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Wisconsin Engineer

FEBRUARY 2010 VOLUME 114, NUMBER 2

Wisconsin water:
Is it safe? p. 12

Also inside:


Photo by Steven Shutt

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wisconsin engineer

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Feature

General

Cover photo by Kristen Juve

Commentary

A letter from the editors

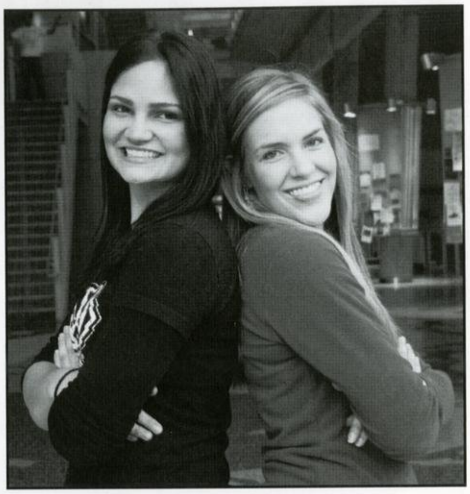
Technology is constantly progressing and, with that, there is pressure to produce a magazine that is compatible with the modern age. Like computers, television sets and video game systems, a magazine like the *Wisconsin Engineer* must keep itself updated.

Yet, prior to making updates, we, as editors-in-chief, need to have a full understanding of why the magazine is the way it is. For example, why was the logo changed from the vintage style of the 80s to the present sleek and modern swoosh? Or for what reason was it decided to highlight professors through a "Professor Profile," or include a "Just One More?"

Understanding these fundamental components of the magazine is critical to making well-informed decisions for the future. And, particularly with a magazine that has been around since 1896, we must ask: What aspects of the magazine can we modernize without sacrificing traditions?

In a pursuit to gain a better understanding of the magazine's roots, we flipped through file cabinets' worth of magazines and contacted previous editors and faculty advisors. What we learned was that although the 400-plus issues of the magazine reflect various style changes, we still do not have a thorough record of what motivated these changes.

Thus, we have decided to re-establish a letter from the editors. Every issue, the Wisconsin Engineer staff works hard to fill the blank, crisp pages of the magazine with content we hope intrigues our readers. And, as the pages are filled, stylistic changes are often made, like our decision this issue to accredit our graphic designers (renamed from "production" in November) and writers at the end of stories. We hope that this brief introduction to the issue provides you, our valued reader, with insight into how the magazine was forged –sparing you the gory details of final edits. we



Anna Mielke Victoria Yakovleva

Anna Mielke & Victoria Yakovleva

Shoulda, coulda, woulda

I was up early one crisp morning back in the spring of 2007, having a cup of coffee with my grandfather. As "Good Morning America" broke into commercial, I guided the conversation towards my work. With that, my grandfather's mood switched from causal morning coffee to you-better-listen-good. He said to me, "Boy, in my day, there have been times when I have made a lot of money, and there have been times when I made no money at all. It was not always easy for your grandma and me, but no matter what, we were always happy. For that, I can say I would not change a thing about my life, and I live with no regrets."

As I worked through my last barrage of undergraduate finals this past December, I found myself thinking, "Should I have done more? I was always interested in Engineers Without Borders. And what ever happened to going to Bucky Badger mascot tryouts?"

I then heeded my grandfather's words. I realized how irrelevant it is to think about what I could have, should have or would have done throughout my six years at UW-Madison. What's more important are the lessons I have learned and the actions I take now to improve myself and my future life.

I find myself at a major milestone – a new full-time job in a new city, and an open opportunity to take on new challenges.

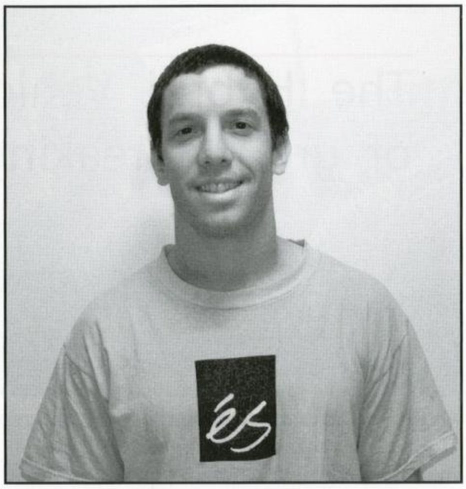
Realistically, there is only so much we can do as college students. While UW-Madison offers numerous opportunities for involvement, we must choose where to apply our individual efforts and talents. For me this meant writing for the magazine, tutoring and working on two international non-profit education projects.

With class work, extracurricular activities, part-time jobs, social gatherings and basic life-sustaining essentials like sleeping and eating, there hardly seems time to cram any more in to our tiny college package. Yet, taking time for yourself is so important to maintaining the high energy and focus necessary to perform in the classroom.

For me, the nature trails of Picnic Point and the Arboretum provided a scenic escape that allowed me to temporarily leave behind the stress of my studies. I believe that it is important to have a personal place on campus that is not associated with school or work to go and decompress.

In addition to our amazing feats as UW-Madison students, I think what's equally important is our ability to have fun. Take, for example, our "Great Snowman Wall of Gillman Street," built the eve of our snow day this past semester.

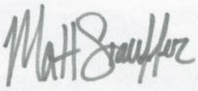
As I enter the real world, the simplest words of wisdom I can offer are to have fun. When you are working hard and there seems no end in sight, take a break and get away to your personal sanctuary for a brief spell of rest and relaxation. Taking a personal break to get out and play is so



important. I believe that this past semester's snow day exemplified UW-Madison students' eccentric nature and great knack for having fun.

Navigating through the challenges of my college experience wasn't easy; I often found myself working long into the night, and down to the last dollar. But, no matter what, I always had fun. And, for that reason, I can say I would not change a thing about my time at UW-Madison. WE

On Wisconsin,



Matt Stauffer

COLLEGE OF ENGINEERING
UNIVERSITY OF WISCONSIN-MADISON

THE UNIVERSITY of WISCONSIN MADISON

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WHAT A VUE

The Hybrid Vehicle Team keeps UW-Madison's reputation of groundbreaking research alive with its fuel efficient car

It's been a long, stressful week packed full of midterms and papers. As you stumble home Friday after class, all you can think about is how good your pillow will feel on your tired face when you fall into bed for an afternoon nap. But while you and many other UW-Madison students are off to sleep the daylight away, members of the Wisconsin Hybrid Vehicle Team are just reporting for duty at the Engineering Centers Building. Their goal? To develop a hybrid car that could benefit all of humanity. Does this make you feel lazy? Join the club!

The Wisconsin Hybrid Vehicle Team is a student organization that works to develop and improve techniques to make the world's vehicles more efficient and less harmful to the environment. The team consists of nearly 60 members from all disciplines in the college of engineering.

Since 1992, the Hybrid Vehicle Team has participated in a national competition called the EcoCAR challenge. The EcoCAR challenge is a three-year engineering competition in which collegiate teams from all across the country design advanced vehicle propulsion systems that focus on alternative energy methods. The teams then implement their systems in vehicles donated by General Motors. Despite tough competition from across the country, UW-Madison has experienced great success in the past. The last competition, called the Challenge X, wrapped up in June 2008. UW-Madison's vehicle finished second out of seventeen teams.

**Their goal?
To develop a hybrid car that could benefit all of humanity.**

The current EcoCAR competition is titled the NeXt Challenge. The Hybrid Team is currently in year two of this competition. The first year involved theoretical development, in which math-based computer systems were employed to test ideas fleshed out by the team. Now in year two of the NeXt voyage, the team has just received the 2009 Saturn Vue they will be modifying. According to assistant team leader Adam Strutz, the next step will be to dismantle and revamp the entire power train.

Photo by Danny Marchewka

In addition to revamping the inside of the car, the Hybrid Vehicle Team customizes the outside to represent UW-Madison.

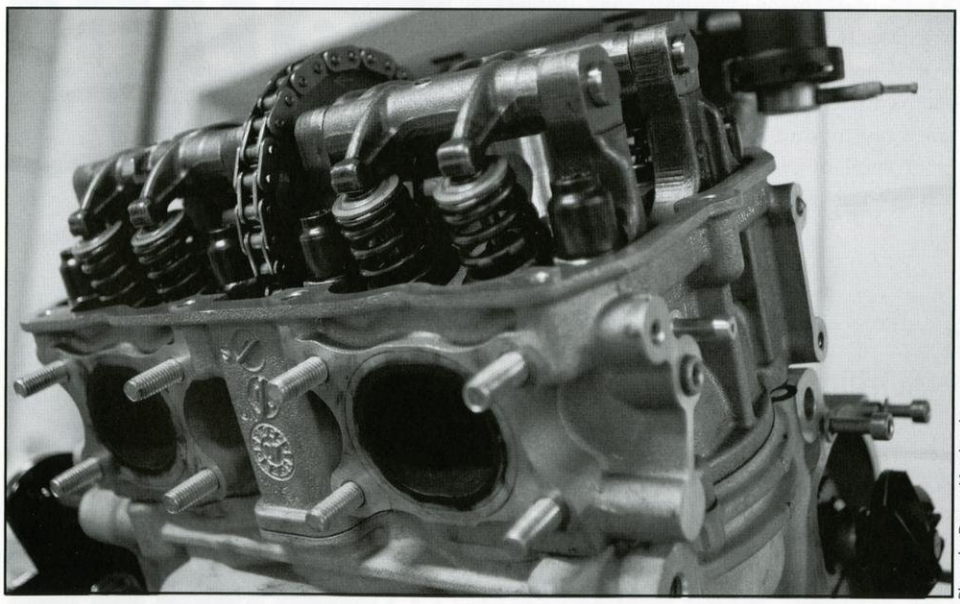

Photo by Danny Marchewka

The hybrid team will make use of a two-cylinder engine borrowed from the UW-Madison clean snowmobile team that runs on E-85.

"The whole team displays a little bit more energy when the vehicle arrives. You can start to see your work paying off firsthand, not just on a computer screen," Strutz says.

All the materials utilized by the team—including the car—do not just appear out of thin air. The major sponsors for the competition include the US Department of Energy, the Government of Canada, the

California Air Resources Board and General Motors (GM). General Motors donates a vehicle (this year it's the Saturn Vue) to each of the 17 teams competing across North America. The teams are also allotted $10,000 worth of parts courtesy of GM to work into their respective vehicles.

