friend Keri, hands me a guitar and before you know it, we're rocking out to "Say it Ain't So," by Weezer.

We're not an aspiring garage band running through our favorite 90s hits; we're just playing "Rock Band," an interactive musical video game. In the game, players imitate actual musicians by playing instrument-shaped controllers, including drums, guitar, bass guitar and vocals. Released last fall, "Rock Band" is very similar to its older sister game, "Guitar Hero," except that "Guitar Hero" has only guitar parts. In both games, colored bars that stream across the screen indicate which notes to play and when to play them, requiring players to have good hand-eye coordination, timing and dexterity. Real musical talent, however, is optional. As Sua says, "Playing 'Rock Band' will make anyone think they can sing."

Photo by Tom Moran

Both games feature controllers modeled after Gibson guitars.

"Rock Band" and the recently released "Guitar Hero III" are huge hits on college campuses…

"Rock Band" and the recently released "Guitar Hero III" are huge hits on college campuses—and not just among traditional "gamers." The unique style of interactive play appeals to nontraditional video game players as well. According to Sua, the final push for him to buy the game came from the idea that he could get his introverted friends to sing in front of others. Though both games are similar in play, "Rock Band" tends to be a "better party game" because it incorporates more players and more instruments.

"Rock Band" is more or less an expansion of "Guitar Hero," sharing the parent company Harmonix, under which "Guitar Hero I" and "II" were released. Last year, however, the "Guitar Hero" name was bought out by Activision Inc., which then released "Guitar Hero III" in competition with "Rock Band" last fall. Despite shifting ownership, neither game has strayed much from the format introduced in the previous versions of "Guitar Hero," including similar controls, set-up and mode of play.

The changes that have been made, though, reflect the blurring lines between the music industry and the video game industry. After the first two "Guitar Hero" games grossed over $360 million, record companies finally recognized the potential of these games to help salvage plummeting record sales. While the songs on "Guitar Hero I" and "II" were almost exclusively covers of famous rock songs, "Guitar Hero III" and "Rock Band" feature nearly all original recordings licensed by the record companies, with artists ranging from the Rolling Stones to the Yeah Yeah Yeahs. Furthermore, Metallica, a group who has been especially vocal against illegal file sharing in the past, will debut a new song on the next version of "Rock Band."

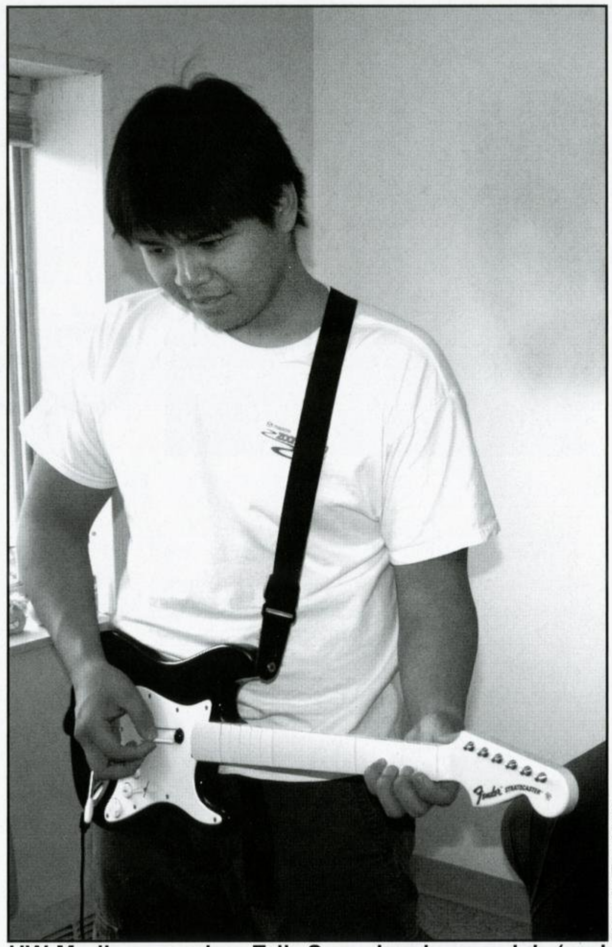


Photo by Tom Moran

UW-Madison senior, Erik Sua, develops quick (and sore) fingers through a healthy dose of "Rock Band."

