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wisconsin engineer

NOVEMBER 2007 VOLUME 112, NUMBER 1

Beyond ethanol

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wisconsin engineer

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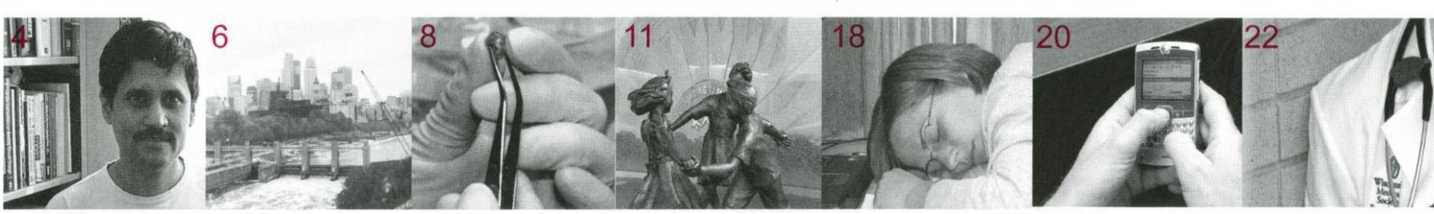
COVER STORY

Photo by Matson Contardo

FEATURES



COMMENTARY

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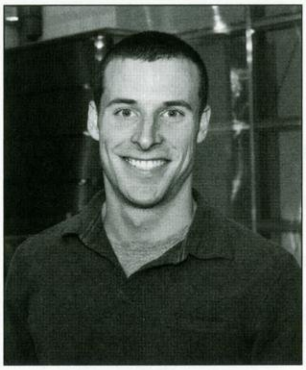

Marty Grasse
Writing Editor

Reflecting on catastrophe:
Implications for engineering

It was 6 p.m. in Minneapolis. I had finished a day of work at my internship and just completed the final exam of my night class at the University of Minnesota. I was feeling pretty good—until I walked outside and onto a disaster scene. Just three blocks away, the Interstate 35W bridge had collapsed into the Mississippi River. The collapse occurred during rush hour on August 1, and the bridge—my usual route home—had been lined with cars. Cell phone service was out, so I walked around gathering details about what had just happened in bits and pieces from panicked pedestrians.

Unable to get my car out of the parking lot and with nowhere else to go, I made my way along the river, searching for a route to walk back to the east bank and towards my apartment. I finally found an open bridge, and a clear vantage point of the wreckage that had been a major artery of the city. Rescuers frantically used boats and helicopters to help those on the bridge and in the water. As I stood and watched, I felt a chill. *Engineers designed this.*

The cause of the collapse will undoubtedly be under investigation for years to come. It could have been anything from normal wear to a combination of perfect loading and freak vibrations. It could have also been an engineering error.

This semester, I will finish my degree at UW-Madison and begin a career as an engineer. Amidst my excitement to launch this new chapter of my life, it is sobering to realize that engineers' work is so much more than solving problems and designing new technology. What engineers do can greatly enhance life for many people. However, slight miscalculations and unforeseen influences can turn a "perfectly" designed product into a failure. More than that—and what really struck close to home for me—a design failure is no longer just a few points off the grade for a school project, it can affect the safety and wellbeing of real people, even impact entire cities.

Engineering is an enormous responsibility. Whether evaluating bridge failures (see page 6), formulating alternative fuel sources (see page 14) or brainstorming novel medical treatments (see page 8) engineers need to be mindful of their duty to society. The National Society of Professional Engineers maintains an engineering code of ethics. The first point of this code, I believe, says it all. It reads:

"Hold paramount the safety, health, and welfare of the public."

Like all graduates of UW-Madison, I know that there is something special about this university. I cannot imagine spending the last four (and a half) years anywhere else. This place, along with the people with whom I have shared my time here, has challenged me and changed me in ways that I never imagined possible. As I reflect on my preparedness to enter the ranks of engineers, I am thankful that UW-Madison has equipped me, and my fellow graduates, with the requisite knowledge and skills. But perhaps more importantly, I appreciate that my experience here has made me mindful of the societal responsibility that I take on when I accept a job in engineering. This mindfulness is something that I hope to carry with me throughout my career.

Thanks for reading and On Wisconsin. WE

COLLEGE OF ENGINEERING
UNIVERSITY OF WISCONSIN-MADISON

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Traveling with the Wind

Courtesy of windpowersavings.com

By Zachary Prefontaine

Giri Venkataramanan, UW-Madison professor of electrical and computer engineering, has recently returned from a sabbatical. His experiences abroad will influence new programs and classes on and off the UW-Madison campus.

Sabbaticals are scholarly activities that professors participate in to help perform research, develop new courses and curriculum or enhance their teaching abilities in their field of expertise. Influenced by the movie "Motorcycle Diaries," Venkataramanan originally intended to travel to South America on a motorcycle, but this plan did not work out. Instead, he decided to take a different path.

"I wanted to plan something that is meaningful, that will allow me to do something I have not done before," he says. "I put a plan together of my own, focusing on wind turbine generators and how to bring them into the college education."

His ultimate goal was to learn how to build a wind turbine and use this knowledge to create new courses about wind-turbine theory and, most importantly, have students learn how to build them through hands-on experience.

Venkataramanan's first stop was a little village in Scotland that was, at the time, off the power grid. Citizens there were forced to find a way to generate their own electricity. Wind turbines—machines that utilize the power of wind to generate electricity—are very popular in the village, and many of the villagers have made their own. The homemade wind turbines are scaled-down versions of the very large turbines people typically see. The 30 to 40 houses in the village used a combination of solar power and wind turbines to power their homes.

At the beginning of every summer, a wind turbine designer with 30 years of experience puts on a workshop teaching the villagers how to build the turbines out of wood and metal. Venkataramanan's trip allowed him the opportunity to take part in this workshop where he learned information he could use to teach students at UW-Madison the same skills. He worked with the featured designer and learned about the tools, materials and knowledge he would need to build turbines on his own.

Venkataramanan's next stop was at the University of California-Berkeley, where he began to use what he learned in Scotland. He worked with a group of 10 students who volunteered time outside of class. The group met and worked on their wind turbine in a team member's garage off campus.

Desiring more practice with building wind turbines, Venkataramanan then traveled to Brazil and Turkey. In each country, he gathered small groups of students to teach them the trade. Venkataramanan was now

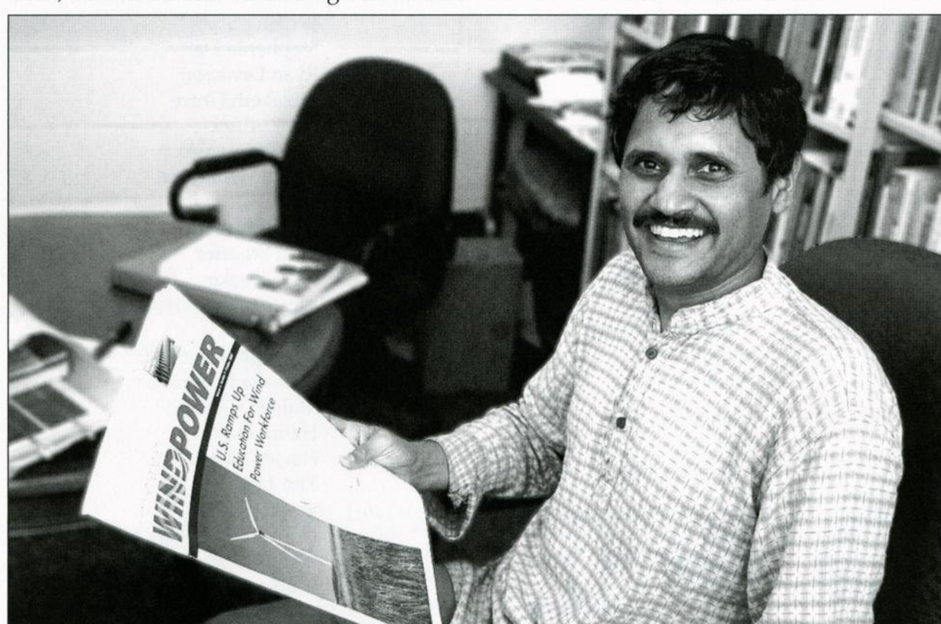


Photo by Ahmad Rosli

Professor Giri Venkataramanan has traveled all over the world to pursue his passion for modern wind turbine design. Upon returning to UW-Madison, Venkataramanan used his international knowledge of wind turbines to develop courses related to alternative energy.

starting to perfect the process of building the turbines, so he returned to UW-Madison inspired to create new classes and programs.

Venkataramanan's first big move on campus was leading two small groups of students in INTEREGR 160: "Intro to Engineering Design." He worked with each group every Monday night for three hours, producing two small wind turbines as he did in Scotland. As Venkataramanan had hoped, his efforts to spread his knowledge did not go unnoticed.

A technical communications group asked Venkataramanan if they could film part of every lab to air on the new Big 10 Network, which features academic material 90 minutes a week.

"I wanted to plan something that is meaningful, that will allow me to do something I have not done before ... I put a plan together of my own, focusing on wind turbine generators and how to bring them into the college education."

-Giri Venkataramanan

"This was one of the first non-sports programs they aired on the Big 10 Network," Venkataramanan says. He was very excited to know that his new knowledge was being spread to schools other than UW-Madison.

Today, building wind turbines is not Venkataramanan's only goal. He is currently seeking grants to start new courses that deal with the theoretical operation of a wind turbine as it will be a good compliment to learning about practical construction issues. He is also starting to plan out a new certificate program for the engineering curriculum called Engineering for Energy Sustainability. This certificate will give engineers a different way to specialize their major and will be a great opportunity for those concerned about energy issues.

In addition to his other exploits, Venkataramanan is writing a proposal for a program to build turbines off campus. His goal is to hold classes around the Madison area to attract high school graduates who did not go to college. The idea would be to get these individuals interested in a technical field and encourage them to continue their education past high school.