One benefit for both GM and Hybrid Team members is that GM looks at participants for future employment. Hybrid members already know about GM's software and components, thus GM is able to hire them and expect a contributing employee almost immediately. However, the team members make it clear the possibility of future employment is just an added bonus. The real fulfillment is getting to apply what they have learned in the classroom to real world situations. Members must rely on their own investigation and analysis to acquire knowledge, rather than relying on the pages of a text book.

While many student groups may meet for only an hour or two per week, the Hybrid Vehicle Team is a much more substantial commitment. Adam Richards, the team leader, explains that the team has small group meetings throughout the week for the three different areas of the competition: controls, business and mechanical. Full team meetings take place on Fridays. It's during this time that actual work is completed on the car. The meetings start at 3:30 p.m. and can extend into the wee hours of the morning. In the team office there is a board with members' names on it. Under each name lie tallies for the number of all-nighters the member has completed.

"If we have a report that is due the next day by noon, members are staying there all night to make sure it gets done. Writing reports of our testing would probably be the least favorite part of the group activities," Richards says. "The most rewarding part of development is when you've done all the testing on the computer, written the reports, and you're able to implement your ideas into the actual vehicle and see it all work; all of the hard work paying off."

With all the long hours the team spends together, strong friendships form. Zack Ward, a member of the mechanical group, says that members often get together outside of meetings to have a cold, refreshing beverage and enjoy a Badger football game.

As the team continues work on the Saturn Vue this semester, all members look excitedly to the month of May. The competition will be held in Yuma, Arizona this year at

Photo by Danny Marchewka

Assistant team under Adam Strutz shows where each of the engine components will go in the currently empty engine bay.

GM's new proving ground. At the competition, the team will be evaluated on 0-60 mph acceleration time, emissions, drive quality and new this year, towing events.

As the team develops the vehicle throughout the year, they must meet the reduced emissions goal, while maintaining the vehicles' performance and consumer appeal. "One of the challenges we face is packaging, fitting everything into the space allotted. No one wants a huge battery pack sitting in the back of their vehicle," Strutz says.

To meet the many goals of the competition, the team must show dedication, but also resourcefulness. The team exemplified this inventiveness in the last competition two years ago when they took over The Kohl Center. This arena is known for housing some epic battles on the ice rink, but the Hybrid Vehicle Team saw the sheet of ice as a great place to test their traction control systems in preparation for the competition.

As UW-Madison is a major hub for groundbreaking research, it seems fitting that there is such a focus on alternative energy methods on campus. So if you meet a member of the Hybrid Vehicle Team tell them thank you, because you know they are working to preserve this planet we call home. And best of all? They have fun doing it.

Article by Ben Weight
Design by David Jones

Recovery, reinvestment & research

When it comes to research, UW-Madison is used to being on top. UW-Madison has ranked in the top five public research universities based on total expenditures for the last two decades. This year is shaping up a little differently because UW-Madison, like many research institutions, is receiving millions of dollars from the American Recovery and Reinvestment Act. This single act has drastically changed the landscape of research funding in the United States.

As of early November 2009, researchers at UW-Madison had been awarded 235 grants totaling $78.4 million in stimulus money. The money found its way from Washington, D.C. to UW-Madison through several organizations, including the National Institutes of Health, the National Science Foundation and the U.S. Department of Energy. These organizations award the money to deserving research teams through a competitive process that evaluates all aspects of the proposed research, with special emphasis on collaboration and interdisciplinary research.

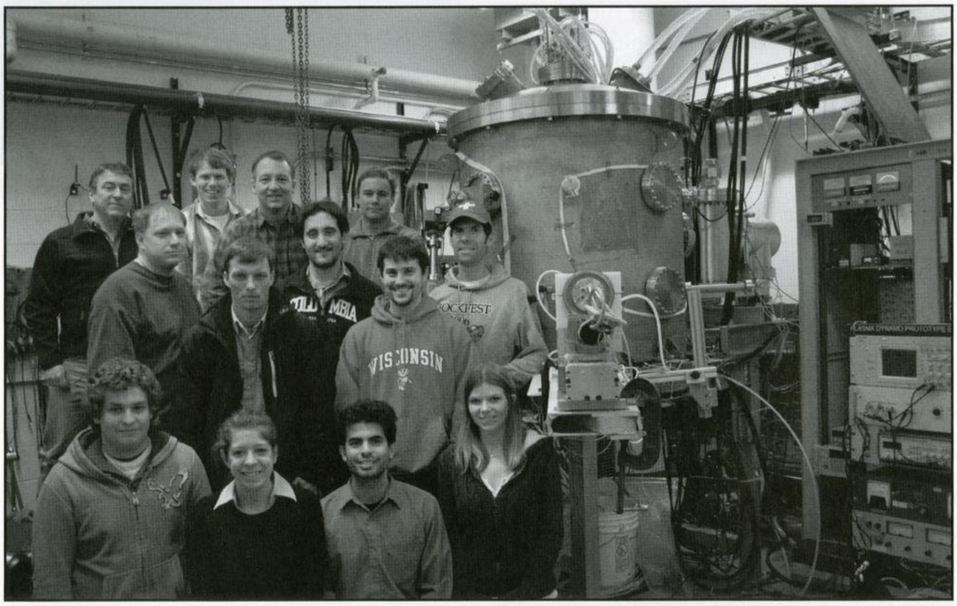

Photo by Kevin Lee

Research efforts, like that of John Wallace, have been bolstered by the federal stimulus, with UW-Madison receiving over $78 million.

"We see the infrastructure as a mechanism for developing a long term relationship with NSF. This sets up maybe a decade of funding to follow."

-Professor Forest

One of the organizations that currently has the most influence on UW-Madison researchers is the National Science Foundation (NSF). So far, the NSF has been allotted $2.4 billion of the stimulus package. The NSF, like many other governmental agencies, has many smaller divisions and programs that ultimately decide how money is allocated.

One such program is the Academic Research Infrastructure program (ARI). The ARI program will award a total of $200 million strictly for making repairs and renovations to our nation's research facilities. The ARI program not only helps to create construction jobs, it also sets the stage for cutting edge science.

"[President Obama] is depending on NSF to help lead the nation to a new era of discovery and innovation," NSF director Arden Bement says.

To fill the newly renovated facilities, the Major Research Instrumentation (MRI) program at NSF has been allotted $300 million to help researchers purchase state-of-the-art equipment. This equipment helps foster research and education, thus breathing life into the newly renovated infrastructure. These MRI grants carry the stipulation that they can only be awarded to institutions with an emphasis on education, such as universities, museums and science centers.

All of the grants made possible by the American Recovery and Reinvestment Act serve the two very broad purposes of stimulating the economy and advancing science through research. The first purpose is pretty clear. The latter, however, is limited only by the curiosity and inspiration of the research teams. Advancing science could mean exploring hazards to our health, curing diseases and cleaning up the environment. At UW-Madison, researchers are working on all three.

Researchers at the Great Lakes Bioenergy Research Center, like bacteriology professor Tim Donohue and biochemistry professor John Ralph, have received a grant totaling $8.1 million to investigate the sustainability of biofuels and their effectiveness as a renewable energy source. This project will analyze a broad spectrum of impacts associated with biofuels. Donohue acknowledges that the stimulus package has allowed for the quick deployment of new technology used for the analysis of cellulosic biofuels that may have otherwise taken a long time to arrange.

Medical research at UW-Madison is another focus of funding for the stimulus package. Professor of chemical engineering Regina Murphy received $800,000 to continue her research into blocking the effects of Alzheimer's disease. Veterinary epidemiologist Dörte Döpfer and professor of bacteriology Charles Kaspar were the recipients of a grant

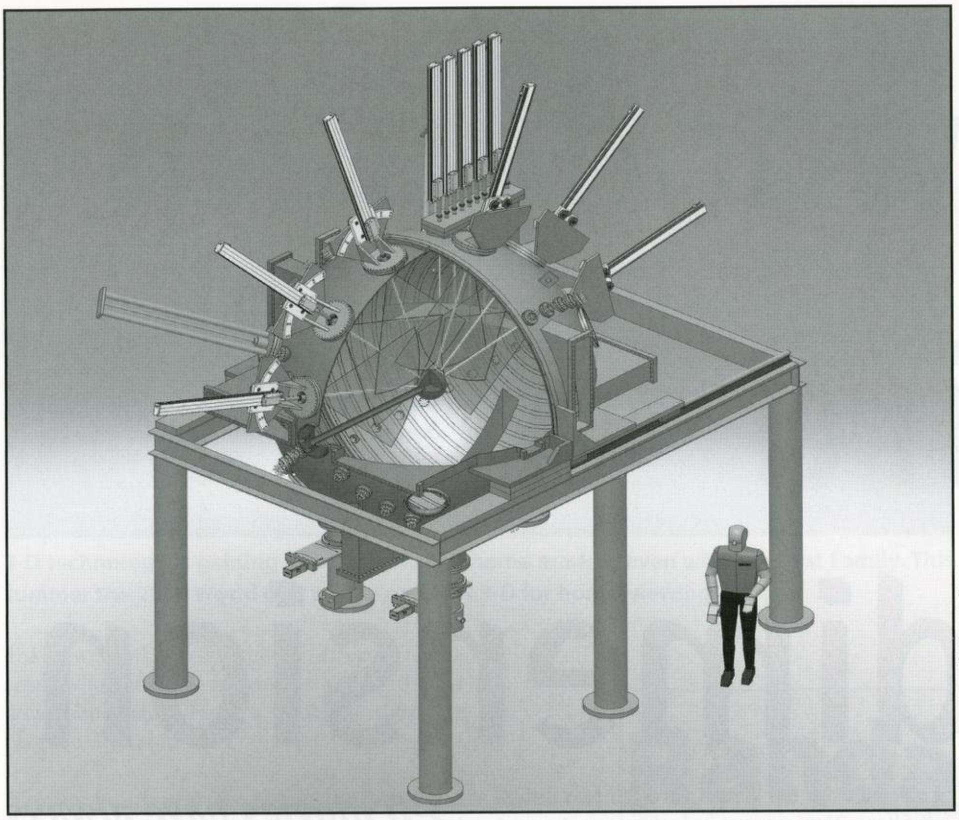

Illustration courtesy of John Wallace

Conceptual drawing of Professor Forest's Madison Plasma Dynamo Experiment (MPDX), a project made possible by the federal stimulus money.

totaling $1 million to help gain an understanding of the E. coli bacteria. Their research will investigate how the bacteria survive in certain environments. Hopefully, their findings will reduce the chance of human infection.