Another key factor that influences the soundtracks is each game's emphasized style. According to UW-Madison sophomore Jon-Erik Jepson, "'Guitar Hero III' places more emphasis on rhythm guitar instead of lead guitar," meaning fewer face-melting solos and more melodic jams. For Jepson, "Guitar Hero II" features the best songs, which makes it his favorite version of the game.

"The song selection definitely affects how much I like the game, seeing as 'Guitar Hero I,' 'II' and 'III' are basically the same exact game except for the songs on them."

Similarly, Sua says that the multi-instrumental format of "Rock Band" has led to songs with "sections that emphasize vocals more, or bass guitar, or drums," rather than just guitar. This allows for a greater range of songs, making up what Sua considers a "more enjoyable song selection" than the "Guitar Hero" games.

If players are looking for more songs, they'll find them available online. For "Rock Band," the songs are around $1.99 each to download, as are "Guitar Hero" songs, although actual prices can vary. It may not seem like much, but the costs can add up quickly for avid fans of the game.

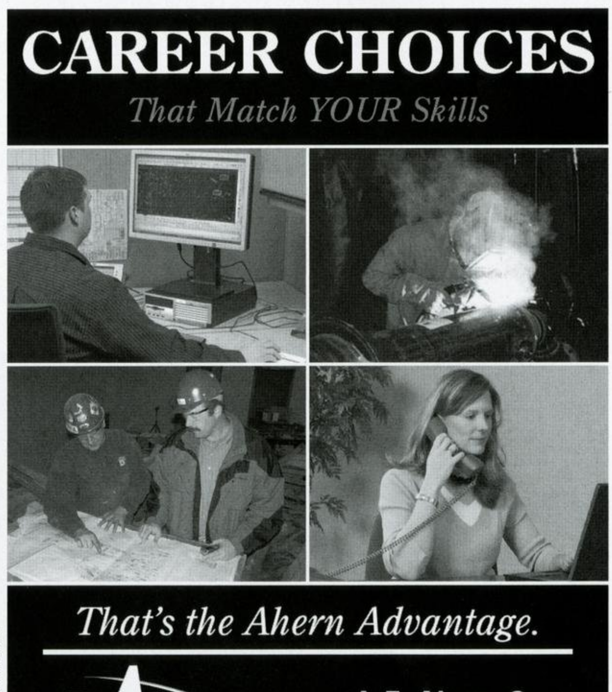
"The songs can get pricey to download," Sua says, adding that he'd like to see more affordable choices with the next version of "Rock Band." Jepson agrees and says that a larger database of songs would be convenient.

Until new versions are released, however, Sua, Jepson and other college students around America are content with current versions of "Rock Band" and "Guitar Hero." Living the life of a rock star from the comfort of a dorm room has never been so easy or so fun. But students who play the game better watch their habits; as Jepson jokes, "Above all, 'Guitar Hero' is a great way to waste time." WE

Auhor bio: Carrie Boecher is a sophomore majoring in civil and environmental engineering.


Photo by Tom Moran

Drums are one of the features differentiating "Rock Band" from "Guitar Hero."



Capability through Collaboration

By Karl Chan

The partnership began in 2002 when General Motors (GM) agreed to fund a $5 million Collaborative Research Laboratory (CRL) at UW-Madison. The Engine Research Center (ERC) will use part of its funding to conduct extensive modeling of diesel exhaust after-treatment systems and diesel particulate emission traps; in other words, they seek to advance new combustion technologies through development and application of advanced experimental diagnostics and simulation tools provided by the ERC.

"UW-Madison is uniquely positioned for this because of our experimental and computational capabilities," David Foster, Phil and Jean Myers Professor and co-director of the GM-ERC CRL, says.

This is a great opportunity and honor for UW-Madison, since the ERC is one of only seven laboratories to partner with General Motors. The other universities include Brown, Michigan, Carnegie-Mellon, Stanford, Jiao Tong in Shanghai, China and the Indian Institute of Science in Bangalore, India.

"We're pleased that General Motors has chosen our Engine Research Center to become its latest collaborative research laboratory," Paul Peercy, dean of the college of engineering, says. "... this partnership with General Motors will continue that tradition of cutting-edge research and technology transfer."