UW-Madison is glad to have Venkataramanan back on campus, and his curriculum improvements are sure to expand the education received by future UW-Madison engineers. WE

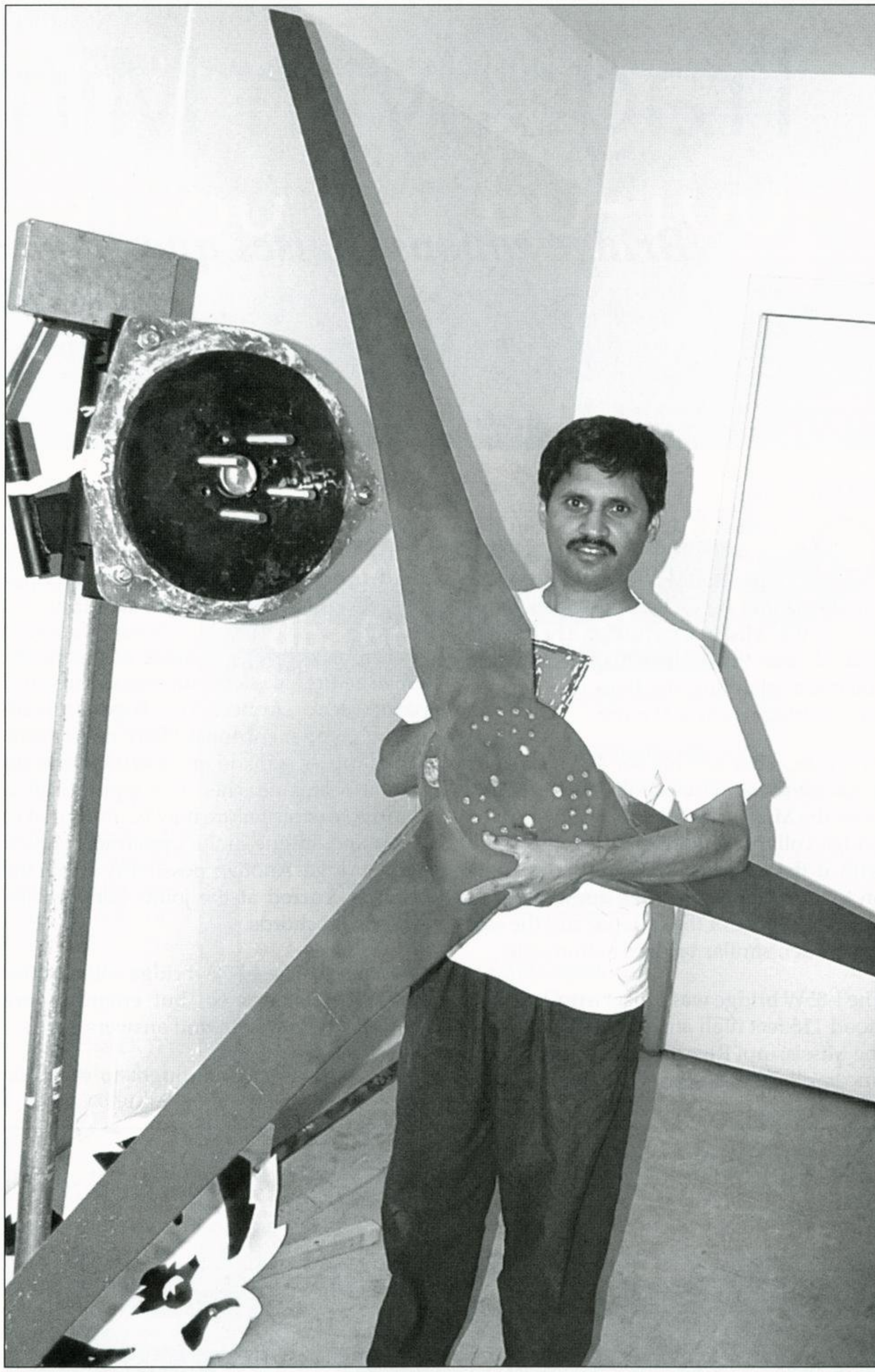


Photo by Ahmad Rosli

Along with a group of freshmen students from an introduction to engineering design class, Venkataramanan succeeded in building a wind turbine featuring UW-Madison mascot, Bucky Badger.

Author bio: Zachary Prefontaine is a third-year student studying nuclear engineering. This is his first semester writing for Wisconsin Engineer.

For more information and a video featuring Venkataramanan's work, go to: http://www.news.wisc.edu/13833

Tragedy in Minnesota

Bridge collapse raises questions about safety

By Matt Treske

On August 1, during peak-hour traffic, a section of the Interstate 35W bridge in downtown Minneapolis came crashing down into the murky waters of the Mississippi River. The bridge, located near the University of Minnesota, collapsed, claiming the lives of 13 people and injuring nearly 100 more.

At 6 p.m., after serving for 40 years as the main route for Minneapolis commuters to cross the Mississippi, the central span of the bridge collapsed. As it crashed, it brought with it the adjacent spans and everything on top. As the dust settled, questions arose about the cause of the collapse and the safety of other, similar bridges nationwide.

The I-35W bridge was a steel truss bridge. It stood 115 feet high and ran 1900 feet across the Mississippi River. Featuring a relatively uncomplicated design, truss bridges have been used in the United States for over 150 years. Their simplicity, efficiency and cheap construction cost have made them a popular style of bridge around the world.

A steel truss bridge is made of a concrete substructure, a steel superstructure and paved deck surface. The superstructure — the component most likely responsible for failure — is made up of vertical and diagonal beams attached to supports called chords. Possible failure may be attributed to stress and fatigue in the uppermost chords of the bridge. Another possibility is that the failure occurred at the joints between the beams and chords.

The cause of the I-35W bridge collapse has yet to be determined, but engineers are working diligently to find answers.

This catastrophe has brought to the table a host of questions from the average commuter. How is the safety of a bridge rated by engineers? How are funds distributed for bridge maintenance and repair? These issues have come under much public scrutiny since August 1.

Many bridges are classified as "structurally deficient," but the term's meaning is often unclear. It is used to describe a bridge's condition as it has weathered the elements over the years.

"Even though some of the numbers look frightening, they do not mean that the bridge is unsafe to drive on."

-Lawrence Bank

"'Structurally deficient' does not mean that a bridge is unsafe, but that some part of it needs to be repaired," Lawrence Bank, professor of civil engineering at UW-Madison, says.

Two rating systems are commonly used in determining whether or not a bridge is in need of replacement or repair. The first is the American Association of State Highway and Transportation Official's Guide for Commonly Recognized Structural Elements. It is a number-based ranking system in which a surveyor assigns the substructure, superstructure and deck a rating between one and nine. A score from 1-3 is a very poor rating and from 6-9 is an acceptable to excellent rating. Middle scores, however, are difficult to interpret.

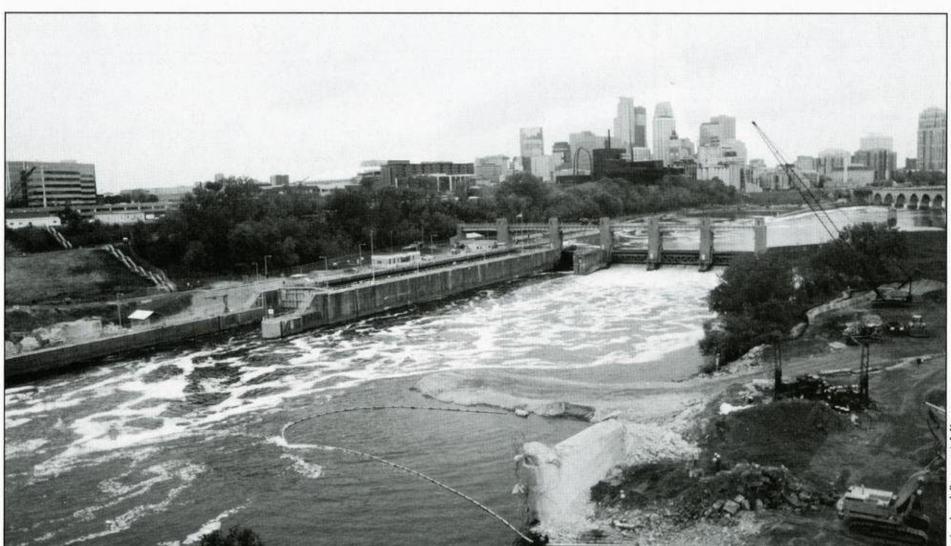


Photo by Vincent Mi

The I-35W bridge wreckage as seen from the adjacent 10th Avenue Bridge. Construction on a replacement bridge began in mid-November.

Department of Transportation Sufficiency Number

1-50	51-80	80-100
Bridges that fall into this category need immediate attention. Minnesota's I-35W Bridge was rated 50.	Bridges in this range are eligible to receive funds for improvements.	A rating in this range means a bridge is in good condition and requires no immediate attention.

If a section of the bridge scores a 4, then it must be repaired immediately. However, if it achieves a 5, it does not require immediate attention. Naturally, assigning a bridge either rating comes with enormous consequence. There is a fine line between a rating of 4 or 5, and it is often unclear which a bridge should receive.

Another, more precise, rating scale used in determining the integrity of a bridge is the Department of Transportation (DOT) Sufficiency Number. This rating gives a slightly more clear idea of a bridge's health.

The DOT Sufficiency Number is a rating from 1-100 describing the amount of deterioration on a bridge. A rating of 80 or above is a good rating and requires no immediate attention. If a bridge drops below a rating of 80, it is eligible to receive funds for rehabilitation. If a bridge drops below 50, it is in need of immediate repair. The I-35W Bridge had been given a DOT sufficiency number of 50.

There are also translation to action difficulties with the DOT Sufficiency Number as the rating does not explicitly state what kind of repairs are necessary or a time line for their completion.

"Even though some of the numbers look frightening, they do not mean that the bridge is unsafe to drive on," Bank says. The I-35W bridge's score of 50 may seem alarming at initial glance, but further research would explain that it was just the result of expected wear and tear.

"You could have a bridge rated below 50 on sufficiency and yet it is structurally sufficient. After this disaster in Minneapolis, I think we will rethink the way we refer to this," Bank says.