The goals of the stimulus package are certainly met by professor of physics Cary Forest's project, which is currently constructing a lab that will be used to study plasma-generated electric fields. The lab will be the first of its kind, attempting to explain astrophysical properties that are not yet understood, specifically the origin of the sun's magnetic field.

"We proposed to build [the lab]. It's a construction project," Forest says. For this project, Forest received a grant totaling $2.4 million from the National Science Foundation, $1.7 million of which came from the stimulus package. "We see the infrastructure as a mechanism for developing a long term relationship with NSF. This sets up maybe a decade of funding to follow," Forest says.

Forest notes that the funding for construction will support a full time engineer as well as hourly paid undergraduate students who will help to build the lab. "It might even pay for pizza to feed them," Forest says with a laugh.

"My read is that most of my colleagues are benefiting in one way or another," Forest says, when asked about his perception of how the stimulus package is impacting research. "It's mostly because there's a little less pressure on the system. It makes it possible to win grants that weren't otherwise likely to be funded."

Even if a project were likely to be funded, an influx of money from the stimulus package provides far-reaching scientific and economic impacts. This means that deserving research teams that might have fallen just short in their competitive grant process can now go forth with their projects, thanks to stimulus money. The result will be more innovation as well as more constructing of labs, new equipment, more campus research and more jobs.

These examples are only a glimpse of the expansive list of researchers who are currently benefiting from the stimulus package at UW-Madison. The list is growing as the stimulus money flows into campus. Over the course of writing this story, the sum of stimulus money has increased by $3 million dollars. Researchers here at UW-Madison are continually trying to get their hands on funding while it is available, so that they might get a needed boost for their research.

For more details on the American Recovery and Reinvestment Act at UW-Madison, go to www.stimulus.wisc.edu. we

Article by Marcus Hawkins
Design by Emily Chan

Hollywood in the third dimension

3-D movies have always had depth, but will new technologies finally give them some weight?

The history of Hollywood filmmaking has been marked by distinct eras. Silent movies were replaced with "talkies," and black-and-white pictures made way for color flicks. In the future, this decade may be seen as the end of another era: the 2-D era.

Stereoscopic 3-D motion picture technology predates the 20th century and is almost as old as the motion picture camera itself. 3-D film experienced some success in the 1950s and 1980s, but earlier versions often left audiences with eye fatigue and nausea. Today, industry executives claim these side effects are in the past. 3-D movies are making a push for market share with strong financial backing from theater chains and studios, which are beginning to turn out more 3-D films.

"I think in a reasonable amount of time, all movies are going to be made in 3-D."

-Jeffery Katzenberg

From its inception to the present, 3-D film technology has operated on the same principles. When a pair of eyes focuses on an object, the brain receives two slightly different images. The brain can process differences in the images, called ocular disparities, allowing one to perceive depth. 3-D films are made using two cameras filming scenes side-by-side, similar to a pair of eyes. In the theater, the images are projected onto the screen through two different filters. The images reach the correct eye of the viewer through another set of filters—the viewer's 3-D glasses.

While the concept hasn't changed, modern 3-D movies and the drive-in 3-D flicks of yesteryear aren't exactly working with the same tools.

The driving force behind the new wave of 3-D movies is a technology called RealD. RealD differs from past methods of projecting 3-D movies in that it only uses one projector. The images for the left and right eyes are alternated at 144 frames per second, six times the rate of traditional film. Moviegoers are given clear, circularly polarized glasses, which do not block out light when the head is tilted or produce washed out colors like the red and cyan glasses of old.

Additionally, new 3-D cameras have improved from their predecessors. Esteemed director James Cameron, one of the largest supporters of 3-D cinema, has pioneered a camera system that he thinks can finally do 3-D films justice. The switch from traditional film cameras to high-definition digital cameras means that the lenses can be separated from the bulky recorders. The smaller size allows the lenses to be placed only a few inches apart, replicating the distance between human eyes. A camera operator can shift the angles of the lenses to simulate converging pupils, creating an experience that is much more true-to-life and doesn't cause nearly as much strain on the eyes.

To industry executives, this new technology has big potential. DreamWorks' animation chief executive officer Jeffrey Katzenberg praised the new RealD technology at the International Broadcasting Convention in late 2008. "I think in a reasonable period of time, all movies are going to be made in 3-D," Katzenberg says. "2-D films are going to be a thing of the past."

If the trends of the last few years continue, Katzenberg may be right; 11 major 3-D films or shorts were screened in 2007, 14 in 2008 and 21 in 2009. The increase in pictures has been met with an enthusiastic response from audiences. DreamWorks' "Monsters vs. Aliens" pulled in $58.2 million over 7,000 screens, 2,100 of which played in 3-D. According to Katzenberg, 56 percent of the ticket sales were for 3-D showings. The drastic increase in per-screen revenue is enough indication for the DreamWorks' executive to promise that all of his future films will be released in 3-D.

Photo courtesy of the official photo stream of the White House

3-D technology is gaining popularity in the home market, even with the First Family. This summer the 2010 World Cup will be on ESPN 3-D for home-viewing.

This enthusiasm is shared by director Cameron, who sees 3-D movies as a way to slow down internet piracy, a problem that has plagued digital films.

"I'm not going to make movies for people to watch on their cell phones," Cameron said during his keynote address at the Digital Cinema Summit in Las Vegas in 2006. If anyone has a say over the future of Hollywood, it's Cameron, renowned director of "The Terminator" (1984) and "Titanic" (1997). Cameron's next picture, "Avatar," was released in December 2009 with rumors circulating that this film could be more successful than his past blockbusters. The film was also release in 2-D, but "Avatar" was touted as a landmark in filmmaking of Star Wars portions for its use of Cameron's 3-D camera system.

Films such as "Monsters vs. Aliens," the critically-acclaimed "Up!," and the recently released "Avatar" will provide feedback on the future of 3-D technology—not only in films, but for all forms of media. Eventually, household televisions may show the Packers game in 3-D, and personal laptops will browse the internet in 3-D. It is this expandability that has so many in the tech industry excited—and not just for technology's sake. "Think of the power of [the 3-D technology]," Cameron said during his keynote speech. "Think what you could charge." WE

Article by Jack Johnson
Design by Dan Farley

Photo by Emily Sorensen

The number of 3-D movies being produced has increased by 50 percent over the last two years, as shown by the influx of 3-D titles at local theaters.

Avatar movie reviews:
point and counterpoint

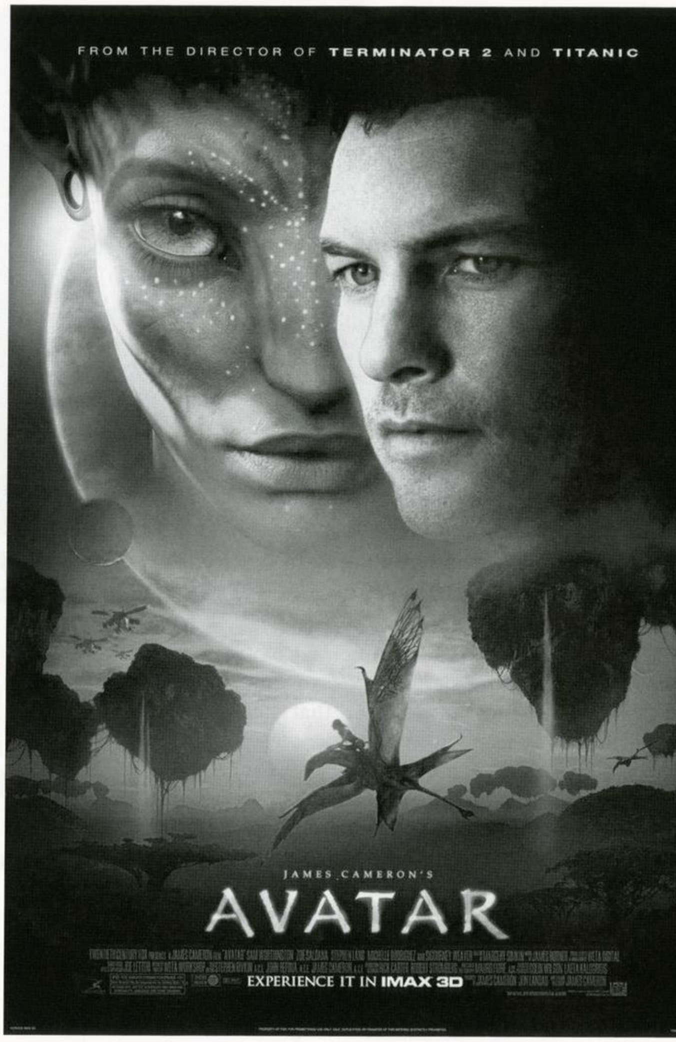

Image courtesy of impawards.com

Plot Summary

In Avatar, humans have invaded Pandora, an Earth-like moon inhabited by a race of blue humanoids called the Na'vi. In their quest to find the mineral unobtanium, humans have grown Na'vi bodies crossed with human DNA that can be controlled. Jake Sully, a paralyzed veteran, is one of the humans given the chance to be an avatar. While he starts his mission determined to find the unobtanium no matter the cost to the Na'vi, Jake quickly becomes entangled in the lives of the Na'vi and starts to question the intentions of his own race.

As of January 19,2010 Avatar had grossed $1.6 billion—just $200 million short of Titanic's record-setting box office gross in 1997.

Point

I saw the movie, Avatar, in its full three-dimensional glory and must admit that I was quite skeptical going into the movie. I recall seeing a preview for Avatar and thought the plot looked ridiculous. I felt that the movie would be nothing more than over-the-top effects with a dry storyline. On top of it all, those blue things just looked bizarre. I couldn't have been more wrong. Everything about Avatar impressed me, and the film was appealing on many different levels. The plot was captivating and the graphics and effects were not overdone. There was romance, action, drama and even a little humor. Overall, director James Cameron scored another hit and Avatar is well deserving of the praise and accolades, especially its "titanic" box office revenue.