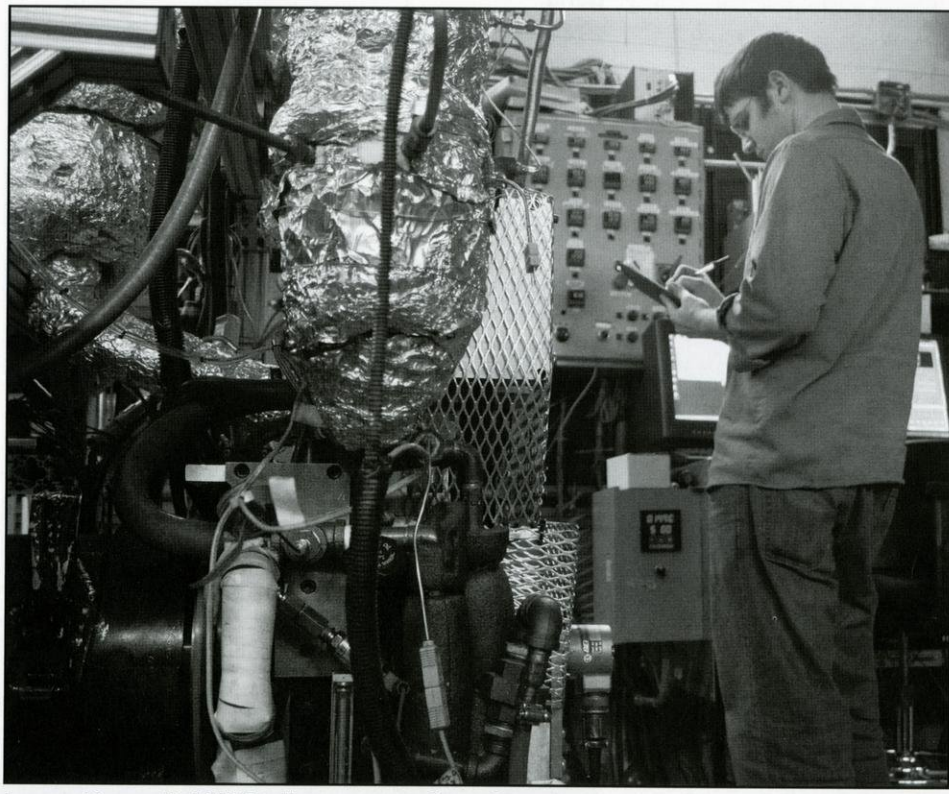


Photo by Harley Hutchins

James Krasselt, UW-Madison research assistant, monitors gauges on the laser diagnostic research engine as it warms up.

"It has been a tremendously productive collaboration."

-Professor Foster

The collaboration focuses on five research areas, one of which is after-treatment—cleaning exhaust once it leaves the engine through the use of catalytic converters and filters. Among other CRL projects are low-emission, high-efficiency combustion schemes for gasoline and diesel fuels, computer simulations of low-temperature diesel combustion, improved fluid-dynamics models for turbulence and combustion modeling, and increased understanding of near-nozzle spray processes.

One of the highlights from these five research areas is diesel low-temperature combustion. This idea features high synergistic activities in fundamental research experiments, laser diagnostics and high-level simulation experiments among UW-Madison, GM and the combustion research facility labs in Sandia. This research focuses on different modes of combustion, in which the fuel and air is pre-mixed to auto-ignite when injected into the engine.

"If the required conditions in the engine are met, the emissions of nitrogen oxides and particulates could be well below the most stringent regulations that exist so no after-treatment would be needed at all," Foster says.

Using fundamental understanding of the engine system, Foster and his team developed sub-programs, which can be incorporated into a GM analysis program to generate predictions of how the engine works. Together with experimental results from the Sandia labs, the team can compare the data and enhance further knowledge of the engineering model regarding low-temperature diesel combustion. "It has been a tremendously productive collaboration," Foster says.

According to Foster, one of the benefits of this partnership is that, through the CRL, GM and the ERC have been able to address the differences in culture between academia and industry, as well as forge a mutually beneficial research relationship. GM researchers, with the ERC students and staff, interact and exchange ideas through web conferences and frequent visits; students also have opportunities to do research in GM residence, where they can interact with technical staff at the company on a day-to-day basis.