The collapse of the I-35W bridge in Minnesota has called attention to the perhaps abstruse way we rate the integrity of our nation's bridges. It may lead to changes or amendments in safety rating systems and a new definition of the term "structurally deficient." The catastrophe in Minneapolis will help our nation to better prioritize funding and rehabilitation efforts in maintaining our bridges and ensuring the safety of commuters. WE

Author bio: Matt Treske is a second year student at UW-Madison. This is his third semester with Wisconsin Engineer.

Keeping it simple

A new device developed at UW-Madison may lead to a safer, more effective treatment for aneurysms


Photo by Natasha Benkovich

Professor Kristyn Masters (right) and her research associate, Fangmin Xu, test out their aneurysm occlusion device inside a constructed blood vessel that simulates blood flow. This device is designed to block blood from entering the aneurysm while withstanding dynamic forces acting upon it.

By Victoria Yakovleva and Stephanie Dar

One morning, while making breakfast, you spill a little milk. To clean up the mess, you rip off tiny pieces of paper towel and place them on the puddle, one by one.

This inefficient process is similar to the current aneurysm treatment available for patients.

An aneurysm is a balloon-like dilatation in a blood vessel wall. This dilatation can form in any vessel throughout your body; however, Dr. Roham Moftakhar, chief resident in the UW-Madison neurological surgery department, is specifically concerned with cerebral aneurysms.

"These aneurysms take place because the [blood vessel] wall in your brain gets weakened, and it sort of blisters out, and when it blisters out there is a risk of rupture," Moftakhar says.

When an aneurysm ruptures, blood flows out into the area of the skull surrounding the brain. There's often quick onset of a headache—the worst headache of a person's life. Half the people with a ruptured aneurysm, Moftakhar says, never make it to the hospital—they die at home.

In the other half, the puncture is blocked off by clotted blood, thus containing the aneurysm. These patients can make it to the hospital in time for surgery.

However, the procedures that are currently used in the operating room, endovascular coiling and open surgery clipping, are often inefficient and unsafe.

Endovascular coiling involves "a bunch of wire [coils] that they just randomly shove into the aneurysm," Wendy Crone, professor of engineering physics at UW-Madison who partnered up with Moftakhar, says.

A catheter is a thin, hollow, flexible tube that is inserted through a blood vessel in the groin and guided through the venous system, with the help of an imaging technique called fluoroscopy. Small metal coils are then deposited through the catheter into the aneurysm to block off blood flow. This process can take anywhere from two to eight hours.

According to Kristyn Masters, professor of biomedical engineering at UW-Madison who later joined Moftakhar's team, the metal coils are about three times the diameter of a human hair. They are made out of Nitinol, a shape-memory alloy that can be treated to remember a specific shape. Even after being straightened for travel through the catheter, the coils return to the predetermined shape inside the aneurysm.

However, this procedure is relatively unsafe.

"Every time you introduce a new coil, it's more risk of death—more risk of complications—because it's essentially many procedures all in a row," Masters says.

Another risk of endovascular coiling is coil compaction, the result of blood flow pressure pushing the coils deeper into the aneurysm. According to Masters, 30 percent of aneurysms treated with endovascular coiling undergo coil compaction, which may "lead to enlargement or rupture of the aneurysm."

"[The method is also] really imprecise in terms of they don't even know how many coils they're going to use [and] how long it's going to take. It's just shove coils in there until it's full, and that's not how engineers like to do things," Masters says.

The other treatment available to block off blood flow to the aneurysm is open surgery clipping. This extravascular procedure involves removing a piece of the patient's skull, locating the aneurysm, then "clipping" it at the neck with a device similar to a metal clothespin. It takes about three to four hours to complete.

"When you have to approach from outside the blood vessel, especially somewhere as sensitive as your head, it's going to be really hard to be digging around and finding the aneurysm," Masters says.

Rather than resorting to the lesser of two evils, Moftakhar wanted to develop a less time-consuming and less hazardous treatment. Together with Crone and Masters, the team came up with the idea of a single coil opening up a polymer shell.

Consequently, clipping as an aneurysm treatment is being phased out.

Rather than resorting to the lesser of two evils, Moftakhar wanted to develop a less time-consuming and less hazardous treatment. Together with Crone and Masters, the team came up with the idea of a single coil opening up a polymer shell.

The Nitinol alloy is used to create a sturdy and compliant coil, which essentially inflates a balloon-like shell by aligning along its circumference.

The shell is composed of polyurethane, a biocompatible elastic material, and hyaluronic acid, a substance necessary for wound healing.

"People complain about their breast implants looking all funny and misshapen; it's because the body essentially came in and performed what's called a fibrotic response, which means it formed a scar around the implant. In that case, it was really bad; in this case, it's what we're trying to do. We want the body [to] form a scar around this [device] in order to wall off the aneurysm," Masters says.

This copolymer shell combined with the Nitinol coil frame results in a device that, as Moftakhar puts it, "blocks the aneurysm in one step."

It's also a much safer treatment. Using one coil as opposed to multiple coils decreases the chance of puncture. The risk of compaction also drastically decreases because the polymer surface in contact with the blood is very elastic and tailored to withstand blood flow pressure.

Large-scale tests of the device were performed to simulate the conditions it would need to withstand inside a cerebral aneurysm. These tests showed no blood entering the aneurysm and no compaction.

Before the device will be available in the operating room it has to undergo further testing. The team still needs to ensure that the device will become integrally connected with the surrounding tissue, Crone says.

Finally, the device needs to get approval from the Food and Drug Administration (FDA), which can sometimes take as long as 12 years.

"It's possible that some of the FDA hurdles will be overcome in that we're not including anything new in our material," Masters says.

The Nitinol coil is already an FDA approved material. The material for the shell, while newly developed in the laboratory, is a polymer of polyurethane and hyaluronic acid, both of which are approved.

When this device is fully approved, it will offer surgeons and patients a safer, more effective treatment option. Like the principle of Occam's razor states: the simplest solution tends to be the right one.

Author bios: Victoria is a sophomore studying biomedical engineering and Stephanie is a sophomore majoring in journalism and mass communications.

Photo by Natasha Benkovich

A close-up of the aneurysm occlusion device exhibits the internal coil structure that gives the polymer shell its shape.

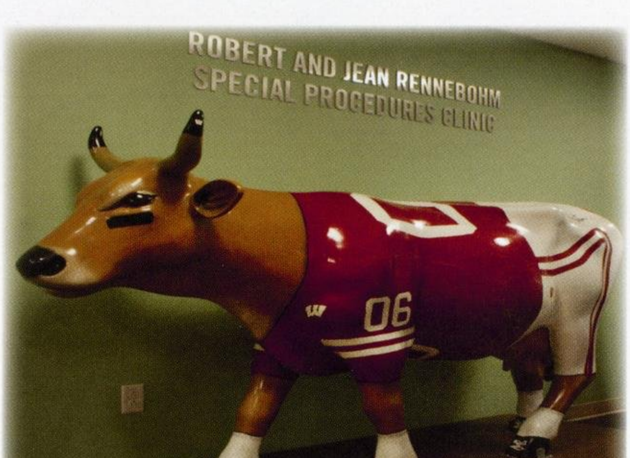
American Family Children's Hospital

Story by Elizabeth Grace
Photos by Anna Mielke

Madison has a brand new facility to provide top-notch healthcare for children. This fall, UW Hospital expanded to include the brand new American Family Children's Hospital (AFCH). After an initial flagship contribution from American Family Insurance, donations came from a variety of sources to fund the $78 million project, designed by HDR Architecture and built by J.H. Findorff & Son.

"This was a community effort to put this together," Jim Yehle, Findorff Project Manager, says.

A tour through the hospital reveals an "All Things Wisconsin" theme, from a cardinal-clad cow signed by head football coach Bret Bielema, to the familiar chairs of UW-Madison's Union Terrace.



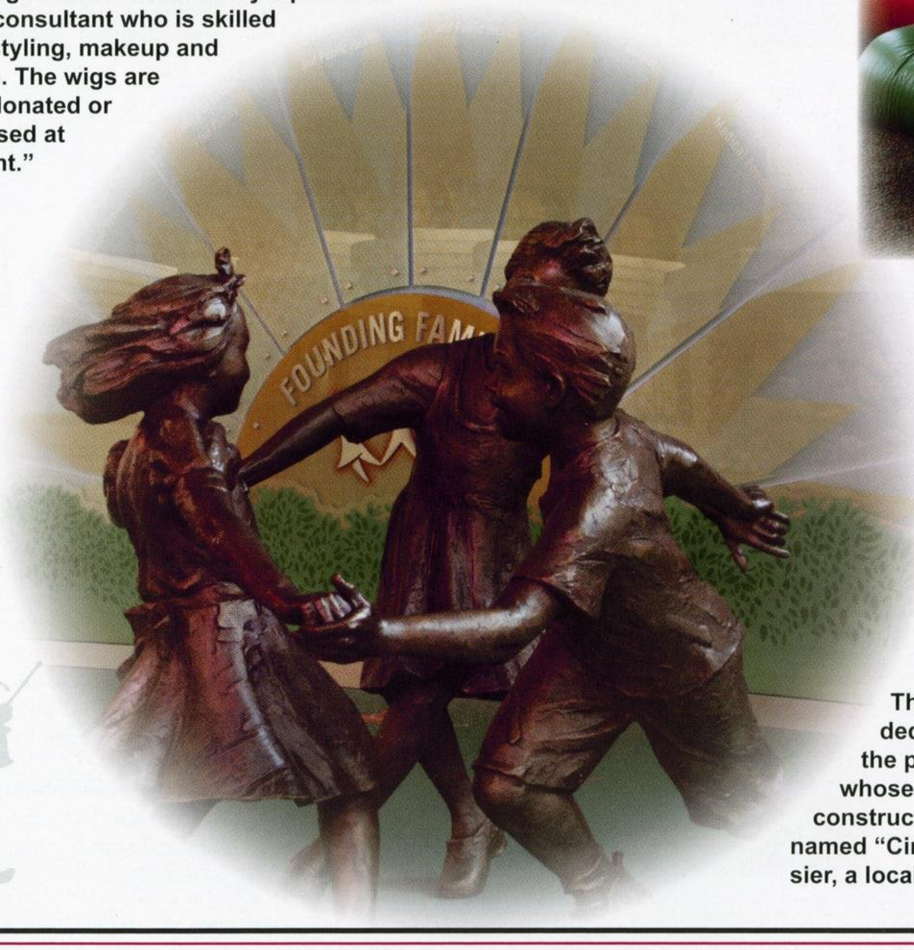
This world-class facility not only demonstrates the community's generosity towards children and UW-Madison, but it also marks a commitment to healthcare development and an improved quality of life for those in need of care.