By Lauren Kern

Counterpoint

If you haven't seen Jim Cameron's Avatar yet, don't worry about having the plot spoiled for you. You already saw it when it was called Pocahontas or Dances with Wolves. The entire story is driven by the evil capitalists' desire to mine the unobtainable unobtainium. The film must be seen in 3D since the only way the laughably cliché plot can be excused is with a 3 hour special effects orgy. The jungles of Pandora are teeming with glowing plants straight out of Fern Gully and incredibly unique creatures (they all have ponytails and 6 legs!). In the end, we all learn the evils of technology as we sit in our air-conditioned theaters, drive home in our cars, and finally pop in a DVD to watch a popular movie that isn't driven just by special effects ... like Transformers.

By Steven Shutt

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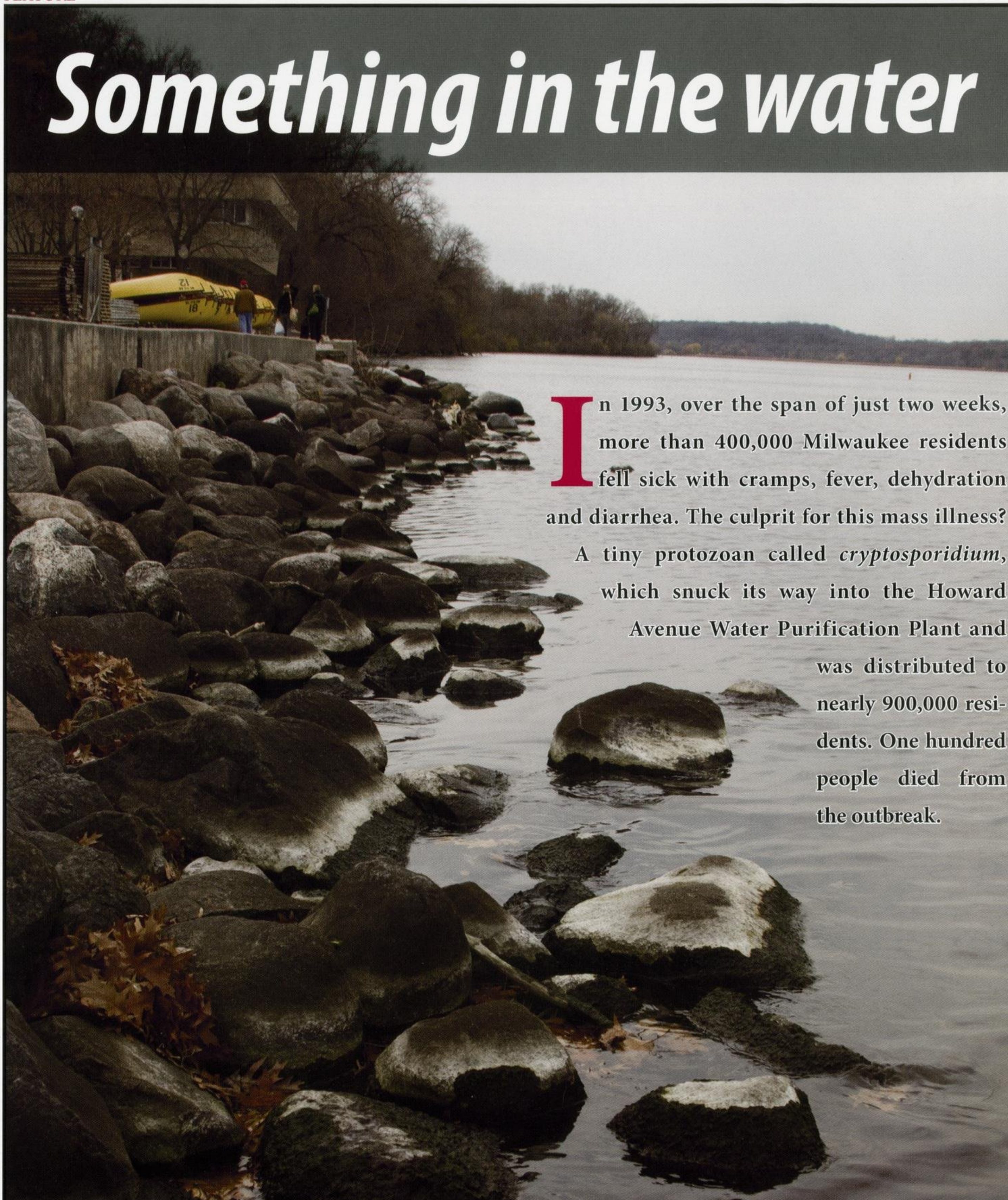
Something in the water



In 1993, over the span of just two weeks, more than 400,000 Milwaukee residents fell sick with cramps, fever, dehydration and diarrhea. The culprit for this mass illness? A tiny protozoan called *cryptosporidium*, which snuck its way into the Howard Avenue Water Purification Plant and was distributed to nearly 900,000 residents. One hundred people died from the outbreak.

Professor Harrington demonstrating the second part of filtration in which the water filters through coal and sand, similar to what would happen naturally in an aquifer.

One may have expected such an outbreak to occur in a developing nation with unstable infrastructure, but not as close to home as Milwaukee. Luckily, water treatment engineers from all around the country paid attention to this incident and have taken measures to try to prevent it from happening again. Despite their best efforts, however, harmful contaminants still pop up in our drinking water from time to time.

"[Recent studies] have found viruses [in the groundwater]," Ken Potter, professor of civil and environmental engineering at UW-Madison, says. "Not only that, but they have found viruses that are less than a year old. The viruses aren't a problem because we chlorinate our water, but it's a little scary. It's an indicator that we have to always be on guard … One should never get overconfident as an engineer or as a citizen."

Sometimes it seems that we take our drinking water for granted as it streams from our showers and kitchen sinks. What we often fail to consider is the extensive engineering that goes into the mechanical and chemical systems that bring our water to us cleanly. Thanks to tough water regulations and efficiently engineered systems, there's virtually no chance that *cryptosporidium* will attack again.

"I'm confident that the regulations we have in place … are enough to ensure the public that there's a very low risk of getting cryptosporidiosis from drinking water now," professor of civil and environmental Greg Harrington says. "When they turn on the tap to get a glass of water, they can be confident that they're not going to get cryptosporidiosis."

Fortunately, the geological formations from which most of Wisconsin gets its drinking water mostly keep contaminants like *cryptosporidium* from reaching drinking water to begin with. Public water systems in Milwaukee, however, draw from surface waters like Lake Michigan, which is vulnerable to any contaminants that can find their way into the lake.

Madison is just one of many cities in Wisconsin that draws its water from the estimated 1.2 quadrillion gallons of water that lie beneath the surface. The Madison city wells drill about 600-700 feet below the surface into a deep sandstone aquifer. Above this main, deep aquifer, there is a shallow aquifer separated by a layer of shale. In theory, the shale should keep anything that has contaminated the shallow aquifer from leaking into the deep aquifer. However, this may not be the whole story.

"There's some recent literature that suggests that maybe the geologic formations don't provide as much filtration as we like to believe they do. But in Madison … we add chlorine when the water comes out of the ground, and then we provide an adequate contact time with that chlorine before we send the water out to the distribution systems," Harrington says. "The calculations that have been done suggest that we use adequate contact time to kill viruses that might be present in the water supply. There's no evidence that people are getting sick from the water here."

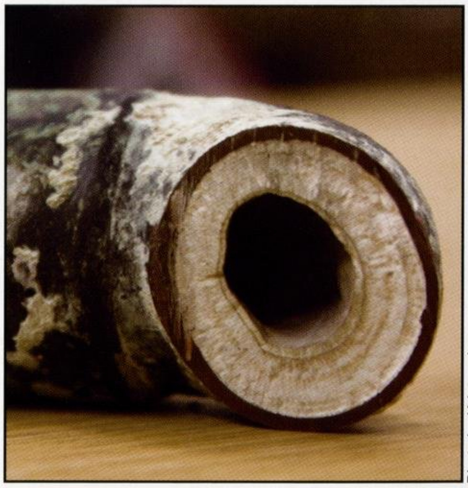
The State of Wisconsin recently decided that all groundwater supplies in the state are vulnerable to contaminants and must be disinfected. Most municipalities, like Madison, chose to disinfect with chlorine, but this technique is sometimes controversial.

"I see [it] as a benefit; I think it's a good idea," Harrington says. "But there are some communities that will not like it because they'll be tasting chlorine in their water for the first time." However, Harrington offers a simple solution. "[T]ake a bottle and collect some tap water and put the bottle in the refrigerator. When the water's cold, you don't taste the chlorine as much."

Homeowners can also buy water filters that take chlorine out of the water, but removing chlorine encourages bacterial growth. "Studies on all of these [filters] find microorganisms growing on them … so it's a tradeoff. Do you want to drink the bugs or do you want to drink the chlorine?" Harrington says. "I'm not convinced that the water is any healthier coming out of a filter than it is out of the tap to begin with. For the people that feel better protected by using a filter, I just strongly encourage them to maintain that piece of equipment in accordance with the recommended schedules because those devices can ultimately do more harm than good if they are not adequately maintained."