All in all, the project has been able to put students' thesis work into a context that can address problems relevant to GM, creating a plethora post-graduate opportunities. WE

Author bio: Karl Chan, from Hong Kong, is a freshman studying chemical engineering. This is his first semester writing for the magazine.

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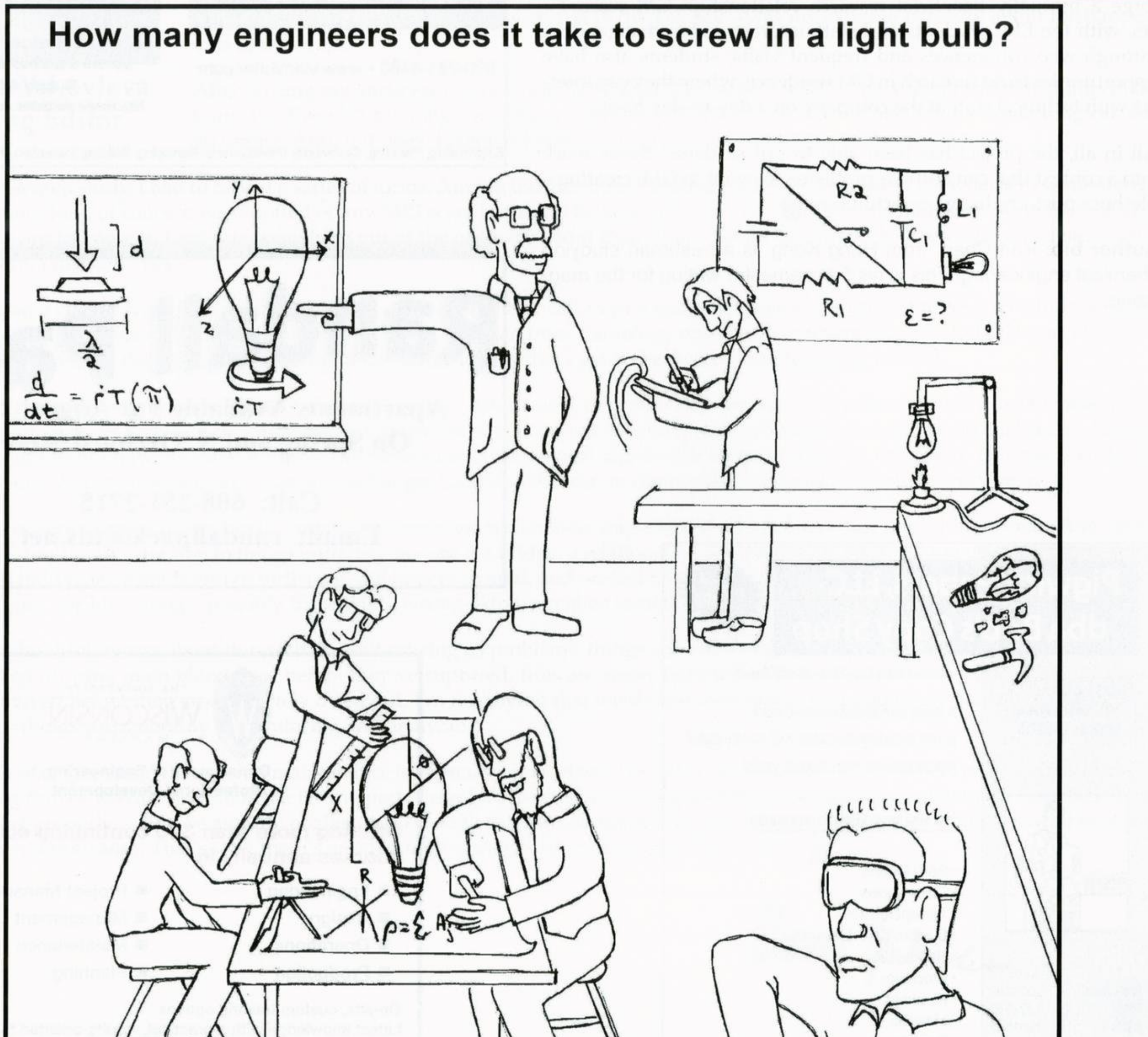

By Sam Sinozich

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