For those who have not yet had the opportunity to visit the hospital, please enjoy a photo tour detailing several of the building's new features. WE

Author bio: Elizabeth Grace is a senior studying English and technical communication.

The AFCH is the first hospital to have an image center just for kids. According to Aaron Conklin, senior media consultant for UW Hospitals, "The Positive Image Center is staffed by a part-time image consultant who is skilled in hairstyling, makeup and fashion. The wigs are either donated or purchased at discount."

The fifth floor is home to the Hospital School where three full-time Madison school teachers tutor children who have to stay in the AFCH. This tutoring helps the children reintegrate themselves back into the school system upon hospital departure.

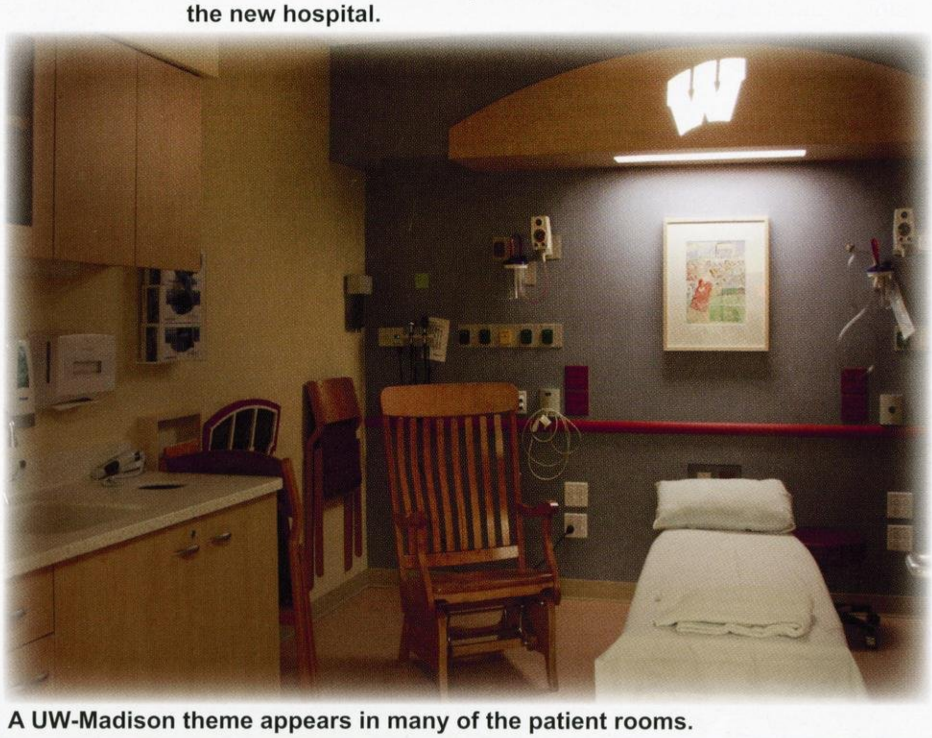


The hospital lobby has a display dedicated to the Founding Families — the private, public and corporate donors whose contributions significantly funded the construction. In front of the display is a statue named "Circle of Peace" donated by Jack Lussier, a local philanthropist.

The flashing marquee of the Pierce Family Theater is a prominent feature of the hospital lobby. Here, families can gather and watch movies on the big screen.

David and Jordan Wanner of Wanner Sculpture Studios designed this statue — a part of "The Gifts of Play," — as a gift from American Family Insurance to the new hospital.

The lobby of the AFCH has an "All Things Wisconsin" theme capturing the university's trademark Memorial Union Terrace chairs and vibrant fall colors.



A UW-Madison theme appears in many of the patient rooms.

Beyond Ethanol

UW-Madison researchers develop biomass-derived alternative fuel

By Matt Stauffer

Without question, finding alternative fuels for electricity production and transportation is one of the nation's top priorities. Consider fossil fuels: a non-renewable source of cheap fuel, which has been burned in the past few decades as if it were going out of style. A growing number of politicians and scientists think that using fossil fuels is in fact "out of style" and believe we should employ "greener" fuels to meet our energy demands. One such alternative is waste biomass — the leftovers from forestry and agriculture practices — to produce a feedstock of simple sugars which can be converted into liquid fuel. The United States Department of Energy (DOE) thinks that biomass has high potential as an alternative fuel and has contributed significant funds for further research in the area. In fact a bill was passed late this summer which allocated money to create three bioenergy research centers.

UW-Madison is the central location for the Great Lakes Bioenergy Research Center (GLBRC). The other locations are Oak Ridge National Labs in Oak Ridge, Tennessee and the Lawrence Berkeley National Lab in Berkeley, California. Each center is a collaboration of universities, national laboratories and private-sector businesses, all working towards the common goal of bringing biomass-derived fuel from the lab bench to the gas pump.

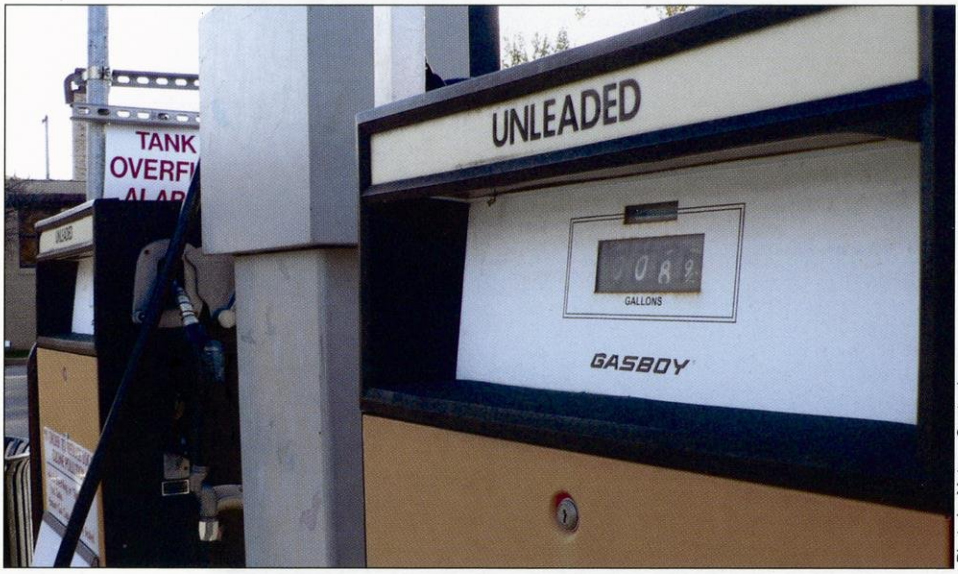


Photo by Matson Contardo

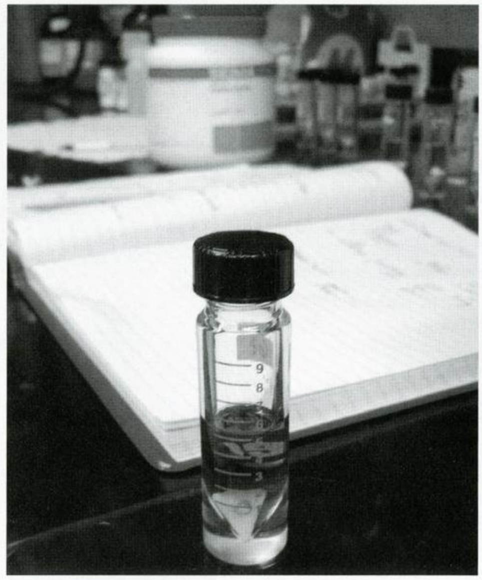
"If we could accomplish [the process of deriving ethanol from biomass], the consumer would not even know the difference. What you pumped into the tank would just be gasoline or diesel; you would never know where it came from," Dumesic says.

"The mission of the Great Lakes Bioenergy Research Center is grand but simple: we will remove bottlenecks that currently prevent us from realizing the promise of bioenergy as one way of reducing our dependency on fossil fuels," Tim Donohue, UW-Madison professor of bacteriology, says.

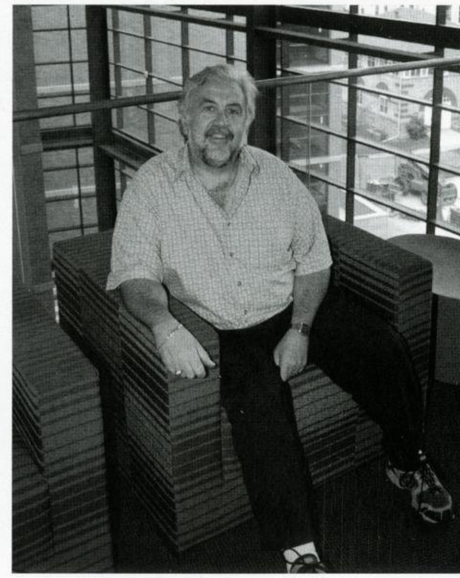
Donohue is currently acting as the GLBRC director. Donohue's role is to be a direct connection between partners within the agency and the DOE to ensure that the research priorities are aligned with the federal government's objective, which is to convert plant biomass into liquid fuel. Donohue's second role is to oversee the scientific aspect of all the partners and institutions involved in the GLBRC. He aims to ensure that everyone is working in a coordinated way to make the best use of each organization's strengths. With so many entities contributing to this project, communication is critical. Good communication will ensure that technologies and resources are shared in a synergistic fashion to give this project its best shot at success.