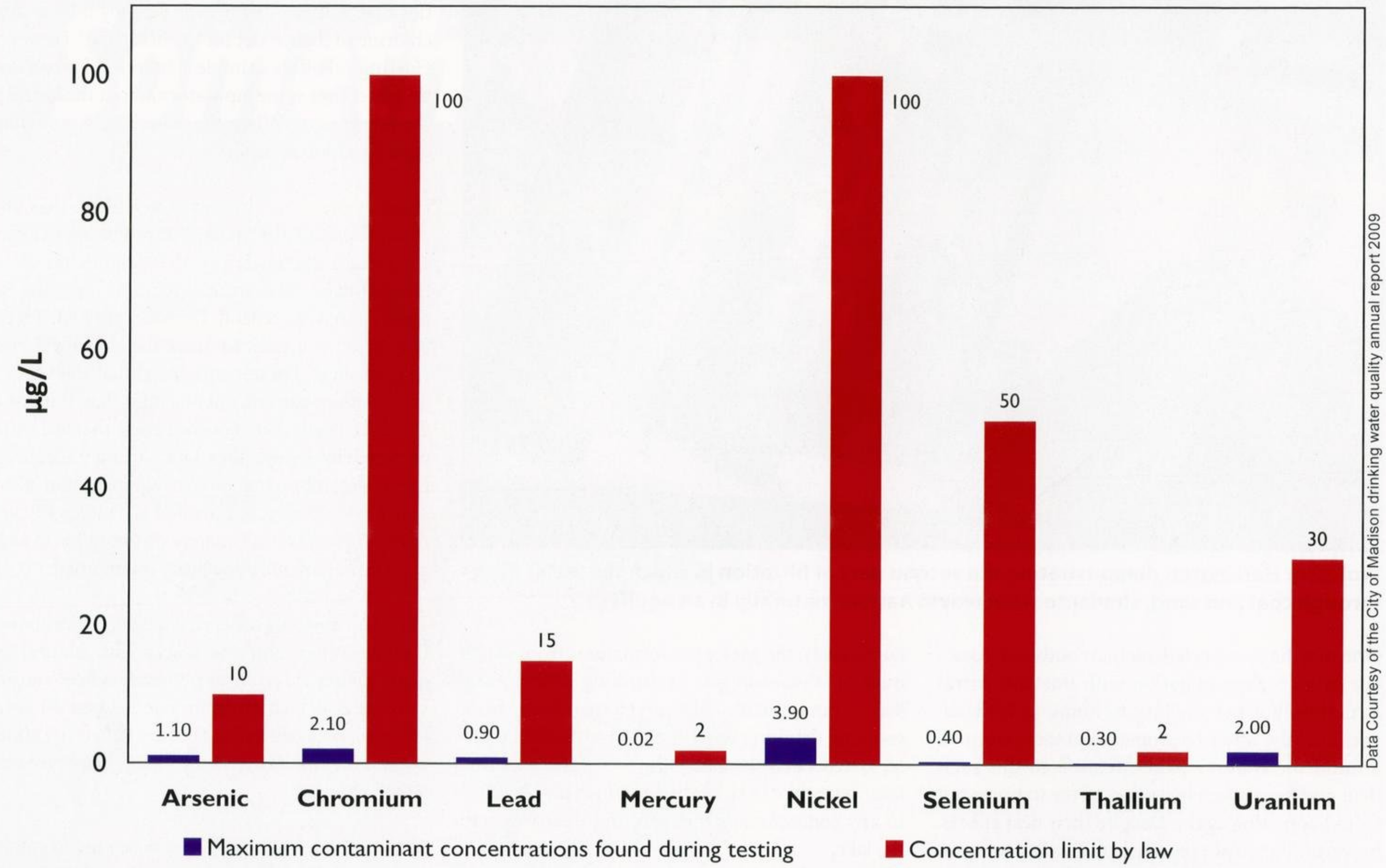
Taste isn't the only concern related to chlorination, though. When chlorine reacts with natural organic matter it can form potential cancer-causing substances like chloroform. For the past 30 years, chlorine by-products have been regulated by taking natural organic matter out of water before treating it with chlorine.

Some communities that have chosen not to employ chlorine met the disinfected water regulation using ozonation, which infuses O_3 through the water to kill microorganisms. Others use UV light treatment, in which light of a very short wavelength is applied to the water to destroy viruses and bacteria. "[Each of these systems] has their own set of by-products, but we have ways of engineering treatment plants to minimize the formation of those things," Harrington says.



A thick layer of off-white calcium and magnesium has built up inside this brown pipe taken from a water processing plant.

Contaminant levels in Madison drinking water



Despite the public's concerns over water safety, most contaminants found in Madison drinking water are much lower than their legal limits.

One type of contaminant that has been garnering a lot of attention over the past few years and isn't treated by chlorination is pharmaceutical waste. Medication remnants are introduced to the water system when users excrete them into wastewater. When the treated wastewater is put back into the system—either poured into surface waters or recharged into groundwater aquifers—the pharmaceuticals go with it.

The concern for pharmaceuticals in drinking water is relatively new, and as a result, regulations have been slow to develop. "We just don't have the studies to set standards on them yet," Harrington says. "Utilities have gone through programs to look for these substances in water and they know they're there, but they just don't know what to do about them yet."

Despite the presence of such contaminants, experts on water treatment assure that our drinking water is safe. "By and large, the municipal water supplies in the state are safe," Harrington says. "I'll drink the water anywhere I go."

Quality isn't the only thing some communities need to consider with drinking water. Luckily for us, Madison has a solid supply of drinking water, but other communities are concerned about the amounts they are using. For instance, Waukesha County has been using water at about twice the rate that it is recharging in the deep aquifer.

"They've been taking water from the shallow aquifers. It's not as reliable of a supply, and it's lower quality," Potter says. "Also, if you take that water out, you're going to reduce groundwater flows to streams and lakes, so you're going to degrade natural systems."

A major factor that slows the recharge of these aquifers is development. Impervious surfaces, such as parking lots and roads, prevent water from infiltrating back into the ground. While this is a serious issue elsewhere, it's not such a problem in Madison, since the developed area is so small compared to the farmland around it. Instead, Madison faces a different problem caused by the impervious surfaces: "Madison actually has to worry about the excess runoff that goes into the lakes and causes flooding. That's a huge issue," Potter says.

For those communities concerned with their groundwater supply, however, there is hope. "One solution that could be a lot more effective if we continue to use it is to infiltrate storm water using design practice. That practice can be a so-called rain garden or it could be something that's more engineered," Potter says. A rain garden is just a small depression in the soil to which you can route runoff from a roof, parking lot or other impervious surface. The area can be used to grow plants, hence the name. "These things, if they are properly designed, can not only make up for the impervious area, but they can make up for some of the pumping," Potter says.

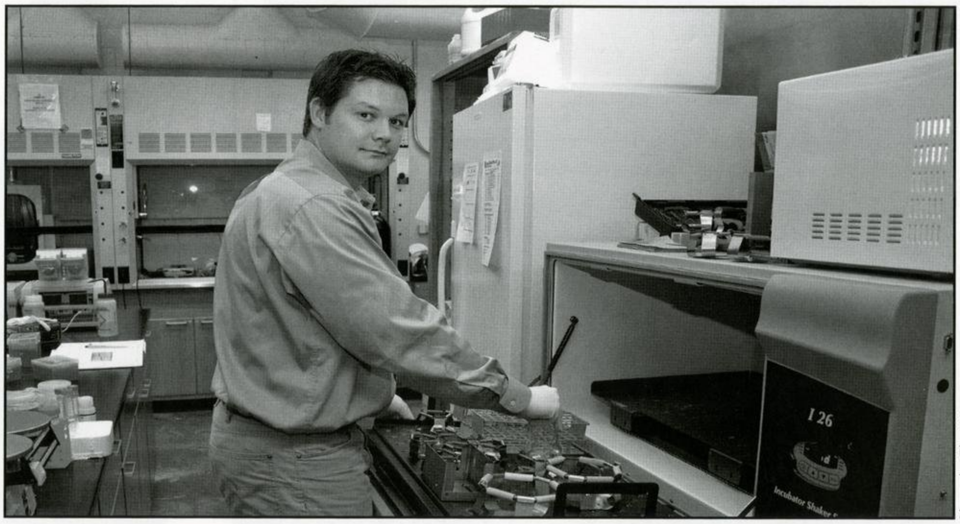
Potter himself recently bought rain barrels that collect roof runoff and drain into the lawn, reducing the need to water it. Practices such as this not only increase infiltration into the groundwater, but also reduce the amount of storm water that drains into the lakes and causes flooding. "[Stormwater recharge] is a pretty powerful solution. The challenges are getting people to do it and do it right," Potter says.

Those concerned about a Madison water shortage need not worry—at least for now. "We're not going to have a problem in the long term," Potter says, "[but] we haven't come close to conserving." WE

Article by Dylan Liebl
Design by Tim Lam

Synthesizing the fuel of the future

We all know that we can use a computer to calculate complex integrals on our physics homework. But what if that computer was a living organism—a computer that was completely sustainable because it acquired energy from food and processed it biologically in the same way that your body does? The emerging field of synthetic biology holds hopes such as this, and professor of chemical and biological engineering Brian Pfleger and his team are at the forefront of the technology.



Professor Pfleger uses incubators to culture bacterial cells. The cells can be genetically manipulated to produce fatty acids and biodiesel precursors.

From his office in Engineering Hall, which conveniently overlooks the biotechnology building across University Avenue, Professor Pfleger leads a dozen or so undergraduates, graduates and postdoctoral researchers through this emerging field. Having earned his Ph.D. in chemical engineering a mere four and a half years ago from the University of California – Berkeley, Pfleger and his team are making remarkable headway. They aren't the only ones either. "Things are flying out of the literature faster than we can analyze them and build them into our projects," Pfleger says of research in synthetic biology around the world.

Pfleger's venture into the field of biotechnology was anything but deliberate. He originally planned to pursue a career in pharmaceuticals. "I had a misconception that if I wanted to work in the pharmaceutical industry I had to learn biology. Along the way I discovered that biotechnology is a really fascinating idea. If you can understand the metabolism in a cell, you can understand diseases, the ability to produce compounds and many more amazing things," Pfleger says.

The advantages of using a biological system, also called an organism, to make a product or perform a task is that the energy used to do the work is completely sustainable. Biological systems run on sugars and harvest the energy stored in the biomolecules to perform work. For instance, take a look at your coffee maker. Normally, you plug the coffee maker into an outlet to give it the electricity it needs to make your morning brew. If this appliance was a product of synthetic biology, instead of plugging in your coffee maker, you would feed it biomolecules from which it would produce the energy it needs to operate.

"And that's taking the viewpoint that biology is like any other complex engineering system."

-Professor Pfleger

"It's taking the viewpoint that biology is like any other complex engineering system. It's a series of parts that are built on one another and interact with one another," Pfleger says. "The idea is that you understand the parts that perform a biological function, and you understand how they interact with one another, and then you can build a system. You can build a cell. You can build a chemical factory inside a bacterium."

Here at UW-Madison, Pfleger's group is implementing techniques to synthesize biofuels. "What we are doing is making diesel fuel in bacteria," Pfleger says. The designer bacteria produce certain fatty acids that can be processed into the same types of petroleum precursors that enter refineries today to make hydrocarbon fuels like gasoline and diesel fuel.