The biggest hurdle in converting plant biomass to liquid fuel is the conversion of cellulose to simple sugars. Every year more than 1.3 billion tons of biomass cellulose is disposed of as waste. Cellulose is a polymer of sugars which is resistant to chemical, enzymatic and temperature degradation. This means that the compound cannot be readily broken down into its component simple sugars. According to Donohue, if a process was available to convert 1 billion tons of biomass cellulose into simple sugars, there would be enough feedstock for ethanol production to offset nearly 30 percent of imported petroleum-derived fuel.

The future use of biomass as a potential fuel source will dramatically influence rural landscape as production becomes commercial.



Dimethyl furan, or DMF, is used by the UW Catalysis Research Lab as a catalyst to convert simple sugars such as D-fructose into long-chain hydrocarbons.



Photos by Matson Contardo

Tim Donohue, GLBRC director and professor of bacteriology at UW-Madison.

The ethanol we use today comes from simple sugars in corn kernels. Therefore, the process of deriving ethanol leaves the corn cob and stalk as unusable biomass. One major goal of the GLBRC is to figure out how to break down cellulose, releasing the simple sugars to be used as the feedstock for liquid fuel. This will be accomplished either by breeding plants with a cellulose polymer, that is easier to degrade, or by deriving a new process that effectively breaks down cellulose.

"There is a lot of interest now to focus on ethanol as the end product, because we know how to make it. We have been making ethanol from sugars for hundreds of years. We make a lot of it in Milwaukee and in St. Louis," Donohue says.

There are many groups on campus and around the country who are working to make the fermentation process more efficient on a large scale, but ethanol has intrinsic properties which make it a less-than-ideal transportation fuel. First, ethanol has a lower energy value than gasoline. This translates to fewer miles per gallon when used in automobiles. Also, ethanol is a polar molecule and readily dissolves in water. Water present in the fuel further degrades its energy value.

While most of the biological communities work on producing ethanol, James Dumesic, UW-Madison professor of chemical and biological engineering, and his team in the catalyst community are looking at using catalysts for converting biomass to liquid fuel in forms other than ethanol. One such fuel that they've derived is dimethyl furan (DMF). This research was published in Nature on June 21 of this year. DMF is a molecule that is similar to ethanol in that it contains oxygen and can be used as a fuel additive; but it has a 40 percent higher energy content and is non-polar, so it separates from water.

Dumesic and his team are trying to develop a process that can convert biomass-derived simple sugars into liquid alkanes ranging in length from 7 to 15 carbon atoms — the same composition as premium sulfur-free diesel fuel or gasoline.

"If we could accomplish that process, the consumer would not even know the difference. What you pumped into the tank would just be gasoline or diesel, you would never know where it came from," Dumesic says.

> There is an inevitable give-and-take relationship between energy production and the environment.

The fuel source would not need to be specified at the pump, as with other alternative fuels like E85, because the characteristics of the fuels would be exactly the same. This research has been proven in the lab and, at press time, results had been submitted for publication in Green Chemistry.

The technologies used in this conversion of biomass-derived sugar into gasoline or diesel are about five years out. According to Dumesic, the major hurdle is taking this process to large-scale production. The catalyst currently used in the lab is expensive, and there is no indication of its working lifetime. If the catalyst is able to last for a long time, its cost will not be much of an issue; however, if the catalyst becomes contaminated and needs to be changed frequently the cost will fall on the consumer and likely block this technology from taking hold in the market.

Having a petrol-like liquid fuel seems to be the direction in which we are inevitably headed. Reasons such as national security, energy independence and global climate change all weigh heavily, and the push for a diverse and sustainable energy portfolio is gaining momentum.

"In less than 100 years we have used a significant portion of fossil fuels which took millions of years to form, and we are going to run out of these fuels sooner than later," Donohue says.

Since the year 2000, the U.S. has imported more than 12 billion barrels of oil. Numbers of oil barrels have been increasing for the past several decades. If we were to reach the bottom of the petroleum well or upset trade conditions, the U.S. as a nation would be in a very vulnerable position.

"From a state's perspective we would like to reduce our dependence on energy that comes from outside the state. The people of Wisconsin would like to be a cost-neutral energy state. Given the amount of forestry and agricultural land, there is no reason that we should not be energy-independent and cost neutral," Donohue says.

Beyond ethanol

(continued from page 15)

Furthermore, the scientific community seems to have reached the general consensus that we are in the midst of a massive global climate shift. Whether or not humans are the direct cause of this shift still sparks debate, but our means of producing power and fueling transportation do emit significant amounts of carbon dioxide, a known greenhouse gas.

"What we have done…is put a lot of old carbon into the atmosphere. As we start to use plant material, we are also going to be converting that into carbon, but it will be new carbon which was fixed in the last year's growing cycle," Donahue says.

By relying on biomass-derived fuel, we will theoretically reduce the amount of old carbon released into the atmosphere, potentially stifling the negative effect burning fossil fuels has on the atmosphere.

The GLBRC will consider technologies which are economically viable and environmentally sustainable. Both aspects are of equal importance.

"We are very interested in developing technologies which will work on the land in the long run. We do not want to produce new breeds of plants or new agriculture practices that prevent the land from being able to sustain farming because then we will have created a larger problem than we have solved," Donohue says.

There are many issues to consider before rolling out technologies such as those that the GLRBC will generate. Also, scaling the technologies to the level which will be needed to make up a significant portion of our liquid fuel demand will be complicated. There is an inevitable give-and-take relationship between energy production and the environment, and careful thought and foresight must be used with any new technology.

"The DOE realizes that we are embarking on a long-term mission. Like the mission we embarked on in the 60's to send a man to the moon and in the 80's when we said we wanted to sequence the human genome—we are part of a grand scientific mission," Donahue says.

It is understood that this is a massive undertaking and the DOE does not expect to see an immediate solution. They do, however, expect that the funds provided will produce certain deliverable products and processes which will aid the cause. The DOE will evaluate the progress of the GLBRC based on yearly deliverables, at which point they will determine the subsequent year's funding. These are critical to the future of the GLBRC as they will be a way for elected officials to see what the program has accomplished and where it is headed. This is a large investment and there is no way politicians can micromanage the center. Deliverables will give the annual feedback needed for politicians to justify the cost to their taxpaying constituents.

Through the joint effort of many people working towards a secure and sustainable energy future, it is not hard to imagine that the wasteful consumption of fossil fuels will be soon out of style and a thing of the past.

"For every gallon of fossil fuels we don't use, that is one less gallon we have to worry about replacing," Donohue says. WE

Author bio: Matt Stauffer is a fourth year student in materials science engineering and a force to be reckoned with on the ping-pong table.

Digging

By Ryan Denissen

In February 2002, Chronic Wasting Disease (CWD) exploded into headlines as the Wisconsin Department of Natural Resources tried desperately to contain it. Since then, the number of infected deer multiplied and spread across Wisconsin. Five years later, deer have continued to test positive across most of the southern portion of Wisconsin.

How is this disease able to spread between animals so efficiently? A team of UW-Madison researchers has found that the agent responsible for diseases such as CWD and Mad Cow Disease can bind to soil particles, allowing it to remain in the environment for many years. In addition to increasing longevity, the binding also makes the agent far more infective. When bound to soil, there is a higher probability of infection.

This disease-causing agent is actually an abnormal protein, termed a prion. These prions are responsible for diseases such as CWD, Mad Cow disease and scrapie in sheep. The disease primarily targets the brain and spreads from there.

"There is an interaction between the abnormal form of the protein, that all of us have with the infection associated form of the protein and that somehow that interaction results in conversion… creating more abnormal proteins," Judd Aiken, UW-Madison professor of veterinary medicine, says.

The prion has a very different structure from that of normal proteins. As the disease progresses, this structure change literally opens holes in the animal's brain. These prions also "have a tendency to clump into a cluster of proteins," Aiken says. The growing cluster of these prions is eventually fatal to the infected animal.

Prions can also be easily transmitted orally from one animal to another. The disease can spread when an infected animal interacts with a healthy one. Scientists have also known for decades that prions are capable of surviving in the environment.

"There have been deer studies in Colorado where they place healthy deer in pens that once held infected deer, and those deer came down with the disease," Aiken says.

for answers

In the interest of determining how an environment could be infected, Aiken and Joel Pedersen, UW-Madison professors of soil science, formed a partnership to determine what was happening to the prion when it reached the soil.

"Is that infectious agent filtering through the soil, or is it staying up on the soil potentially as a source of infection for other animals?" Aiken says.

Photo by Noor Asyikin Che Mat Rosli

Chris Johnson prepares a soil sample that will be bound with disease-causing prions.

As the team began to investigate, they found that when soil and prions are mixed, a bond is formed between the two. The prions bind to the soil on their own, without the use of a catalyst.

"We were surprised by the avidity with which they bind to the soil," Chris Johnson, a lab assistant for the project, says.

The bond formed between the soil and the prions is so strong that it is very difficult to separate them after bonding.

The team has found that prions are capable of binding to virtually any type of soil. They tested clay, silt, sand and three different organic top soils. The results demonstrate that the prions are capable of binding to clay soils with small particle sizes, up to large particle size soils such as sand.

"This binding was so tight that I originally thought—wrongly—that the bound material would not be as infectious... and I was completely wrong on that guess," Aiken says.

It turned out that the prions are far more infectious when they are bound to the soil.

"You bind it to clay and you end up with something that is 700 times more infectious," Aiken says.

This discovery may explain why the disease is so easily transferred from one animal to another. Even in a heavily infected area, the animals are exposed to very low levels of prions through the saliva of infected animals. In addition, according to Aiken, oral infection isn't a very efficient means of transmission. These facts have left many researchers puzzled at how the disease can spread so quickly and easily.

"We think this binding to soil is probably the answer," Aiken says. The soil in an infected area may serve as a catalyst that increases the chance of infection.

Pedersen and Aiken have not definitively determined why prions bound to soil are more infectious, but they have developed several plausible theories. The team believes that the prions can transfer from the gut to the body more easily when they are bound to soil. Aiken believes there may be some active transfer of the bound prion that does not exist when the prion is not bound to soil particles. Another possibility is the soil particle protects the prion as it moves through the animal's digestive system. Finally, it is possible that the protein aggregate gets broken into smaller pieces by the bound soil particles.

"If you have more pieces you have more infectious agent," Aiken says. Aiken admits that there is still much work to be done to fully understand this binding.