Pfleger and his team have hopes to improve this process so that the bacteria can produce the diesel fuel directly. "It's a matter of whether you know which genes do the job you want and whether you can get them to work," Pfleger says. By inserting the correct genes into the bacteria's genome, the organism can theoretically produce the tools it needs to process the precursor fatty acids directly into the hydrocarbon fuel that enters refineries. Gaining the ability to do so would eliminate an expensive process that is currently needed to decarboxylize the product before it can be fed into a refinery.

In the ideal sustainable situation for energy production, the net output of the process equals the input. Our current ways of pro-

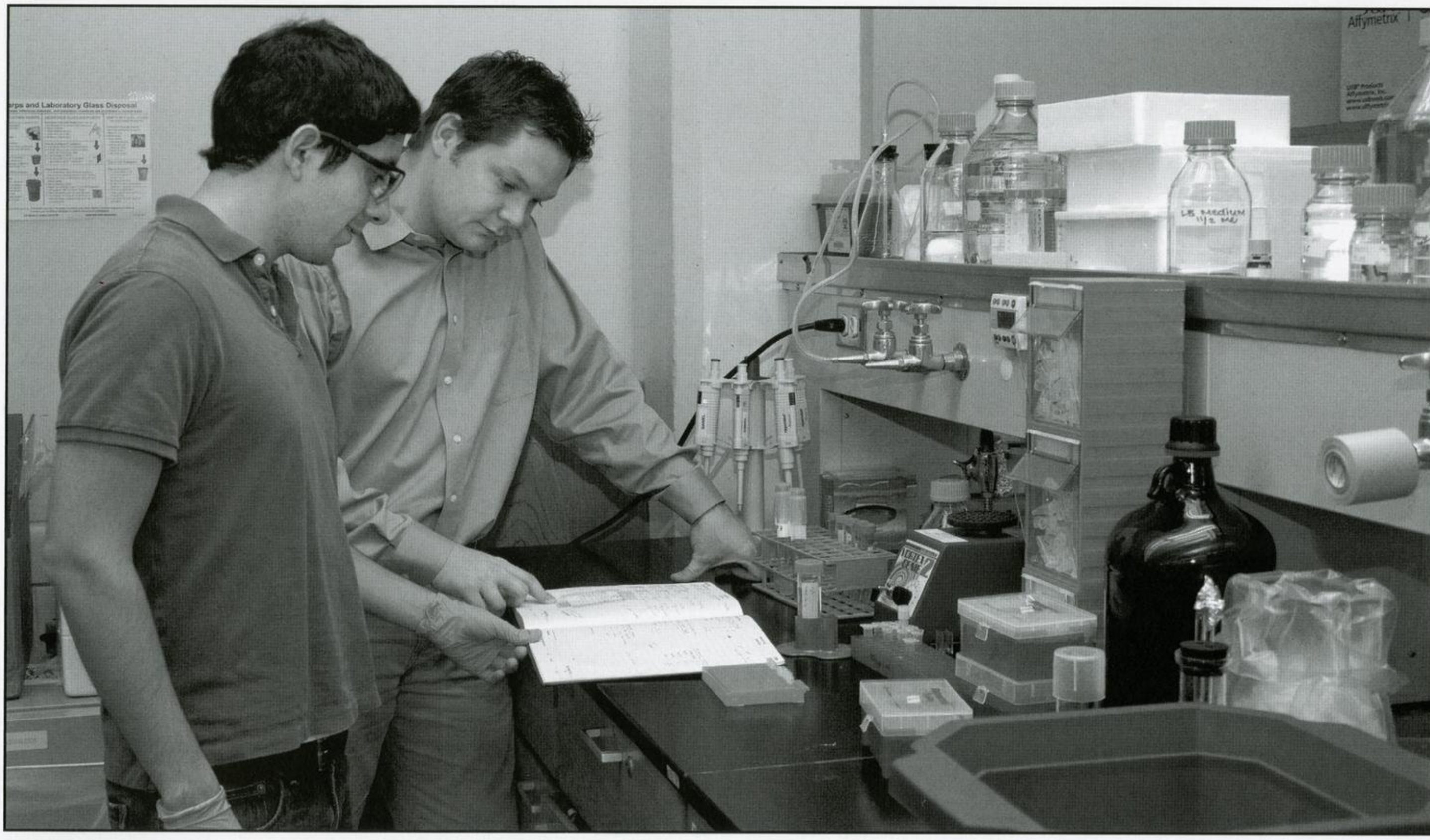


Photo by Thai Nguyen

Professor Pfleger (right) works closely with his graduate students, such as Daniel Mendez Perez (left), providing continuous feedback and insight from his knowldge in the field of synthetic biology.

ducing energy are far from reaching such efficiency. "[With our current methods], we're taking energy out of the ground. It's carbon that was fixed a long, long time ago, and we're combusting it and putting carbon dioxide out in the atmosphere. So from a carbon dioxide perspective, that is not sustainable. We would like everything we are burning to have been captured recently," Pfleger says. Bacteria that produce diesel fuel are thus ideal candidates for this task, since they get their energy from metabolizing recently produced biomass, not a nonrenewable resource that will run out.

Pfleger's research and laboratory are funded by the Great Lakes Bioenergy Research Center (GLBRC), which is a collaboration of universities and national labs, most of which are located in the Midwest. One of the efforts of the GLBRC is to convert cellulosic biomass into advanced biofuels. In addition to Pfleger's research with the center, there is research being done to engineer plants that produce ideal biomass for the bacteria to turn into fuel. "What is really exciting about this center is that it's taking people from all over campus," Pfleger says. "You've got the whole spectrum from chemistry, physics, math, engineering and biochemistry and they are all working together towards the same large problem."

Pfleger's work in synthetic biology doesn't stop at the GLBRC. His research has inspired the design of a new lab course in the college of engineering that teaches students the techniques "they need to understand in order to do synthetic biology research," Pfleger says.

The hopes for this new and exciting field of synthetic biology is that scientists will have the technology to build organisms from the ground up that are programmed to produce a desired product or perform a certain function. The next generation of biotechnology aims to utilize the ability to build a cell that acts as a chemical factory and to design communication between that cell and another. A synthetic biological organism would theoretically have the ability to send electrical signals from cell to cell, similar to the technology of a computer. In this way, Pfleger's novel research provides tremendous opportunity for the merging of biology and engineering. WE

Article by Melody Pierson
Design by Rachel Leicht

Itty bitty qubits

The next big thing in computers

In 1946, the world's first computer, Electronic Numerical Integrator And Computer (ENIAC) was introduced. Covering 680 square feet, ENIAC could add and subtract two numbers and hold a 10-digit value in its memory at the rate of about 5,000 operations per second. In contrast, your iPod, performs about 2.4 billion operations per second and fits in the palm of your hand. For more than 60 years, we have been working to make computers smaller and faster, and we have succeeded tremendously.

But how small can we get with our technology? Traditional physics would tell us that the smallest possible computing components require several electrons per bit. New research into the quantum world, however, tells us differently. Quantum computation is changing the way we think about computers-everything from how we process complex calculations to how we protect information on the internet.

Many of us are shamelessly dependent on computers in our daily lives. However, we often neglect the complex hardware that fuels our electronic devices. Consumers need only worry about the next fastest, smallest and sleekest device to execute our every command. As these devices get smaller and smaller, though, our current computer technology fast approaches its physical limit.

"The old philosophy about computers ... was to get smaller and smaller gate sizes," Robert Blick, professor of electrical and computer engineering, says. "Now we only need a couple thousand electrons to get a one and zero. Even recent flash memories are down to five or ten electrons. [Computing] is really going down to single particles, but sooner or later you reach a physical limitation. Then you must address the wave function of the particle: the quantum information."

This is where the qubit comes in. A qubit is a unit of quantum information described by the wave function of a particle, which defines the probability of an electron's physical state at a given time. Unlike a traditional computing bit, which can be either a 0 or a 1, a qubit can be a 0, 1 or a combination of both.

"We are revising our ideas about what information really is, because quantum mechanics tells us that if you look at bits on a finer and finer scale, the standard idea of the 0/1 bit goes away. There isn't any really small thing that acts like a classical bit," computer sciences professor Eric Bach says. Observing the quantum state of matter in real-time is difficult, however, because of the incredibly small scale and the dynamic nature of particles.

Professor Blick leads one UW-Madison research group studying quantum computing. With the help of graduate student Hyuncheol Shin (Caleb), the team is focusing on the development of qubits in semiconductors called quantum dots. Semiconductors are a special type of material whose electrical conductivity can be controlled. Because of this unique property, semiconductors are responsible for several recognizable technologies, including the LED monitor on your personal computer. Working with quantum dots is exceedingly difficult because of the time it takes to prepare the dot, requirement of cryogenic temperatures and extreme signal sensitivity to internal and external noise.

Donning the full-body white lab suit, Caleb first prepares a single quantum dot in a clean room by trapping an electron on a semiconductor chip. To do so, he uses electrically charged nanoscale metal gates to create a potential well on the two dimensional electron gas blanketing the semiconductor surface. These gates can confine electrons and control the number of electrons in the potential well. Such a system is known as a top-gated quantum dot.

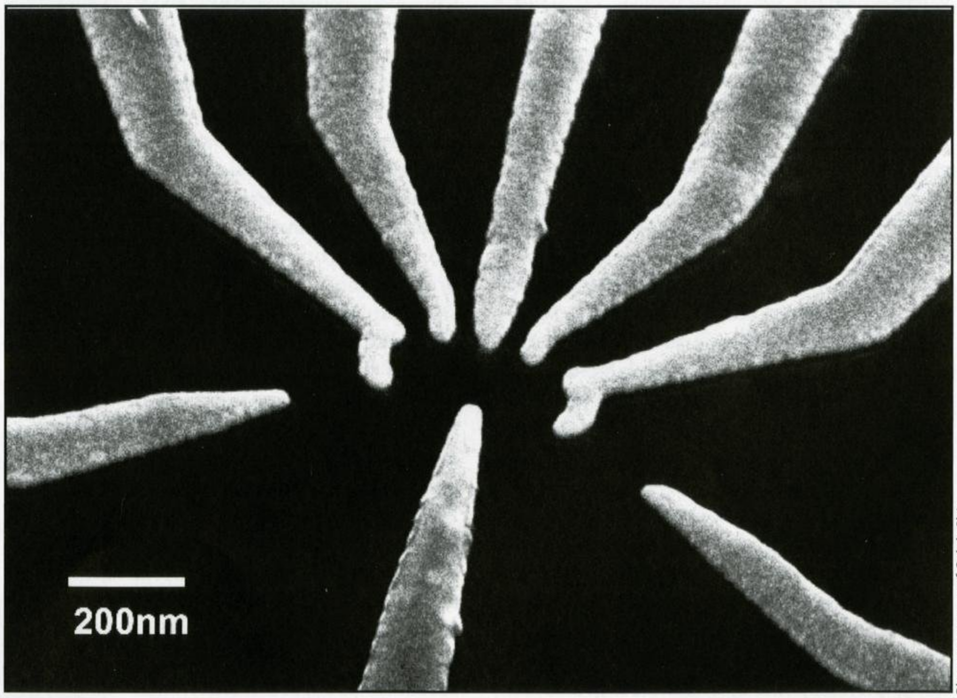


Photo courtesy of Caleb Shin

Preparing a chip like the one shown can take weeks due to the qubits' need for optimal voltages.