The team of researchers is just beginning to dig into the implications of these findings and find a definitive answer to how these diseases can spread so easily. They hope that through further research a treatment will be found that can prevent this binding, thereby limiting the transmissibility of prion-based diseases. WE

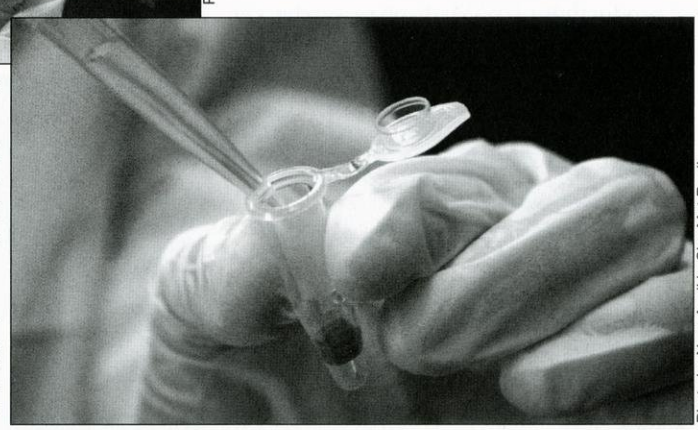


Photo by Noor Asyikin Che Mat Rosli

Author bio: Ryan Denissen is a senior majoring in mechanical engineering. This is his third article for Wisconsin Engineer.

Who needs sleep?

By Paul Kamenski and Debjit Roy

Sixteen credits translate to roughly three hours of lecture and discussion per day, plus 10 hours for homework and studying per day. Let us assume two hours are needed for daily personal activities leaving nine hours a day for glorious sleep. Wait! We still can not seem to get all our work done and somehow seem to have forgotten partying and racquetball in the calculation. How do we all manage?

Transcranial magnetic stimulation (TMS) may provide a solution. Consider achieving the benefit of eight hours worth of sleep in only a few hours, meaning a classic 16 hour waking day would turn into 21 hours of productivity. UW-Madison researchers at the Center for Sleep and Consciousness are working towards this Holy Grail by using TMS to understand the functions of sleep and address sleep-related issues.

Picture a person sleeping. Now, picture a coil of conducting wire encased in a plastic paddle placed directly over the person's head. Driving a pulsed current through the coil creates a changing magnetic field up to two Tesla (equivalent to the magnetic field strength of 400 refrigerator magnets) that lasts less than one millisecond. This noninvasive stimulation creates weak electric currents in the brain through electromagnetic induction. These currents can be targeted specifically in time and space, allowing researchers to stimulate very specific areas of the brain. UW-Madison is one of the first universities in the country to purchase commercially available TMS equipment that is coupled with an electroencephalogram (EEG) for brain activity monitoring. Now, researchers are using the TMS/EEG equipment to try to induce the brain to transition from light to deep sleep.

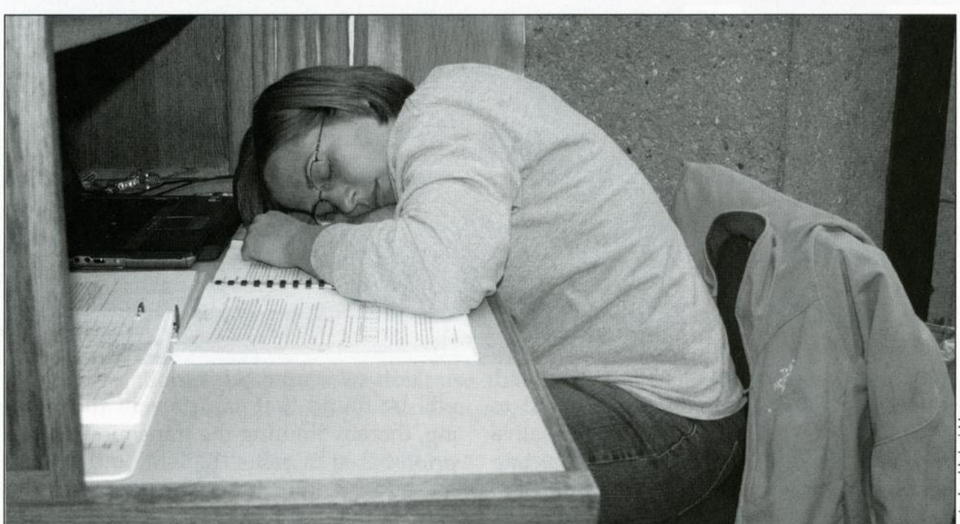


Photo by Helmi Hasan

Lianne Streng, a senior in chemical engineering, has probably not reached deep sleep as she naps. Researchers hope that transcranial magnetic stimulation may shorten the time needed to reach this restorative stage of sleep.

TMS is currently used in conjunction with high density electroencephalography (hd-EEG), a technique used to measure temporal and spatial electrical activity in the brain.

> "Deep sleep is needed to downscale the level of activity in the part of the brain that gets stressed the most in a day."
>
> -Steve Esser

"If we record the EEG after a TMS pulse, we can measure the spread of the activation and thus the ability of cortical areas to talk to each other," Marcello Massimini, research associate in the department of psychiatry, says.

Understanding this cause and effect relationship provides the basis for the great advances in many TMS applications. One may expect experiencing TMS to be painful; on the contrary, Massimini says, "The effect of the magnetic field and the induction of current in the brain are not painful." The UW-Madison Center for Sleep and Con-

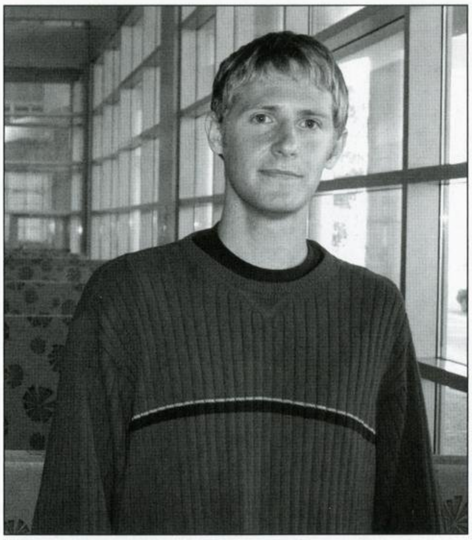


Photo by Helmi Hasan

Steve Esser, a graduate researcher, currently uses a computer modeling technique to gain a better understanding of how TMS affects neural circuits.

sciousness in the department of psychiatry is breaking new ground in the application of TMS for sleep enhancement.

"Deep sleep is needed to downscale the level of activity in the part of the brain that gets stressed the most in a day," Steve Esser, graduate researcher at the Center for Sleep and Consciousness, says. So far, the researchers at UW-Madison, using hd-EEG as a measure, have shown great efficacy in using state-of-the-art TMS to induce brain activity resembling natural deep sleep.

"[The] waves, triggered by TMS, were by all means identical to the ones that characterize the deepest stages of sleep. . . The fact is that we don't know yet whether these artificial slow waves can benefit or restore the brain," Massimini says. The research group is working to clarify this issue regarding the end-all effectiveness of "magnetic sleep" as a restorative, rejuvenating technique. TMS-induced deep sleep is exciting for all those looking to get more out of their day.

"The transition phase of sleep from mild sleep to deep sleep consumes about 50 percent of the time. This time can be reduced with the TMS deep sleep inducer," Fabio Ferrarelli, assistant researcher in the center, says. Tackling such a large and compelling research issue has necessitated the collaborative efforts of many researchers in the psychiatry department as well as the College of Engineering at UW-Madison.

"The simultaneous use of TMS and hd-EEG is challenging and has required the solution of several technical problems. A major one is the EEG artifact induced by the magnetic pulse," Massimini says. Electrical and biomedical engineers have worked hard to solve the issue of extremely high residual measurements in the hd-EEG coming from TMS. The standard circuitry in hd-EEG machines was not designed to handle the artificially large signals, "six orders of magnitude larger than the typical EEG signal," Massimini says.

Current advancements in this area of simultaneous TMS induction and hd-EEG measurement are allowing for unprecedented research and development in active electrical brain probing. In addition to the obvious benefits of sleep, this research could give researchers a better understanding of the brain and help people who are suffering from mental disorders.

Akin to the wealth of knowledge gained from relating the human genome to resultant attributes, probing and understanding the incredibly complicated network of neurons in the brain has clear, profound implications. Previous findings have already led to the use of TMS in treating a myriad of issues including depression, stroke rehabilitation, sleep disorders and auditory hallucinations. The research is especially relevant considering roughly one-third of the world's population at some point in their life goes through a period of mental disorder.

When asked if there are any plans for the commercialization of TMS, Massimini says, "not for now. If the magnetic slow waves clinical application can be envisaged." So, sleep lovers, take it in while you can, and for the restless, your time is coming soon.

As Benjamin Franklin said, "There will be sleeping enough in the grave." WE

Author bios: Paul Kamenski is a fourth year student in the materials science and engineering department. He is interested in pursuing a Ph.D. in materials science and engineering in the fall of 2008.

Debjit Roy is a second year Ph.D. student studying industrial and systems engineering and is a research assistant with the Center for Quick Response Manufacturing.

College of Engineering Nap Spot Checklist

- ❒ Union South lounge
- ❒ Booth in Engineering Hall
- ❒ Wendt conference room
- ❒ Engineering Mall lawn
- ❒ Cheney Lounge (E-Hall)
- ❒ B555 E-Hall (Unix Lab)
- ❒ Lecture of your choice

SUPER SMARTPHONES

A PC FOR YOUR POCKET!

Photo by Timothy Lam

By James Kadunc

Not long ago, phone calls came and went from a contraption on the wall in the kitchen. Today, corporations and consumers alike have the ability to keep themselves connected in an increasingly seamless manner. First came the 10-pound cellular phone and its now-humorous cousin, the car phone. These devices shrank in size and grew in power at an amazing rate over the last 15 years. Today, we see devices that fit neatly in our pocket and connect us to the world in ways we once only dreamed of.

Today's "mobile Internet devices" offer an Internet browser, e-mail client, messaging client and cellular phone rolled into a highly portable device that can comfortably fit into a pocket. Many more sport digital cameras, portable music players, remote access clients and voice recorders. Imagine every portable device on your desk duct taped together and compressed to the size of a deck of cards.

"...they always needed to have their workers in one location. These devices allow you to be outside the four walls of your building."

-Scott Converse

These devices, often called smartphones, allow businesses to communicate much faster and more efficiently. Scott Converse, director of technology programs for the executive education department of the UW-Madison School of Business, feels that the main reason businesses invest in outfitting employees with smartphones is that it allows functional communication regardless of location.

"One of the constraints organizations have had is that they always needed to have their workers in one location. These devices allow you to be outside the four walls of your building," Converse says.

With all this power in such a small package, manufacturers are having issues giving users a trouble-free interface, both on the hardware and software fronts. Converse believes the problem comes from the multitude of ways users need to interact with devices coupled with the fact that devices need to remain small enough to be portable.

"I have a Motorola Q. It's got an input device and a display. Both of them are too small for most people," Converse says.

Few manufacturers have addressed this issue. The Samsung i760 (as well as many other Samsung smartphones) has a keyboard that slides out from beneath the phone, allowing the device to have a larger screen without compromising portability. Apple took the high-tech route, integrating the keyboard with the display on its iPhone; the touch screen keyboard is only consuming device real estate when it's in use. Unfortunately, many smartphones use a very small, confusing keyboard and display.

Converse believes that manufacturers and service providers have not taken enough steps to bring this technology out of the realm of "obscure proprietary" and into mainstream acceptance. Smartphones use a variety of operating systems which plug into a heap of wireless technologies. No two providers offer the same service set, and no two phones implement these services in the same manner. This creates a headache for application developers who, in turn, need to account for the innumerable combinations of interfaces to implement their application with.

Oddly enough, this lack of a standard interface and implementation plan has temporarily solved an often overlooked aspect of these communication devices: security. With so many platforms to code against, hackers have been largely unsuccessful in developing anything malicious, though there have been instances of Bluetooth-distributed viruses directed at a specific operating system. As handheld operating system technology progresses, the need for actual security will increase.

Once smartphones play along, are proven secure and give customers a user-friendly experience, Converse believes their popularity with the average consumer will take off. Consumer-grade smartphones will (hopefully) seamlessly integrate the basic functions of our desktop computer into our pocket. E-mail, documents, instant messages and music from a home computer could, with little to no user interaction, synchronize with a future smartphone.

As with any flashy, buzzword-laden technology, smartphones are still slightly out of the price range of the average personal-use consumer. An entry level smartphone will set you back at least $100 and you can expect to pay up to $600 for something with serious power. This price barrier isn't likely to stop smartphones from hitting the pocket of the average consumer for much longer. The costs of cellular data and portable technology as a whole are constantly decreasing, so cellular providers could be literally giving smartphones away within 15 years. WE

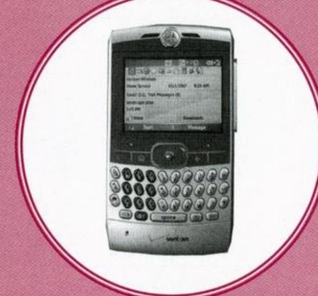
Author bio: James Kadunc is a sophomore majoring in chemical engineering and economics.

Photo by Timothy Lam

Today's "mobile Internet devices" offer an Internet browser, e-mail client, messaging client and cellular phone rolled into a highly portable device that can comfortably fit into a pocket.

Popular Smartphones

Here is a sampling of some popular smartphones. At about $400, these are no small investment, but the increases in productivity may be worth it.



Motorola Q

The Motorola Q runs Windows Mobile and offers a full QWERTY keyboard.

Blackberry Pearl

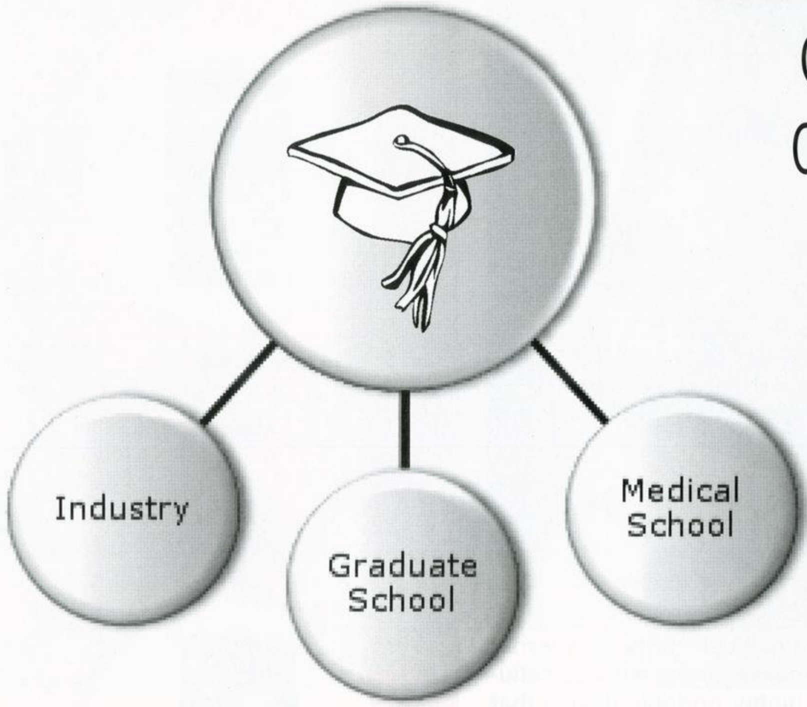
Featuring powerful, professional-grade e-mail and software, this is the phone to get if productivity is priority one.

iPhone

Chic and trendy, the Apple iPhone has won the hearts of casual users everywhere based on its multimedia capabilities and touch screen.

Ummmm.... now what?

Graduates of the UW-Madison College of Engineering discuss their post-graduate decisions



By Jaynie Sammons

Graduation is a word so heavily loaded with emotion it's nearly impossible to assign it a definition. As if choosing what college to attend and what major to complete wasn't enough, now we're expected to decide what to do after graduation.

When seeking advice about life after graduation, by far the most useful resources for advice are past graduates. Although they may seem intimidating, most College of Engineering graduates are more than willing to answer any questions an undergraduate might have.

An engineering degree from UW-Madison allows for plenty of options for post-graduate work. Three popular choices include going straight into industry, getting a masters degree and going on to medical school—all of which have their own set of advantages and disadvantages.

Choice One: Industry

Choosing to work right out of college is the most popular post-graduation decision. After four to five years of undergraduate study, most students are burnt out with academia and ready to jump head-on into the career they've worked hard to prepare for. With U.S. News ranking the UW-Madison College of Engineering thirteenth among all doctoral-granting institutions and seventh among public doctoral-granting universities, UW-Madison graduates appear very desirable to employers.

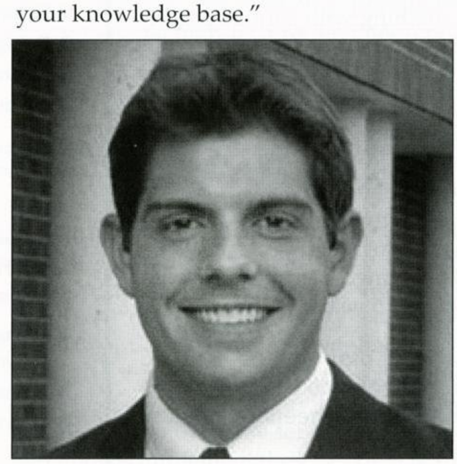
Dan Healy graduated with a degree in industrial and systems engineering in May of 2007 and is now working for General Electric Co. Consumer and Industrial in Louisville, Kentucky. As a business team leader and materials control specialist, he says that having a busy academic schedule as well as being involved in student organizations taught him time management skills that he now applies in his daily routine.

Healy interned with GE for three rotations (two internships and a co-op term).

"Co-ops and internships are great as far as work experience goes, but they are also fantastic opportunities to see how well you do living on your own, outside of a comfortable environment," Healy says.

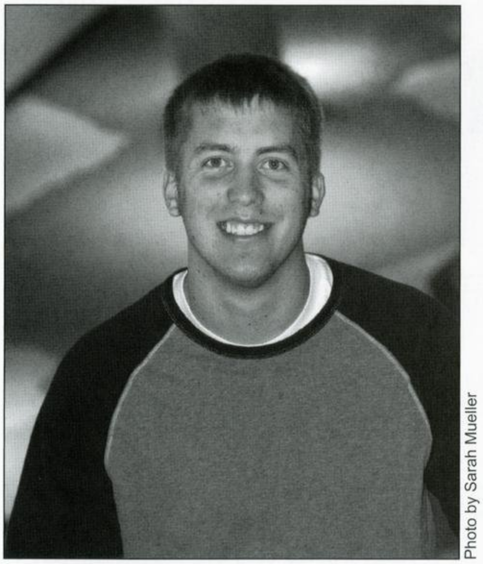
When asked if he regrets the decision to enter industry right out of college, Healy says he feels it was best for his future. "During my undergraduate career I was hesitant to attend grad school without first experiencing the different areas that I would be able to pursue as a graduate student."

As final word of advice for undergrads, Healy says, "Look for a company that is willing to give you a lot of experience and exposure. Personally, I feel that rotational programs where you have four to five jobs over a two- to three-year period are an excellent way to increase your skill set and your knowledge base."



Courtesy of Dan Healy

"Look for a company that is willing to give you a lot of experience and exposure," Dan Healy says.



"From here on in, it's pretty much only classes that you want to take," Matt Smith says of graduate school.

Choice Two: Graduate School

For the Bachelor of Science graduates that want to become more focused in a particular area, getting a Master of Science degree is an excellent option. There is also the added benefit of making more money, since you are considered more valuable and in possession of more specialized knowledge.

Matt Smith is a graduate student in the Medical Physics department with future plans to work in medical imaging. He graduated with a bachelor's degree in biomedical engineering and is now working on his master's degree. He says he made the decision to go on to graduate school during his junior year when he realized that he was not learning as much as he wanted to about his specific interests.