"The forming work of the dot is very challenging, so you spend a lot of time optimizing gate voltages to have good dots," Caleb says. "It is not given for free." Preparing a chip can take a few weeks because the top gate voltages must be perfectly tuned to define desirable potential well and barriers.

Once constructed, the chip is placed under a shimmering-gold cryogenic freezer that resembles a death ray from a James Bond film. Liquid helium cools the freezer, plummeting the chip temperature to tenths of degrees Kelvin; cold enough to slow atomic movement to a crawl.

"These are like artificial atoms slowed down so you know where the individual electrons are," Bach says.

Once the system is cooled, Caleb observes the electron current and attempts to optimize the electron spin lifetime, called the coherence time, with radio frequency pulses. It is this electron spin that enables quantum data storage. Scores of data are collected during each run through a network of current amplifiers, voltmeters and other electronics stacked nearly ten feet high next the cryogenic freezer. Similar to a computer monitor, these devices receive and display the quantum information from a single qubit.

"We are revising our ideas about what information really is."

-Professsor Bach

The experimental procedure allows Caleb to measure the qubit coherence time, which essentially determines if the top-gated technique will store information long enough to be utilized in computation.

"A coherence lifetime of a couple milliseconds is still long enough to perform maybe a thousand gate operations if the gate operations are fast enough," Blick says. "If you have a thousand gate operations you can do some computation, which might ... be sufficient for coding."

"One of the reasons people are very excited about quantum computing is that it gives the effect of computing on many inputs at the same time. Normally if you have a computer you have n bits, then you can only put those n bits in one state and operate on it to get a result," Bach says. "With a quantum computer there is, at least in principle, the possibility of having operations going on for all of those 2n states at the same time." Because these quantum computers have the potential to be exponentially more powerful than classical computational methods, they are applicable in the most complex of computational problems.

Not every aspect of this computational power is desirable, however. Once scaled up to accommodate the size of online security codes, quantum systems could break the encryption of nearly any security code on the internet, anything from your email to your bank account password.

Although true quantum computers are limited by our current technological understanding, small supplemental quantum registers may enhance our current computational processes. "Another interesting thing is that even if you could not go all the way to a realization of [true quantum computation], you could use tens of qubits to speed up classical computation, a hybrid algorithm that uses quantum computation to focus in on the solutions that you could then explore classically," Bach says.

Future quantum computing technologies, including Blick's quantum dots, could also be integrated into quantum optical equipment, which is currently available. "You can dream up applications where the quantum cascade lasers are integrated in the qubit chip where you use the light from the quantum cascade lasers to flip the qubit states," Blick says. "Quantum optics equipment could be integrated into these systems to transfer information over larger distances." Such technologies will also help merge classical computational devices and emerging quantum technologies in the future.

A final application of quantum computing is realized in biology; specifically, simulation for sequencing amino acids in proteins. "Biologists need to do simulations in which they use a couple of super computers that take forever," Caleb says. "If they have quantum computers it might boost biological sciences, and engineering too."

"Quantum computing is still a very primitive technology ... Definitely, I can tell you, [a quantum computer] wouldn't be like a consumer electronics laptop," Caleb says. "The first configuration would be a super-big, room-size computer like the first computer, the ENICA." Despite its large size, such a quantum computer with a few thousand qubits, could rival the computational power of today's more advanced machines. How we use such computing power will need to be decided when we get there.

In time, quantum computing may be integrated into the most complex computer systems owned by the government or multibillion dollar corporations. However, this may not happen in our lifetime, though it is today's bright minds that may make quantum computers commonplace in the future. WE

Article by Tim Busse
Design by Josh Dawson

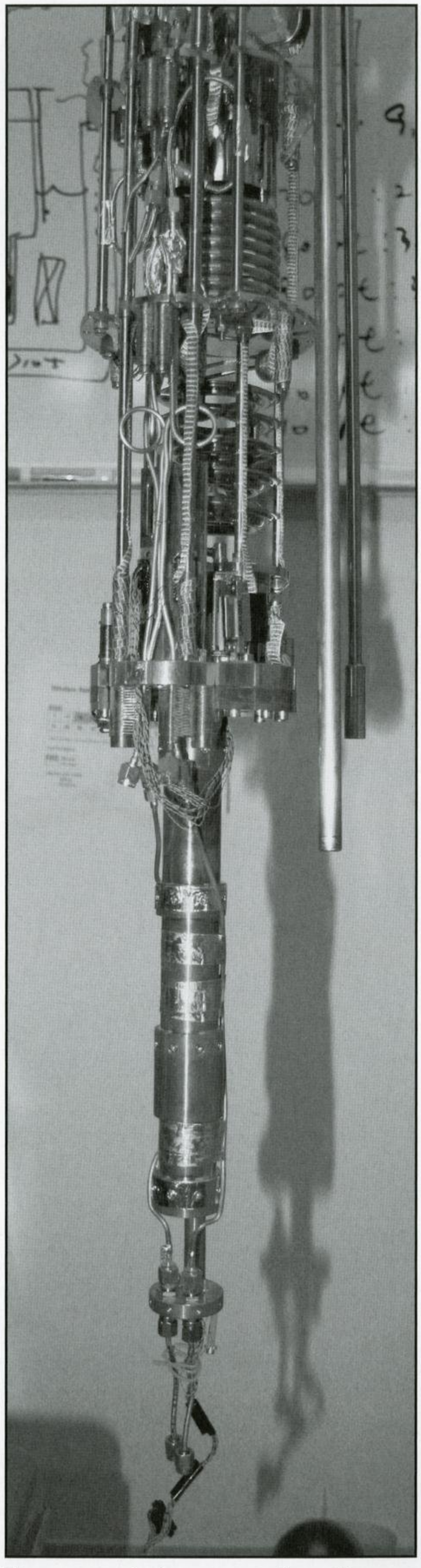
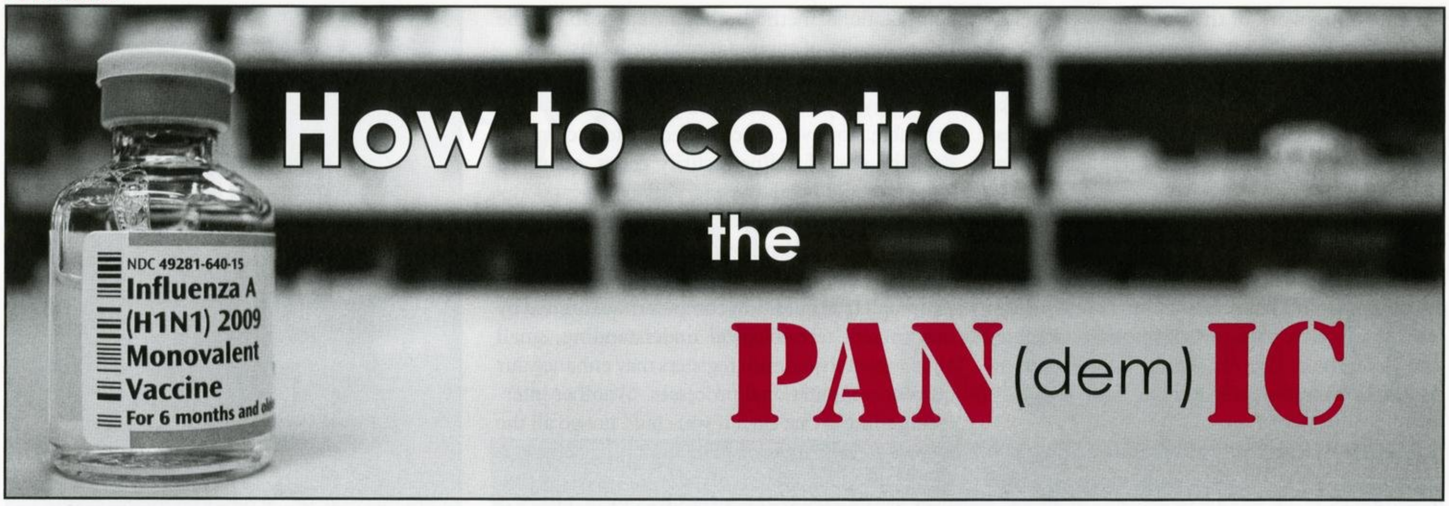


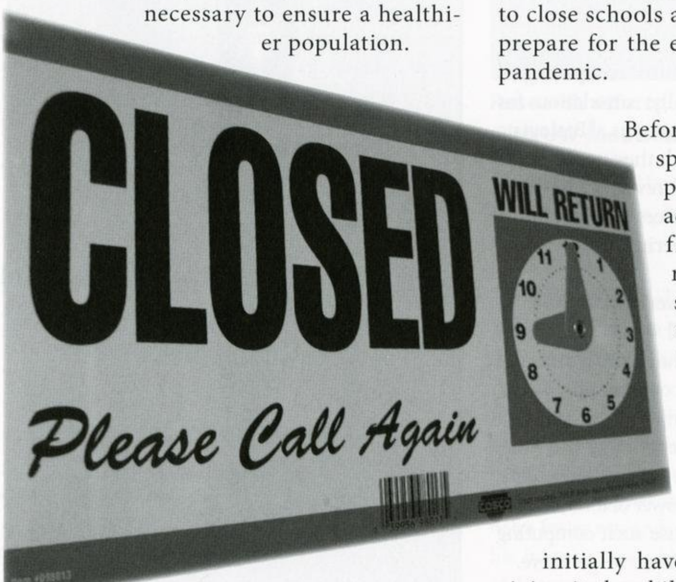
Photo by Lakshay Gupta

The cryogenic freezer, used to plummet the chip temperature within degrees of absolute zero, slows atomic movement on the semiconductor chip to a crawl.