Graduate students typically take only 12 credits per semester, but vacant time is usually filled with research. Smith says he feels that graduate school is easier than undergrad, but this may be because he's taking classes focused in his specific area of interest.

"From here on in, it's pretty much only classes that you want to take," Smith says. "It's more of what you enjoy doing; if you didn't enjoy doing it, you wouldn't be in the graduate program."

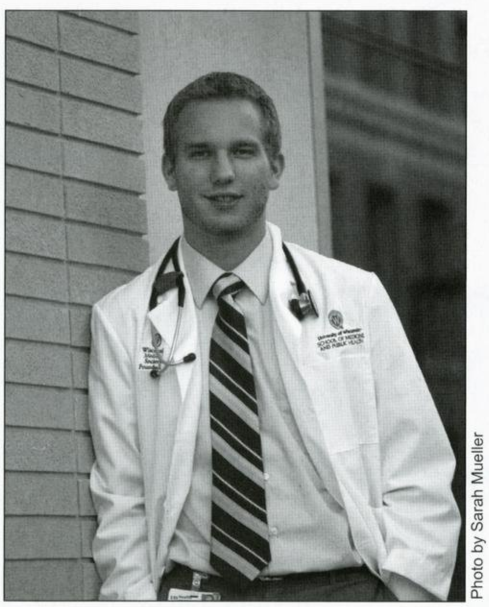
Smith says a part of him wishes he had gone on to work with a company directly out of college, but these feelings only stem from seeing his fellow graduates who are already settled down.

"Although, the farther you go in school, the more money you tend to make, so it will eventually even out. I'll start that life when I'm done, so I may as well get more school in now. As long as you're not burnt out, I would suggest grad school to anyone."

Smith's advice for students looking to go to grad school: "Keep in mind what the requirements are for grad school earlier on so you know what to shoot for…also, make sure you're going to (grad) school in something you enjoy. If you have to work every hour of the day you're not in class, but it's in something you enjoy doing, then it's not that bad."

Choice Three: Medical School

For some engineers, especially biomedical, attending medical school after graduation is a good next step. Medical schools look favorably on applicants with engineering backgrounds, because those students have unique premedical degrees which show that the student is willing to work hard.



"Even if you're set on, say, cardiothoracic surgery, you'll still have rotations in OBGYN, pediatrics, emergency medicine, dermatology, everything," Tony Wampole says, describing his future in medical school.

Tony Wampole is a first year medical student at UW-Madison. He was a biomedical engineer (BME) as an undergraduate and applied for early acceptance to medical school.

In order to get into medical school, Wampole recommends having a well-rounded resume to aid the application process. Volunteering is especially valuable, as is having worked in a hospital setting. Prospective medical students also have to take the Medical College Admissions Test (MCAT), which tests the prerequisite skills required for medical school.

Wampole says one of the most valuable skills he developed as an undergraduate was time management. Medical school classes are very rigorous and time-intensive, so optimizing time outside of class is imperative.

"With the amount of work that the BME department has us do, especially with the night labs, you really have to work out a schedule beforehand and manage your time well," Wampole says.

Medical students are slowly integrated into the hospital setting, starting with a basic course during their first semester. The third and fourth year is when medical students typically start clinical rotations, gaining experience in nearly every field of medicine.

"Even if you're set on, say, cardiothoracic surgery, you'll still have rotations in OB-GYN, pediatrics, emergency medicine, dermatology, everything," he says. "It's not until you graduate that you start your actual residency."

Wampole's final advice for undergraduates interested in medical school:

"Don't freak out about grades. At least with Madison, they also look at the person, not just the GPA. You need to have good grades, but not necessarily a 4.0. And when you get to medical school … it's all about balance."

A degree in engineering from UW-Madison is good preparation for many different paths, whether in industry, graduate school, medical school or something else. The advice from these three graduates, as well as that of professors and—let's face it—even parents, is a great resource to guide engineering graduates-to-be. WE

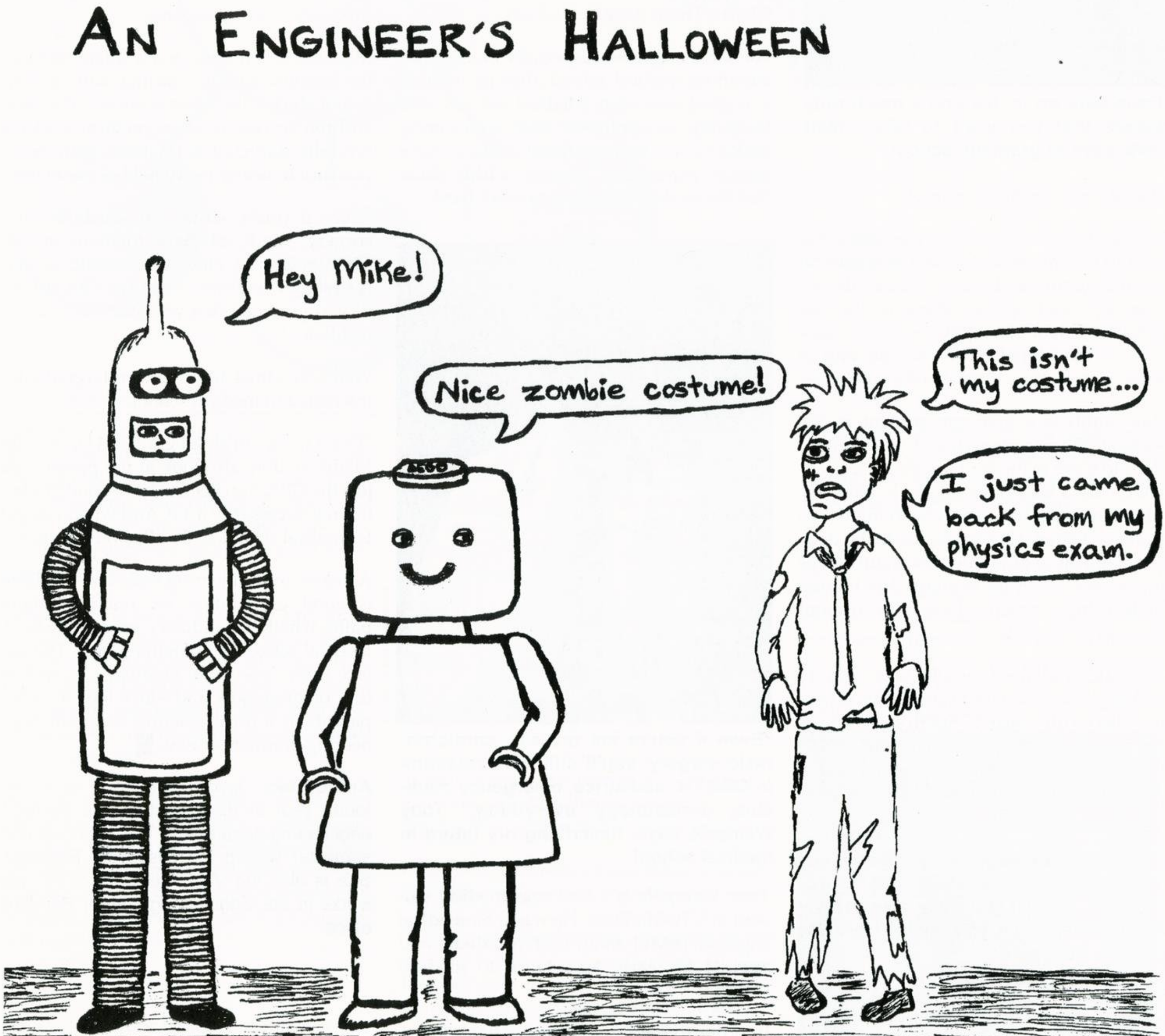
Author bio: Jaynie Sammons is in her fourth year in the industrial and systems engineering department. This is her second semester writing for Wisconsin Engineer. She is also the Vice President of IIE and works in the Engineering Career Services office.

COMMENTARY

Just one more

The finest in eclectic humor

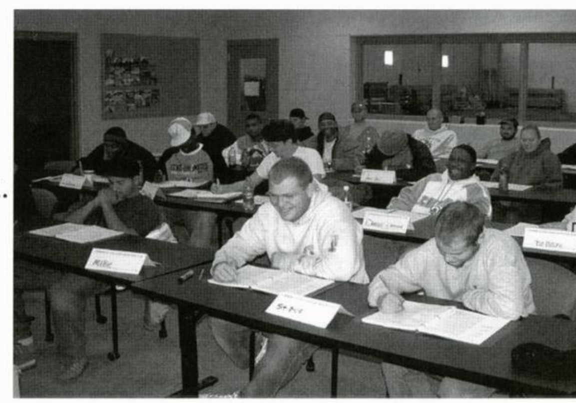
By Victoria Yakovleva



Construction Craft Laborers' Union

Training for the Future of Wisconsin Contractors

Wisconsin Construction Craft Laborers bring value to the Building Contractor because of the extensive training they receive. The Apprenticeship and Training Center instructs and upgrades the Laborers in the many skills necessary to efficiently erect structures to today's specifications.



The training and experience that the Construction Craft Laborers bring to the job-site help our building contractors bring projects in on time and under budget.

The skills training that the Craft Laborer receives is accompanied by instruction in the safety techniques that are so important to the crew on a building project.

Professional and safety-conscious in their building proficiency, the Construction Craft Laborers deliver value to the building contractor and to the building project owner!

To start increasing the Profitability and Productivity of your building project, contact the offices of

The Wisconsin Laborers' District Council

4633 LIUNA Way

Suite 101

DeForest, WI 53532

Tel: 608-846-8242
Fax: 608-846-5460
www.wilaborers.org

CROSS CAMPUS PHOTO CONTEST

Amateur and practiced photographers, come join the cross campus photo contest. In addition to prizes, winners will have their photos published in the April 2008 issue.

Wisconsin Engineer readers will be able to vote on their favorite photos on our Web site in February. We would like to encourage all to enter.

CATEGORIES:

Black and White
Computer Enhanced
Landscape/scenery
People
Random

DETAILS:

Submissions due March 1
See our Web site for more details
www.wisconsinengineer.com

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