How to control the PAN(dem)IC

It is a question that most people hope will never need answering. What should be done in response to a widespread and possibly deadly flu pandemic? For the government, the answer may be setting aside funds from an already thin budget to help treat sick citizens. For some companies, the answer might be shutting down, leaving thousands unemployed but less susceptible to the disease. For students at UW-Madison, the answer might be canceling an entire football season or shortening the academic semester. These are certainly drastic measures to be taken in case of a deadly flu pandemic, but they may be necessary to ensure a healthier population.



A flu pandemic is something that researchers have feared for a long time, and some believe it could be more fatal than any natural disaster or war. Imagine millions of people infected with a deadly virus that cannot be immediately combated with any medication. Thousands could be forced to miss work, resulting in a crumbling economy. And here on the UW-Madison campus and at college campuses all around the world, students will be at very high risk because of the close proximity to each other in classrooms and dorms. Thankfully, researchers around the United States are preparing for such a flu pandemic so that we may respond appropriately.

One researcher is Vicki Bier, professor of industrial and systems engineering, who has been studying the effects of a flu pandemic and providing planning strategies in the case that one should arise. In 2007, she and several colleagues published a report providing detailed information about when to close schools and businesses and how to prepare for the economic impacts of a flu pandemic.

Before jumping into the response plan, it is very important to understand exactly what characterizes a flu outbreak as a pandemic rather than a normal flu season. A flu pandemic is described by the World Health Organization as an outbreak caused by a strain of flu that is new to a population, and easily spreads and infects that population. With a flu pandemic, people won't initially have immunity to the virus, giving it the ability to spread more widely and more quickly. Professor Bier's paper estimates that 30 percent to 40 percent of people in a workplace may be absent during a flu pandemic. "It's similar to a snow day but it's a snow day that could last for weeks and you can't really get back to business in a day or two," Bier says.

The initial idea for the pandemic response paper was Professor Bier's own. "Back when people we were more concerned about avian flu, it occurred to me that there were a lot of things that individual organizations had to do for themselves," Bier says. "I initially started by putting on a workshop and had a lot of volunteers in planning, both from government agencies, from the private sector and the university." She was later approached by the U.S. Department of Health and asked to help plan for a pandemic.

In writing the paper, Bier and her fellow researchers turned to history for some insight. They looked back at the 1918 Spanish flu pandemic to compare the actions taken by various cities and whether those actions were successful. While records were not as well kept 100 years ago as they are now, the researchers found that the cities that took stronger actions seemed to have, in general, less illness, Bier says.

> **"A dire situation would go beyond what public health could handle and involve a lot of other parts of society."**
>
> **-Professor Bier**

The paper itself doesn't focus so much on the medical aspects of a pandemic, such as vaccines or medicine, because the effects of a pandemic would reach beyond any hospital or pharmacy. "We tried to focus on some of the broader systems issues or social issues that could be affected by a pandemic. The three things we chose [to focus on] were school closure, business closure and what would happen as far as the needs of the working poor," says Bier.

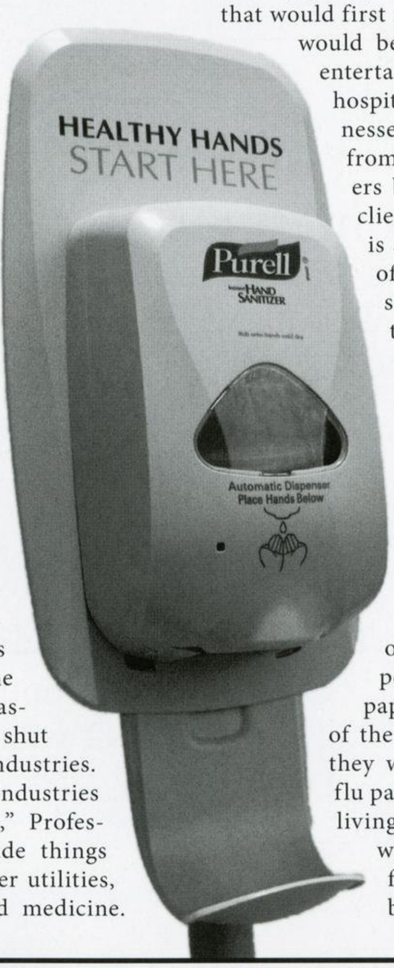
They found that the effects of a pandemic would be much broader than just a medical issue to be dealt with by public health officials. "A dire situation would go beyond what public health could handle and involve a lot of other parts of society," says Bier.

The close confines of classrooms and lecture halls are a breeding ground for deadly flu viruses, so it would be extremely important to consider the closure of schools.

So just how should governments, schools and businesses respond to the impacts of a flu pandemic?

"The big interventions early on are what the public health people call non-pharmaceutical interventions," Professor Bier says. Non-pharmaceutical interventions include many common-sense measures like thorough hand-washing and staying home when sick. Other things to consider may be slowing the spread of influenza by canceling events that draw large crowds. "One of the things we looked at was whether we would cancel football games or other major social events," says Bier.

While many Badger fans may gasp at the thought of canceling an entire football season, it could be a necessary measure to slow the spread of a flu pandemic. Ironically enough, the H1N1 virus hit the UW-Madison football team this past fall. While the team was able to beat the viral opponent, the episode highlighted how quickly the disease can spread. In a crowd of 80,000 at Camp Randall, this is a serious concern.



While closing down Camp Randall for an entire season would be disappointing, canceled football games would not be the end of the world. However, in some cases, it may not be possible to shut down some businesses or industries. "There are some critical industries that need to remain open," Professor Bier says. These include things like electricity, gas and other utilities, or even grocery stores and medicine. "Most of those critical industries have already done a lot of their own planning," she says, but the paper also explores the possibility that government assistance may be needed to maintain some critical infrastructures.

Just as in a typical flu season, children would play a major role in the transmission of a deadly virus in the case of a pandemic. The close confines of classrooms and lecture halls are a breeding ground for deadly flu viruses, so it would be extremely important to consider the closure of schools. The question of when schools should be closed, however, is a difficult one to answer. "It [isn't] clear to me that closing schools when there [is] a high rate of absenteeism is soon enough," Bier says.

Such a widespread closure of schools and businesses would not go unnoticed by society or the economy. In fact, the state of Wisconsin would see about a 2 percent loss in annual GDP from a pandemic. Typically, the businesses that would first require closing would be those in the entertainment and hospitality industry. "Businesses may suffer the most from a large amount of workers being absent, or limited clients and revenue. It really is a trade-off with severity of disease," Professor Bier says. "The more severe the pandemic, the more dire the economic consequences may be. But in the end, losing several weeks of class or a month's revenue will be worth saving lives from a flu pandemic."

In addition to business and school closure, one of the most unique aspects of Professor Bier's paper explores the needs of the working poor and how they would be impacted by a flu pandemic. As it is, families living paycheck-to-paycheck would suffer the most from such a pandemic, because they could lose irreplaceable wages due to missing work. As a result, these families might turn to government assistance, putting more of a strain on the government's resources. Furthermore, low-wage industries are very susceptible to closures, resulting in unemployment for the workers.

While people may be concerned about the impacts of a flu pandemic, they can find relief knowing that government, schools and businesses have action plans. It is true that scientists may never be able to predict just how severe a flu pandemic may be. However, thanks to Professor Bier and her colleagues, we now know how best to respond to a pandemic to keep our lives moving along as usual. WE

Article by Lauren Kern
Design by Evan Owens
Photos by Stefan Jedlicka

Engineering television shows

Haven't had enough knowledge shoved in your head for one day? Why not go home and flip to one of these classic science and technology shows—guaranteed to be much more interesting than your 9:30 power lecture.

"Modern Marvels": Since 1995, the History Channel's "Modern Marvels" has explored 500 of the most amazing engineering projects of our time, from the construction of the Chrysler building to the manufacturing of candy. Using a documentary-style narration, the show delves into the history of each topic in addition to its technological traits.

"Time Warp": In the Discovery Channel's "Time Warp," MIT scientist Jeff Lieberman and cameraman Matt Kearney use high-speed cameras to capture split-second occurrences: exploding, men who can catch arrows barehanded, and a college student favorite, smashing out the bottom of a beer bottle with one hand.

"World's Toughest Fixes": The industrial world's version of "Man vs. Wild," National Geographic Channel's "World's Toughest Fixes" follows expert Sean Riley as he takes on challenging and dangerous repairs on some of the most complex mechanical systems in the world. Since the show's start in 2008, Riley has worked on a nuclear turbine, a cruise ship engine, and the Columbia River dam, among others. WE

By Carrie Boecher

November 2009 caption contest results - Top 5

1. Play me off piano horse
   - Jane Doe
2. This is how "Horse the Band" got started
   ("Horse the band" is an electronica/rock band based on synthasizers)
   - Peter Znameroski
3. Bad Horse
   - John Doe
4. The begining of Mr Ed's music career
   - Covington Raymond
5. No! I don't WANT your old hardware
   - David Nelson

Just one more

The finest in eclectic humor

"Jersey Shore" transfer student's class schedule

Time	Monday	Tuesday	Wednesday	Thursday	Friday
12:00PM-3:00PM	GTL: Gym, Tan, Laundry	GTL: Gym, Tan, Laundry	GTL: Gym, Tan, Laundry	GTL: Gym, Tan, Laundry	GTL: Gym, Tan, Laundry
3:30PM-4:30PM	Sociology 106: Migration & Mating Patterns of Guidos & Guidettes		Biomed 255: Artificial Tanning & Skin Cancer		
5:00PM-5:30PM		Linguistics 625: Howta Purfect dat Joisey Shor Aksent		Physcis 101: Physics of Fist Pumping	
5:30PM-6:00PM		Chem 114: Polymers and Hair Gel	Self Defense 497: How to "beat up that beat"		
10:00PM-2:00AM				Sociology 106: Migration & Mating Patterns of Guidos & Guidettes	

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